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The technological product platforms and industrial ecosystems development based on the innovative solutions potential

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Abstract. The relevance of the topic is related to the need to develop technological product platforms (hereinafter CCI) and industrial ecosystems (hereinafter PE), based on the transformation of cardinal innovative solutions using digital technologies to ensure the creation of highly competitive products developed and manufactured to replace analogues previously imported due to high sanctions pressure. The development of CCI and PE requires the development and creation of economic tools for transforming the potentials of innovative solutions for the mechanism of managing the transition of an organization to a position of technological leadership through the production and commercialization of radically new products. The research objectives include analyzing existing approaches to transformation and identifying their main types in industrial ecosystems, developing recommendations for managing the organization's transition to a position of technological leadership through the production and commercialization of radically new products. The purpose of this research is to study the role and effectiveness of digital technologies in the processes of transformation into industrial platforms and ecosystems as part of strategies for transforming the potential of innovative solutions. It is assumed that an integrated approach can significantly increase the company's competitiveness in the international market and accelerate the growth of its economic performance. The research methods are content analysis of sources and economic and mathematical modeling of network multilateral effects of platforms. As a result, the effects of industrial platforms and ecosystems were studied, and a mechanism for the development of an organization based on a platform approach was formed.

Keywords: technology platforms, industrial ecosystems, innovations, digitalization of production, product lifecycle management

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Развитие технологических продуктовых платформ и промышленных экосистем на основе потенциала инновационных решений

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Аннотация. Актуальность темы связана с необходимостью развития технологических продуктовых платформ (ТПП) и промышленных экосистем (ПЭ), основанных на трансформации кардинальных инновационных решений с использованием цифровых технологий для создания высококонкурентных продуктов, разрабатываемых и производимых взамен ранее импортируемых аналогов из-за высокого санкционного давления. Развитие ТПП и ПЭ требует разработки и создания экономических инструментов для преобразования потенциала инновационных решений в механизм управления переходом организации к позиции технологического лидерства посредством производства и коммерциализации радикально новых продуктов. В задачи исследования входит анализ существующих подходов к трансформации и выявление их основных типов в промышленных экосистемах, разработка рекомендаций по управлению обозначенным переходом. Цель исследования — изучить роль и эффективность цифровых технологий в процессах трансформации в промышленные платформы и экосистемы в рамках стратегий преобразования потенциала инновационных решений. Предположено, что комплексный подход может значительно повысить конкурентоспособность компании на международном рынке и ускорить рост ее экономических показателей. В исследовании применены метод контент-анализа источников и экономико-математическое моделирование сетевых многосторонних эффектов платформ. Изучено влияние промышленных платформ и экосистем и сформирован механизм развития организации, основанный на платформенном подходе.

Ключевые слова: технологические платформы, промышленные экосистемы, инновации, цифровизация производства, управление жизненным циклом продукции

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Introduction

In the modern economy, especially in the context of geopolitical and sanctions pressure, strategic alliances and innovation networks play a key role in creating a synergistic effect for high-tech production (Drogovoz et al., 2021; Chursin et al., 2017). These aspects contribute to strengthening cross-industry innovation, optimizing resources and expanding market opportunities, which contributes not only to technological progress, but also to economic sustainability in difficult conditions.

The global competitiveness of an industrial company can be defined as a multifactorial state of the organization's potentials, which allows the company not only to produce "traditional" goods, but also to make a breakthrough in the creation of innovative technologies, products and solutions. This condition implies that the company has a set of necessary resources and conditions for the introduction of advanced scientific and technical achievements (Plakhin, Tkachenko, Evseeva, 2020).

Considering this provision in more detail, it becomes clear that it includes not only the development of unique technologies, but also the organization of their production at a new qualitative level, as well as the development of unique technological competencies, which requires in-depth research and development, the use of advanced engineering thinking and the integration of advanced technical solutions.

In practice, global technological competitiveness is manifested in the ability of an industrial company to quickly adapt to changes in the technological landscape and transform these changes into long-term competitive advantages.

It is important to note that maintaining a high level of innovation processes requires significant investments in research and development, as well as in the creation of strong research teams, engineering groups, and the formation of strategic alliances with educational and research institutions, as well as more complex network forms of cooperation in the field of innovation, in the form of technological product platforms and industrial ecosystems.

The use of technology platforms allows companies to standardize certain aspects of production processes and components, which simplifies the development

of new products. This not only reduces development costs and time, but also facilitates the integration of innovations, since different products can use a common base of technologies and components. Industrial ecosystems include the interaction of various participants — manufacturers, suppliers, consumers, scientific and educational institutions — aimed at the joint creation and development of new products, services and technologies. They can be formed on the basis of a specific technology or market and include various types of cooperation, from rigid integration to more open network structures (Abrosimova, Klimova, 2020).

Strategic alliances improve access to new technologies and knowledge, technology platforms standardize developments, increasing their effectiveness, while industrial ecosystems create conditions for cooperation between various market actors.

Thus, strategic alliances, technology platforms and industrial ecosystems create a synergistic effect that significantly accelerates the process of innovative developments, contributes to a more efficient and economically justified introduction of new technologies, and strengthens the global competitiveness of companies.

Thus, the global competitiveness of an industrial company is a combination of different types of potentials, which allows the company not only to adapt to current market requirements, but also to form new directions of market development, creating products with high technical and economic characteristics to achieve competitive leadership (Tyulin, Chursin, 2017; Chursin, Makarov, 2015; Chursin, Vlasov, Makarov, 2016; Chursin et al., 2024).

Relevance, problem and hypothesis of the study

With the advent of platform solutions and technologies, companies have the opportunity to effectively expand their innovation areas, improve productivity and competitiveness. Platform technologies offer a unique basis for the creation and launch of new products and services, which makes them a tool for transforming the potentials of innovative solutions.

According to IDC[1], Global spending on digital transformation is expected to reach $2.3 trillion by 2023.

Digitalization of industry includes the use of technologies to diversify innovations such as:

1. Artificial intelligence and machine learning that can analyze big data to identify new innovation opportunities and optimize existing processes. AI is able to analyze data many times faster than a human, which allows you to save up to 30–50% of the time for data processing and decision-making in production. According to McKinse[2] using of AI can reduce production downtime by 20–50%.

[1] International Data Corporation. (n.d.). Worldwide Digital Transformation Spending Guide. IDC. Retrieved 16 April 2024, from https://www.idc.com/getdoc.jsp?containerId=IDC_P32575

[2] McKinsey & Company. (n.d.). McKinsey technology trends outlook 2023. Retrieved 16 April 2024, from https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-top-trends-in-tech

According to the PwC report[3], Global GDP could grow by 14% by 2030 thanks to AI, which is equivalent to a $15.7 trillion increase in economic value.

2. Blockchain: Provides opportunities to create transparent, secure and immutable data storage systems. In the logistics sector, the use of blockchain can reduce supply chain costs by 20%, thereby improving product transparency and traceability. Experts note[4], that blockchain can reduce data loss by 55–65% by increasing the level of security and data integrity.

According to forecasts, the blockchain technology market will reach $39.7 billion by 2025, which shows the high interest in this technology in the industry.

3. Internet of Things (IoT): Integrates physical objects with digital platforms to create intelligent control and monitoring systems. The introduction of It in production allows you to reduce operating costs by 30%, while increasing productivity by 25%. IoT also speeds up the decision-making process by 36%, due to real sensor data and fast analysis.

According to Gartner, there will be over 43 billion connected IoT devices by 2023. The Industrial Internet of Things (IIoT) sector is growing with an expected growth to $110.6 billion by 2025, according to information from MarketsandMarkets[5].

4. Cloud technologies (Cloud tech): provide flexibility and scalability of resources, simplifying the process of innovation of various business models. Cloud technologies make it possible to reduce initial investments in IT infrastructure by 40–50%. With the ability to scale, cloud solutions offer a 50–70% increase in efficiency for business processes.

As the report shows Forrester[6], Global public cloud spending reached $175 billion in 2021 and is projected to rise to $350 billion by 2022. According to the report IDC[7], worldwide spending on cloud computing will reach $1 trillion by 2023.

These tools are not only capable of improving the efficiency of production and operational processes, but also provide unprecedented opportunities to personalize products and services to the specific needs of the end user, as well as the development of radically new products. The role of these technologies in analyzing large amounts of data to predict market trends and changes in consumer preferences should be emphasized. The above data confirm the scale, dynamism and, most importantly, the economic development of digital technologies and the processes of "platformization".

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[3] PwC. (n.d.). PwC's global artificial intelligence study. Retrieved 16 April 2024, from https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html

[4] Yaga, D., Bark, J., & Scarfone, K. (2018). Blockchain technology overview (NIST Interagency Report 8202). National Institute of Standards and Technology. Retrieved 16 April 2024, from https://csrc.nist.rip/external/nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8202.pdf

[5] MarketsandMarkets. (n.d.). Internet of things (IoT) in retail market size & forecast. Retrieved 16 April 2024, from https://www.marketsandmarkets.com/Market-Reports/retail-iot-market-43188550.html

[6] Forrester Research. (n.d.). Gain insights that accelerate growth with Forrester research. Retrieved 16 April 2024, from https://www.forrester.com/research/

[7] IDC. (2025). Digital transformation in manufacturing: Why integrated business planning is key. Board International. Retrieved 16 April 2024, from https://www.board.com/en/analyst-report/idc-digital-transformation-manufacturing

The purpose of this study is to explore the role and effectiveness of digital technologies in the processes of transformation into industrial platforms and ecosystems within the framework of strategies for transforming the potentials of innovative solutions. The work is aimed at analyzing current practices, identifying key advantages and limitations, as well as developing recommendations for the implementation and optimization of digital tools to increase the sustainability of industrial ecosystems (Kulapov, Pereverzeva, Kirillova, 2022).

The transformation of traditional industrial companies into platforms and ecosystems, leading to the ability to use strategic opportunities to transform the potentials of innovative solutions, is an extremely relevant issue in the modern economy (Markova, Kuznetsova, 2021). Globalization, increased international competition, accelerated technology transfer and changes in consumer preferences require industrial enterprises to be flexible, innovative and able to quickly adapt to changing market conditions. Transformation into ecosystems allows companies not only to integrate effectively into the digital economy, but also to expand their sphere of influence, strengthening innovation processes and creating new market niches (Gutenev, Shiboldenkov, 2024; Kashevarova, Panova, 2023; Kashevarova, Shiboldenkov, 2020). Significant difficulties in the process of transforming traditional industry into platform solutions and ecosystems include a number of key issues: resistance to change on the part of managers and employees, the need for significant investments in technological infrastructure, risks associated with data security, as well as the need for new competencies and knowledge. An additional difficulty is the process of integrating old and new systems, which can lead to temporary performance losses. There is also a problem of legislative regulation of innovations, which often does not keep pace with technological development (Shiboldenkov, 2024; Shiboldenkov, 2022).

The hypothesis of this study is that in the context of the development of the above-mentioned tools, the implementation of this will solve the issues of increasing the efficiency and successful development of the "platformization" of industrial enterprises into innovative platforms and ecosystems depends not only on investments in technology, but also on a strategic change in organizational culture, management tactics and the involvement of all stakeholders in the process of innovation. It is assumed that an integrated approach to transforming the potentials of innovative solutions, combining the development of new products, process optimization and the creation of new business models within the framework of the created ecosystems, can significantly strengthen the competitiveness of the company in the international market and accelerate the growth of its economic indicators.

The basics of the platform approach

Research and management of innovative potential (scientific and technological potential and unique technological competencies) plays a key role in the formation of radically new products and technologies for their production. The potential of a business in a broad sense is a set of resources that determine the functioning

of an organization, depending on the conditions. In various aspects of activity, it is possible to distinguish between financial and economic, scientific and technical, industrial and technological, commercial and other types of potential.

Product potentials based on innovative solutions are closely related to the concept of innovative potential, which is based on a set of scientific and technical resources, including accumulated knowledge, material and technical base, information and financial resources, as well as organizational structure. It ensures the development and implementation of new technologies, products and methods of production organization that enhance competitiveness and production efficiency.

Potential management includes the implementation of impacts aimed at increasing it and transforming it into competitive advantages at various stages of the production cycle, which makes it possible to quickly and effectively respond to changes in the external environment and the dynamic development of competitors (Gorlacheva, Shiboldenkov, Gertsik, 2024; Gorlacheva et al., 2025).

To effectively manage this potential and its role in creating the advantages of new products, it is advisable to develop a specialized algorithm that will allow you to organize the processes of accumulation and transformation of potential in accordance with the development of the organization and market conditions (Figure 1). This will become the basis for solving strategic tasks to ensure sustainable development and productive innovation activities of the company.

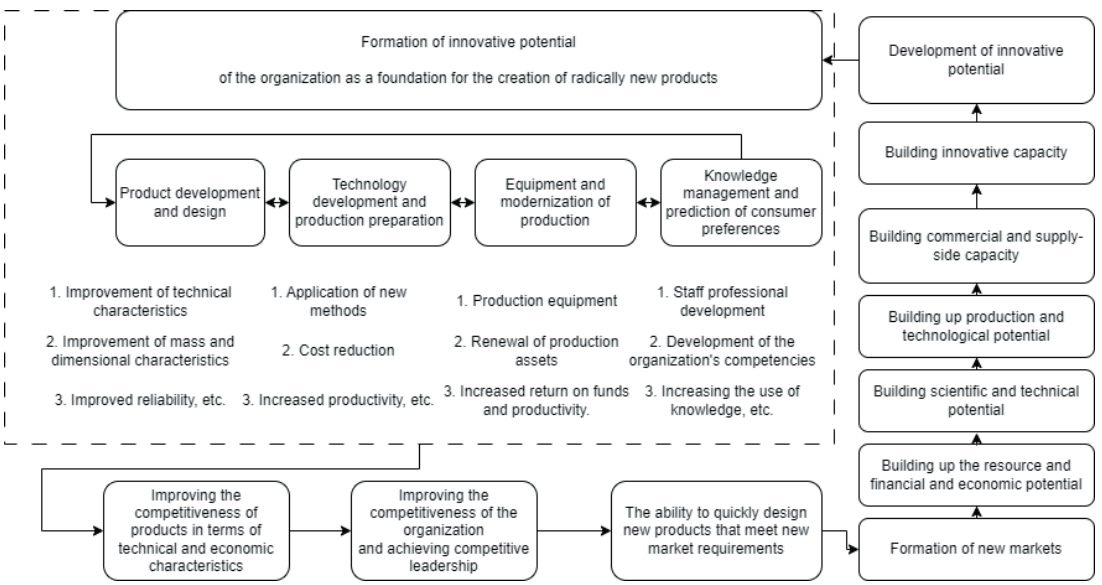

Figure 1. The process of converting product potentials based on innovative solutions of the organization into competitive advantages

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

Platform-based approaches and business models are becoming increasingly popular in the modern economy as they offer effective ways to create value and scale up a business. They also help to increase the level of innovation and improve customer interaction.

Platform business models are business strategies based on the creation and operation of platforms that connect different user groups such as sellers and buyers, developers and end users.

Table 1

Conceptual framework of the platform approach[8,9]

Characteristics	Platform	Ecosystem	Superapp
Definition	A business model that creates a base for interaction between various users and services	A set of interconnected services, products, and organizations operating in a specific domain	A mobile application that combines multiple functions and services, enabling users to perform various tasks without leaving the app
Objective	Providing a structure for interaction among participants and promoting the creation of network effects	Creating value through synergy among ecosystem participants	User convenience by integrating multiple functions into one interface
Examples	Amazon (commerce), Airbnb (accommodation), Uber (transportation)	Apple or Android ecosystems, including devices, OS, applications, and services	WeChat (China), offering services from messaging to payments
Key Functions	Connecting various types of users (buyers, sellers), facilitating transactions	Supporting innovation, resource sharing, product/service integration	Performing various actions within a single app (e.g., chat, payments, food orders, taxis)
Interaction	Multiple (many-to-many), typically through the platform	Multidimensional, including various levels of relationships (within company, between companies, with customers)	Unidirectional (user to services within the app)
Market Significance	Expanding market opportunities, achieving economies of scale	Long-term growth through innovation and sustainable relationships	Increasing convenience and reducing time spent on various operations

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

[8] Central Bank of the Russian Federation. (2021). Ecosystems: Approaches to regulation: Report for public consultations. Moscow. Retrieved April 16, 2024, from https://cbr.ru/Content/Document/File/119960/Consultation_Paper_02042021.pdf

[9] Ministry of Economic Development of the Russian Federation. (2021). The concept of general regulation of the activities of groups of companies developing various digital services based on a single "ecosystem". Retrieved April 16, 2024, from https://www.economy.gov.ru/material/file/cb29a7d08290120645a871be41599850/koncepciya_21052021.pdf

Table 1 presents a comparison of the main aspects of platforms, ecosystems and supercaps, illustrating how they differ from each other in definition, purpose, use cases, as well as functionality and marketing significance.

The basic architecture features of platform solutions cover interoperability and integration: components must seamlessly exchange data and functions, unifying business processes and ensuring the integrity of services. Scalability and modularity are critical, allowing you to safely and predictably increase load and functionality without degrading performance and without interfering with the core. Security and confidentiality, regulatory compliance, and resilience to change are essential while maintaining a high level of convenience and openness to collaboration.

The Nelson-Phelps model is a tool for analyzing technological progress and its impact on economic growth. This model is focused on assessing the speed of adaptation of new technologies in various economies and considers learning as a key factor in the spread of technology (Drogovoz, Kashevarova, Starikova, 2024).

This model becomes especially relevant in the context of the development of a technology platform in business structures, as it allows you to assess how quickly an organization can innovate and adapt to changes in the technological landscape, which directly affects its competitiveness and efficiency.

Below is a generalized formula that takes into account the key aspects of the Nelson — Phelps model

$$\Delta A(t) = \left(\gamma \cdot \frac{H(t)}{A(t)} + \alpha \cdot E(t) + \beta \cdot C(t) \right) \left[A^*(t) - A(t) \right], \quad (1)$$

where $\Delta A(t)$ — is the change in the technology level at the time t; γ — is a coefficient reflecting the basic efficiency of the technology development process, depending on the level of knowledge and technological readiness; $H(t)$ — is the level of human capital (education, training) at a time t; $A(t)$ — is the current level of technology; $A^*(t)$ — is the advanced level of technology available for mastering; α — is a coefficient reflecting the impact of investments in education and development; $E(t)$ — the level of investment in education and staff development; β — is a coefficient that takes into account integration with the external environment and infrastructural support; $C(t)$ — is the level of cooperation in technology alliances, networks and platforms.

Using the Nelson — Phelps model, it is possible to plan your strategic steps for the development of a technology platform, identify key areas for investment and improve the adaptation of new technologies, which, in turn, allows you not only to improve internal processes, but also to respond to changes in the market environment more flexibly and quickly, thereby ensuring sustainable growth and development organizations. In order to expand the model, which adds a change in the level of technology that increases the competitiveness function of products (Gorlacheva et al., 2025), you can introduce the function $K(t)$, which will reflect the

competitiveness of products at a time. This function may depend not only on the current level of technology, but also on other variables such as product quality (including novelty and innovativeness), market reaction (including economic efficiency) of the application of these technologies. Let's include these factors in the equation as follows

$$K(t) = \vartheta \cdot \left(A(t)\right)' + \lambda \cdot Q(t) + \mu \cdot R(t), \tag{2}$$

where ϑ, δ, λ, μ — are the parameters determining the degree of influence of the corresponding variables on competitiveness; $Q(t)$ — product quality; $R(t)$ — is the market reaction (demand, customer preferences, etc.).

A change in the technology level $\Delta A(t)$ will affect not only the function $A(t)$ itself, but also, as a result, will change $K(t)$, since technology improvement directly affects the quality and innovative characteristics of the product, making it more attractive to the market.

Thus, the updated general formula will represent the system of equations of systems (1) and (2).

Such a model allows you to visually see the complex interaction between the level of technology and the competitiveness of products, emphasizing the importance of innovation in the modern economy.

In today's competitive environment, technology platforms serve not only as the basis for creating products, but also as the foundation for the development of ecosystems that are based on the relationship between various actors: developers, suppliers, sellers and end users. It is through such platforms that it is possible to ensure not only process optimization, but also rapid adaptation to changing market requirements, which is a key aspect in achieving and maintaining high competitiveness.

Platform solutions and technologies play an important role in the process of transforming the potentials of innovative solutions. They help companies accelerate the development and implementation of new products, as well as improve interaction within the company and with the external environment (Drogovoz, Kashevarova, Starikova, 2024; Shiboldenkov, Podrezov, 2023; Ryzhkova, 2019). These platforms provide the necessary flexibility and resilience that are critical for successful adaptation in an ever-changing market (Table 2).

Innovative platforms are modern tools designed to stimulate and manage the process of creating new technologies, services and products. They function as an environment where diverse participants (startups, large enterprises, scientists, investors) can work together to develop and adapt innovations. It is possible to give such a definition to an innovative platform: It is an organizational and technological environment that ensures the interaction of various stakeholders in order to jointly develop, test and distribute innovative solutions. Platforms provide tools and resources for collaborative work, as well as mechanisms for commercializing the results of innovations (Denisov et al., 2020).

Table 2

Aspects of effects in platform interaction

№	Aspect	Description	Mechanism	Effect
1	Network Effect	Each new user's connection increases the overall value of the platform for all participants	The more users, the richer the social networks	The platform becomes more attractive and useful for new participants, contributing to its exponential growth.
2	Multisided Market	The platform connects two or more user groups (e.g., buyers and sellers)	Increasing demand and supply on different sides of the platform	The more participants, the more balanced the markets and the higher the likelihood of transactions
3	Positive Feedback Effect	Interaction among platform participants increases its attractiveness, attracting even more participants and interactions	The more participants and interactions, the higher the value of each subsequent connection	The platform gains strength and dominance in its market segment through constant growth and improved functionality
4	Zero Marginal Cost Effect	As the platform expands, the marginal cost to attract new participants tends toward zero	Platform expansion occurs with minimal additional costs	This leads to high scalability and the ability to expand without substantial additional expenses
5	Lock-in Effect	Joining the platform becomes so beneficial that users do not want to switch to alternative platforms	The more integrations and services, the harder it is for users to switch platforms	The platform retains user loyalty for the long term, reducing the risk of churn and loss
6	Data and AI Effect	Platforms collect vast amounts of data used to improve service through artificial intelligence and machine learning	Data helps enhance algorithms and provide more personalized services	The platform becomes "smarter" and can offer higher quality and more tailored services to its users
7	Externalities	The platform triggers external effects that positively (or negatively) impact other companies and ecosystems	Creating additional opportunities for businesses and the economy as a whole	The platform becomes a central element of a broader ecosystem, thereby enhancing its significance and resilience
8	Gap-Filling Effect	The platform can identify and fill new market niches and needs that were previously unmet	Quick adaptation and expansion of service offerings	The platform remains innovative and competitive, attracting the attention of new user segments
9	Transaction Efficiency	Simplification and acceleration of transactions through new technologies and processes	Fast and reliable transactions provide trust and convenience for users	The platform delivers seamless and efficient services, increasing its attractiveness to users and partners
10	Economies of Scale	The platform's growth leads to a reduction in per-unit production or service cost	Increased production volume reduces average costs	The platform can offer more competitive prices and terms to its users

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

Platform solutions for creating radically new products include the use of advanced technologies that allow you to process a large amount of information and generate innovative ideas. These platforms contribute to:

1. Integration between different industries and knowledge, which opens up access to new methods and approaches in product development.

2. Reduce development time and costs by sharing resources and knowledge.

3. Increase flexibility and adaptability to changing market conditions through quick access to innovative solutions and technologies.

Platform development approaches make it possible not only to create cost-effective, but also qualitatively new products that can radically change the market landscape and meet the changing needs of end users.

Network Effect

Network effects are a key component of the success of many modern platform business models, such as social networks, marketplaces, online services and technology ecosystems (Table 3). These effects occur when the value of a product or service increases with an increase in the number of its users (Titova, Ziglina, 2021).

Table 3

Aspects of network effects

№	Aspect	Description	How It Works	What It Means for the Platform
1	Increase in Utility	Each new user's connection increases the overall value of the platform for all participants	The more users, the richer the social networks	The platform becomes more attractive to new users, strengthening its position and appeal
2	Increase in Partner Attractiveness	An expanding user base makes the platform more attractive to external partners and developers who can create apps or services integrated with the platform's API	Growth in user base attracts more partners	The platform expands its functionality and ecosystem, becoming more versatile and convenient
3	Economies of Scale	As the number of users grows, the cost of servicing each user decreases due to more efficient resource distribution	Higher efficiency and lower cost per user	Lower operational costs allow for reinvestment in the development and improvement of the platform
4	Barriers to Competition	Strong network effects create barriers for new market entrants	New competitors find it more challenging to attract users	The advantage of a large and loyal user base deters new competitors and protects market positions
5	Increase in User Retention	High levels of user interaction and engagement keep users on the platform and reduce the likelihood of switching to competing platforms	Strong community reduces user churn	Increased user loyalty supports stable growth and development of the platform

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

Network effects, or network economy, is based on the idea that each new user of the platform not only gets value from existing features and content, but also adds value to other participants through their participation. This is the basis of the so-called "Metcalf effect", according to which the usefulness of the network increases proportionally to the square of the number of its users (Katrovsky, 2020).

Network effects can be divided into two main types:

- Direct network effects: The value of a product increases directly depending on the increase in the number of its users. An example is a telephone network, where each new subscriber directly increases the usefulness of the network for all other subscribers by increasing the number of possible connections.
- Indirect network effects: The value of the product increases due to an increase in the number of additional products and services that become available with the growth of the user base. A classic example is operating systems, where the growth in the number of users stimulates the creation of more software.

Network effects have a significant impact on the success of various industry platforms, confirming that the value of a product or service increases in proportion to the increase in the number of its users. Examples of such platforms include Salesforce, Amazon Web Services (AWS), Apple's App Store, Google Play and Google Cloud Platform, GitHub and Microsoft Azure.

Salesforce, a CRM platform, benefits from the accumulation of applications on the Salesforce AppExchange, increasing its value with the growing number of users and developers. Similarly, AWS and Microsoft Azure attract developers and businesses due to their extensive user bases and integration with other services, which strengthens their network effects. Apple and Google's app ecosystems, such as the App Store and Google Play, also benefit significantly from the scale of their user bases, encouraging developers to create new applications.

A key aspect for all these platforms is that the interaction of a large number of users and developers creates favorable conditions for innovation and collaboration, which enhances their competitive advantages and creates a significant value addition for all participants.

Thanks to network effects, platforms can reach a so-called "tipping point", after which their growth accelerates and they become extremely attractive to new users. This, in turn, can lead to market dominance, and in some cases to the formation of monopolies, as happened, for example, with Facebook in the field of social networks or with Google in the field of search engines.

To describe a mathematical model of exponential revenue growth that emphasizes the presence of network effects on digital platforms and includes transaction cost factors, the following relationship can be proposed. Let's denote:

- $A(t)$ as the number of platform users at time t.
- $R(t) = \alpha \cdot N(t)$ as the revenue of the platform at time t.
- $C(t) = \beta \cdot N(t)$ as the total costs of the platform at time t.
- ρ as a coefficient reflecting the influence of the number of users on the growth of interest in the platform or service (a constant reflecting the strength of the network effect).

- α as a coefficient proportional to the amount of revenue from each user
- β as a constant characterizing the maintenance costs of each user.

Then the growth in the number of users can be represented as

$$\frac{dN}{dt} = \rho N, \rightarrow N(t) = N(t_0)e^{\rho t}. \quad (3)$$

This differential equation describes the exponential growth of users, where with the growth of N, new users come faster due to the network effect.

Thus, the income $P(t)$ (profit after deducting costs from revenue) will be equal to

$$P(t) = R(t) - C(t) = \alpha \cdot N(t) - \beta \cdot N(t) = (\alpha - \beta) \cdot N(t). \quad (4)$$

Substituting the user growth function $N(t)$, we get the final expression:

$$P(t) = (\alpha - \beta) \cdot N(t_0)e^{\rho t}, \quad (5)$$

where $N(t_0)$ — is the number of users at the start of the observation.

Although network effects can significantly strengthen the position of platforms in the market, they also place certain demands on growth management and innovation. Platforms need to constantly update their products and services to meet the growing and changing needs of users. In addition, success often depends on the platform's ability to attract and retain high-quality developers and content partners, which requires strategic planning and investment. Thus, understanding and skillful use of network effects are the key to the success of many platform companies in the modern digital economy.

Multilateral markets

Multilateral markets, or multilateral platforms, are economic platforms that ensure the interaction of several interconnected groups of participants (Kovalenko, 2016). Examples of such platforms include markets like Airbnb, where tenants and landlords interact, or Uber, where drivers and passengers connect. The effectiveness of these platforms significantly depends on their ability to simultaneously attract and serve different groups of users, which then creates network effects that increase the value of the platform for all participants.

Let's look at the main aspects of the multilateral market (Table 4).

Effective management of the multilateral market requires a deep understanding of the needs and relationships between all participants, as well as the ability to innovatively solve the challenges facing the platform (Pudovkina, 2020). These platforms connect different user groups, each of which has its own risks and expectations.

Table 4

The main aspects of the multilateral market

Aspect	Description
1. Balanced user engagement	Attracting one group of users should stimulate the attraction of another. For example, the more products there are on the e-commerce platform, the more buyers it attracts, which in turn attracts new sellers
2. Development of incentives for all parties	Each group should feel that they benefit from participating on the platform. This may include financial and non-financial incentives such as discounts, bonuses for attracting new members or improved terms of use of the platform
3. Ensuring quality and trust	Multilateral platforms should actively manage quality and trust between users, for example, through rating systems, reviews, as well as providing guarantees and support
4. Conflict Management	Inevitably, conflicts between different user groups require careful resolution. The platform should provide effective dispute resolution mechanisms
5. Adapting to changes in the industry	Multilateral platforms must be flexible and adaptable to market and technology changes to maintain their competitiveness and attractiveness to all participants
6. Data integration and analytics	Data collection and analysis helps to understand the needs and behavior of each of the parties, which allows you to optimize the platform's efforts to meet these needs and anticipate trends
7. Legal aspects	Multilateral markets face unique legal issues, including regulation, data protection and consumer rights, and must actively manage these risks

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

Multilateral markets (multilateral platforms) are economic platforms that connect two or more distinct but interdependent user groups. A mathematical description of such systems can be built on the basis of supply and demand modeling (based on the utility function U), taking into account these network effects.

$$U\left(N\left(t\right)\right) = f\left(P\left(t\right), Q\left(t\right)\right) \to \max, \tag{6}$$

where $Q(t)$ is the quality or capacity of the platform to meet the needs of the $n \in N$.

To effectively create a sustainable digital ecosystem, it is necessary to pay attention to such aspects as a deep understanding of user needs through thorough market research, the choice of a scalable technological infrastructure that guarantees high performance, as well as the integration of data and services to expand functionality. It is also important to ensure data security and confidentiality in compliance with regulatory requirements, to develop user-friendly interfaces and management tools to optimize the operation of the platform. It is also necessary to strive for modularity and scalability of the system, ensuring cross-platform accessibility and developing effective monetization strategies. Finally, cooperation and partnerships will help expand the technology platform's offering

and strengthen its competitive advantages, which is the key to attracting and retaining users, which will solve the issue of its progressive development.

The development and integration of various strategic networking approaches and platforms contributes to the creation of an industrial ecosystem. An industrial ecosystem is a network of interconnected organizations, including suppliers, manufacturers, competitors and others, who collectively create a product or service, which allows participants to jointly create innovations, optimize processes and increase efficiency at all stages of the value chain.

Results

The industrial ecosystem is an integrated and multimodal network of enterprises, suppliers, consumers, research institutions and other stakeholders united within a single production and innovation activity. This phenomenon goes beyond the classical logistics supply chain, as it is characterized by multidimensional interaction and cooperation of participants, which ensures not only the efficiency of production processes, but also stimulates innovative development and knowledge exchange. By emphasizing the role of globalization and digitalization, industrial ecosystems are becoming even more adaptive and flexible, which is necessary to effectively respond to changes in the global economy and technological environment. In this context, digital technologies act not only as an instrumental resource, but also as a catalyst for deep transformations in production and management processes (Nesterov et al., 2019).

Digitalization of industrial ecosystems includes the introduction of integrated IT solutions and platforms that allow the creation of so-called "smart production". Such technologies, including the Internet of Things (IoT), artificial intelligence and machine learning, maximize production capabilities, optimize work at enterprises, minimize costs and time losses, and contribute to the development of new business models and strategies in the market.

Moreover, this digital infrastructure supports the creation of horizontal and vertical links between various actors in the ecosystem, including software developers, hardware manufacturers, technology providers and end users. These links ensure closer interaction and coordination between the participants, which is important for the implementation of joint projects and innovations (Table 5).

Thus, industrial ecosystems in the era of digitalization are transformed into complex highly organized structures capable of effectively responding to rapidly changing external conditions, managing risks and creating new value in conditions of constant economic and technological competition.

Industrial ecosystems include various enterprises, from suppliers of raw materials to manufacturers and service providers, as well as end users. In industrial ecosystems, each participant influences the others. Manufacturers, suppliers, service companies and end users create a complex network of interactions. Network effects reinforce these interdependencies because the success of one participant can contribute to increased revenue or lower costs for others.

Table 5

Types of industrial ecosystems

Type of Ecosystem	Main Participants	Industries	Technological Features	Innovation Focus
Traditional	Manufacturers, Component Suppliers, Distributors	Automotive, Heavy Machinery	Process Automation	Productivity Improvement and Cost Reduction
Research	Research Institutes, Universities, Startups, Corporations	Pharmaceuticals, Biotechnology	High-Tech Technologies	Development of New Products, Implementation of New Treatment Methods
Technological	IT Companies, High-Tech Startups, Investors	Information Technology, Robotics	AI, IoT, Big Data	Production Digitalization, Smart Technologies
Environmental	Environmental Protection Organizations, Green Startups, Eco-Farms	Energy, Agriculture	Renewable Energy Sources	Development of Sustainable and Eco-Friendly Technologies, Resource Efficiency Improvement
Creative	Design Studios, Advertising Agencies, Media Companies	Fashion, Publishing, Entertainment	Media and Advertising Technologies	Content Innovation, User Interaction

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

The compatibility of components, machines and systems is critically important in industrial ecosystems. Standardization, enhanced by network effects, allows different ecosystem participants to easily integrate and interact with each other. This reduces production costs and increases the efficiency of operations at all levels. The more participants join the ecosystem, the more the consumer base for each participant grows. This can lead to a significant increase in revenue and expansion of sales markets for all parties involved.

Network effects in industrial ecosystems form a dynamic, interdependent space where each new connection increases value and opportunities for all participants. However, it is important to manage these relationships in such a way as to promote sustainable growth and innovation, as well as avoid creating monopolies and barriers for new players (Molchan, Tolstykh, Nadaenko, 2020).

The mechanism for managing the transition of an organization to a position of technological leadership

It is possible to imagine an extension of the model (1), including the competitiveness of the product (2), due to the network effect of platforms (5) and the effect of the multilateral ecosystem market (6). This can be done by modifying the standard variables and functions of the model

$$\begin{cases} \Delta A(t) = \left(\gamma \dfrac{H(t)}{A(t)} + \alpha \cdot E(t) + \beta \cdot \left(\xi \cdot S(t) + \eta \cdot M(t) \right) \right) \left[A^*(t) - A(t) \right]; \\ K(t) = \vartheta \cdot \left(A(t) \right)^{\delta} + \lambda \cdot Q\left(t, S(t) \right) + \mu \cdot R\left(t, M(t) \right), \end{cases} \quad (7)$$

где ξ, η — are coefficients reflecting the influence of network and multilateral market effects, respectively; $S(t)$ — the impact of network effects; $M(t)$ — the impact of the effects of multilateral markets.

The addition of network effects and multilateral market influence to the Nelson — Phelps model makes it possible to more fully reflect the real conditions of modern technological and economic development.

Such modifications help to better understand how network interconnectedness and the market ecosystem can enhance the competitiveness of products. At the same time, an important aspect is the development and implementation of management mechanisms that allow the organization not only to adapt to changing conditions, but also to take a leading position in the market through the use of modern technologies and the creation of sustainable innovative platforms.

The concept of a mechanism for managing an organization's transition to a position of technological leadership through the production and commercialization of innovative products implies an integrated system of dynamically interacting tools (Figure 2) (Chursin et al., 2017; Tyulin, Chursin, 2020):

1.Tools for the development of scientific and technological potential and competencies: This complex The tools are aimed at expanding and deepening research and technological skills within the business structure, which creates the basis for innovation.

2. Tools for transforming scientific and technological potential into unique product characteristics: Converting the collected knowledge and skills into specific technological solutions that make new products not only innovative, but also uniquely adapted to current market requirements.

3. Tools for managing economic growth through innovation: Tools and techniques designed to stimulate business growth through the strategic introduction and promotion of new products.

4. Economic instruments accompanying the creation and entry into the market of high-value products: These tools support the financial aspects of innovation, including valuation, pricing and profitability.

5. Tools for creating service-oriented business models: Methods and approaches to product commercialization, which include strategies for building customer relationships, developing after-sales services and support.

6. Tools for managing advanced business development: Tools that help predict future market trends and adapt development strategies in accordance with these predictions.

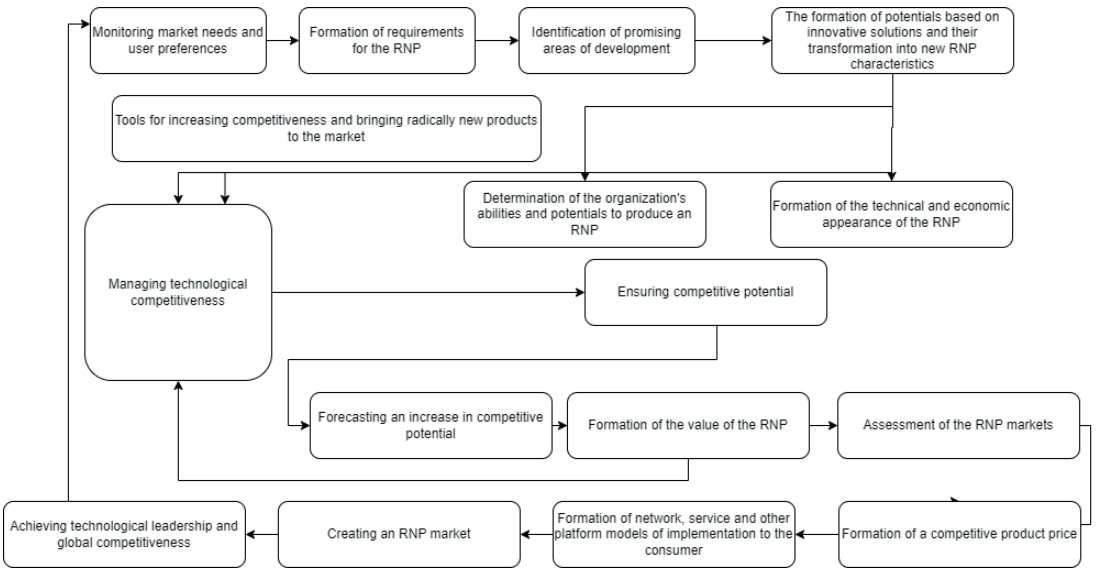

Figure 2. The mechanism for managing the transition of an organization to a position of technological leadership through the production and commercialization of radically new products

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

Each of the above-described elements of these tools contains a set of methods and approaches focused on evaluating, analyzing and managing various aspects of creating high-tech and innovative products, thereby forming an extensive mechanism for the transition to technological leadership. These tools, built into the processes of creating and selling new products, help to form a coordinated and effective approach to achieving advanced development and sustainable technological advantage (Tyulin et al., 2019; Chursin, Tyulin, 2020).

Discussion

The successful transformation of industrial enterprises into innovative platforms and ecosystems depends not only on investments in technology and their technological maturity, but also on a strategic change in organizational culture and the inclusion of stakeholders in the innovation process. An important aspect here is the change in organizational culture, which involves a revision of standard approaches to management, communication and decision-making within the company.

The transformation of governance structures is a critical element to support innovation, which means moving from vertical hierarchies to more horizontal, flexible structures that accelerate decision-making and knowledge sharing. Management practice should focus on the development of policies and procedures that promote experimentation and innovation at all levels of the organization.

The integration of external and internal stakeholders into innovation processes is moving from an optional to a mandatory element of the company's development strategy. This includes building open innovation platforms where customers, suppliers, universities and research institutes can work together to create new products and

services. It is also important to ensure transparency of processes and actively use feedback from consumers to continuously improve the company's offerings.

Transforming the potentials of innovative solutions using a platform approach is a strategy aimed at using modular platforms for the development and adaptation of new products and services in various market segments. This approach allows companies to quickly respond to changes in customer needs and preferences, as well as effectively expand their market niches. Let's look at the key aspects and steps to implement such a strategy Table 6).

Table 6

Steps to implement the "platformization" strategy

Aspect	Description	How It Works
1. Defining the basis of the platform	The central element of the strategy is the development of a universal platform that can be used to create a variety of products or services	Market research to identify the common needs of target segments. Technological audit to assess the possibility of creating modular and scalable solutions
2. Development of a modular architecture	The platform should include modules or components that can be easily reused or adapted for different products	Standardization of components reduces costs and simplifies the process of developing new products. The flexibility of the configuration allows you to customize products to meet the specific needs of users
3. Integration and synergy	The key point is to integrate new products into the existing ecosystem of the platform to create synergies	Cross-use of data between products to improve user experience and optimize operational efficiency. Sharing infrastructure to reduce operating costs
4. Innovative development	The platform should provide for continuous innovative development	Openness to integration with new technologies and third-party developments. Support for startups and partner programs to update and expand the functionality of the platform
5. Marketing and Scaling	The platform requires active marketing and scaling	Targeted marketing to attract different segments of users. Actively attract users through partner channels, online platforms and social networks

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

The systematic application of these recommendations will not only improve the sustainability and efficiency of industrial ecosystems but also ensure their development in the long term.

Practical cases in industrial ecosystems of the Russian Federation

In recent years, Russia has been actively developing industrial ecosystems and platforms, which is becoming a key factor in accelerating the process of modernizing the economy and increasing its competitiveness at the global level. The main emphasis in these efforts is on the integration of digital technologies, the development and

implementation of innovative solutions, which allows creating new opportunities for industry and improving management processes (Katrovsky, 2020).

Russia's industrial ecosystems are a complex of interconnected industries that form the structure of the national economy. These ecosystems include not only large industrial enterprises, but also many small and medium-sized companies, as well as scientific and educational institutions that cooperate at various levels. The main feature of industrial ecosystems is their ability to self-regulate and adapt to changing conditions of the external and internal environment, which is ensured by close ties between participants.

Key criteria by which industrial ecosystems can be assessed include (Table 7):

1. Integration of raw materials bases — how closely producers are connected with suppliers of raw materials.

2. Innovation activity — the degree of introduction of new technologies and developments.

3. Environmental sustainability — measures to minimize the impact on the environment.

4. Export potential — the ability of the industry to enter international markets.

5. Interaction with the state — the level of support or regulation from the state.

The integration of industrial ecosystems can lead to increased efficiency, reduced costs and increased innovation potential of companies (Table 7). The main directions of this integration include the development of cooperation between enterprises, the introduction of digital technologies and the creation of synergies across various industries and sectors (Gamidullayeva, Tolstykh, Shmeleva, 2022).

Table 7

Directions of integration of industrial ecosystems

Industry	Integration of Raw Material Bases	Integration of Innovations	Integration of Ecology and Sustainability	Integration of Export	Integration with Government
Oil and Gas	High	Medium	Low	High	High
Nuclear Energy	Not Relevant	High	High	Medium	Very High
Machinery	Medium	High	Medium	Medium	Medium
Chemical Industry	High	High	Medium	High	Medium
Information Technology	Low	Very High	Not Relevant	High	Medium

Source: developed by A.A. Chursin, V.A. Shiboldenkov, A.V. Gutenev.

The development of new areas of integration allows not only to optimize current processes, but also opens the door to the creation of new products and services, strengthening positions in the global market and increasing resilience to economic changes.

Let's present examples of production platforms in industry[10, 11].

Light industry:

Legprom: This is a digital platform created to support light industry enterprises. It is aimed at small and medium-sized enterprises and includes functions from the search for suppliers of materials to the distribution of finished products. The platform also provides tools for online trading, which helps manufacturers expand their sales market.

Textile Contact: It is a specialized online platform for textile industry professionals, which ensures the interaction of all market participants from manufacturers to end consumers. The platform offers effective tools for networking, ordering materials, sharing technologies and experiences.

Heavy industry:

Rostselmash Digital platform: One of the leading companies in the production of agricultural machinery in Russia, Rostselmash, has developed its own digital platform for managing production processes. The platform includes quality management systems, production planning, as well as integration with supply and logistics systems.

NLMK Digital Platform (Novolipetsk Metallurgical Plant): This platform is designed to optimize production processes in metallurgy. It includes digitalization of all key aspects of the work — from the purchase of raw materials to the sale of finished products in the domestic and foreign markets. The use of advanced analytical tools can significantly increase efficiency and reduce costs.

Let's present examples of production ecosystems in industry and the fuel and energy sector. In the conditions of the modern Russian economy, the oil and gas industry and related industrial sectors form integral ecosystems in which large processing companies play a key role. SIBUR, as one of the leaders of the Russian chemical and petrochemical industry, is an important element of this system, providing links between hydrocarbon production and a wide range of consumer industries.

SIBUR closely cooperates with large oil and gas companies, receiving from them the necessary raw materials for the production of polymers, elastomers and other chemical products. SIBUR's products are used in various industries, including the automotive industry, construction, etc. This multiplicative interaction increases competitiveness and contributes to the quality of final products in the market, thereby supporting the growth of the efficiency of the national economy. SIBUR occupies a strategic position in the industrial ecosystem of Russia, defining development vectors not only for the petrochemical industry, but also for a number of other industries.

NOVATEK is one of the largest independent gas producing companies in Russia, actively implementing advanced technologies to effectively manage its assets and risks. The use of cloud technologies and artificial intelligence tools allows

[10] Aviation and Transport Infrastructure Association (AviaTP). (2023). List of Russian technology platforms. Retrieved 16 April 2024, from https://aviatp.ru/files/cabinettp/2023/List%20(TP).pdf

[11] Kommersant. (2010). A structured list of technology platforms. Retrieved 16 April 2024, from https://www.kommersant.ru/doc/1557065

the company to optimize processes in gas fields and in the management of logistics chains. These innovations not only increase operational efficiency, but also contribute to closer control over the safety and environmental aspects of production.

Gazprom Neft is actively developing and implementing digital technologies at all stages of oil production, from exploration and production to transportation, refining and sale. The company focuses on the creation of smart technologies and their integration into industrial processes, which significantly improves production efficiency and ensures a high level of safety.

The main directions of development of the Gazprom Neft digital ecosystem:

- Intelligent mining management system — using machine learning and artificial intelligence to analyze geological data and optimize mining processes.
- Robotic technologies — the introduction of automated systems for performing complex and dangerous operations, minimizing the human factor in high-risk conditions.
- Digital twin technology — the creation of virtual copies of objects, which allows them to be modeled and analyzed in real time to prevent accidents and optimize operation.
- Electronic document management and blockchain — the translation of documentation into electronic form and the use of blockchain technology to guarantee the security and authenticity of data.
- Remote monitoring and management platforms — development of remote monitoring systems for equipment and production processes, which allows you to quickly solve emerging problems without the need to be present at the facility.

Gazprom Neft is considered one of the leaders in the implementation of innovative solutions in the Russian oil and gas industry, which makes its industrial ecosystem one of the most advanced and technologically equipped. These measures are aimed at maintaining a high level of competitiveness of the company in the global market.

Industrial platforms and ecosystems in Russia cover various sectors: from the oil and gas industry and energy to heavy engineering and light industry. They include not only large public and private enterprises, but also many small and medium-sized enterprises, as well as research organizations.

Conclusion

These examples demonstrate how traditional industries in Russia are actively adopting digital technologies in an effort to improve their production processes and competitiveness in the market. Ecosystems and platforms help create new business models and management approaches, boost innovation and stimulate industry growth.

Digitalization of industrial ecosystems is a complex but very promising process that requires an integrated approach to planning and implementation. The strategy of transforming the potentials of innovative solutions through a platform approach allows companies not only to expand their market boundaries, but also to strengthen sustainability and competitiveness in the market. The main principles of this approach

include the creation of a universal, modular and integrated platform that facilitates rapid adaptation to changing market requirements and increases the efficiency of business processes.

Digital industrial ecosystems are often interdisciplinary, and it is important to develop cooperation between the various players in the ecosystem. This helps to share knowledge, share resources and accelerate innovation processes. The effectiveness and sustainability of such ecosystems largely depend on the level of integration and cooperation of its participants, as well as on government support and the ability to adapt to global trends and challenges.

The transformation of industrial enterprises into innovative platforms and ecosystems requires an integrated approach that includes not only technological modernization, but also fundamental changes in corporate culture and management models. The development of such transformations should be accompanied by a strategy of long-term development and investment in the skills and competencies of employees, as well as constant interaction with all stakeholders. This makes it possible not only to increase the competitiveness of the company, but also to ensure its sustainable growth in a dynamically changing economic environment.

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