Potential of the Industrial Enterprise Ecosystem Digitization

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Abstract: The authors of the article analyse the potential of digitalization in the ecosystem of an industrial enterprise, emphasizing the importance of integration into digital platforms. Describing changes in the business environment caused by uncertainty and turbulence, the authors emphasize that collaboration and network effects are key to achieving competitive advantage. The central theme is the development of digital technologies, which not only create new business opportunities, but also contribute to its evolution within the framework of an ecosystem approach. The article discusses how the digital ecosystem promotes cooperation, sustainable development and the creation of new market opportunities. The authors discuss the contributions of technologies such as artificial intelligence, the cloud, and the Internet of Things to improving manufacturing processes, reducing costs, and improving product quality. The conclusion emphasizes that successful digitalization requires a strategic approach and the active involvement of all ecosystem participants to achieve sustainability and global competitiveness.

1 INTRODUCTION

In general, cyberspace is a system consisting of different digital systems. This is more like an evolutionary digital ecosystem than a holistically engineered system: ecosystem members survive and thrive because of their fitness and ability to change themselves in the face of competition and other evolutionary pressures (Lippert and Cloutier, 2021). At the same time, from the point of view of studying the development of digital ecosystems, at the moment scientists do not have a unified approach and, as a rule, distinguish several types of schools; in a general approximation, some consider the development of digital ecosystems based on digital platforms, and others consider digital ecosystems from the point of view of the influence of individual digital innovations (solutions, tools) on the subject of digitalization (for example, business) and on the stakeholders of this object. However, no matter from what point of view we look at the digitalization process, it is obvious that any entity that integrates into such an ecosystem receives greater potential than entities located outside the digital ecosystem.

From a practical point of view, integration into digital ecosystems is in one way or another associated with resource costs (financial, time, labor, etc.); accordingly, a management decision on the need for such costs should be made based on an understanding of the benefits, payback, and positive potential of these investments. Unfortunately, at the moment, the issue of the potential for digitalization of the ecosystem of an economic entity has been little studied and there are no qualitative and, especially, quantitative solutions for assessing such potential unanimously recognized in the scientific community. In this article, we will take a first look at what exactly this potential is for an industrial enterprise.

2 FEATURES OF THE ECOSYSTEM OF AN INDUSTRIAL ENTERPRISE

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In the modern world, we are faced with significant changes in social relations, which are especially noticeable in the business environment. These changes are characterized by a high degree of uncertainty and turbulence, which forces companies to seek new ways to achieve competitive advantage. One of these ways is collaboration based on the use of shared resources, knowledge and network effects, as well as the use of institutional conditions. An important role in this process is played by the development of digital technologies, which open up new opportunities for information exchange and business organization.

These changes create a need for a new research approach that goes beyond the individual firm and takes into account the indirect effects of interactions among ecosystem participants. Thus, ecosystems come to the fore as new objects of research. However, the popularity of the concept "ecosystem" leads to its ambiguous and often vague use.

The ecosystem metaphor in business dates back to the work of J. F. Moore, who, inspired by ideas about coevolution, proposed that an economic community be viewed as a system of interacting organizations (Moore, 1993). The approach to ecosystems as objects of research allows us to better understand the agglomeration interaction of organizations in various aspects: from regional to industry and business. This quest to describe interactions and their effects has a long history, beginning with the work of A. Marshall (Marshall, 1993) and continued in the studies of many scientists, including M. Porter (Porter, 1990) and R.R. Nelson with S. Winter (Nelson and Winter, 1982). Organizational ecology, neo-institutional theory and the theory of dynamic capabilities had a significant influence on the formation of the concept of ecosystems. These areas have provided a theoretical framework for understanding ecosystems as environments in which organizations can develop their competitive advantages through interaction and coordination. The concept of ecosystems provides a powerful tool for analyzing and understanding the complex interactions in modern economies. It allows us to assess both the direct and indirect effects of cooperation and competition between organizations, as well as the role of digital technologies and institutional conditions in the formation of new business models.

An examination of the concept of “ecosystem” in academic discourse reveals its diversity and adaptability, while highlighting the challenges associated with its use in scientific work due to the lack of uniformity in definitions. The diversity of approaches to defining an “ecosystem,” including “business ecosystem” and “innovation ecosystem,” reflects the concept's rich potential for application in a variety of research and practice contexts. Particular attention is paid to platform ecosystems as an important area of research in the context of the modern digital economy and innovation.

L.A. Ramenskaya's work examines four key discourses in the study of ecosystems, each of which represents a unique perspective on the structure, functioning and strategic importance of ecosystems in various areas of business and innovation (Ramenskaya, 2020). A business ecosystem emphasizes how a firm interacts with its environment to maximize revenue and enhance competitive advantage. This concept covers a wide range of participants, including suppliers, distributors, outsourcing companies, manufacturers of related products and services, regulators and even the media, emphasizing their role in the creation and distribution of value and benefits. Research within this discourse examines how the effectiveness of the ecosystem as a whole affects the success of its components and how the participants co-evolve. An innovation ecosystem focuses on analyzing the interactions between participants to stimulate the creation and commercialization of innovations. Here, the ecosystem is seen as an environment that facilitates the implementation of innovative projects through cooperation and coordination of the actions of all stakeholders. The entrepreneurial ecosystem is closely linked to innovation discourse, with an emphasis on the territorial aspect and the role of the entrepreneur as a key participant in the ecosystem. This approach emphasizes the conditions and resources needed to promote entrepreneurship and new venture creation, including access to finance, markets, and institutional support. A platform-based ecosystem explores the dynamics between a central platform (leader) and multiple participants (followers) connected through technology standards and interfaces. This discourse views platforms as the basis for the creation of innovation, entrepreneurial activity and the development of multi-sided markets. Common to all discourses is the recognition of the importance of interconnections and interdependence between participants, unification around a common value proposition and the need to adapt to the characteristics of the ecosystem. These characteristics highlight the complexity and multidimensionality of ecosystems, as well as their strategic importance for innovation and business development in modern economies.

Most scholars use the concept of ecosystem to refer to the synergies and complementarities achieved between the activities, resources, or outputs of multiple organizations. Such synergies and complementarities are portrayed in the literature as specific to resources or services that significantly enhance the value or profit of ecosystem participants (Adner, 2017), (Jacobides, Cennamo, Gawer, 2018), (Teece, 2018). Ecosystems emerge around specific value-adding activities and resource complementarities that typically span multiple organizations, industries, and platforms.

Current research on ecosystems, including those in the form of platforms, examines the connections of ecosystem participants in terms of the operational and economic benefits they provide to them. The formation of an enterprise ecosystem results from specific and value-enhancing complementarities that go beyond bilateral relationships and entail multilateral connections that often cross industry boundaries. The multilateral relationships that industrial enterprises have with material and technology suppliers, buyers, banks, scientific and educational organizations, government, media and other organizations provide a good illustration of how the interdependent nature of such relationships leads to the formation of an ecosystem, as well as resources and services, which acquire higher value to the extent that they are related to each other. However, what is combined in this way consists of data. Most connections between firms, resources, or activities are expressed and instrumentalized as data relations, and it is in this form that they become objects of ecosystem practices and exchange.

At the same time, if we talk about the features of the ecosystems of industrial enterprises, then in a key sense, in contrast to, for example, the banking sector (fintech) and the service sector in general, at the moment there is a more superficial and uneven process of digitalization between the actors of the system. Of course, there are differences here based on regional and industry characteristics, but nevertheless, due to the low base effect, the potential from digitalization of ecosystems of industrial enterprises can be significant. Unfortunately, now in the scientific world there are virtually no recognized specific methodologies for assessing (calculating) potential; there are mainly two types of approaches to this issue: the integral method of calculation and the method based on a system of balanced indicators (KPI), so the issue of analyzing and calculating potential is the next step for scientific research into industrial ecosystems.

3 RESEARCH METHODOLOGY

The object of this study is the ecosystem of an industrial enterprise, the subject of the study is the economic relations of the elements of the ecosystem with the core - the enterprise based on platform digitalization, deepening specialization and digital cooperation. The methodological basis for the study was the concept of the relationship between the potential of digitalization and individual components of the organization's potential: financial, personnel, production and technological, and scientific and technical (Dunenkova, 2022). Thus, we, in turn, note that the potential for digitalization of the enterprise ecosystem should influence these components (Figure 1).

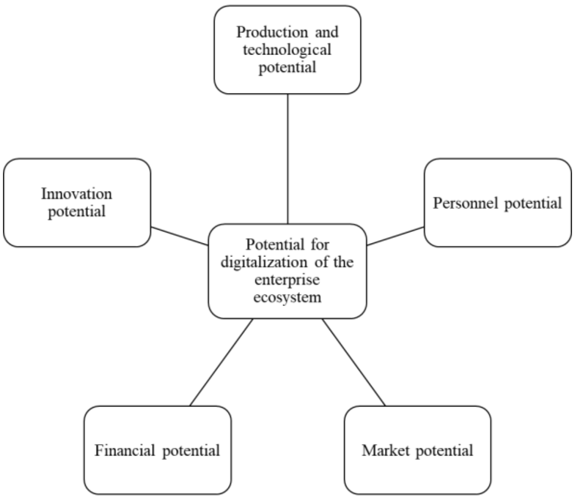

Figure 1: Elements of the digitalization potential of an industrial enterprise ecosystem

The information base of the study consisted of scientific articles indexed in the WoS, Scopus and RSCI databases. The result obtained in the work is based on a review of previous studies with justification of the research problem, identifying ecosystem stakeholders, defining digital technologies or interactions in the ecosystem, as well as taking into account the transformation of key resources as a result of using an integrated approach to the digitalization of the enterprise ecosystem.

4 FORMALIZATION OF THE DIGITALIZATION POTENTIAL OF AN INDUSTRIAL ENTERPRISE

By analogy with the digitalization of individual economic entities, the digitalization of an entire ecosystem and the integration of an industrial enterprise into it gives such an enterprise a range of new opportunities and resources (Chirumalla, 2021). Such a transformation involves both qualitative and quantitative business growth, as well as the formation of new potential for such an ecosystem. At the same time, the fragmented digitalization of the ecosystem creates a loose, disconnected, heterogeneous environment for the company. Here it is possible to compare it by analogy with the so-called “patchwork automation”. In this case, digitalization becomes the automation of individual directions of information flows between system actors, and not the ecosystem formed by a single digital platform. Nevertheless, of course, a certain effect can be obtained by reducing the labor intensity and cost of information transactions, reducing the duration of individual stages of processes, but overall capabilities will not fundamentally improve, and the development of potential will be weak and one-sided. To enhance the digitalization potential of an industrial enterprise, new digital technologies must not only be implemented systematically, but also form a full-fledged digital ecosystem supporting all information flows of the organization.

Due to the fact that at the moment, from the point of view of ecosystem development, companies from the field of fintech , social networks, services are in the foreground, and the vast majority of these ecosystems are developing according to the platform principle, in order to maximize the possible potential of the industrial enterprise ecosystem from the process of digitalization of information flows By analogy, it can be represented in the form of the development of several platforms with key ecosystem actors (Figure 2). The concept of a platform ecosystem, or simply ecosystem, has become increasingly used over the past few years as a means of capturing the benefits provided to ecosystem participants by linkages of resources or activities that cannot be categorized as standard supply chain configurations or other resource and activity interdependencies associated with the concept of industry, cluster, or networks (Gawer and Cusumano, 2014).

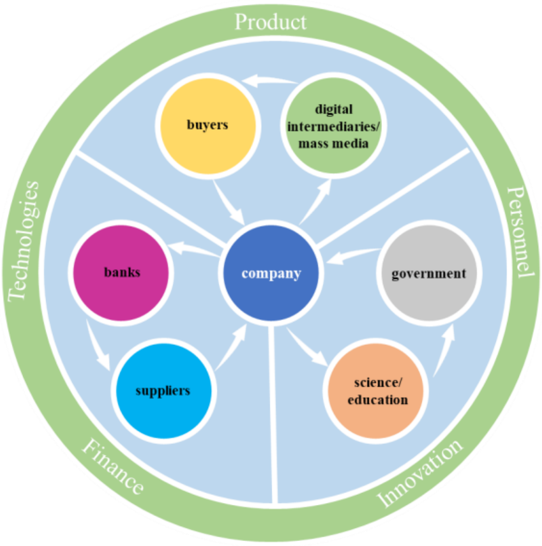

Figure 2: Illustration of platform interaction for the development of an industrial enterprise ecosystem

At the center of the ecosystem is an industrial enterprise, which interacts with certain actors (stakeholders) of the system through key digital platforms. Let us consider in a little more detail the composition and interaction data, which in each case give rise to the development of potential in the directions indicated in Figure 2.

4.1 Platform interaction Company-Suppliers-Banks

The use of digital platforms is becoming key to improving the efficiency of production and technological processes in enterprises in the era of digitalization of ecosystems. These platforms, which include a set of algorithms for the interaction of many participants in a single information environment, can significantly reduce transaction costs by optimizing communication and data exchange, which significantly increases the efficiency of using the production and technological potential of enterprises (Savina and Stepanov, 2020).

At the moment, the banking sector of the economy is actively developing its digital platforms not only for interaction in B2C markets, but also in the B2B direction, being the developer and owner of the platforms. These platforms allow participants (including industrial enterprises, their suppliers and customers) to interact more flexibly in terms of exchanging information digitally, which provides enormous not only technical but also financial potential. It is expressed in minimizing transaction costs when obtaining financing for projects (credit, leasing, insurance and other instruments), operating activities, thereby reducing the financial costs of the ecosystem. In addition, this provides a significant expansion of opportunities, primarily for an industrial enterprise, in increasing its production and technological potential, through direct access through the platform to the technological solutions of supplier actors connected to these platforms.

Thus, the banking digital eco-platform connects banks and entire supply chain systems for the enterprise into a single system, which leads to an increase in both the production and technological potential of the company and the financial one. There are several examples of such collaboration, where banking platforms help companies optimize and establish supply chains, including searching for suppliers. This became possible thanks to the development of digital technologies and the desire of banks to provide comprehensive solutions for business:

a. Alibaba Group - Ant Financial Services. Although Ant Financial (a division of Alibaba Group, now known as Ant Group) is not a traditional bank, its financial and digital solutions are significantly influencing the global B2B services market. Ant Financial offers a range of products that help companies improve their supply chains, including Alipay for financial transactions and 1688.com, a B2B platform that connects Chinese manufacturers with domestic and international buyers. This platform facilitates sourcing, simplifies purchasing processes and provides access to a wide range of products.

b. Sberbank. In Russia, the development of banking digital platforms is also actively keeping pace with global trends. Banks are trying to offer businesses not only electronic financial services, but also solutions for optimizing supply chains and managing production processes. Sberbank, for example, together with leasing or credit products, offers on the basis of its platform to immediately select the most profitable options for equipment suppliers from the pool of its partners and organize interaction with them.

4.2 Platform interaction Company-Digital Intermediaries-Buyers

Digital intermediaries have a significant impact on the product potential of industrial companies by optimizing advertising strategies, improving consumer interaction and expanding market presence. This influence can be viewed through three main categories: online advertising platforms, social networks and marketplaces.

a. Online advertising platforms offer businesses the opportunity to precisely target their audiences using contextual and targeted advertising. An example is Yandex.Direct, which allows companies to place advertisements for their products directly in the search results of potential buyers, significantly increasing visibility and brand awareness.

b. Social networks such as VK or Telegram provide a unique opportunity for brands to interact with consumers, collect feedback and build long-term relationships. With targeted advertising and content promotion capabilities, companies can fine-tune their marketing campaigns to specific audience segments, improving loyalty and increasing product demand.

c. Marketplaces such as Ozon or Alibaba provide industrial companies with access to international markets, providing a platform for large-scale distribution of products. They enable small and medium-sized businesses to compete with large players by offering a seamless experience for end users to search and purchase products.

Overall, integration with digital intermediaries allows industrial companies to not only improve the visibility of their products, but also manage their marketing and sales strategies more effectively, which ultimately leads to increased product potential and a stronger market position (Cozzolino, Leonardo Corbo and Paolo Aversa, 2021).

Thus, interaction with digital intermediaries (social networking platforms, marketplaces, news aggregators, etc.) allows industrial companies to offer comprehensive solutions to customers, again reducing transaction costs for the system. At the moment, there is huge potential in the formation of special platforms that use industrial protocols for the development of the Internet of Things, which is still poorly represented on the market in terms of B2B solutions. Such platforms can multiply the potential of Product solutions (Market potential) of industrial companies, both for consumers and for manufacturers themselves.

4.3 Platform interaction Company-Science/Education-Government

Collaboration between business, government and universities plays a critical role in creating a sustainable ecosystem based on the development of both human resources and innovation potential. Universities, understanding the needs of employers for digital competencies, prepare specialists who can work effectively in digitalization conditions. Governments, in turn, are facilitating the digitization of services and operations, thereby stimulating demand for digital talent. Corporations are actively integrating these talents into their structures, ensuring successful digital transformation.

Collaborations between government, business, and universities based on digital technologies are becoming a key factor in innovative development and digital transformation in many countries:

a. Russia: Innovation Center Skolkovo. The Skolkovo Innovation Center is one of the largest projects in Russia aimed at supporting innovation, developing startups and attracting investment in high-tech projects. Skolkovo cooperates with Russian and international universities, research institutes, as well as large companies and startups to implement scientific research and commercialize developments.

b. Singapore: Smart Nation Initiative. The Smart Nation Initiative in Singapore is an ambitious program aimed at maximizing the use of digital technologies in the economy and society to improve the quality of life of citizens. It involves close collaboration between government, the private sector and universities. For example, the National University of Singapore (NUS) is actively involved in research and development in the field of AI, cybersecurity and big data analysis, supporting government initiatives and interacting with businesses based on the created technologies.

c. Germany: Industry 4.0. Industrie 4.0 is a strategic initiative of the German government aimed at creating “smart factories” where digital technologies are integrated into production processes. This initiative includes the participation of universities and research institutes in the development of new technologies and training of specialists, as well as collaboration with industrial companies to introduce innovations. Examples include partnerships between Fraunhofer - Gesellschaft (a leading organization for applied research in Europe) and large industrial enterprises such as Siemens and Bosch to develop and implement intelligent systems and solutions for smart manufacturing.

These examples demonstrate how collaboration between government, business and universities can support the development and adoption of digital technologies, stimulating innovation, strengthening the economy and developing people.

Creating a digital culture within the enterprise, where flexibility, collaboration and innovation become the basis of daily work, is critical to developing the potential of staff. Continuous learning and skills development programs, including both technical and soft skills, are becoming an integral part of corporate strategy. Particular attention is paid to programs developed in collaboration with universities and government agencies aimed at closing digital competency gaps.

Thus, on the basis of educational platforms with the support of governments, powerful human resources potential is revealed, which should drive not only the innovative component of industrial companies, but also the development of industries and regions on the scale of state entities.

In addition to organizing platform interactions between various groups of stacked leaders in the enterprise ecosystem, the development of the digitalization potential of an industrial enterprise should be based on the integrated use of a wide pool of digital technologies. The next section proposes to discuss the directions of its development, taking into account the possibilities of digital technologies.

5 DIRECTIONS FOR DEVELOPING THE POTENTIAL FOR DIGITALIZATION OF AN INDUSTRIAL ENTERPRISE

The main goal of an industrial enterprise, like any other business organization, is to achieve sustainable profitability and increase value for its owners or shareholders. And at the next stage, as a derivative of the company’s goal, other stakeholders receive their values - the business environment as a whole (the market) through the development of competition, authorities through the tax system, consumers through the consumption of competitive products, education and science through the formation of demand for innovation and highly professional specialists, mass media - through the formation of a transparent information field.

In this sense, in the context of digitalization of an industrial enterprise, the concept of “potential” can be perceived as a set of opportunities and prospects in relation to the growth of profitability and value of the company, which can be realized through the application of digital technologies to the enterprise ecosystem. This is not just a set of technical tools, but a wide range of improvements and transformations in various aspects of the enterprise. Below are the main aspects of this concept:

a. Untapped Opportunities: Potential indicates that there are certain areas or areas of the enterprise that can be improved or optimized through digital technology.

b. Long-term perspective: Potential is often associated with long-term opportunities. This means that investing in digitalization today can yield significant benefits in the future.

c. Innovation and Growth: Capacity includes the ability to develop new products, services, business processes and models that can lead to innovation and growth of the enterprise.

d. Overcoming limitations: Digitalization helps overcome traditional limitations associated with manual labor, slow processes and limited information, thereby expanding the capabilities of the enterprise.

e. Adaptability and Resilience: Capacity also reflects the ability of an enterprise to adapt to changes in the external environment, including market conditions, technological changes and environmental requirements.

f. Integrated approach: The concept of potential implies that to achieve maximum effectiveness, you need to take an integrated approach, integrating different digital technologies and strategies into the ecosystem.

In general, ecosystem digitalization potential is an assessment of how strongly and deeply digital technologies can transform an enterprise, improving its productivity, innovation and competitiveness.

The real potential from the digitalization of the ecosystem should generally affect two strategies: growth - that is, be aimed at increasing Income (Innovation Potential); and efficiency - to reduce the costs of the enterprise (Resource potential). Here, as a rule, the key impact of information technology affects the issue of optimizing the use of the resource part of the enterprise: material, labor, financial, information and time.

Let's look at how specific digital technologies can drive various potential improvements in the industrial enterprise ecosystem:

1. Artificial intelligence (AI), machine learning and cloud technologies:

a. Informed Decision Making: AI processes large volumes of data to provide accurate forecasts and analytics, helping to make informed decisions.

b. Improved product quality: AI can analyze production processes, identifying ineffective steps and suggesting improvements.

c. Innovativeness: Development of new products and services, adaptation to changes.

d. Cost reduction: Savings on IT infrastructure and increased scalability.

e. Security and reliability: Protecting against cyber threats and ensuring data security.

2. Additive technologies (AT):

a. Innovativeness: Allows rapid prototyping and testing of new product designs.

b. Sustainability: Reduce material waste through precision and resource-saving manufacturing.

3. Blockchain (BC):

a. Security and Reliability: Ensures data and transaction security, eliminating fraud risks and increasing transparency.

b. Digital Supply Chain Integration: Improves traceability and accounting, increasing the efficiency of logistics processes.

4. Internet of Things (IoT):

a. Increased productivity: IoT sensors and devices provide online data to monitor and optimize production processes. It also allows you to automate various processes and actions, such as lighting and temperature control, monitoring and control of production lines, automatic notification in case of emergency situations, etc.

b. Predictive Maintenance and Product Quality Improvement: Allows you to predict the need for equipment maintenance, preventing operational failures.

c. Integration with other technologies: IoT is often integrated with other technologies such as artificial intelligence, cloud computing and big data to improve data analysis and decision making.

5. Robotics (RB):

a. Automation of production processes: Robots increase the efficiency and speed of production, reducing labor costs and operation time.

b. Cost reduction: Replacing manual labor with automated processes leads to increased efficiency in the use of resources.

6. Social Networks (SM):

a. Improved customer experience: Allows you to interact with customers, collect feedback and offer personalized services.

b. Personnel development and training: Used to share knowledge and improve the skills of employees.

c. Improved communication: Allows you to expand the information field both within the company and with external counterparties (buyers - improved customer experience, personalized service and better interaction with clients, suppliers, the labor market, etc.).

7. Virtual (VR) or mixed reality:

a. Staff training and development: Virtual training and simulations help teach complex manufacturing processes.

b. Flexibility and Adaptability: Helps in visualizing and modeling production processes and products, improving planning and adaptation to change.

8. Enterprise resource planning (ERP) systems platforms:

a. Increased productivity: Efficient management of resources and processes.

b. Cost reduction: Optimization of inventory and logistics.

Each of these technologies contributes to creating a more efficient, innovative and resilient manufacturing ecosystem that can adapt to rapidly changing conditions and market demands. It is also important to take into account that the greatest efficiency is achieved with an integrated approach, when various digitalization tools are integrated and interact with each other.

6 CONCLUSION

A study of the digitalization of the industrial enterprise ecosystem demonstrates its key importance for sustainable development and competitiveness in the modern economy. Digital transformation allows enterprises not only to optimize existing processes and reduce costs, but also opens up new opportunities for innovation, deepening specialization and developing flexible cooperation. The main message of our research emphasizes that integration into digital ecosystems provides businesses with significant growth potential, which is especially important in an increasingly global competitive environment.

The advantages of digitalization cover not only the production and technological sphere, but also the financial, personnel, innovation, and also the sphere of products and services. Through interaction with banking digital platforms, social networks and marketplaces, enterprises can not only improve their financial performance, but also significantly increase their market and product potential. The key aspect is the creation of a full-fledged digital ecosystem that helps reduce transaction costs, improve interaction with customers and partners, and also stimulates the development and implementation of innovation.

It is important to emphasize that successful digitalization requires a strategic approach and the active involvement of all participants in the ecosystem. Collaboration between business, government and universities is a powerful catalyst for developing digital talent, strengthening innovation and enhancing enterprise competitiveness. Examples from countries including Russia, Singapore and Germany illustrate the successful use of digital technologies to create efficient ecosystems that support sustainable industrial and economic development.

In conclusion, digitalization of the industrial enterprise ecosystem is not just a technological upgrade, but a strategically important step towards creating sustainable, innovative and competitive business models. This process opens up new horizons for growth and development, while requiring an integrated approach to managing change and adapting to new market conditions.

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