Formation of Organizational and Economic Model of Cross-Industry Ecosystems

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Abstract. The study focuses on the research of fundamental reasons underlying the emergence of digital platform providing the formation of the global view on the role of digital platforms for building of a new organizational structure - “high-tech industrial ecosystem”. The purpose of the study is the validation of development a modern mechanism for the coordination of high-tech market entities within a single economic and organizational space – the ecosystem based upon the cross-industry digital platform. This study, using general methods of scientific knowledge in various aspects, analyses the modern vector of the industrial growth explained by the implementation of ecosystems as new organizational and economic models. The principles for their formation, the probable structure, main differences from the traditional cluster and network models are reflected. It is proved that it is the ecosystem model that makes the ecosystem members achieve a positive synergetic effect during the implementation of their strategic growth targets in the conditions of digital transformation. The article considers the application of tools of the industrial digital platform providing for the implementation of interaction between ecosystem members. Platform-based solutions have the big future from the viewpoint of the large data arrays analysis, reduced transaction losses and “perfect information” obtaining. As a result, the immediate course for introduction of cross-industry digital platform and ecosystem building is justified. Digital cross-industry interaction within the platform will help to expand external communication and promotion channels, introduce digital business models and diversify production but it requires the provision of compatibility between the systems of industrial companies, functioning of a single digital platform and the cloud-based environment.

1. Introduction
Under the terms of the fourth industrial revolution, the speed of decision-making impacts leadership in the race for technological advancement and the market share. The reason for emergence of new...
business organizational forms, the mutually profitable activity and new ways to maximize the added value is the “digitalization” of the economics as a whole and the industry in particular. Experts predict that the introduction of digital technologies, including artificial intelligence, will provide up to 14% of GDP growth that is equal to 15 bln USD.

Main concepts of digital industrial transformation are Industry 4.0, Digital Manufacturing, Smart Manufacturing, Internet of Manufacturing, Open Manufacturing.

Digital industrial transformation is not only technological transformation but the search for new organization and economic models. Any changes start with administrative levels and mostly require mental changes. Digital technologies stipulated the emergence of such model as an ecosystem. The term “ecosystem” was introduced by A. Tansley to describe the functional unity of living beings and their habitat. As projected to organizational and economic models during the digital transformation period, the industrial ecosystem means a functional unity of economic participants (actors) and the environment for their interaction. The ecosystem implies the formation of the innovative and friendly partnership environment for all its members when each actor is necessary for the other actor while the main principles for joining the ecosystem are voluntary basis and equality. The ecosystem model does not contain a single administrative body; the actors interact through the self-organization (Figure 1).

![Figure 1](image-url)

**Figure 1.** The ecosystem model for organizational and economic interaction between actors. Source: developed by the authors.

Ecosystems have no territorial borders, thus, actors from various territories and various industries interact with each other. Ecosystems have no accurate time limits, the time lag of interaction between specific actors is done within innovative engineering projects. Actors unite by new knowledge, technologies and materials. The environment formed on the principles of the ecosystem model makes each actor effectively achieve their targets in the area of digitalization, initiate, develop and implement the projects of new technologies and business processes while achieving the powerful synergetic effect [1-3]. Main methodological principles for the formation of ecosystems are shown in Figure 2.
Figure 2. Principles for formation of the ecosystem model of high-tech industrial development. Source: developed by the authors.

One could assume that the ecosystem model is the development of cluster and network models for business organization. The main administrative body of clusters are usually federal or industrial administrative bodies that take principal decisions for development of the cluster and make financial investments into it. The body for strategic administrative decision-making in network companies is a large company that “selects” partners by the chain of its product added value. One of the main differences between ecosystems, clusters and network companies is the principle absence of a single administrative body. Each company takes its own administrative decisions concerning interaction with other companies within the ecosystem. That’s why such interaction requires a set of tools for its organization.

Digital platforms are becoming such sets of tools more and more frequently. The platform helps companies create ecosystems providing the growth due to:

– network effects: platforms facilitate attraction of new users, both the seller and the purchaser form the added value of the product while getting the mutual profit;
– asymmetric growth and competition: each company finds its own market place within the ecosystem;
– use of digital distribution channels.

It is relevant to determine the effectiveness of digital platform introduction in the industry and to organize cross-industry ecosystems. Due to the fact that digital transformation is a complex measure, it is very difficult to make the map for effective criteria of all tools in the platform. However, if we compare it with the technological platform building in Russia during 2011-2018, one may generally assess the effectiveness of digital ecosystem development.

2. Fundamental implications for emergence of digital platforms
The economic activity organization has been the subject of research and experiments for the whole human history. For almost the whole 20th century, two global geopolitical centers, the USSR and the USA, tried to demonstrate the advantages of their economic systems – the planned economics and the market economics, respectively. As a result, all former Soviet republics of the USSR chose the decentralized approach to the organization of national economies. There is the cliché that the market economy is more effective than the centralized planning. However, there is a significant assumption that makes this statement true. It is the concept of “perfect information”. The meaning of this concept is that all market players have a complete information about all market factors. But such situation is a priori impossible.
The issues of the large-scale economic management are studied in the papers of L. Kantorovich [4], F. Hayek [5], R. Coase [6], B. Henderson, M. Porter [7], G. B. Kleiner [8] et al.

Information is the most important element of any administrative process. The quality of the information and its relevance provides effective coordination of the economic activity. Modern data processing technologies and conceptual change in the attitude towards the processed information encourage transition from the 20th century linear business model to the modern platform business. Nowadays, such category is represented not only by IT companies, such as Google, Amazon and Microsoft but also high-tech companies from the industrial section of the economics: Apple, Samsung, General Electric.

At early 1970-s the concept of the first prototype for “industrial digital platform” was developed in the Soviet Union. It was the Nationwide Automated Data Processing and Control System (NADPCS), the project of the automated economic administration system in the USSR [9]. The NADPCS was based upon the application of industrial automated administration systems for each individual industry and for each national region integrated into a single computer management system for all hierarchy of territorial administration, up to the Union-wide level. If the system was launched on the open data, it would be a good tool to analyze the industry, cooperation chains and to form the added value in production and trade of industrial products. However, those plans would never come true.

3. Platforms in the economic digitalization period

The Industrie 3.0 concept suggested the automation of individual machines and processes but it was not as effective as we expect it from the Fourth industrial revolution. The feature of the Industrie 4.0 concept is the end-to-end digitalization of the cost formation chain and integration of the data with multiple ecosystems. Products and services are offered on the basis of the collected data, the operation of related physical and virtual assets becomes also possible [10]. Due to the data and their special treatment algorithms, business models are transformed, partnerships are formed and the customer service is personalized.

Transformations result into Factories of the Future based upon information and technological systems for development and digital design (Digital Factory), organization of production (Smart Factory) and Product Lifecycle Management.

The effective management of internal and external cooperation relations and end-to-end industrial processes within the paradigm of Factories of the Future is the main factor for reduced transactional costs and the increased added value of high-tech customized products. In order to provide for operation of Factories of the Future's ecosystem, the digital infrastructure for provision of interaction between the subjects of the scientific and research activity, industrial production, logistics and distributions shall be implemented on industrial and cross-industrial levels. The infrastructure shall be based upon the digital platform that combines technologies and services demanded by ecosystem entities [11].

There are a lot of definitions for “digital platforms” but all of them ultimately disclose their most important essence: a digital platform is the system for the algorithm-driven interaction between the significant number of entities from the economic sector (or the market) made in the single information environment that provides for decreased transactional costs due to application of digital tools to work with the data and modify of business processed [12].

According to the definition by the Center of Competences for the ANCO “Digital Economics”, the main criteria for a digital platform are:

1. Algorithm of interaction between members of the platform;
2. Mutual profitability of relations between members of the platform;
3. Number of members using the platform for interaction;
4. Single information environment;
5. Economic effects: decreased transactional costs, maximization of the added value.

Three types of platforms, characterized in Table 1, may be found out on the basis of the criteria above:
Table 1. Typification of digital platforms by ANCO “Digital Economics”.

| Instrumental | Infrastructural | Applied |
|--------------|----------------|---------|
| Used to build applied software or software and hardware solutions | Used to provide the activities of ecosystems and granting members access to solutions for the automation of their activity based on end-to-end digital technologies. | Used to provide digital services and tools for the significant number of members within a single information environment |

Source: ANCO “Digital Economics” https://data-economy.ru/infrastructure#rec36248210.

We think this classification of digital platform is generalized. Digital platforms are the infrastructural bases of ecosystems and may have extended functional characteristics and the area of application. The members of the high-tech industrial ecosystem may also use several digital platform of different type and use at once. That’s why we suggest the following typification of digital platforms (Table 2).

Table 2. Typification of digital platforms according to their functional characteristics and area of application.

| Class of platforms | Functions | Examples |
|--------------------|-----------|----------|
| Technological      | Provide for availability of IT sources and end-to-end digital technologies | Alibaba Cloud, AWS, ExactFarming, SAP, 1C, 2GIS |
| Functional         | Provide for availability of the specialized software | |
| Infrastructural    | Grant access to the digital infrastructure | |
| Corporate          | Digitalization of administrative processes | Gazprom, X5RetailGroup, Avito |
| Information        | Grant informational access to the market | |
Marketplaces | Grant access to the market while providing for interaction between parties
---|---
Industrial | Provide for interaction between members of the same industry or market
Cross-industry | Combine functions of other platforms and provide for interaction between members of ecosystems

| European digital platform of industry (a prototype) | Eurasian digital platform for the development of production of drone aircrafts (a concept) |

Nowadays, three types of industrial platforms may be pointed out:

- basic industrial platforms performing functions of data collection and analysis to monitor the equipment condition;
- applied platforms implementing the logics of business and industrial process scheduling;
- applied platforms for the automation of product lifecycle management process (PLM/SLM).

Within the context of development of high-tech industrial ecosystems such as production of drone aircrafts, cross-industrial digital platforms are the solution that is urgently required. This type of the platform naturally completes three types of industrial platforms mentioned above.

The module architecture of the cross-industrial digital platform makes various members of the ecosystem to create interdependent components of the system, such as tools and services. The other feature of such platform is the property of self-coordination of the mutual activity by companies of various industrials in terms of the ecosystem without any elements of the organization hierarchy characteristic of companies with the traditional organizational form [13].

The digital ecosystem of high-tech industries accumulates all necessary sources previously unavailable to its members while granting the unlimited number of members the access to technologies, information, high-quality development, analytical, network interaction services. However, the main benefit of the ecosystems is granting almost unlimited access to the market: to material and intellectual sources, customers, manufacturers, maintenance companies etc.

The introduction of cross-industry digital platforms in the manufacturing area [14] gives great opportunities to members of its ecosystem that were impossible within traditional organizational forms of the economy:
- reduced transactional costs: transformation and intensification of business processes; optimization of the administrative structure, low information, communication, logistic costs, increased flexibility of production, accelerated economic cycles;
- consumer value growth: effective use of production facilities and intangible assets, the opportunity to choose the best terms and transparency of the market, availability of financial sources, feedback;
- facilitation of innovations: customized products and services, access to technologies; innovative business models, a flexible organizational structure;
- open markets: supply and demand management, opportunity for entry of small and medium business entities to the market, export opportunities, decreased administrative barriers, partner network;
- decreased corruption risks: increased coordination of economic structures, information openness, digital traceability and transparency of transactions.

The introduction of digital platforms has not only a national importance but also addresses the issues of international economic interaction and operation of international economic areas [15]. The synchronization of economic and organizational processes within the single ecosystem will allow one to organize a highly effective interaction between all actors of the high-tech product development, manufacturing, sale and post-sale maintenance process no matter where the company is. Due to this, within the 2025 EAEU Digital Agenda the project of creation of the digital industrial cooperation is being implemented in order to increase production volumes of consumer goods and their sale on the international market.

4. Introduction of Digital Industrial Platforms in Russia and All Over the World
The introduction of intellectual systems into the industry provides the approximation of physical and digital worlds and has the revolutionary nature [16]. Technological changes are accompanied by the development of ultimately new business processes at all levels of manufacturing chains. The introduction of end-to-end digital technologies, building of industrial platforms open great opportunities for the international technological expansion to both companies and countries.

Many national governments catch the trend of the period and countries manage these changes at the national level. Nowadays, first-world countries implement large-scale technological programs of industrial development. The United States of America carry out the digitalization policy [17] within the Industrial Internet Consortium and the Advanced Manufacturing Partnership. Germany implements the Industry 4.0 initiative with the view to transform existing business models via introduction of cyber physical systems. One should point to the general European Factories of the Future initiative as well as to the People's Republic of China's Made in China 2025, the National Technological Initiative (NTI 20.35) in Russia etc.

Nowadays Russia has the State Industry Information System (SIIS) that combines several hundred thousand medium and large businesses. The functions of this system put it into the category of information platforms but the Russian Ministry of Industry and Trade is going to use it to develop the ecosystem of industrial platform within the ministerial project “Digital Manufacturing”.

The project [18] implies designing, integration and development having the significant effect on the development of industrial companies, platforms:
- effective investment into the industry;
- building and development of manufacturing in industrial companies;
- selection of state support measures, their obtaining and control under achievement of the project's effective rates;
- provision for manufacture and promotion of industrial products on the internal market;
- promotion of products on the external market, increased export volumes;
- analysis and forecasting of the growth of manufacturing based upon the objective statistical data.

The program's priority is also the development of digital platforms providing for the cross-industry and intersystem integration of companies during the development, production and implementation of
high-tech products. It is the organization of the cross-industrial interaction that may catalyze innovative activity and design of new products and services as they are based on “disruptive”, including “end-to-end”, digital technologies with the cross-industrial origin.

The important factor for the development of the Russian industrial digital platform is the opportunity to integrate them into ERP systems installed at the Russian industrial companies.

As a whole, the development and introduction of industrial and cross-industrial digital platforms in manufacturing may be based upon the existing infrastructure and has the opportunities for growth.

The implementation of corporate digital transformation programs is exemplified by the industrial platform EvOil by Gazprom Oil Company [10], that forms the industrial ecosystem in the oil&gas sector. KAMAZ PJSC moves in this direction as they introduce the corporate digital platform and transfer to digital engineering, production, supply chain, sales and maintenance.

OAK PJSC develops their own Industrial Cooperation Platform [Figure 4] including the single administrative information space, the single engineering information space, replacement of natural tests by mathematical modeling, the information system management – by distributed manufacturing, the digital environment for interaction with suppliers, platform for operation and acceleration of digital technologies etc.

Federal executive bodies (Minpromtorg, Minkomsvyaz, Minekonomrazvitiya), state-owned companies (Rostech, Rosatom, Rostelecom), institutes of development (RVC, Skolkovo Foundation, FSI, RFRIT), industrial and technical associations and largest private-owned corporations have the target to build ecosystems for digital industry. But, despite of a whole set of existing programs and strategies influencing the digital transformation of the industry, there are no coherence and interconnection of initiatives among its principal authors.

Above the programs were mentioned that are used to develop the industry and the economy of the first-world countries. To get a deeper knowledge of specific features for the building of industrial ecosystems as they are, the EU experience is interesting. The EU confirmed and implemented the following pilot projects of digital platforms [20] since 2017 within Horizon 2020 programs:

–Digital Manufacturing Platforms for Connected Smart Factories;
– Digital Platforms/Pilots Horizontal Activities;
–Agricultural Digital Integration Platforms;
–Interoperable and Smart Homes and Grids;
–Big Data Solutions for Energy.

During the implementation of these initiatives the special focus will be made on the development of cross-industrial, integrated digital platforms and large-scale pilot platforms for experiments and co-creation with users.

The USA is the unequivocal leader in the development of platform business models. Real leaders on the global market of digital technologies, software development and technological solutions are American corporations Apple, General Electric and Microsoft. At this, the rate of state investments into the creation of industrial platforms is comparatively low. The government mostly controls and builds the environment, while the R&D are delegated to the private-owned business. The industry digital transformation in the USA is done in the direction of Industrial Internet within the Digital Economy Agenda program and the activities of the Industrial Internet Consortium.

China develops a digital platform within the Internet + strategy included into the Made in China 2025 program. The Chinese approach is directly opposite to the American one: the rate of state investments is more than 30 bln USD. At this, industrial transformation is strictly supervised by the State Council of China that determines the strategy on the basis of the ten-year plan that allows mobilizing the resources in the scale exceeding the one in other countries.

Germany, the European industrial leader, combines the initiatives of private-owned and state-owned sectors and also integrates itself into general European initiatives.

The knowledge of the fact that digital platforms have already become a key competitive industrial asset providing for the effective and flexible manufacturing process, the data analysis, the optimization
of supply chains and distribution has made many countries include their introduction into priorities of the industrial policy.

5. Conclusions
No advanced industrial technology is able to provide for the stable long-term competitive advantage on the global market by its own. Nowadays we see emerging new markets based upon manufacturing of high-tech products and combining the technologies of absolutely different industries: biosensors, drones, city farms. It is required to introduce the system of complex solutions that provides for the high rates of global development and production of competitive new generation products in order to implement the unlimited potential of industrial digitalization, to introduce digital platforms and to create cross-industry ecosystems [21, 22]. These solutions are based upon the concept of the Factory of the Future that is an absolutely new industrial model based upon the multi-discipline approach for the building of the advanced industry including:

- Development and introduction of industrial digital platforms. The platform-based approach allows uniting the members of development and production processes that are distributed across various territories, to increase the level of flexibility and customization taking into account requirements of customers. The combination of advanced digital technologies including artificial intelligence technologies and the big data on the single platform will provide companies with the opportunity to maximize the value of products with minimum costs;
- Introduction of Digital Twin technologies, information and technologies development and digital design systems (Digital Factories), manufacturing organization (Smart Factory) and Product Lifecycle Management.

The processes mentioned above help to form the organizational and economic system of high-tech industries uniting all actors of the industrial policy and the innovative area: executive bodies, state-owned corporation, small innovative companies, institutes of development, educational establishments, scientific and research companies, researchers and consultants.

The economic effect of Technological Platform programs in Russia cannot be unambiguously assessed as many projects included in scientific research programs of technological platforms have already existed before them. This instance has not shown extraordinary results as a communication platform also and it has become the tool for representation of business interests by the companies moderating platforms. However, the effect from the introduction of artificial intelligence technologies on PJSC SBERBANK platforms was estimated to be 42 bln RUB in 2019. That's why the advantages of the digital ecosystem economy become evident.

The following factors prevent successful introduction of industrial digital platforms and building of high-tech industrial ecosystems in Russia:
- no complex strategy for digital industrial development;
- low motivation of officials and top managers of large companies, rejection of new technologies and interaction forms;
- no coordination between large industrial companies and SMC subjects, scientific and research and educational establishments;
- low level of investments in digital transformation of Russian industrial companies;
- prevailing vertically integrated industrial groups, low level of horizontal cooperation relations;
- focus on MIC, secrecy and fear of competition.

The features of disruptive technologies may be maximally used if there is the complex program including the formation of active partnerships, stimulation of digital transformation of state-owned corporation, engagement of the scientific and research community, assignment of resources and creation of the beneficiary taxation to stimulate investments into digital technologies.

An especially important aspect of digital transformation is preparation of highly qualified employees meeting requirements of the digital economy. As I.V. Novikova points out, the most effective implementation of the human potential and the tangible asset potential is possible if information competences of the employee optimally match the information components of the
workplace [23]. Feedback from the introduction of digital technologies will appear only if all stages of the value formation chain will be managed well.

The single strategy of digital industrial development is needed that would determine the mechanisms for the introduction of new technologies to achieve the goals of industrial development and to accelerate the economic growth in Russia. Based upon the author's concept of strategy development by W.L. Quint, it is important to analyze global trends and to assess industrial and regional trends at each stage of the development strategy design [24, 25]. Due to that the development of the strategy may be based upon the National Technological Initiative (NTI) that forms approaches to conquer new markets with the cross-industrial nature (Aeronet, Autonet, Marinet, Healthnet etc).

The prospective area for the introduction of cross-industry digital platforms and creation of ecosystems is their application for markets of the National Technology Initiative including the area of drones (Aeronet). Building the Aeronet digital ecosystem will boost the development of the drone industrial production in Russia and will accelerate formation of the relevant market.

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