

Evolution of Organization: From Herd to a Cyber-Physical System



Vladimir Grigorievich Prudskiy, Andrei Mikhailovich Oshchepkov, Maxim Aalexandrovich Zhdanov

Abstract: *The modern approach to the digital economy is conditioned by the forth industrial revolution and the mastering of cyber-physical technologies of the sixth industrial practice. It stimulates appearing new technological and socio-economic conditions of social reproduction, which result in new specific forms organizing the public economy and social management. In order to understand and analyze these new forms, it is necessary to study the evolution of organization as an object of management in detail. Being a socio-economic system, the history of the organization has covered a long way, accompanied by the extinction of old and appearance of new organizational forms. The article also discusses organizational and legal characteristics of future cyber-physical organizations based on the analysis of their evolution as an object of management. Public-private partnership becomes one of the forms to develop an organizational support to integrative cyber-physical, technological and economic processes in the public economy and social management in industrial countries in the 21st century. This partnership also has a potential to become an important competitive advantage of the Russian economy in the conditions of an intensive transition to a digital economy, as it is an integral factor to develop cyber-physical technological chains and digital economic links. This paper aims at analyzing the evolution of organization as a managerial object. It also seeks to work out a theoretical notion of public-private partnership, which should not only be a common project of the state structures and private business to solve separate investment tasks in the infrastructural sphere, but also become a social-economic development factor of a country and its regions. This factor should ensure the growth of a synergetic effect from integrating cyber-physical technological systems and digital managerial and economic structures. The methodological base of this research include such scientific methods as generalization, analysis and synthesis, systematic approach, and the combination of historical and logical approaches.*

Keywords: *digital economy, cyber-physical technologies, organization, object of management, historical forms of organization, management, public-private partnership, competitiveness, competitive advantage, strategic competitive competence.*

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* Correspondence Author

Vladimir Grigorievich Prudskiy*, Perm State University, Perm, Russia.

Andrei Mikhailovich Oshchepkov, Perm State University, Perm, Russia.

Maxim Aalexandrovich Zhdanov, Perm State University, Perm, Russia.

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I. INTRODUCTION

A historical analysis of the current economic stage gives a clear evidence that the world community is at the point of the next industrial modernization, which is called the fourth industrial revolution or the Industry 4.0. Since the end of the 20th century, there has been a lot of discussion concerning the character and perspectives of this modernization. It resulted in different concepts, views and approaches to social-economic nature and technological content of the pressing change in the economic model existing in industrial countries.

In these conditions, it is crucial to analyze the evolution and perspectives of organizations as social and economic systems and managerial objects, because the establishment and development of new organizational forms, meeting the demands of innovative economy, is becoming a strategic competitive competency of any national economy.

This analysis allows to put forward the following theoretical hypothesis. The evolution of the form and the content of the organization as a managerial object will cause the appearance of cyber-physical structures, and they are historically determined by the transition to the sixth technological order of industrial production. These practices are based on the mastering of cyber-physical technologies and modern development of property relations (public and economic practices). During its development, a cyber-physical organization can become the most important strategic competitive advantage of the Russian economy in the 21st century.

In the practical political and economic aspect, this implies integrating such organizations into the system, which implements strategies of the social and economic development of the country and its regions as a way to increase their efficiency. In the future, a cyber-physical organization may be a special management intellectual asset that provides the national economy with a skillful management efficiency greater than that of competing countries. As a result, a cyber-physical organization, as a subsystem of a national (or regional) economy, can play a part of its core competitive advantage and serve as a growth factor for national, regional and corporate competitiveness.

II. METHODS

The increase in public production is not only the growth in production of goods and services, but also includes the rise in labour force and institutes of people's socio-economic interaction.

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As a result, this growth represents the consequences of material and technical accumulation that is both a quantitative increase and a qualitative (structural) improvement in production means and technologies (physical capital).

It also involves the development of human resources (human capital) and organizational forms of socio-economic interaction between agents and structures of the market

economy (the accumulation of managerial capital as a special intangible asset).

Having analyzed the dynamics of these growth components of social reproduction, the authors concluded, that three processes interact in its content: a technological (material and technical resources), socio-economic (human resources), and organizational and institutional (managerial processes) ones. (Fig.1).

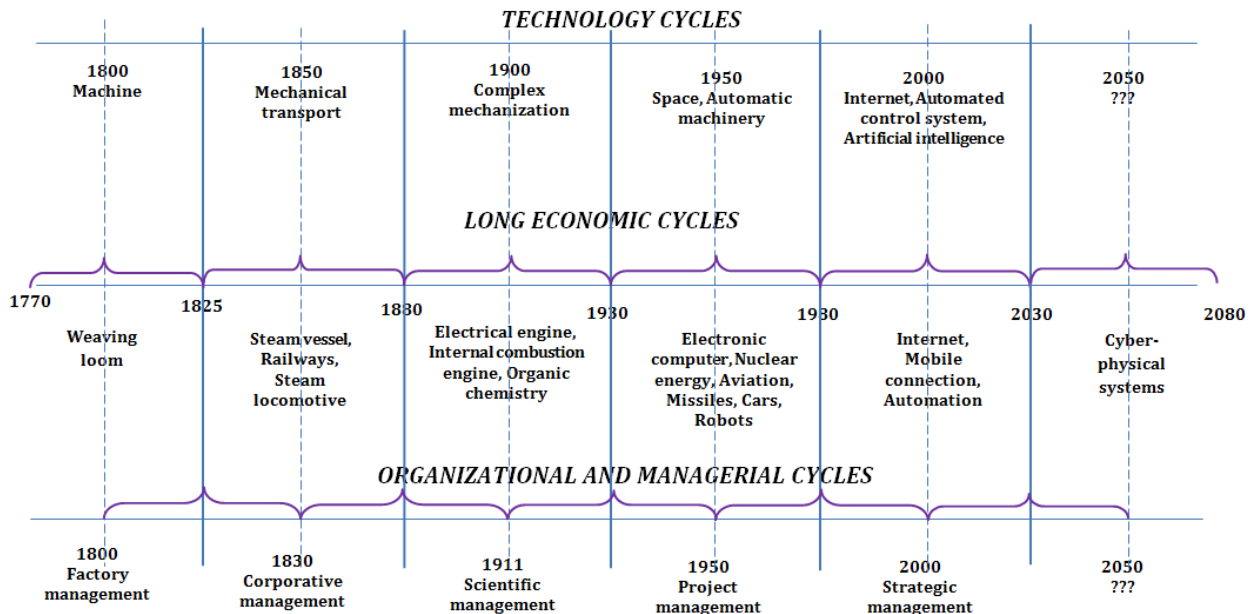


Fig.1. Interrelation of technological, economic and management cycles

In this point of view, a technological and socio-economic progress (on the one hand) dialectically relates to a managerial one (on the other hand) as the content (technical and technological development in producing material goods and services, and labour force) and the form (the development of economic relations and organization of managing people's socio-economic interaction).

The first stage of the research included the study of the technological cycles' concept, highlighting the key innovations that qualitatively changed the economy in certain historical periods.

The second stage compared these concepts from a chronological point of view.

The third stage studied the concept of management cycles and compared them to the concepts of technological and economic cycles in a chronological aspect.

Based on the revealed interconnections and interdependencies, a hypothesis about the form of the future organization - the cyber-physical system – was formulated at the fourth stage of the research.

III. RESEARCH RESULTS

Historically, social and economic development of human society is determined by the economic law of permanent increase in people's material and spiritual needs.

This causes the action of the economic law of the people's endless ambition to satisfy these needs fully. This ambition in its turn stimulates the search for ways and means to expand public production, enhance labor productivity and production efficiency as a means to increase the volume of consumed goods and services as well as to decrease their production

cost and to raise their accessibility.

The desire of the society to expand social reproduction for the fullest satisfaction of the needs of its members objectively determines the action of the economic law of saving social labor and working time because of the productivity growth.

In the market economy, the growth in labour efficiency causes the rise in competitiveness of goods, enterprises, and economies [1].

Three economic factors determine the increase in labour and production efficiency.

First, it is technical and technological progress, stimulating the scientific and technological development and enlarging the possibilities to explore natural resources.

Secondly, the increase is determined by the progress of human resources, the development of people's knowledge and skills in using tools, materials and supplies.

Thirdly, an important productivity growth factor is the progress in dividing, cooperating and coordinating public labour, which stimulates the development of organizing and managing public production.

The change in the scale of social production, as well as in its structural, technological and labour content demands respective changes in organizing management both in general and in separate enterprises.

The following examples demonstrate the interrelation between the developments of technique, socio-economic conditions, forms of organizing social production and an increase in the competitiveness of social groups in historical and economic aspect.

The prerequisites of dividing and cooperating in public labour were created by mastering the use of stick, bone, and stone as primitive tools; the development of hunting and gathering, the transformation of apes into humans.

These resulted in the appearance of a social organizational form in the primitive people's common labour, that is the primitive human herd. These herds showed a greater survival rate compared to animals' ones.

The domestication of plants and animals finished about 9 – 10 thousand years ago creating the possibility to develop farming and animal breeding as basic industries. This led to the appearance of new institutions of people's socio-economic interactions – primitive communal tribes and clans. The primitive societies, which managed to master tribal forms of organizing common labour, received additional knowledge and skills of self-government, and therefore respective competitive advantages in the struggle for survival compared to societies, which stayed at the level of primitive herds.

The transition to metal tools and instruments happened approximately 5 – 6 thousand years ago, which resulted in labour productivity rise and led to the creation of economic conditions of the simple reproduction with a stable surplus product. This gave an impulse to the development of property relations resulting in new institutions (the ways of people's economic interactions), such as the family, the state, the property, the temples. That was the way different economic forms appeared they were natural family households, state-owned, temple-based households, and entrepreneurial and commodity-based ones.

As a result, the societies, which were able to master these institutions and their managing mechanisms, acquired additional advantages in the struggle for economic resources, having turned their rival tribes into slaves.

In ancient and medieval times, technical progress in rural areas stimulated the development of the slaveholding economic system, later replaced by the feudal one, which caused the search for new institutions and organization forms of economic activity. This resulted in slaveholding palace households, villas and latifundia, agricultural family allotments, feudal patrimonies and manors, peasant households and communes, craft producers' workshops, trade shops and houses. In the middle of the 15th century, manufactories appeared in Europe.

Those countries became the centers of competitive world resources reallocation, which mastered the systems of craft and manufactories entrepreneurial economy after the great geographic discoveries.

Industrial revolutions have become an important development factor of social production since the second half of the 18th century. Due to their influence, the industry became the main economic sector of the leading countries, determining their competitive perspectives in the 19th - 20th centuries. The machine production changed the manual labour, rocketing labour productivity, and technical progress constantly demanded to increase capital investments, that led to searching new forms of the industrial production organization.

The agricultural economy was gradually transforming into an agricultural-industrial one in the countries, experiencing an industrial revolution. In England, steam engines

determined the appearance of factories as a form to organize machine production, and an industrial form of organizing the public economy developed respectively. As a result, a prescientific industrial management started to progress in industrial countries, becoming an important competitive advantage of the industrial economy over the craft-manufacturing system.

In the first half of the 19th century, factories, which were forcing out manufactories, were formed based on the individual or partner (group) private property. But the growth in industrial production determined the appearance and the development of industrial corporations in the second half of the 19th century, due to an increase in the railroad and steamship construction.

The industrial capital merged with the bank one, creating overseas branches and subsidiaries due to the electrification of industrial production and a rapid development of the machine building, chemistry, and metallurgy, influenced by the technical revolution at the end of the 19th century. In the beginning of the 20th century, this led to the creation of new organizational forms of the economic activity, such as corporate industrial and financial groups, transnational corporations. As a result, a scientific management appeared in the USA and later in the Western Europe, which gave a strong innovative impulse to the labour productivity and competitiveness growth in these countries.

In the second half of the 20th century, the transition to the industrial-service model of the economic development conditioned the appearance of a systematic approach to managing organizations in the industrial countries. Structural and technological changes started to progress in the industrial economies that formed new opportunities to raise labour productivity and expand output. The technological breakthroughs in the middle of the 20th century include electronic digital computers, atomic energy, rockets and automation [2].

These breakthroughs influenced a gradual change in the reproduction structure of the industrial countries, which was divided into processing, extracting, and production complexes, as well the service sector, which gradually became the main one.

New technological breakthroughs happened in the 1980-es, including computers, the Internet and mobile phones. Knowledge-intensive services and technological automated productions started to occupy the leading positions in the service sector (70% of GDP) and the processing and extraction sectors respectively. The middle class, that is a highly qualified workforce engaged in the intellectual labour, began to play a leading part in the social structure of the industrial countries.

Influenced by the widening in the use of cyber-physical technologies and as increase in the digitalization, the modern economy activates its technological and structural reconstruction.

The structure of modern production consists of several groups. Firstly, this is the group producing material benefits, namely extracting and processing productions. They account for about 20 – 30% of the GDP produced in developed countries.

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The second group consists of the service industries, both usual and knowledge-intensive. They account for approximately 70 to 80% of the GDP in these countries.

The ecological service sector is gradually appearing and widening in the structure of the service industry. It disposes of and recycles the growing wastes of industrial production. Besides, the share of knowledge-intensive and highly technological services is constantly growing – up to 40-50% of the GDP.

This can be explained by the fact that the market of knowledge-intensive services grows much faster than the economy in general. For example, in Russia, the economy grows by 1,5 – 2% annually, while the IT sector grows by 15 – 20% [3].

Therefore, cyber-physical organizations appeared in the beginning of the 21st century as a form to organize the public economy, which represents an objective result of economic relations and institutions development. This was influenced by the production and technological progress, as well as the development of human resources.

Secondly, the scientific management as a social governing form progressed in the 20th century due to its previous forms, such as the industrial management, the state and municipal regulations of the economy, the corporate management, the management of state, municipal, unitary and mixed companies, the formation of state and municipal governmental enterprises, the cooperative management [4].

Different countries have different levels of managing these forms of the public economy organization. Those countries possess a competitive advantage, which achieved a higher level of organizing management in the certain economic forms. The basis of the advantages constitute the certain core innovative competitive competences (intellectual assets).

The concept of public-private partnership (PPP) can be one of such competences (intellectual asset) in the competitive development of the Russian economy, as well as the government system implemented on its basis.

Therefore, developing and implementing of innovative concepts and management models of PPP make up the factor that increases productivity and competitive ability of the Russian economy, as well as the innovative development of other forms organizing the public economy [5].

The characteristic feature of the fourth Industrial revolution is the fact that the production automation, actively implemented in the 20th century, had a closed local character. The management systems were worked out for each separate sphere, and often even for every particular enterprise, resulting in their incompatibility. However, at the beginning of the 21st century many systems started to provide the interaction possibility due to the introduction of new programs for managing companies.

The key production development factor lies in «speeding up the integration of «cyber-physical systems» into industrial processes that is connecting the machinery and equipment to the Internet. Intangible assets, such as software and processing, and tangible production equipment connect and form «cyber-physical» systems...this is the concept to name the software, included into the machinery for the integrated management of such processes as development, production, distribution, and after-sales service...» [6].

If cyber-physical systems are interconnected within

enterprises, this will cause the appearance of cyber-physical («smart») factories. The development of interactions between smart plants will give an impulse to the creation of cyber-physical industries as well as the economy in general.

If traditional programming methods hardly take into account the time factor, the cyber-physical processes will require a dynamic self-programming in real time.

The transition to the knowledge economy stimulates the creation of new economic conditions. The technological, structural, and industry-specific reformation of the social reproduction induces the reconstruction of its social-demographic and institutional-organizational structures, as well as the public economy's spatial organization.

The cyber-physical technological integration of productions and enterprises will develop due to the full cycles of knowledge-intensive products in the frames of production complexes, including the knowledge-intensive service, the raw materials extraction, the production of construction materials, the manufacturing of final products, the after sales service and the usual ones, the deposition of waste and the ecological service.

Influenced by these tendencies and processes «the industrial and service sectors are gradually blending. The new hybrid giants, which produce tangible goods, contain a powerful network and computer infrastructure and simultaneously develop software products and services, sell these services and serve clients» [7].

The modern technological development stimulates an increase in the share of cyber-physical technologies and production systems in the material and technical bases of the national economies. This, in turn, leads to the key role of the digital infrastructure in the structure of social reproduction in the industrial countries as the basis for material and technical production of technological goods and knowledge-intensive services.

Several factors induce the reconstruction of socio-economic (or labour) relations, including the current structural-technological modernization of the industrial economy, the mastering of cyber-physical technologies and production systems. They, therefore, cause the reconstruction of the organizational and institutional economic relations, the creation of new forms and institutions to implement the productive and economic activity. This reconstruction aims at implementing new technological opportunities, raising the labour productivity, which should result in the rise in the economic competitiveness and dynamics.

Thus, the latest modernization of the industrial economy continues the evolution of the organization as the objects of management. It is connected to the fourth Industrial revolution and the transition to the digital knowledge economy. It also presupposes a respective organizational and institutional transformation of the economy. Since the end of the 20th century, the development of the public-private partnership forms has become the most important result of this transformation [8].

IV. CONCLUSION

The organization as an object of management has gone through a long evolution. Its main historical forms include the primitive human herd;

the primitive communal tribe and clan; the natural family, the state-owned, temple (monastery), entrepreneurial commodity and slave owning palace households; the villas and latifundia; the agricultural family allotment; the feudal patrimonies and manors; the peasant households and communes; the craft producers workshops; the trade shops and houses; the manufactures; the factories and plants; the industrial corporation; the corporate industrial-financial group; the decentralized digital factory (plant); and the cyber-physical organization.

In our viewpoint, the cyber-physical organization will be implemented in Russia in the form of the public-private partnership.

First of all, it should be stressed that this partnership represents a specific organizational form allowing to implement the opportunities, provided by the latest digital modernization of the modern economy, synthesizing the dynamics of private entrepreneurship, which is risky, with the stability of state (public) economy, which is bureaucratic and clumsy.

In a narrow, practical sense, the public-private partnership acts as an implementation mechanism for socially important investment projects, where the state and the private business are equal partners.

In a broad social and economic sense, PPP represents a historically justified specific organizational and institutional complex of organizations as economic subjects in the system of the national digital economy. This complex is a speeding factor for the infrastructural development in the country and it creates conditions for starting integration processes in its technological and economic systems, which will result in the transitional conditions favourable for the digital production.

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REFERENCES

1. M. Porter, *Competition*. Moscow: Williams, 2006.
2. S. Glashev, "How to bridle hegemon", *Expert*, vol. 25, 2018, pp. 36-38.
3. M. Shekhovtsev, "What the Internet of things promises to the world", *Expert*, vol. 48, 2016, pp. 20-27.
4. V. Varnavsky, "Public-private partnership: some theoretical and practical issues", *World economy and international relations*, vol. 9, 2011, pp. 41-50.
5. V. A. Mau, "At the final stage of the global crisis: Economic tasks in 2017-2019", *Voprosy Ekonomiki*, vol. 3, 2018, pp. 5-29.
6. S. Tolkhachev, "Two neoindustrializational models: Germany – «The Industry 4.0», the USA – «Industrial Internet»", *The Economist*, vol. 9, 2015, pp. 13-23.
7. S. Ermak, T. Lopatina, D. Tolmachev, *Upgrade. Expert – Ural*, vol. 27, 2018, pp. 15-22.
8. I. Yu. Merzlov, *Public-private partnership and economic competitiveness: regional aspect*. Perm: PSU, 2015.