

Digitalization of Regional Industrial Complex Technological Processes

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Abstract. The process of economy digitalization has become customary in the activities of business entities. Digital technologies increase the operating efficiency, the accuracy of production and other activities, as well as the quality of manufactured products. Currently, the pace of the progress in the area of digital technologies in the industrial sector is high, so it is impossible to operate without their use.

This paper reveals that in terms of the terminology “digitalization” means the transformation of the third technological paradigm into the fourth and fifth ones through its large-scale introduction into the economy and other areas of digital technology.

It also presents a set of theoretical concepts, methodological approaches and practical recommendations on the formation of the technological potential of industrial enterprises and intensification reserves based on the use of scientific achievements, digital technologies and development of innovative activities of enterprises.

Theoretical and methodological issues related to the intensification of the use of industrial enterprises technological potential based on digital technologies are presented as an addition to the research in the area of the research vocabulary and provision of the authors’ concept of digitalization and digital economy.

The authors substantiated the outlines of regional industrial complex innovative development, which are proposed to be formed on the basis of network models of the digital economy.

The authors also presented a model of the organizational and economic mechanism for the intensification of technological potential reserves of industrial enterprises based on the digitalization of business processes using digital technologies limited to the creation and operation of “digital twins” of regional industrial enterprises.

1. Introduction

Issues related to the digitalization of economic processes in the regional industrial complex are in the forefront of all states that care about their socio-economic development.

Currently, both analog and digital information processing systems are used for the management of business process in industry. Analog information processing systems use a specific frequency spectrum to create and transfer arrays of information. 60 percent of the current information market belongs to the analog sector. Its main disadvantages are low data transfer rate, large amounts of resources used, low quality of transmitted information, and the occurrence of errors.

Digital systems, in contrast to analog systems, provide better quality of information use, need insignificant amounts of resources, are distinguished by fast information transfer and better process controllability. A digital economy is based on digital systems of business process management.

The beginning of the 21st century was marked by a rapid development of digital technologies based on the information revolution and the ongoing processes of economic globalization. Today the most important factor in the activities of economic entities is digitalization of management processes and organization of digital business processes. At the same time digital transformation affects all economic activities, sectors, as well as branches of economy.

A digital economy has a great potential for the acceleration of economic development. The introduction of “Industry 4.0” concept, implementation of infrastructure network projects and cross-innovation networks as integrators and communicators of economic entities, development and implementation of strategies and programs for the innovation activities of enterprises play a special role.

The study and analysis of innovation activities of the regional industrial sector showed that it is necessary to conduct total digitization of the industry based on various mechanisms in order to enhance the economic performance.

2. Relevance

Currently the development of the digital economy sector is directly related to the competitiveness of national economic systems, since the chronic lag in the use of relevant information, incomplete and untimely use of digital resources of the region are accompanied by a loss of its market position [16]. From the point of view of the world economy, the asymmetry in the use of digital technologies by different countries makes individual states dependent on more digitally developed countries, which results in a lag in the economic development.

The digital economy is based on the information economy. It uses a special kind of resources – information data that represents a special factor for the effective development of the regional economy [3]. The authors note that the digital economy causes new effects associated with the transformation of the existing economic relations and a change in the use of information in the activities of business entities. In other words, new models of the economic behavior of market entities emerge through the use of the digital economy. It is associated with the fact that the existing models are based on analog data, no longer meet the requirements for the reliability, quality, completeness and relevance of information [7].

The relevance of this paper lies in the fact that the use of digital economy parameters, namely, large flows of continuous information, the Internet of Things, big data cause new effects both in the newly formed digital economy and in the whole society, and it has not been explained by science yet.

There is also a problem related to the fact that these effects are also subject to change, and there is every probability that science, trying to find a scientific explanation for these effects, will also be subjected to considerable modernization and changes over time due to new discoveries in the digital economy.

The scholarly importance of the study consists in the development of a set of theoretical concepts, methodological approaches and practical recommendations on the formation of the technological potential of industrial enterprises and intensification reserves based on the use of digital technologies. It involves the following:

- Supplementing theoretical and methodological issues related to the intensification of the use of the technological potential of industrial enterprises with digital technologies.
- Substantiation of the outlines of the regional industrial complex innovative development associated with the development of digital economy network models.
- Development of the model and formation of the organizational and economic mechanism for the intensification of technological potential reserves of industrial enterprises based on business processes digitalization.

3. Brief review of literature and opinions of authors on the subject under study

The first concepts related to the definition of the essence of digital technology, as well as its concept, appeared at the end of the twentieth century: in 1994 Canadian scientist D. Tapscott gave the following definition to the term “digital economy” - an economy based on the use of information and computer technologies [10,11]. Around the same time information scientist from the USA N. Negroponte applied a metaphor about transition from the study of atoms, which make up the matter of physical substances, to the study of bits that form software codes [13].

According to the Oxford Dictionary, a digital economy is an economy that functions through the use of digital technologies, electronic transactions made using the Internet.

People became interested in the digital economy last century. In the 1970s academician N.N. Moiseev and his research team launched computer modeling of economic systems [5].

According to the authors, the scientific developments of N.N. Moiseev’s school were underestimated both by the scientific community and the leadership of the country, and the process of development of domestic informatization technologies was stopped. If otherwise, possibilities to create a “digital economy” and make a breakthrough in the real economy on its basis would have been used. But half a century ago this opportunity was missed.

Academician A.P. Ershov, one of the first founders of Novosibirsk School of Computer Programming, assumed that computer science and programming would be the most popular professions in the future [12,13,15]. Informatization of economic systems predetermined its importance for scientific research, to improve the performance of industrial enterprises and boost homeland security. In 1956, the Nobel Prize in Physics was awarded to J. Bardeen, W. Brattain and W. Shockley for their researches on semiconductors and their discovery of the transistor effect [27,29].

Discoveries in this field laid the foundation of the microminiaturization of the element base in the area of informatization. The miniaturization of processors, the associated increase in the speed of computers and reduction of prices for them were prerequisites for the active introduction of informatization tools into various sectors of the economy, thus creating the conditions for the digitalization of economic processes in industry [6,14].

In 2000, the Nobel Prize in Physics was awarded to academician Zhores I. Alferov for the development of semiconductor heterostructures [15,18,19].

Recently, the popularity of a new universal term – the Third Industrial Revolution or TIR – applied to economy digitalization has been growing. The main scientists, who adhere to this definition, are American researchers J. Rifkin and R. Kurzweil [29].

According to the authors, this term does not reflect the essence of the digital economy to the fullest extent, since the activity of any economic system consists in the organization of its internal processes to achieve the final result. And, taking into account the fact that the digital economy permeates all spheres and industry activities, its internal processes consist of processes occurring in other spheres of activity, including production, consumption, exchange, and distribution [4,20].

TIR supporters consider that the 1st Industrial Revolution is based on the use of fuel resources, the 2nd – on the use of hydrocarbons, and the 3rd – on the use of high technologies in the field of renewable energy, 4D technology, etc. And it is based on the digitization of industry [21,24].

In addition, different approaches to the concept and content of the digital economy are further complicated by the fact that there is a wide range of analysts' interpretations related to the technological paradigm in which the humanity is today. And this is also not an idle question, because some branches of the economy are still in the third technological paradigm, others – in the fourth, and the rest ones – in the fifth. And their integration in the area of digitalization looks very problematic [23,24].

Researcher A.N. Biichuk notes that the main factors of digitalization of the economy, which is intended to form the near future, are information and communication technologies that are conditionally divided into 4 blocks: cloud technologies; the Internet of Things; robotics; big data and 3D technology; quantum and supercomputer technologies; artificial intelligence; cyber-physical systems, blockchain technology; digital modeling and design [7].

Currently, there are two approaches to the essence and construction of the digital economy besides the ones presented above. The first approach, the classical one, says that the digital economy is an economy based on the use of digital technologies. It characterizes the sphere of using digitalization in the economy as the area of using electronic products: data transmission, digital communications, digital modeling, telemedicine, distance learning, etc. [8]

The second approach is more advanced. According to it, the digital economy is an economic production, in which digital technologies are applied. According to a number of scientists, this space needs to be expanded and product chains that use digital technologies, including “smart enterprise (factory)”, “smart city”, engineering services, industry technology 4.0, the Internet of Things, prototyping, etc. need to be introduced into it. [23]

A number of scientists believe that the digital economy represents an integrated concept – digital information transfer or the “third technological information and communication platform” [24].

According to the authors, the basis of the digital economy is the production of goods (services) associated with the use of digital technologies and incorporating elements of digital technology. Digital technology allows getting an innovative product of better quality; digitalization elements make the product unique and give it new consumer properties.

In other words, digitalization of industry is an activity that is directly related to the development of digital information industrial technologies, including services for the provision of online services, electronic payments, crowdfunding, online trading, and so on.

4. Setting objectives

The study is intended to complement the set of theoretical concepts and practical recommendations, as well as form a model for the formation of the technological potential of industrial enterprises and intensification reserves based on the use of digital technologies, substantiate the outlines of the innovative development of the regional industrial complex related to the creation of digital economy network models based on business digitalization.

5. Theoretical part

In December 2016, the President of the Russian Federation signed a decree on the formation and approval of target government program “Digital Economy”, which was approved by Order of the Government of the Russian Federation No. 1632-p of July 28, 2017 as program “Digital Economy of the Russian Federation” [1].

In the wide sense “digitalization of the economy” shall mean the socio-economic transformation initiated by mass development and the use of digital technologies, i.e. technologies for the formation, processing, transmission and exchange of information. Such a definition is given by UNCTAD experts [28]. The Bureau of Economic Analysis of the U.S. Department of Commerce includes the following three items in the definition of the digital economy [26]:

1. A digital economy is an economy that has a digital infrastructure providing the necessary conditions for the functioning of a computer network.
2. Digital transactions are made through e-commerce.
3. Digital economy users form the content of access to the information network (digital media).

In other words, a digital economy is seen as a solution to technical and technological issues related to the processing of large volumes of information at high speed (BIG DATA), as well as an infrastructure project and a means of interaction within the existing community development paradigm.

Currently, many regional industrial enterprises try to comply with the European standards for the organization and management of business processes in production. It is achieved through the modernization of technological processes and intensification of the use of production reserves.

Despite the existing favorable conditions for investing in the modernization of regional industrial enterprises, the overall technological potential of domestic plants and factories is significantly lower than the global one [2]. At the beginning of 2017 the average indicator of the complexity of technolog-

ical business processes (the Nelson Refinery Index) at domestic industrial enterprises was 8-10. As for high-tech enterprises in the USA, the Nelson Refinery Index reaches 22.

Hence it appears that the main direction for the modernization of enterprises in the regional industrial complex is the creation of conditions for innovative activities based on digital technologies. When implementing this modernization direction, enterprises strive to [3]:

- Achieve the maximum efficiency of production business processes.
- Reduce technological costs by improving the technology of production business processes.
- Increase the use of the company's reserves.
- Ensure a high degree of industrial safety, increase the security of enterprises against risks and cyber threats by using organizational technologies and technical means.

A modern tool for the implementation of these tasks is the technology called "smart plant". In the author's interpretation, the concept of building a smart plant is proposed for the regional industrial complex (see Figure 1).

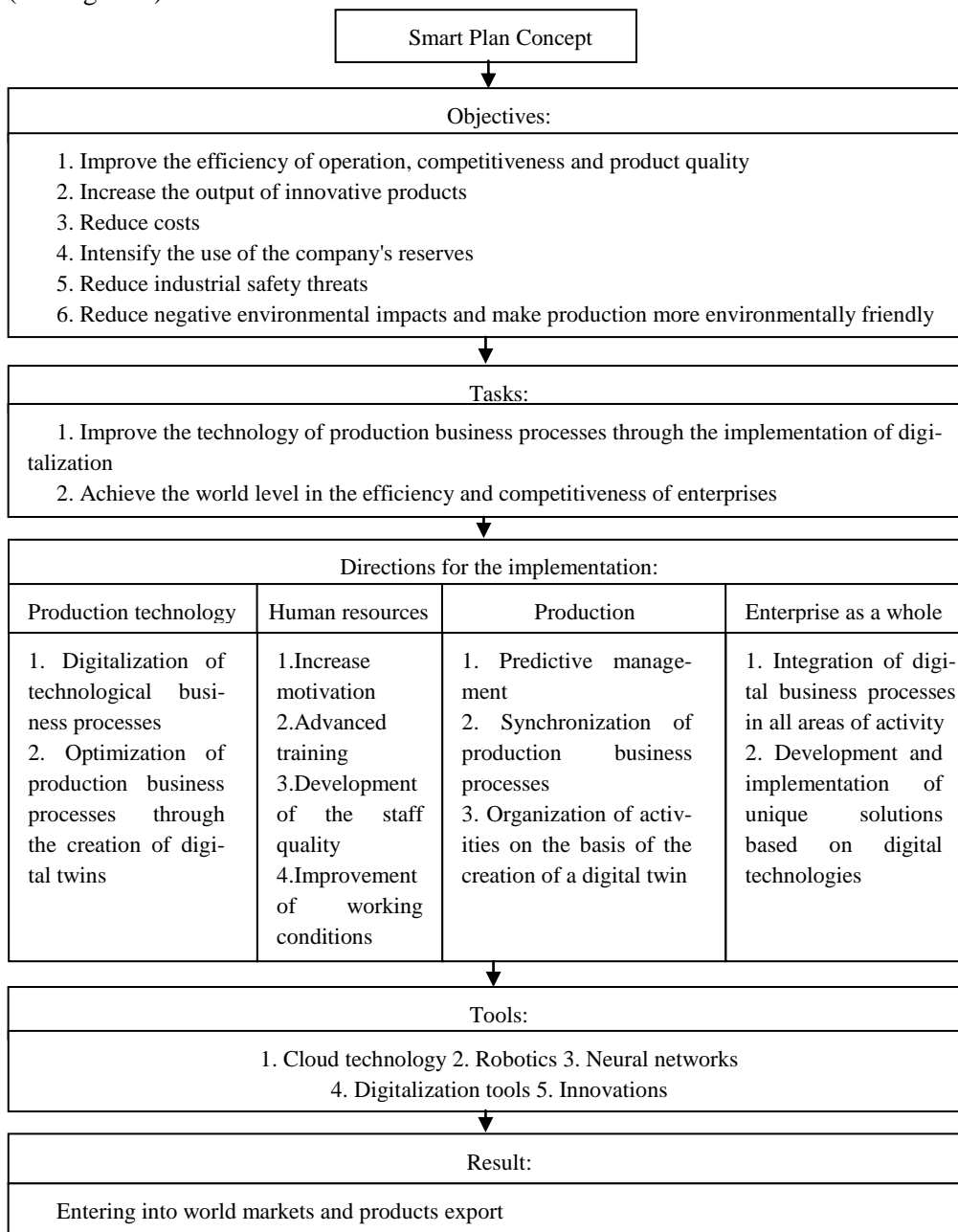


Figure 1. The proposed concept of building a smart plant.

This concept presupposes the formation of digital twins at industrial enterprises in order to analyze their activities and make decisions related to the real enterprise in the online mode based on the use of continuous monitoring of enterprise assets and technological equipment elements. The concept of a “smart plant” proposed by the authors is a combination of technological business processes, the existing potential of an enterprise (reserves), and capabilities of management and production personnel to maintain the dynamic production efficiency.

The use of digital twins in modelling industrial processes of industrial enterprises is a technology that describes production business processes and the relationship between them both in separate production environments and within the framework of the entire enterprise using virtual simulation models.

The basis of 3D digitalization models is artificial intelligence with the use of neural networks. A digital twin of an enterprise can form and propose optimal modes of technological equipment operation, the optimum deadlines for repair works, predict downtimes and equipment failures.

When creating a digital twin, a virtual copy of real production is formed. The use of a digital twin helps to quickly model and forecast the implementation of production business processes depending on the influence of real factors, offer the most productive modes of operation, estimate potential risks, integrate new digital technologies into enterprise operation, and improve production safety and labour productivity [4].

According to the concept proposed by the authors, a smart plant (a factory using digital twins) connects to the cloud information space, which directly links the production itself with equipment manufacturers, service providers, logistics and product sales organizations.

The authors propose to create a network interaction of all participants to ensure a rapid exchange of information between them, which will have a positive impact on the quality of decisions made, synchronicity of enterprise operation, and reduction of downtimes and failures. Connecting industrial and infrastructure enterprises into a network will expand the outlines of the innovative development of the regional industrial complex associated with the development of network models of the digital economy (see Fig. 2).

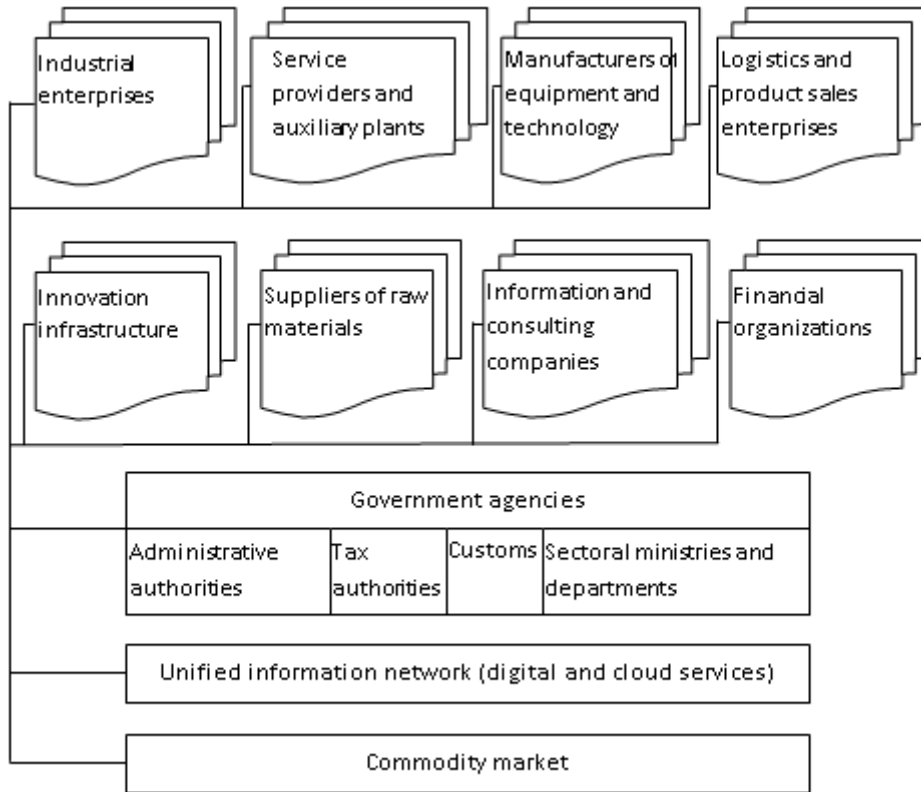


Figure 2. Networking of the regional industrial complex.

The authors propose to use the base of technology parks available in regions for the development of a model and formation of an organizational and economic mechanism of intensification of technological potential reserves of industrial enterprises based on the digitalization of business processes obtained using innovative technologies. The basis for building a model of the organizational and economic mechanism for the intensification of technological potential reserves of industrial enterprises is the “open innovation model”, which allows effectively attracting innovative and advanced ideas for the development of technological potential. It is proposed to use technology platforms by type of economic activity (FEA), shown in Figure 3, in the author's open innovation model.

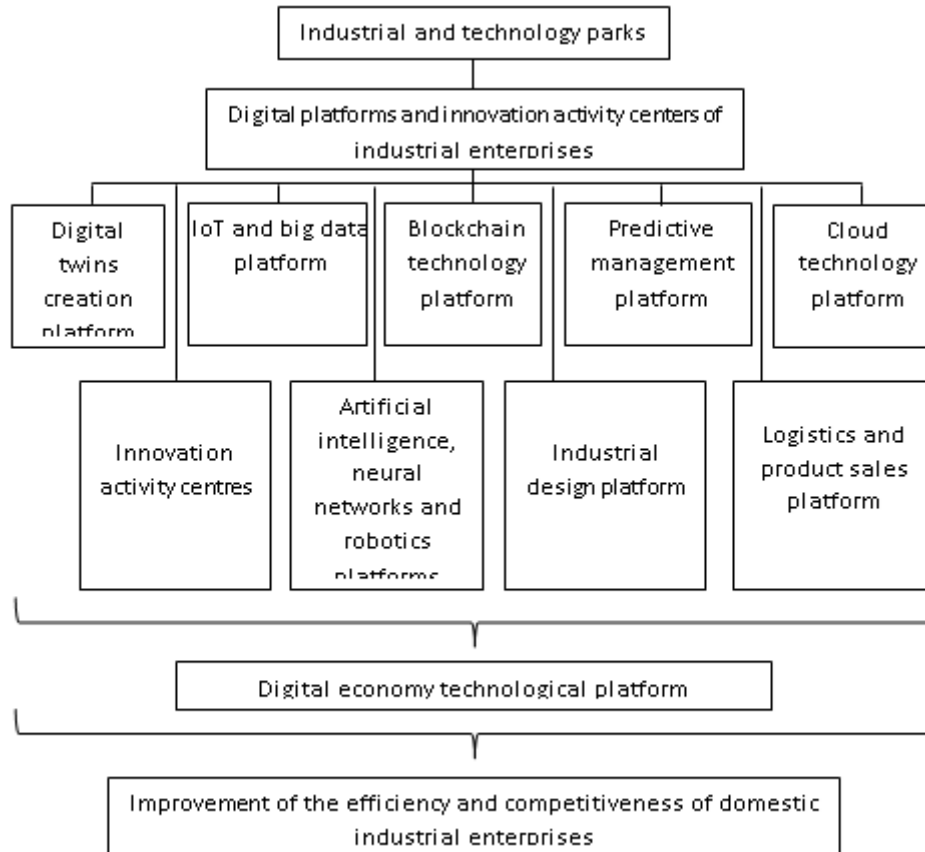


Figure 3. Model of the organizational and economic mechanism for the intensification of technological potential reserves of industrial enterprises.

Digital transformation of the regional industrial sector should not be carried at a single enterprise, it should be carried out in all sectors and foreign economic activities of the industry, which requires a new format of the state industrial policy [5].

A unified technological platform (corporate innovation incubator) is required to carry out a global digital transformation of the industrial sector. It will allow implementing innovative solutions of enterprises, creating breakthrough technologies and introducing them into the production in the shortest possible time.

Based on the development of new digital technologies in the industry, new models and forms of business organization, new digital network structures that transform traditional market relations into digital relationships of market participants are emerging.

In this situation, foreseeing potential directions of digital technologies market development, many states use all advantages of a digital economy, meeting the challenges of modernity, including an in-

crease in the efficiency of industrial foreign economic activities, development of competitiveness of regional industrial enterprises, unemployment reduction, and environmental protection [27].

The theoretical significance of the study is in the fact that it develops a theory of management of digitalization and innovations of regional industrial enterprises; it is based on the summarization of the existing theoretical approaches to the subject of research and is aimed at developing the technological potential and intensification of the use of industrial enterprises' reserves based on the introduction of digital technologies in business processes.

The theoretical results of the study are brought to the degree of practical solutions and recommendations, and can also be used for further research on this issue.

6. Practical significance of the study, proposals and results of implementation, results of experimental studies

The practical significance of the study lies in the fact that the proposed models, approaches and directions for the development of the technological potential of the regional industrial complex based on the digitalization of business processes help to increase the level of competitiveness and operation efficiency in the global market, since they represent tools for the development of innovation activities.

The authors' practical proposals and developments can be applied in innovation activity and innovation management of industrial enterprises, in the educational process at educational institutions, in studying such disciplines as “Digital Economy”, “Innovation activity”, “Digitalization of the industrial complex”, “Innovation management”.

7. Conclusions

1. This paper complements theoretical issues related to the study of the digital economy and digitalization of the regional industrial sector: an analysis of the approaches to the disclosure of the concept of a digital economy and digitalization of the industrial sector was carried out; the authors proposed an addition to the term "digital economy".

2. The authors proposed to create a network space for the participants of industrial sector digitalization to ensure rapid exchange of information that has a positive impact on the quality of decisions made, synchronization of enterprise operation, and reduction of downtimes.

3. It is proved that the outlines of the innovative development of the regional industrial complex expand due to the creation of a network of industrial and infrastructure enterprises in the area of digitalization.

4. The model and formation of an organizational and economic mechanism for the intensification of the technological potential reserves of industrial enterprises based on the digitalization of business processes is proposed.

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