Bulletin of Taras Shevchenko National University of Kyiv. Economics, 2021; 3(216): 25-34
УДК 336.7; 336.5
JEL classification: O10, O14, O33
DOI: https://doi.org/10.17721/1728-2667.2021/216-3/3

O. Grishnova, Doctor of Economics, Prof.
ORCID ID 0000-0002-4178-1662
Taras Shevchenko National University of Kyiv, Kyiv, Ukraine,
I. Berezhna, Doctor of Economics, Prof.
ORCID ID 0000-0001-7174-7556,
E. Mikhurinskaia, Doctor of Economics, Prof.
Fondo Bilateral para el Desarrollo en Transición Chile – Unión Europea, Santiago, Chile,
A. Berezhnoy, Doctor of Economics, Supply chain manager
Hunland Impex BV, Netherlands

THE ECONOMIC CRISIS OF 2020 AND THE SIXTH TECHNOLOGICAL ORDER: INTERCONNECTION AND PATTERNS

It is justified that the economic crisis is cyclical and is associated with a change in technological paradigm. The economic crisis is a process characterized by fluctuations in economic activity and it manifests itself in economic, social, environmental and political disruptions. In the sixth technological paradigm, economic growth ensured by the introduction of fundamentally new forms of combining tools and labor items that can ensure the maximum productivity in use of resources. The "core" of the sixth technological paradigm is alternative and nuclear energy, healthcare, education, aviation-, ship- and machine tool engineering, electrical engineering, telecommunications, etc., and "key factors" – information and communication technologies, biotechnology, nanotechnology. The formation of the sixth technological paradigm significantly transforms the structure of productive forces and the system of industrial relations, it change the product and the process of its advancement in various areas: health, education, energy, public services, etc. As a result, the quality characteristics of services and goods are significantly changed, as well as, the level of accessibility to material and intangible benefits of all groups of the population is increased. In this regard, effectiveness of inclusive initiatives requires the consolidation of the efforts of civil society, the State and business, the reform of the education system and the creation of conditions for increasing the level of motivation and social responsibility of society.

Keywords: economic crisis; sixth technological paradigm; bio and nanotechnology; inclusiveness.

Introduction

Statement of the problem. It is fundamentally important to determine the prerequisites for the emergence and regularities of the world crisis, which will allow the world community to adjust not only the strategy of the development in the future, but also to formulate new imperatives of economic growth that meet the challenges of our time.

It is important to bear in mind that each economic crisis is triggered by economic phenomena or events that manifest themselves in sharp fluctuations in energy prices, fluctuations in stock market indices, and planetary disasters. For example, the economic crisis of 2000–2001 is associated with the collapse of the stock market of IT companies and the fall of indices of high-tech companies. In 2008–2009 the crisis was triggered by a mortgage crisis in the United States and activated by the consequences of the bankruptcy of Lehman Brothers investment bank.

It is obvious that the prerequisites of the global economic crisis 2020 are the result of a ten-year long recession of the world economy and are associated with the achievement of the threshold value of the capital intensity of the world's GDP (93 %) in 2018, and USA (148 %) and are intensified by the pandemic of COVID-19.

The trends of declining economic growth and business activity, rising unemployment and declining income and purchasing power are characteristic of most countries in America, Asia and Europe. According to IMF forecasts, global GDP will decline by $9 trillion, and a sharp decline in jobs and incomes will be observed in 170 countries [34]. The World Bank's World Economic Outlook report noted a 7 per cent decline in activity in advanced economies and 2.5 per cent in emerging and developing economies. Per capita income could fall by 3.6 per cent this year, increasing absolute poverty. In the US, GDP decreased by 1.2 % quarterly, unemployment reached 14.7 %, and the annual rate of economic decline in the first quarter was 4.8 %. According to estimates by the International Monetary Fund, the decrease of the US economy will be 6 %. In the European Union, GDP decreased quarterly by 3.5 % (in France – by 5.8 %, Spain – by 5.2 %, Italy – by 4.7 % and Germany – by 6.3 %), and the annual rate of economic decline in the first quarter exceeded 13 %. According to estimates by the International Monetary Fund, the decrease of the economy in the EU countries will be 7 %, production will decrease by 9.1 %.

In the countries of the Asia-Pacific region in 2020, GDP may decrease by 0.8 % (132–172 billion dollars). Japan's GDP is projected to reduction by 6.1 %. China's economy will grow by 2.5 % in 2020, and almost 30 million jobs are expected to be lost this year in the country due to measures to combat the pandemic and falling global demand.

Latest scientific progress and publications review

It should be assumed that the economic crisis is a process characterized by fluctuations in economic activity (recession, depression), activated by economic (collapse of the financial market, nationalization of the economy), social (environmental disasters, pandemic) and political (change of political regimes) phenomena. The economic crisis is, by its nature, a cyclical and logical process, which is due to the achievement of the world threshold value of GDP capital intensity and a decrease in the level of capital profitability, which determines the need to introduce fundamentally new forms of combination of means and labor items that can ensure the highest productivity of the resources used and, consequently, ensure the economic growth. There is an assumption that exceeding the global threshold value of the capital intensity of GDP (100–120 %) and lowering stock indices will lead to a decrease in economic growth and, as a consequence, to the economic crisis. It should be noted that the highest thresholds correspond to Great Britain and the USA and constitute 180–200 %, and for countries with developing economies they are 100–150 %.

The cyclical nature of the economic crisis and its connection with the change in technological paradigm according to Michael A. Alexander [5] is also confirmed by the theory of long waves of N.D. Kondratiev, according to which the processes of decline in economic

development are accompanied by the formation of prerequisites for qualitative changes in production, giving impetus to productive forces and the transition to a new technological paradigm.

According to the theory of long-term techno-economic development, (Glaz'ev, Kharitonov, et al. [16]), the technological paradigm is a holistic and sustainable formation, within the framework of which a closed cycle is carried out, including the extraction and receipt of primary resources, all stages of their processing and the production of a set of final products that meet the appropriate type of public consumption.

Usually, the technological paradigm is associated with the development of a new technological method of production and its adaptation (modernization) by industries of production that have developed within the framework of the previous one. As a result of a change of technological paradigm, the "core" of the economy (a set of economic activities) is also being transformed by using the results of fundamental and applied research as "key factors" of economic growth, which are technological innovations determining the formation of the core of technological paradigm and transforming the technological structure of the economy.

The use of innovations as key factors over the past 250 years has been a prerequisite for the change of five technological paradigms, and the period of 2020–2050 is characterized by transition to the sixth technological paradigm. Information and communication technologies, biotechnology, nanotechnology, which are products of innovative development and form the "core" of the paradigm (alternative and nuclear energy, health care, education, aviation, ship and machine tool engineering, electrical engineering, telecommunications, etc.) are considered as "key factors" of the sixth technological paradigm.

The evolution of social development confirms the role of innovation as the main factor that has a complex impact on the parameters of economic growth (introduction of innovative products on average increases the GDP of developed countries by 60 %), through the increased productivity of work and capital. Kondratov, I. and Zadumkin, K. [21] note that the increase in labor productivity during the study period increased the GDP by 1.1 %, the share of capital accumulated over this period is 0.3 %. At the end of the twentieth century, new knowledge in the transformation of technology and the organization of production, in the EU accounted for 45.5 % of GDP growth on average (France – 58 %, Finland and Sweden – 63 %, Austria and Germany – 67 %), and now it is only about 50 %. At the same time, in countries with a high level of economic development (USA, China, and Singapore), the contribution of innovation to GDP growth is 70–85 %, and the share of innovative enterprises is 90 %.

The fundamentals of the innovative and technological development of the economy were laid and developed in the studies of many scientists and representatives of various scientific schools from the points of view of classical economic theory, the theory of innovation, the theory of basic models of innovative and technological development, theories of harmonization of the results of technological development and the processes of society's life. We recognize the significant contribution of researchers to the formation of modern theory and methodology of structural and dynamic harmonization of technological processes and economic development. At the same time, there is a need to further study the problems associated with the consequences and results of the sixth technological order, which significantly transform the structure of productive forces, qualitatively change processes in such spheres as health care, education, energy, public services, etc. In this regard, of great importance are the issues related to the study of mechanisms and institutional instruments that make it possible to form conditions for the development of inclusive initiatives in society.

Research on these topical issues has intensified in recent years. The reason for this is the unprecedented acceleration of the progress of science and technology. Of great importance are the works of [22; 24; 27; 30]. LEE, Changhun; LIM, Chiehyeon analyzed 660 journal papers and 3,901 news articles through text mining with unsupervised machine learning algorithms. Based on the results, this work identifies 31 research and application issues related to Industry 4.0. These issues are categorized and described within a five-level hierarchy: 1) infrastructure development for connection, 2) artificial intelligence development for data-driven decision making, 3) system and process optimization, 4) industrial innovation and 5) social advance. Further, a framework for convergence in Industry 4.0 is proposed, featuring six dimensions: connection, collection, communication, computation, control, and creation [22].

The purpose and problem of research

The innovation of economic actors is manifested through the ability to generate and commercialize innovation at all levels of the national economy, which ensures economic growth through increased labor productivity and the efficiency of capital application. It is important to assess the degree of conformity of the national economy with the conditions for the transition to the sixth technological paradigm, including the possibility of creating "key factors" and the availability of infrastructure for their implementation.

The purpose of the paper is to identify the patterns and causes of the economic crisis, its interrelationships with the technological paradigm, to determine the role of the key factors of the sixth technological paradigm in the inclusive development of the economy.

The analytical base of the study is the rankings of countries by the level of innovative development, which are presented by international organizations and agencies.

The methodology.

The existing information and empirical base for assessing the processes associated with overcoming the consequences of the economic crisis in the context of a change in the technological structure requires a synthesis of methodological approaches. It is necessary to consider the peculiarities of the organizational, regulatory, legal, informational, financial, material and technical and personnel subsystems of the national innovation system. In our opinion, the methodology for studying the problems of economic development in the sixth technological order should consider the following specific features: fundamental differences in the system of creating and transferring new technologies; the level of the gap between science and industry; institutional features of the organization of management of scientific, technical and innovative development, features of financial relationships in the field of creation and commercialization of innovations, the level of the development of science and innovations state statistics; socio-cultural features of the national innovation system.

The study used the methods for assessing and analyzing the processes of technological development of systems at different levels:

– general scientific methods of cognition (modelling, synthesis, analysis, analogy, the method of hypotheses, etc.);

– theoretical constructions of a paradigmatic nature (Kondratyev's theory of long waves);

– instrumental approaches to the study of innovation processes (survey method, qualitative methods, modelling of innovation processes);

– instrumental approaches to the procedure for collecting empirical data (questionnaires, method of expert assessments);

– data collection and measurement techniques (method of paired comparisons, scale of total assessments);

– types of data analysis (factor analysis, causal analysis);

– mathematical methods for formalizing and analyzing data (cluster analysis, methods of mathematical modelling, methods for testing statistical hypotheses).

In order to assess the level of innovation of the economy, methods have been developed that take into account innovative costs, results of innovation, level of infrastructure development, conditions for commercialization of innovation, level of provision of the national economy with innovative resources and intensity of innovation production. Thus, the global innovation index methodology is based on an estimate of the average value of two subindexes: innovation costs and innovation results. The subindex of innovative costs allows you to evaluate elements of the national economy in five groups: institutions, human capital and scientific research, infrastructure, market development level, level of business development. The subindex of innovation results reflects actual results in the field of knowledge and technology, creative activity [19].

Results of the research

Innovation: correlation to economic growth and technological paradigm

In accordance with the value of the global innovation index, world leaders are identified in the field of innovation in 2019. In the regional context, the positions in the ranking were as follows: North America: USA – 3, Canada – 17; South Africa: Kenya – 77, Mauritius – 82; Latin America and the Caribbean: Chile – 51, Costa Rica – 55, Mexico – 56; Central and South Asia: India – 52, Islamic Republic of Iran – 61, Kazakhstan – 79; North Africa and West Asia: Israel – 10, Cyprus – 28, United Arab Emirates – 36; Southeast Asia, East Asia and Oceania: Singapore – 8, Republic of Korea – 11, Hong Kong, China – 13; Europe: Switzerland – 1, Sweden – 2, Netherlands – 4.

The first position in the TOP-10 ranking of world leaders in the field of innovative development (indicator position in the ranking/value) is held by Switzerland – 1/(67.2), followed by Sweden – 2/(63.7); United States of America (USA) – 3/(61.7); Netherlands – 4/(61.4); United Kingdom – 5/(61.3); Finland – 6/(59.8); Denmark – 7/(58.4); Singapore – 8/(58.4); Germany – 9/(58.2); Israel – 10/(57.4).

Leaders in their regions were India, South Africa, Chile, Israel and Singapore, while China, Vietnam, and Rwanda topped the ratings in the respective categories of countries grouped by income level.

According to the global innovation index, a comparative analysis of the ranking of countries indicates a significant differentiation in the scientific, technical and innovative development of countries over the past decades. Middle-income countries, particularly in Asia, are increasingly contributing to the research and development. Their share in the total number of international patents constantly increases. There is a tendency for change of leading countries according to the level of public funding for fundamental and innovative R&D. At the same time, in 2019, high-income countries showed a slowdown in the pace of R&D financing. Along with this, there is an increase in protective measures, which should be considered as an obstacle to the spread of innovation in the global space. There is also a geographical differentiation of countries by the level of concentration of innovative clusters placement. Most of the leading science and technology clusters are located in the USA, China and Germany. Brazil, India, Iran, Russian Federation and Turkey also appear in the first hundred of cluster ratings. The first five ranks are occupied by the following clusters: Tokyo – Yokohama (Japan); Shenzhen – Hong Kong (China); Seoul (Republic of Korea); Beijing (China); San Jose – San Francisco (USA) [19].

The results of the ranking of innovative economies of the world: Bloomberg Innovation Index, Bloomberg agencies confirm the trends in the assessment of countries of the world according to the global innovation index.

The methodology for ranking innovative economies of the world involves the use of seven criteria on a scale from 0 to 100, including research and development, research and development costs in % of GDP; production of added value in % of GDP per capita; performance; high technology density; the effectiveness of higher education; concentration of researchers; patent activity. The rating takes into account the concentration of high-tech companies in the country, production capacities, and research and development costs [32].

According to the results of the ranking of innovative economies in the world in 2019, South Korea, Germany, Finland, Switzerland and Israel were the leaders. Over the year, Germany rose in the ranking by two positions, Finland – by four, and Israel – by five. South Korea has been leading for six years. Sweden, which took second place in 2018, fell to seventh place. Patent activity increased the positions of China and Israel, which showed a significant increase (by 5 positions). Singapore worsened its position to the 6th. The United States returned to the top ten leaders of innovative economies. The country rose in the ranking, advancing from No. 11 to No. 8. Japan and France slightly deteriorated their positions, dropping three and one positions, respectively. The second dozen of innovative economies in the world is mainly represented by European countries, China (ascended from No. 19 to No.16), Australia (No. 19) line and Canada (No. 20). Poland was ranked 22nd, Czech Republic – 25th, Russia took the 27th position. Ukraine and Tunisia are not even a part of TOP-50 of innovative economies.

Thus, the TOP-20 countries in 2019 with a high level of economic innovation are as follows (indicator position in the ranking/value): South Korea – 1/(87,38); Germany – 2/(87,30); Finland – 3/(85,57); Switzerland – 4/(85,49); Israel – 5/(84,78); Singapore – 6/(84,49); Sweden – 7/(84,15); USA – 8/(83,21); Japan – 9/(81,96); France – 10/(81,67); Denmark – 11/(81,66); Austria – 12/(80,93); Belgium – 13/(80,43); Ireland – 14/(80,08); Netherlands – 15/(79,54); China – 16/(73,35); Norway – 17/(77,79); Great Britain – 18/(85,87); Australia – 19/(75,38); Canada – 20/(73,65).

Analyzing the trends of innovative development in 2020 before the pandemic began, it should be noted that Germany pushed aside South Korea, which was the leader in the ranking for six years. In the Bloomberg index, Germany received top 5 rankings on three criteria: for value added production (No. 4), high technology density (No. 3) and patent activity (No. 3). The main reason for the change in South Korea's leadership is due to a relative drop in labor productivity (a shift of 11 position to No. 29). Singapore returned to the third position of the ranking (from No. 6 in 2018). Singapore takes first and second positions in terms of higher education efficiency and value

added production. Of the post-Soviet countries, Russia is ranked 26th, Estonia, Latvia and Lithuania are at No. 36, No. 37 and No. 38, respectively. Ukraine lost three positions and was ranked 56th in 2020, and Kazakhstan corresponds to 59th position.

At the beginning of 2020, the United States took No. 9, dropping one position compared to last year, despite the leading position in terms of high technology density and patent activity. The highest innovation activity corresponds to large companies, 50% of the world's biggest companies are located in the United States (Amazon.com Inc., Alphabet Inc. and Microsoft Corp), and the second position corresponds to Germany (Volkswagen AG, Daimler AG, Siemens AG and Bayer AG). The world's second largest economy, China ascended by one position over a year (No. 15), due to the level of patent activity and the effectiveness of higher education. The most significant changes in the ranking of countries in terms of the level of innovation of the economy correspond to Slovenia, which advanced from No. 31 to No. 21 taking into account the improvement by 34 positions on patent activity, as well as Chile showing a leap by seven positions, to No. 51.

Thus, the TOP-20 countries with high levels of innovation in 2020 are as follows: Germany – 1/(88,21); South Korea – 2/(88,16); Singapore – 3/(87,01); Switzerland – 4/(85,67); Sweden – 5/(85,50); Israel – 6/(85,03); Finland – 7/(84,00); Denmark – 8/(83,22); USA – 9/(83,17); France – 10/(82,75); Austria – 11/(82,40); Japan – 12/(82,31); Netherlands – 13/(81,28); Belgium – 14/(79,93); China – 15/(78,80); Ireland – 16/(78,65); Norway – 17/(76,93); Great Britain – 18/(76,03); Italy – 19/(75,76); Australia – 20/(74,13).

One of the key indicators of the country's scientific and technological development is the level of research activity, which reflects the dynamics of basic and applied research, as well as the possibility of presenting their results in the media. The world ranking of countries by level of research activity is calculated by the number of research papers published in peer-reviewed scientific journals included in the scientific citation index system: Science Citation Index (SCI) and Social Sciences Citation Index (SSCI). The source of information is the database of scientific statistics of Thomson Reuters, US National Science Foundation and international scientific organizations. The indicator of research activity of the countries of the world is published in a special report of the US National Science Foundation called "Science and Engineering Indicators."

Thus, the TOP-20 countries in 2018 with a high level of research activity include countries such as China – 1/(426.165); USA – 2/(408.985); India – 3/(110.320); Germany – 4/(103.122); Great Britain – 5/(97.527); Japan – 6/(96.536); France – 7/(69.431); Italy – 8/(69.125); South Korea – 9/(63.063); Russia – 10/(59.134); Canada – 11/(57.356); Brazil – 12/(53.607); Spain – 13/(52.821); Australia – 14/(51.068); Iran – 15/(40.975); Turkey – 16/(33.902); Poland – 17/(32.978); Netherlands – 18/(29.949); Switzerland – 19/(21.128); Malaysia – 20/(20.332).

Based on the results of the presented ratings, as well as taking into account the experience of innovative development of countries such as the USA, Germany, Switzerland, Sweden, Israel, Singapore, Finland, Denmark, South Korea and Netherlands, it is obvious that a high level of economic growth is provided by the conditions for the creation and commercialization of innovations that determine the possibility of change to the sixth technological paradigm.

Information and communication technologies and informatization of society

Information and communication technologies are a systemically important factor of the sixth technological paradigm, which contributes to the creation of connections and relationships between individual objects or resources (human capital, innovation), phenomena or processes (informatization of society, intellectualization of labor, entrepreneurial activity) combining them into a single system, which is characterized by the development and introduction of high-tech innovations that ensure economic growth.

The role of information and communication technologies in the global economy is confirmed by their contribution to the creation of world GDP, which amounted to $3.74 trillion in 2019, showing an increase of 0.5 % compared to 2018. The leading countries (USA and China) of the global information and communication technologies (ICT) sector correspond to almost 40 % of their production of added value. Relative to GDP, the share of this sector is highest in the Chinese province of Taiwan, Ireland and Malaysia. The number of employees in the ICT sector in the world increased from 34 million people in 2010 to 39 million people in 2015, while the largest percentage of employees (38 %) works in the field of computer services. During the same period, the ICT sector's share of total employment increased from 1.8 to 2 per cent. The largest component of the ICT sector is computer services, which account for 40 per cent of total added value in the sector. The United States plays a leading role in the global computer services industry, accounting for almost the same share of added value created in this industry as the nine largest economic nations altogether (China, Japan, Germany, India, Great Britain, France, Italy, Brazil, and Canada). India accounts for the largest share among developing countries.

Over the past 10 years, world exports have been dominated by the share of the tertiary sector of the economy, including ICT services, which is a characteristic of the sixth technological paradigm. Thus, according to UNCTAD's "Digital economy report 2019", the volume of exports of services provided using ICT reached $2.9 trillion in 2018, representing 50 % of global services exports. This confirms that information and communication technologies are the main driver of innovative activity, which transform the structure of the economy and ensure qualitative changes in such types of economic activities as medicine, energy, transport, petrochemistry, molecular biology, etc.

Abdrakhmanova, G., Gokhberg, L. and Demyanova, A. [1] claim that the rapid economic growth of South Korea in recent decades is primarily due to the intensification of informatization processes and use of modern information and communication technologies in the industrial sector. The contribution of ICT to South Korea's GDP is 10.4 %, which is higher than the same share in the United States, Japan and Germany.

The high level of development of information and communication technologies in South Korea is ensured primarily by the consolidation of the efforts of government agencies, the scientific community, small and medium-sized businesses and large corporations in the production and implementation of scientific, applied and basic research achievements in most sectors of the national economy. The information and communication technology system, formed by a combination of material, technical and intellectual resources, creates prerequisites for increasing the level of informatization of society and the transition to a digital economy. The process of informatization of society is characterized by the flow of information and knowledge,

a high level of development of technical infrastructure that provides creation of information resources, including modern models for the collection, processing and analysis of digital data that remain on various digital platforms as a result of the activity of individuals, social groups or enterprises. The use of information resources provides a high rate of development of information and telecommunication corporations compared to companies of traditional sectors of economy, as evidenced by the capitalization rating of the world's largest companies [12]. Capitalization of the world's largest companies in 2019 increased by 1.5–2.0 times, and 8 companies from the TOP-10 represent the information and telecommunication technologies sector [7].

***Table* 1. Capitalization of high-tech companies**

Company	Main area of activity	Capitalization, billion dollars
Apple	Electronics and Information Technology Manufacturing	577,4
Google	Internet services, applications, video hosting YouTube	547,9
Microsoft	Software manufacturing	443,0
Amazon	Online Commerce	360,0
Wells Fargo	Banks	299,0
Samsung	Mobile devices, home appliances and electronics	254,0
China Mobile	Telecommunications	250,0
Verizon	Telecommunications	229,0
AT&T	Telecommunications	226,0
Walmart	Retail	216,9

The level of informatization of society is assessed through the calculation of the Information and Communication Technologies Development Index (ICT Development Index) and IMD World Digital Competitiveness (WDC). ICT Development Index reflects the quality of information and communication technologies, degree of compliance of network infrastructure with new technical and operational requirements, as well as the level of development of personal competencies that characterize the ability and readiness of society to operate new technologies [31].

The ICT Development Index is complex and includes three sub-indices: access subindex, usage subindex and competence subindex in the use of information and communication technologies. Due to different approaches to the definition of subindex indicators on the quality and quantity of data, latest ranking is presented according to the results of 2017. According to the assessment of countries on the level of development of information and communication technologies (ICT), the ranking of ICT Development Index 2017 presented the TOP-20 leaders: Iceland (8.98), South Korea (8.85), Switzerland (8.74), Denmark (8.71), Great Britain (8.65), Hong Kong (8.61), Netherlands (8.49), Norway (8.47), Luxembourg (8.47), Japan (8.43), Sweden (8.41), Germany (8.39), New Zealand (8.33), Australia (8.24), France (8.24), USA (8.18), Estonia (8.14), Singapore (8.05), Monaco (8.05), Ireland (8.02) [31].

The IMD World Digital Competitiveness (WDC) ranking assesses the level of use of digital technologies by countries, which allows determining significant transformations of business models and the level of informatization of society. A comparative assessment of countries is carried out on 9 indicators, including 51 sub-indicators reflecting the level of use of new knowledge and technologies. Based on the assessment, countries are ranked depending on the level of digital competitiveness. According to IMD World Digital Competitiveness Ranking in 2019, the leading positions correspond to the USA, Singapore, Sweden, Denmark and Switzerland. TOP-20 countries with the highest levels of digital competitiveness are as follows: USA – 1/(100.000), Singapore 2/(99.373), Sweden – 3/(96.070), Denmark – 4/(95.225), Switzerland – 5/(94.648), Netherlands – 6/(94.261), Finland – 7/(93.732), Hong Kong SAR – 8/(93.686), Norway – 9/(93.671), Korea Rep. – 10/(91.297), Canada – 11/(90.836), UAE – 12/(90.295), Taiwan, China – 13/(88.897), Australia – 14/(88.691), United Kingdom – 15/(86.373), Israel – 16/(86.216), Germany – 17/(86.026), New Zealand – 18/(85.863), Ireland – 19/(84.473), Austria – 20/(84.368) [14].

The analysis of this data suggests that the use of information and communication technologies in many countries provides economic growth through qualitative improvements in means of production and technologies, an increase in productivity (up to 60 %) and effective interaction of economic actors. The processes of generation, exchange and storage of information contribute to the rapid development and spread of new technologies, under the influence of which significant changes are experienced in all sectors of the economy, as well as in the social sphere, including the labor market, education and health care. As a result, new forms of business and entrepreneurial activity are formed, the level of labor automation and production management increases, the algorithm of production processes changes and the speed of capital circulation increases, which ensures the digitalization of the economy and the social sphere. The digitalization of the economy is determined by the development of information and communication technologies, including robotics, autonomous vehicles, 3D printing, renewable energy, new materials and substances, blockchain technologies, cloud computing, the Internet of Things, analytical data processing, which implies the presence of highly qualified personnel as carriers of intellectual capital.

Biotechnologies and nanotechnology

In the sixth technological paradigm, an important role corresponds to biotechnology as a "key factor" that allows the production of fundamentally new products based on knowledge-intensive biotechnology production, which cannot be obtained by other methods. Biotechnology is a sphere of activity based on the integration of natural and engineering sciences, which allows creation of qualitatively new products in the food industry, agro-industrial complex, medicine, in the fields of energy and environmental protection.

The determinant nature of biotechnologies with regard to economic growth is due to the minimum time gap between obtaining a fundamental result and its application, the high level of programmability and potential practical value of the results of biotechnological research, as well as the possibility of replacing non-renewable resources with renewable ones. The prospects for the use of biotechnology are confirmed by the forecasts of Frost&Sullivan, according to which the global biotechnology market will reach $2 trillion by 2025, and the

growth rate for some market segments will be 30 % per year [11]. The most significant segment in the structure of biotechnologies is biopharmaceutics comprising about 60 %, industrial biotechnologies and bioenergy correspond to 35 % and agricultural technologies – 5 %. At the same time, the biopharmaceutical and biomedical market is the most dynamically developing segment, which includes development of drugs and vaccines, creation and improvement of molecular diagnostic methods, as well as cellular technologies and personalized medicine. The leader of the global bio-industry is the United States accounting for about 40 % of the global market, and biotechnology financing amounts to 100 billion dollars (China – 1 billion dollars, Russia – 0,04 billion dollars per year) [11].

Advances in nanotechnology make it possible to form a new set of technologically interacting industries that form the architecture of the sixth technological paradigm through fundamentally new nanomaterials, nano-devices, and nano-tools. The development of nanotechnologies allows creating and modifying objects that include components with dimensions less than 100 nm, have fundamentally new qualities, as well as integrating them into fully functioning systems of a larger scale.

According to the European Union policy documents, one of the strategic goals is to strengthen state support for innovative development, including increasing total R&D investment to 3% of GDP by the end of 2020. European countries such as Sweden (3.3 %), Austria (3.2 %), Denmark (3.1 %) and Germany (3.0 %) have already reached the target level of this indicator. The leader in actual R&D funding is the United States, whose National Nanotechnology Initiative (NNI) increased to $1.4 billion in 2019.

Nanotechnology market is projected to reach $121.8 billion by 2025, with an average growth rate of 14.3 % in 2020–2025 [32]. This is due to the growing use of technological advances in nanotechnology in medical diagnostics and the production of nanotechnological devices. Key developers of nanotechnology in the global market are Nanoics Imaging Ltd., Advanced Nano Products, Thermofisher Scientific, eSpin Technologies, Inc., Applied Nanotech Holdings Inc., Imina Technologies Sa, Kleindiek Nanotechnik Gmbh, Bruker Axs and Biosensor International.

Currently, more and more attention is being paid to researches in the field of artificial intelligence and the expansion of its applications. The main innovation is the development of technologies that simulate human thinking, which are based on the principles of automation and formal reasoning logic used in modern computers, in systems designed to support decision-making and smart search. According to forecasts, the global artificial intelligence market for analytical work with huge databases will reach $1.18 billion by 2025. The market for universal artificial intelligence will reach $3.83 billion for enterprise applications and solutions by 2025, and built-in artificial intelligence in construction infrastructure and equipment will amount to 16.7 billion USD by 2025 [9].

Inclusiveness of innovation of sixth technological paradigm

The formation of the sixth technological paradigm is a process of "creative destruction," which is associated with the transformations of social and economic spaces and is manifested, on the one hand, in increased business activity, growth in industrial production, and on the other, in increased concentration of capital and polarization of society by income level, destabilization of natural systems, dominant influence of political elites. Since the sixth technological paradigm is based on knowledge-intensive spheres, new economic activities are emerging; the structure of the labor market is changing, including the nature of employment, the age structure, the requirements for the level of vocational training, as well as the ratio of mental and physical work. So, according to forecasts, 7 million professions may disappear by 2030 and 10 million new ones will arise. These processes are intensified by the consequences of the economic crisis and are manifested in income inequality, rising poverty and social tension. This reveals the importance of creating equal opportunities for the participation of all population groups in education, productive employment, social mobility, creating a personal and social income, which is the goal of inclusive growth. Inclusiveness is ensured by a system of relations between the state and society, that provides conditions for the self-realization of an individual through entrepreneurial initiatives, development of professional skills and involvement in social processes. In our opinion, it is necessary to determine the role of the "key factors" of the sixth technological paradigm in the processes of creating conditions for equal access to social infrastructure for all segments of the population (education, health, safety, etc.), productive employment, social mobility, creation of personal and social income in order to improve the quality of life (social satisfaction, environmental stability, etc.), reducing inequality and overcoming absolute poverty.

In the sixth technological paradigm, "key factors" significantly transform the structure of productive forces and the system of industrial relations through the introduction of innovations in the field of information and communication technologies, nano- and biotechnology. As a result, the product and the process of its promotion in various areas are significantly changing: health, education, energy, public services, etc. This is ensured by a change in the quality characteristics of services and goods aimed at satisfying personalized needs and the large-scale introduction of contactless interaction schemes in the process of providing services and by a high level of use of modern technologies in the processes of organizing life space (personal and public security, Internet trading, online services, etc.). Thus, innovations make it possible to ensure equal access of all groups of the population to the benefits of civilization by creating conditions for improving the quality of live and increase life expectancy (medical technologies), developing professional and personal competencies (educational technologies), involvement in socio-political processes (e-government), targeting the provision of services (public services), reducing the level of bureaucratization and duration of services (business registration, opening a bank account, transactions, etc.), development of electronic services that allow taxpayers to interact with regulatory authorities remotely. Consequently, inclusiveness of the sixth technological paradigm is ensured by reducing the cost of goods and services, taking into account personalized requirements, changing format of interaction between the state and an individual regarding the possibility of each person's participation in social development processes.

The introduction of innovations in various sectors of the economy allows the production of goods and services accessible to the most vulnerable segments of the population. Illustrative examples of inclusive innovation are startups and innovative projects consisting in creation of low-cost products, provided that their basic functional properties are preserved (mobile phones of the American company Hop-On, the price of which is $10 or the Tata Nano model as the cheapest car in the world). These products, despite the limited functional set, have the main properties of more

expensive and improved analogues, which make them popular and accessible to people with low incomes.

Information and communication technologies and informatization of society affect the transformation of the sociocultural structure, the formation of value priorities and consumption patterns. Informatization of society is one of the main resources of innovation (electronic databases, electronic libraries, technologies for processing research results), the use of which creates a qualitatively new level of innovative products on the one hand, and on the other – increases access to information and communication technologies, means of communication and data transfer. According to forecasts, the growth of the number of users in the Internet network and expansion of the Internet of Things will increase the volume of global IP traffic to the level of 150.700 GB per second by 2022 [32]. As a part of the company's project, SpaceX plans to launch almost 12 thousand satellites into space, which will provide Internet communication for the entire planet. According to preliminary estimates, all 12.000 satellites will be able to simultaneously serve 14,000,000 terminals. Dozens of devices can simultaneously be connected to each terminal, which means Starlink can serve hundreds of millions of users around the world.

The use of digital platforms allows increasing the efficiency of electronic business models, transforming existing sectors of the economy, modernizing the work of various services in the banking sector, sectors of providing educational and public services, etc. Thus, the expansion of consumer access to the financial services market is primarily due to the proliferation of online payments and remittances, the simplification of electronic insurance, credit and investment management procedures. At the same time, the use of information and communication technologies in the field of biometrics and blockchain development allows increasing the level of efficiency of modern security systems of various levels through the use of common technological identifiers of individuals. Educational digital platforms provide equal access to educational services for students of all ages and social groups, taking into account the individual characteristics of students.

The inclusion of information and communication technologies (Government as a Platform, GaaP) in the public services sector is linked to the work of e-government in order to improve interaction and develop linkages between public services and citizens. This is ensured by the way of providing information and public services to citizens (G2C – government-to-citizen), to business (G2B – government-to-business), to state organizations (G2E – government-to-employee) and to public administration bodies (G2G – government-to-government), in which personal interaction is minimized and the period of service provision is reduced. Currently, the countries of the world are taking advantage of e-government to varying degrees, due to the level of development of telecommunications infrastructure and preparation of public officials. According to the EGDI (E-Government Development Index), Europe is the leader in the level of professional preparation and use of e-government. The EGDI of the European continent in 2018 was 0.77, while in America – 0.59, Asia – 0.58, Australia and Oceania – 0.46, and in Africa – 0.34. In spite of the fact that Europe is the indisputable leader at the macroregional level, TOP-10 countries (by the level of development of the electronic government) include five European states (Denmark, Great Britain, Sweden, Finland, France), three Asian (South Korea, Singapore, Japan), and two of Oceania (Australia, New Zealand) [15].

The inclusiveness of bio-and nanotechnology is ensured by the creation of resources that increase the level of accessibility to medical services, quality of life and life expectancy, food and environmental security.

In the context of climate change, the use of biotechnology in agriculture increases food security by expanding bio- and agro-diversity, level of resilience of ecosystems, which allows the cultivation and production of environmentally friendly foods of high nutritional value. The relevance of addressing the challenges of hunger caused by climate change and extreme weather events, as well as by armed conflict, is confirmed by the World Health Organization, according to which the level of hunger in African countries reaches almost 20 %, in Latin America and the Caribbean – 7 % and Asia – 12 %, and the total number of starving people in the world amounts to 820 million.

The use of modern genetic and biotechnological methods in agriculture will allow restoring soil fertility and creating new highly productive varieties of agricultural plants resistant to diseases, pests and adverse environmental conditions, as well as producing biologics for crop production, feeding additives and veterinary biologics for livestock.

At the same time, the use of bio- and nanotechnology in the environmental sphere results in ensuring environmental safety by reducing the volume of technogenic, agricultural and household waste, and effective use of secondary materials of various industries.

It should be noted that about 90 % of all biotechnological products in the world are used in medicine and healthcare as new drugs and vaccines, in molecular diagnostics and cellular technologies, in editing the human genome and growing human tissues and organs, which provides a qualitatively new level of medical care and possibility of treating previously incurable diseases. As a result, life expectancy and the average age of a person increase and the number of countries with a high quality of life increases ("Club 80+" by life expectancy: Hong Kong – 83.73 years, Japan – 83.3 years, Italy – 82.84 years, Switzerland – 82.66 years and Singapore – 82.64 years).

Thus, the use of information and communication, bio- and nanotechnology as "key factors" of the sixth technological paradigm can significantly transform the economic space and change the nature of the interaction between society and the state with regard to the realization of the value priorities of inclusive growth. At the same time, the main determinant of these processes is human capital, which, on the one hand, forms a favorable environment for perceiving the imperative of inclusive growth, and, on the other, is able to use the intellectual potential of individuals to produce inclusive innovations and exchange the product of intellectual labor.

In this regard, attention is focused on the inevitable "property stratification of society on the basis of education" in view of the emergence of an intellectual class and the dominance of meritocracy (the power of the intellectual elite), which determines the transformation of ownership of the product of intellectual activity as the main priority of a post-industrial society. Therefore, human capital is the determinant of inclusive growth, which increases the value of education and transforms the nature of labor relations. The result of these transformations will be intensification of the development of associated forms of business organization, change of the status of an employee and improvement of the forms of partnership between employees and employers. Inclusive growth is associated with structural transformations in the production sector, which are manifested in the development of outsourcing, an increase in small and medium-sized businesses, in change of forms of cooperation between large and small manufacturers, in the emergence of new services in

healthcare, science, education, as well as in the development of new forms of business based on the use of modern information technologies (Internet platforms, Internet trading, etc.). Thus, the structure of demand changes in relation to the requirements for the level of professional and personal competencies of workers, the new quality of which is ensured by the use of innovative educational technologies. Acemoglu, D. and James A. Robinson [2] believe that the role of inclusive institutions will be to create the conditions for increasing the level of inclusion of education and the development of an effective learning environment based on the unity of learning capabilities, learning opportunities and demand for competencies and knowledge.

Education inclusiveness is aimed primarily at ensuring equal non-discriminatory access to participation in the educational process, regardless of race, color, sex, language, religion, political or other opinion, national or social origin, economic status or birth. Implementation of this principle provides for the universal right to free quality primary and secondary education. This is due to the modern requirements of the labor market and the need for a guaranteed opportunity for the individual to receive personal income in the form of wages. In this regard, the UN in strategic documents justifies the need to implement state support measures to ensure the right of students to primary and secondary compulsory education. At the same time, attention is focused on ensuring equal conditions for access to education and the formation of a favorable learning environment for the most vulnerable categories of students, including those with disabilities, belonging to minorities, socially disadvantaged, etc. UN experts consider it important to ensure "individual equal right" and "equality in education," as well as fair quality education and the promotion of lifelong learning for all. The inclusiveness of the "individual equal right" provides for the creation of an enabling environment for the realization of creative abilities and goals of personal growth, which can be ensured through the use of modern forms of interactive learning and development programs. In turn, ensuring "equality in education" provides for the development of forms of interpersonal communication that allow the provision of educational services related to the active involvement of students in social processes, recognizing their right to express their own opinions and self-determination.

At the same time, it is important to note that human capital provides structural transformations in the economy, which are manifested in the growing share of tertiary sector income in the structure of gross national product, in the intensification of the introduction of innovative technologies, in the priority of knowledge, education and professional skills, as well as in the growth of incomes of the population. Azizkulov, D. [10] claims that such changes are characteristic of a post-industrial society, which is characterized by the introduction of resource-saving and information technologies, an increase in the volume and modifications of unified products, complete automation of production processes, the introduction of applied and fundamental innovative achievements, as well as the strengthening of the role of small and medium-sized businesses.

Taking into account the challenges of our time, the main imperative of economic growth and civil society is to reduce inequality by creating equal conditions for personal and social income. In this regard, it is necessary to create forms of economically viable entrepreneurial activity, in which poor population groups are involved as consumers, workers and entrepreneurs at all stages of the value chain, ensuring mutually beneficial development for all its participants. Such business models are inclusive because, on the one hand, they provide an opportunity for profit for business, and, on the other hand, create conditions for employment, sustainable income and involvement in the processes of economic and social life of society.

The effectiveness of inclusive initiatives is determined, first of all, by the consolidation of the efforts of civil society, the state and business (small and medium-sized businesses, social businesses). Inclusive business models can be focused on the implementation of innovative solutions to meet the basic needs of the poor in water, food, sewerage, housing and healthcare, as well as on creating conditions for training in specialties demanded in inclusive workshops (ceramic, sewing, graphic, carpentry and culinary, etc.). At the same time, innovative supply chains, including suppliers, distributors, retailers, are being created in the framework of inclusive projects of large corporations. For example, L'Oréal's inclusive initiatives have created a training system for disadvantaged, vulnerable and young people (15.000) seeking valuable skills that have been employed in small value chain enterprises.

One of the effective types of inclusive entrepreneurship is social business projects, within the framework of which various services are provided (design, content, legal support, etc.) by disabled employees with higher education. These projects are financed by the State through grants and other forms of financial support (microcredit, microinsurance, and subsidized loans).

In order to achieve a high level of social mobility and possibility of implementing entrepreneurial initiatives, the experience of creating business incubators, industrial zones and technology parks on the basis of a partnership between the government and a private company. This ensures equal access to business infrastructure, including rental of premises, office equipment, business communication, consulting, which is a significant funding for small businesses. The development of small and medium-sized businesses contributes to the reduction of youth unemployment, the economic empowerment of women and the socio-economic integration of migrants and refugees. For example, the global initiative Business Action Network for Inclusive Development, funded by the European Union and the Government of Germany, aims to support small and medium-sized businesses in their efforts to expand the application of inclusive business models.

Conclusions

1. The cyclical nature of the economic crisis is revealed, which is manifested in the change of periods of growth and recessions, activated by economic, social and political phenomena (pandemic, changes in energy prices, changes in political regimes, etc.). The patterns of economic crises are due to the achievement of a critical level of the world threshold for GDP capital intensity and a decrease in the level of capital profitability.

2. The relationship between the cyclicity of the economic crisis and the change of technological paradigm is justified, which makes qualitative changes in the system of industrial relations through the use and adaptation of innovative technologies. The "key factors" of the sixth technological paradigm are information and communication technologies, biotechnology and nanotechnology, which are products of innovative development and form the "core" of this paradigm as a set of economic activities based on fundamentally new production technologies, which allow creating innovative products and increasing labor productivity and the level of return on capital.

3. The use of information and communication technologies ensures the creation of connections and

interactions between individual objects or resources (human capital, innovation), phenomena or processes (informatization of society, intellectualization of labor, entrepreneurial activity) by combining them into a single system, which allows them to be considered as a systemically important factor of the sixth technological paradigm. The result of the use of information and communication technologies is an increase in the speed of the spread of new technologies, as well as active changes in all sectors of the economy and social sphere.

4. Advances in bio- and nanotechnology form the architecture of the sixth technological paradigm through the use of fundamentally new technologies, devices and materials, which transforms the structure of the economy in terms of increasing the share of science-intensive industries. The efficiency of the use of bio- and nanotechnology is due to the minimum time gap between obtaining a fundamental result and its applied implementation, a high level of programmability and the potential practical value of the results of scientific research.

5. Formation of the sixth technological structure reinforces the importance of highly skilled and creative work, artificial intelligence, which allows increasing the level of automation of production processes and increasing the efficiency of management decisions. These processes are accompanied by changes in the structure of employment, increased requirements for the level of training, including digital competencies.

6. The role of the "key factors" of the sixth technological paradigm is to create conditions for equal access to social infrastructure for all segments of the population (education, health, safety, etc.), productive employment, social mobility, creation of personal and social income in order to improve the quality of life (social satisfaction, environmental stability, etc.), reduce inequality and overcome absolute poverty. Inclusiveness of the "key factors" of the sixth technological paradigm is ensured by reducing the cost of goods and services, taking into account personalized requirements, changing format of interaction between the state and the individual (private-state partnership) regarding the possibility of everyone's participation in social development processes (social entrepreneurship, development of small and medium-sized businesses, self-employment).

References

1. Abdrakhmanova G., Gokhberg L., Demyanova A. Digital Economy: A Concise Statistical Compilation : M: NRU HSE, 2019. P. 92.
2. Acemoglu D., Robinson J. Why Nations Fail. The Origins of Power, Prosperity and Poverty : Profile Books, Ltd. 2012. P. 544.
3. ACETO, Giuseppe; PERSICO, Valerio; PESCAPÉ, Antonio. Industry 4.0 and health: Internet of things, big data, and cloud computing for healthcare 4.0. *Journal of Industrial Information Integration*, 2020, 18: 100129.
4. Aganbegyan A. Human capital and its main component – the sphere of "the economy of knowledge" as the main source of socio-economic growth. *Economic Strategies*, 2017. P. 30. – URL: http://stolypin.institute/novosti/chelovecheskij-kapital-i-ego-glavnaya-sostavlyayushhaya-sfera-ekonomiki-znanij-kak-osnovnoj-istochnik-sotsialno-ekonomicheskogo-rosta/
5. Alexander M. The Kondratiev Cycle. A generational interpretation : Club Press an imprint of iUniverse, Inc., 2002. P. 314.
6. All on Board. Making Inclusive Growth Happen. OECD. 2014. P. 202. URL: https://www.oecd.org/inclusive-growth/All-on-Board-Making-Inclusive-Growth-Happen.pdf
7. Analysis of the capitalization of the largest companies in the world related to the digital economy sector. FXSSI. (accessed 15 April 2019) (in Russian) URL: https://ru.fxssi.com
8. Appelbaum R., Cong Cao, Han X., Parker R., Simon D. Innovation in China: Challenging the Global Science and Technology System : Polity Pres. 2018. P. 200.
9. Artificial General Intelligence Market: General Purpose Artificial Intelligence, AI Agent Platforms, and Software : Report. 2020–2025. P. URL: https://www.researchandmarkets.com/reports/5116895/artificial-general-intelligence-market-general?utm_source=dynamic&utm_medium=CI&utm_code=gvpfjh&utm_campaign=1405092+-+Global+Market+Outlook+for+the+General+Purpose+Artificial+Intelligence+Market+2020-2025+-+Embedded+AI+in+Building+Infrastructure+and+Equipment+Forecast+to+Reach+%2416.7+Billion+Globally+by+2025&utm_exec=cari18cid
10. Azizkulov D. The Concept of Digital Economy, Her Feature and Prospect in the Russian Market : Vector Economy 2018. № 3 (21). P. 62–72. URL: https://elibrary.ru/download/ elibrary_32751051_13924538.pdf (accessed 5 February 2019) (in Russian).
11. Biotechnologies Today. URL: https://intalent.pro/industry/biotehnologii.html
12. Brand Finance Global 500. The annual report on the world's most valuable and strongest brands January 2020 : 2020. P. 27. URL: https://brandfinance.com/images/upload/brand_finance_global_500_2020_preview.pdf
13. Chernyakov B. The role and place of the largest agricultural enterprises in the US agricultural sector. Economy of agricultural and processing enterprises. 2001. № 5, P. 41–46.
14. Digital Economy Report. Value Creation and Benefits: Implications for Developing Countries. 2019. P. 194. URL: https://unctad.org/en/PublicationsLibrary/der2019_overview_ru.pdf
15. E-government rating. 2018. URL: http://2035.media/2019/01/22/eg-map-world/
16. Glaz'ev S., Kharitonov V. Nanotechnology a key factor of a new technological structure in economy : Moscow: Trovant (in Russian), 2009. P. 304.
17. Global Innovation Index 2019 Creating Healthy Lives – The Future of Medical Innovation: Cornell University, INSEAD, WIPO, 2019. P. 451.
18. Global Smart Nanomaterials Market: Focus on Type (Carbon, Metal, Polymer), End-Use Industries and Country-Level Analysis – Analysis and Forecast, 2019–2029. 2019. P. 149. URL: https://www.researchandmarkets.com/reports/5017350/global-smart-nanomaterials-market-focus-on-type#relb0-344105
19. Globalization and Development a Latin American and Caribbean Perspective. Edited by José Antonio Ocampo Juan Martin : a copublication of Stanford Social Sciences, Stanford University Press, and the World Bank, 2003. P. 232.
20. Hanson J. Growth Paradigms and Congruent Institutions: Estimating Context-Varying Effects of Political Institutions on Economic Performance : Political Science Research and Methods, 2013. № 1(2), pp. 239–262.
21. Kondratov I., Zadumkin K. Scientific and technical potential of the region: assessment of the state and development prospects : Vologda. 2010. P. 208.
22. LEE, Changhun; LIM, Chiehyeon. From technological development to social advance: A review of Industry 4.0 through machine learning. *Technological Forecasting and Social Change*, 2021, 167: 120653.
23. MUCCHI, Lorenzo, et al. How 6G technology can change the future wireless healthcare. In: *2020 2nd 6G wireless summit (6G SUMMIT)*. IEEE, 2020. pp. 1–6.
24. Nanomaterials – global market trajectory and analytics. *Report*. 2021. P. 380. URL: https://www.researchandmarkets.com/reports/344105/nanomaterials_global_market_trajectory_and?Utm_source=CI&utm_medium=pressrelease&utm_code=l6tfpv&utm_campaign=1310777+-+Global+Nanomaterials+Market+Report+2019-2025%3a+Market+Overview%2c+Focus+On+Select+Players%2c+Trends+%26+Drivers%2c+Global+Perspective&utm_exec=chdo54prd
25. Nanotools Market-Predictions from 2019 to 2024. *Report*. 2019. P. 102. URL: https://www.researchandmarkets.com/reports/4849608/nanotools-market-forecasts-from-2019-to-2024#pos-0
26. New sources of protein and innovative food products in the world: Research: the main trends of the Russian and world FoodTech market. 2020. P. 13. URL: https://new-retail.ru/tehnologii/issledovanie_osnovnye_trendy_rossiyskogo_i_mirovogo_rynka_foodtech6678/
27. PETERS, Michael A.; JANDRIĆ, Petar; HAYES, Sarah. Postdigital-biodigital: An emerging configuration. 2020.
28. Rating of countries by the level of development of information and communication technologies. 2019. P. 11. URL: https://basetop.ru/reyting-stran-po-urovnyu-informatsionnyih-tehnologiy-2/
29. Roller L-H., Waverman L. Telecommunication's infrastructure and economic development : American Economic Review, 2001. № 4. pp. 909–923.
30. STEZANO, Federico. Approaches in the concept of convergence. A critical review of the literature. *Innovation: The European Journal of Social Science Research*, 2021, 1–17. +-
31. The Bloomberg Innovation Index rates countries on factors that when used together, are a representation of innovation levels. URL: 2017. P. 8. https://innovationcompany.co.uk/2017-bloomberg-innovation-index
32. The Cisco Annual Internet Report (2018–2023): White Paper. Cisco, 2018. URL: https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html
33. The global economy will contract by three percent this year. The IMF, 2020. P. 3. URL: https://news.un.org/ru/story/2020/04/1376072
34. The Nanotechnology Market report – Forecast (2020–2025). 2020. URL: https://www.industryarc.com/Report/15022/nanotechnology-market.html

Received: 25/06/2021
1st Revision: 02/07/21
Accepted: 16/08/2021

Author's declaration on the sources of funding of research presented in the scientific article or of the preparation of the scientific article: budget of university's scientific project

О. Грішнова, д-р екон. наук, проф.
Київський національний університет імені Тараса Шевченка, Україна,
І. Бережна, д-р екон. наук, проф.
Fondo Bateral para el Desarrollo en Transición Chile – Unión Europea, Сантьяго, Чилі,
К. Міхуринська, д-р екон. наук, проф.
Fondo Bateral para el Desarrollo en Transición Chile – Unión Europea, Сантьяго, Чилі,
А. Бережний, д-р екон. наук, менеджер з постачання
Hunland Impex BV, Нідерланди

ЕКОНОМІЧНА КРИЗА 2020 І ШОСТИЙ ТЕХНОЛОГІЧНИЙ УКЛАД: ВЗАЄМОЗВ'ЯЗОК І ЗАКОНОМІРНОСТІ

Обґрунтовано, що економічна криза носить циклічний характер і пов'язана зі зміною технологічної парадигми. Економічна криза – це процес, який характеризується коливаннями економічної активності, проявляється в економічних, соціальних, екологічних і політичних потрясіннях. У шостий технологічній парадигмі економічне зростання забезпечується за рахунок впровадження принципово нових форм поєднання знарядь праці і предметів праці, здатних забезпечити максимальну продуктивність використання ресурсів. "Ядром" шостого технологічного укладу є альтернативна і атомна енергетика, охорона здоров'я, освіта, авіація, корабельне і верстатобудування, електротехніка, телекомунікації та ін., а його "ключові фактори" – інформаційні та комунікаційні технології, біотехнології, нанотехнології. Формування шостої технологічної парадигми істотно трансформує структуру продуктивних сил і систему виробничих відносин, змінює продукт і процес його просування в різних сферах: охорона здоров'я, освіта, енергетика, комунальні послуги і т.д. Істотно змінюються якісні характеристики послуг і товарів, а також підвищується рівень доступності матеріальних і нематеріальних благ для всіх груп населення. У зв'язку з цим ефективність інклюзивних ініціатив вимагає консолідації зусиль громадянського суспільства, держави і бізнесу, реформування системи освіти і створення умов для підвищення рівня мотивації і соціальної відповідальності суспільства.

Ключові слова: економічна криза; шоста технологічна парадигма; біо- і нанотехнології; інклюзивність.

Е. Гришнова, д-р экон. наук, проф.
Киевский национальный университет имени Тараса Шевченко, Украина,
И. Бережная, д-р экон наук, проф.
Fondo Bateral para el Desarrollo en Transición Chile – Unión Europea, Сантьяго, Чили,
Е. Михуринская, д-р экон. наук, проф.
Fondo Bateral para el Desarrollo en Transición Chile – Unión Europea, Сантьяго, Чили,
А. Бережной, д-р экон. наук, менеджер по поставкам
Hunland Impex BV, Нидерланды

ЭКОНОМИЧЕСКИЙ КРИЗИС 2020 И ШЕСТОЙ ТЕХНОЛОГИЧЕСКИЙ УКЛАД: ВЗАИМОСВЯЗЬ И ЗАКОНОМЕРНОСТИ

Обосновано, что экономический кризис носит цикличный характер и связан со сменой технологической парадигмы. Экономический кризис – это процесс, характеризующийся колебаниями экономической активности, который проявляется в экономических, социальных, экологических и политических потрясениях. В шестой технологической парадигме экономический рост обеспечивается за счет внедрения принципиально новых форм сочетания орудий труда и предметов труда, способных обеспечить максимальную продуктивность использования ресурсов. "Ядром" шестой технологической парадигмы являются альтернативная и атомная энергетика, здравоохранение, образование, авиация, корабельное и станкостроение, электротехника, телекоммуникации и др., а его ключевые факторы" – информационные и коммуникационные технологии, биотехнологии, нанотехнологии. Формирование шестой технологической парадигмы существенно трансформирует структуру производительных сил и систему производственных отношений, меняет продукт и процесс его продвижения в различных сферах: здравоохранение, образование, энергетика, коммунальные услуги и т.д. Существенно изменяются качественные характеристики услуг и товаров, а также повышается уровень доступности материальных и нематериальных благ для всех групп населения. В этой связи эффективность инклюзивных инициатив требует консолидации усилий гражданского общества, государства и бизнеса, реформирования системы образования и создания условий для повышения уровня мотивации и социальной ответственности общества.

Ключевые слова: экономический кризис; шестая технологическая парадигма; био и нанотехнологии; инклюзивность.

Bulletin of Taras Shevchenko National University of Kyiv. Economics, 2021; 3(216): 34-43
УДК 338.246.027:631.11(477)
JEL classification: F36, G18, H53
DOI: https://doi.org/10.17721/1728-2667.2021/216-3/4

A. O. Moscardini, Visiting prof.
ORCID ID 0000-0003-4951-0848
Cardiff Metropolitan University, UK,
K. Lawler, Prof., CBA
ORCID ID 0000-002-3409-6755
University of Kuwait, Kuwait,
T. Vlasova, Visiting Research Fellow
ORCID ID 0000-0002-5000-6756
Northumbria University, UK

THE IMPACT OF THE LUCAS CRITIQUE ON MACROECONOMICS: A BRAIDING OF ECONOMIC AND CYBERNETIC INSIGHTS

The Lucas Critique has attracted discussion since it was published in 1976. This article evaluates its impact on the epistemology of Macroeconomics. It probes deeper than an analysis on Rational Expectations into a debate on theory and practice in macroeconomics. The originality of the research concerns the convergence/divergence between the Keynes and Lucas critiques of econometrics/econometric policy. The paper updates and refines Lucas's contribution to econometric policy evaluation framed by the Keynes – Tinbergen – Friedman – Lucas literature. The exegesis uses the expertise of the authors (one a cybernetician and one a macroeconomist) to provide a novel and stimulating platform for further debate.

Keywords: Lucas Critique, Micro/macro divide, Rational Expectations.

1. Introduction

This paper takes a meta view of the epistemology of Economics. It does not concern itself with the differences between the different schools which have developed over the last three centuries but analyses the philosophical underpinnings of economics as a discipline. The paper is a critical appraisal based on a nuanced literature survey of the contributions to econometric policymaking covering