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DIGITAL INFORMATION REVOLUTION IN THE CONTEXT OF THE LONG WAVES THEORY BY N. KONDRATIEV

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Abstract: The article shows the interconnection between Kondratiev's long waves theory and the digital information revolution that is happening in the world today. It describes the cycles (patterns) of the five long time periods in the world economy which have already taken place and have been accompanied by declines and upturns and gives a forecast for the development of the national economy leading sectors in the context of the sixth technological structure.

Keywords: *long waves, technological structure, cycle, crisis, information technology, digital information revolution.*

INTRODUCTION

Nikolai Dmitrievich Kondratiev is a Russian economist, the founder of the theory of economic cycles, known as Kondratiev's Cycles. In 1925 he published the work "Large Cycles of Conjuncture," which provoked scientific discussions, in the course of which he formulated the theory of cycles in the economic, social and cultural development of capitalist countries.

According to Kondratiev's classic theory of large cycles, wars and revolutions arise on the basis of real, mainly economic conditions, on the basis of the increasing pace and tension of the economic environment, the aggravation of economic competition for markets and raw materials. Social upheavals take place most easily during the onslaught of new economic forces.

The main contribution to the popularization of Kondratiev's ideas was made by Joseph Schumpeter in his works – it was him who introduced the term "Kondratiev's waves", and in 1939 in his book "Business Cycles" he supported and developed the pattern discovered by Kondratiev, along with 7-11 year production and employment cycles.

N.D. Kondratiev made a significant contribution to a number of economics areas. However, the theory of long cycles (waves) brought him the biggest honour. Nevertheless, it is worth mentioning that it is a mistake to say that Kondratiev discovered long cycles/waves of conjuncture. Long-term price fluctuations (with a characteristic period of about 60 years) were known even before

Kondratiev was born. William Stanley Jevons greatly contributed to the development of the index theory, and also tried to create a theory of economic cycles based on the periodicity of solar activity. The merit of Nikolai Dmitrievich Kondratiev was the fact that he made the long wave economic and social dynamics the subject of special analysis and for the first time created a logical theory, supported by numerous empirical data and conceptual explanations. Kondratiev was not the discoverer of long waves in economic and social dynamics, but he became the creator of the first scientific theory of these waves, which are therefore deservedly called "Kondratiev's waves" (Grinin, L.E., Korotaev, A.V., Bondarenko, V.M., 2017).

EXPOSITION

The macroeconomic environment is rather unstable, it constantly changes, both at the level of the world economic system and within the framework of one state, therefore it is reasonable to use the theory of long waves in the analysis of various situations.

The world order that prevailed after the Second World War and the well organized economic system are crumbling, crises are following one after another, which leads to significant changes all over the world.

The economy is highly unlikely to do without powerful and systematic state activity. The new model is certain to have its own problems, but, in any case, this trend is a forward movement and, very importantly, a movement at the global scale. At the same time, any change of models is, first of all, a change of ideas, and, therefore, of people who act as their carriers. Therefore, this process cannot be painless. Another fundamental point is that the new model arises as a constructive result of the global crisis, but for each country this crisis has its own individual features (Glazyev, S., 1993).

In light of this, the theory of long waves gains particular importance, as it serves as an essential tool for both an adequate understanding of the current system processes and their prediction. In the 1920s N.D. Kondratiev paid attention to the fact that in the long term dynamics of some economic indicators (at least, starting from the end of the 18th century) a certain cyclic regularity was observed. It showed that after the phases of accelerated growth of certain economic indicators one could observe the phases of their relative decline or slower growth. The duration of one wave was on average from 40 to 60 years.

Thus, Kondratiev's cycles (waves) had a fairly strict periodicity for at least two centuries in a row. Each new Kondratiev's wave was caused by a spiral of basic technological innovations that arose at the descending phase of the previous wave.

Breakthrough innovations always open a vast niche for expanding production and attracting investment. The long wave is on the rise then. As a result, new economy sectors are formed, making a new technological structure. This new structure ultimately reorganizes the entire economic life and creates a new techno-economic paradigm. However, innovations are usually spread for a rather long time. Consequently, the process of economic restructuring takes from 20 to 30 years. At first, the efficiency of new technologies is high, but when they spread widely, their effectiveness drastically reduces. Then comes the descending phase of the long cycle.

The descending phase is characterized by a slower and more difficult economic development. However, it is in the process of overcoming these difficulties that inventions and innovations of a new technological structure appear. Then the core of a new technological structure is formed and the rise of a new wave begins. There are six such technological structures distinguished (the sixth is expected for the period 2020-2060).

It should be noted that in the author's understanding the technological structure is the union of interrelated and interdependent elements of different industries to create a holistic reproducing system.

Only profound changes in various spheres of society, as well as new approaches to regulating the economy, in the end allow us to ensure a transition to a significant upsurge. As a result, there is a transition to a new system of relations, which opens up opportunities for economies to develop in the coming decades with less crisis risks. However, since further development happens relatively mildly, the need for reforming and updating relations weakens. This leads to the accumulation of contradictions and structural defects of the system, which begin to appear after a while (already at a qualitatively new

level of development) in the form of more severe and/or long-running recessions and depressions, and the development itself proceeds with shorter and less intensive phases of upsurge. The changes of previous decades give way to the descending phase. Thus, through medium term cycles, the descending phases of Kondratiev's waves seem to prepare the conditions for transformation into upward ones for themselves. In turn, the lower severity of the crisis-depressive phases of the Juglar cycles in the upward phases of Kondratiev's waves determines their turn to the downward phases.

This is precisely the situation we are currently observing. That is why the most severe crises are, so to speak, "turning" ones, from the upward to downward phases and vice versa (in particular, those that occurred in 1847, 1873, 1929, 1973), which include the latest global crisis.

Crises are always the result of previous active growth, since this growth inevitably creates structural tensions not only in the economy, but also in society as a whole (the institutions of society are designed for a certain number and scale of phenomena and processes). Nevertheless, all crises proceed differently although they have something in common. In addition, they differ markedly depending on which upward or downward phase of the long Kondratiev's wave they occur at.

Almost any cyclical crisis is associated with a disorder (fall or even collapse) of money (currency) circulation, stock exchange rates of securities (shares, bonds, bills, etc.), with various kinds of speculation (including stocks, raw materials, land and residential real estate, plots rich in minerals, etc.). (Glazyev, S., 2017).

As historical analysis shows, the first Kondratiev's cycle lasted about 60 years, from the late 1780s to the end of the 1840s – beginning of the 1850s. As a result of this cycle, the first technological structure arose, based on the water and steam engines, as well as the cotton industry. The second cycle lasted about 50 years, from the late 1840s until the end of the 1890s. In the course of this cycle the second technological structure was formed. It was based on railway construction, ferrous metallurgy and shipbuilding. The third cycle produced the third technological structure – the one based on the electric motor, electrical and heavy mechanical engineering, inorganic chemistry. It lasted about 45-50 years – from the end of the 1890s till mid 1940s. The fourth cycle, associated with the development of the fourth technological system based on the automotive industry, tractor manufacturing, non-ferrous metallurgy, oil refining, and organic chemistry, lasted about 40 years – from the mid 1940s to the mid 1980s. Finally, the fifth cycle and the fifth technological mode based on microelectronics, the production and use of personal computers, the Internet, and telecommunications, has been lasting for about 35-40 years – from the mid-1980s until the early 2020s. Kondratiev's sixth cycle with the development of the sixth technological mode, based on environmentally friendly energy sources, bio- and nanotechnology, the production of new materials, as well as on advanced information technologies, is likely to last even less – from the beginning of the 2020s until the early 2050s.

Table 1. The basic directions of technological structures in the fourth, fifth and sixth Kondratiev's cycles

Fourth technological structure	Fifth technological structure	Sixth technological structure
1940–1980	1980–2020	2020–2050
- automation - oil, coal and nuclear energy - computers, data banks - chemicalization -"green revolution" - aircraft industry - automotive industry	- microelectronics - oil and gas energy - personal computers; - the Internet - biotechnology of microorganisms - information technology - robotics	- nanotechnology - alternative energy, including hydrogen - global information networks, multimedia - biotechnology of plants and animals, new drugs - photonics and optoinformatics - waste recycling

It is obvious that rapid technological and social changes at the beginning of the XXI century are greatly determined by the formation of a new (sixth) technological structure and corresponding social institutions. The basis of the sixth technological mode, which is currently still being formed, will most likely be the latest, more developed information technologies, new materials, nano- and biotechnologies, and more environmentally friendly energy sources.

At the same time, the previous (fifth) technological mode based on the use of microelectronics, personal computers, the Internet, mobile communications, and telecommunications continues to dominate in the world, including developed countries. However, the possibilities of profitable expansion of these technologies are gradually being exhausted. This circumstance, as well as the numerous dysfunctions of modern social and economic institutions, is giving rise to the crisis era of 2005-2020, which we are now experiencing. Even in developed countries, including the United States and EU countries, there is a noticeable degradation of the middle class and the separation of the financial aristocracy from the bulk of the population, and in many other countries unstable democracy often degenerates into an oligarchy, the use of electoral political technologies and the manipulation of mass consciousness. In addition, financial debt problems are aggravating in many countries, and attempts to solve these problems lead to a deterioration in the financing of social programs and education systems.

It can be concluded that the world economy is experiencing the transition to the sixth technological structure, associated with information technologies created on the basis of knowledge on the elementary structures of matter, as well as algorithms for processing and transmitting information obtained by fundamental science. Thus, we are talking about the digital economy.

To date, the digital revolution has embraced almost all types of activities and has involved most of humanity. Since the advent of the first computers, it has gone through three major stages. During this time, two technological structures have changed in the world technical and economic development.

The information and digital revolution in the author's understanding is the introduction and the use of advanced information technologies in all spheres and sectors of the economy as well as changes in the field of information transmission and processing technologies, methods of production and, as a consequence, the restructuring of the system of the society's values and people lifestyle.

At first, each new technological structure in its development uses the existing transport infrastructure and energy resources, thereby stimulating their further expansion. The phase of its rapid growth is accompanied by a cyclical increase in production and consumption of GDP, its energy capacity increases as well compared to the long-term trend. As the next technological structure develops, there appears a new type of infrastructure that overcomes the limitations of the previous one. There is also a transition to new types of energy carriers, which lay the resource basis for the formation of the next technological structure.

In the process of changing technological modes, the structure of demand for scientific discoveries and inventions changes as well. Many of them remain unclaimed for a long time, because they do not fit into the production and technological systems of the dominant technological structure. Only when the growth opportunities of a new technological structure are exhausted, the need for fundamentally new technologies arise and these technologies undergo a competitive selection, thus, forming the basis for new technological courses.

The appearance and spread of computers took place at the final phase of the third technological structure, the core of which was constituted by the electrical industry. At that time, the economy of developed countries was undergoing the rapid development of the fourth technological structure associated with automotive industry, the organic synthesis industry, and new construction materials. One of its elements was the production of semiconductors that replaced lamps in the manufacture of computers. This allowed us to significantly reduce the costs of their production and operation, which dramatically expanded the scope of computer usage. However, the biggest breakthrough was the invention of the integrated circuit and microprocessor, which laid the foundation for microelectronics in the 60-70s of the last century.

Microelectronics became the key factor in the new technological structure, which entered its growth phase since the early 80s of the twentieth century. The miniaturization of computers and the rapid reduction in the cost of their production and operation ensured the rapid widespread dissemination of computer technology. The manufacturing industry changed drastically as production

processes became automated with the use of numerical control machines. The control systems for both technological and administrative processes got automated as well. The advent of personal computers opened the way for their widespread use in all areas of management, in scientific research, and in the consumer sphere. The appearance of the Internet and fiber optic cables connected billions of computers to global information and communications networks.

The complex of information and communication technologies, which constitutes the core of the fifth technological structure, was growing at a rate of about 25% per year until the beginning of this century. Its rapid distribution provided rapid scientific and technological progress in microelectronics, in which the effect of Moore's law rapidly reduced the cost of computers and their maintenance. (Author's report by S. Glazyev to Izborsk Club, 2015).

At the beginning of this century the growth of the fifth technological structure slowed down, and since 2008 the world has been facing a financial crisis, which is supposed to result in the transition to a new, sixth, technological structure. This transition is a structural reorganization of the economy, which is, as usual, accompanied by a sharp surge and subsequent fall in energy prices, depression in the real sector of economy and turbulence in its financial sector. Currently, the transition process is winding up – the new technological structure is entering its growth phase. The core complex of information technology and communication, nano- and bioengineering, as well as additive technologies, is growing at a rate of about 30% per year, and its individual elements are expanding at a rate of 20-70% per year.

There is continuity between the fifth and sixth technological structures. Their key factor is information technology based on the use of knowledge about the elementary structures of matter, as well as algorithms for processing and transmitting information obtained by fundamental science. The border between them lies in the depth of technology penetration into the structure of matter and the scale of information processing. The fifth technological structure is based on the application of the achievements of microelectronics in the management of physical processes at the micron level. The sixth technological structure is based on the use of nanotechnology, operating at the level of one billionth of a meter and capable of changing the structure of matter at the molecular and atomic levels, giving it fundamentally new properties, as well as penetrating into the cellular structure of living organisms, modifying them. Along with a qualitatively higher power of computer technology, nanotechnology allows us to create new structures of living and non-living matter, growing them on the basis of self-reproduction algorithms.

The transition to the sixth technological structure is made through the next technological revolution, which drastically increases the efficiency of the main directions of economic development. The cost of production and operation of computers will decrease more, the scale of their use will increase by many times due to computer miniaturization and adaptation to specific consumer needs. Medicine will benefit from technologies for combating diseases at the cellular level. These technologies will ensure accurate delivery of drugs in a minimal amount and with maximum use for the body, stimulating its ability to regenerate. Nanomaterials will have unique consumer properties created in a targeted manner. Transgenic crops can significantly reduce the costs of pharmaceutical and agricultural production. Genetically modified microorganisms may be used to extract metals and pure materials from mining raw materials, revolutionizing the chemical and metallurgical industry.

There are equally impressive predictions for engineering. It will be possible to invent automated complexes capable of assembling any macroscopic objects using a pre-recorded or developed three-dimensional atomic arrangement grid on the basis of the “nanocomputer – nanomanipulator” system. With the development of nanomedical robots, methods of targeted delivery of drugs to affected areas of the body, and cellular technologies in medicine, the possibilities of preventive treatment and the extension of human life will radically expand. It becomes possible to set the objective of restructuring the human body to qualitatively increase its natural abilities.

CONCLUSION

At present, the sixth technological structure is emerging from the embryonic phase of development, where its expansion was constrained by both the insignificant scale and undeveloped technologies, as well

as the unpreparedness of the socio-economic environment for its widespread use. Nevertheless, the costs of developing nanotechnologies and the scale of their application are already growing exponentially, the significance of the sixth technological structure is rapidly increasing in the modern economy, giving way to the future right now. Thus, one can assured that the transmission to a new technological structure is accompanied by a global crisis.

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