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Modern Challenges of the Knowledge Digitalization: Lessons of the Past and Ambiguity of the Future

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Abstract—The article is devoted to a comprehensive study of the phenomenon of digitalization of socio-economic relations, the analysis of key areas and concepts of the economy model development, which is grounded on the knowledge transfer. The results of the interdisciplinary analysis of the influence of cognitive, agrarian and scientific revolutions on the evolutionary trajectories of humanity are presented. The hypothesis about the absence of a clear correlation between the Global Innovation Index, the Global Competitiveness Index, and the Doing Business Index has been put forward and confirmed. On the basis of the obtained results, the article put forward the author's assumption about the ambiguity of the consequences of the rapid penetration of IT-technologies into all sectors of the economy and the common life of human civilization.

Keywords—digitalization; competitiveness; knowledge; research and development; ICT-sector

I. INTRODUCTION

<…> They were both invented by some man whose mind was nimble and keen, but not great or exalted; and the same holds true of any other discovery which can only be made by means of a bent body and of a mind whose gaze is upon the ground.
Lucius Annaeus Sĕnĕca minor, «Epistulae morales ad Lucilium», Letter 90, line 13

A few years ago, the global scientific and business community became acquainted with the project of the founder and president of the World Economic Forum, Klaus Schwab, The Fourth Industrial Revolution, where he has presented a consolidated vision of the consequences of stunning technological breakthroughs in the widest range of areas, including artificial intelligence, robotization, cars-bots, 3D-printing, nanotechnology, biotechnology and more. In some sense, this book can be regarded as a kind of guide, which is designed to help navigate the changes and derive maximum benefit from technological transformations.

Knowledge, disruptive innovations, digitalization, Big Data, skills, IT-technologies, the Internet – it's not a complete list of key drivers for the future development of human civilization. But individually, man is an ordinary animal, a mammal that has evolved in Homo sapiens with a passion, thirst for discoveries, experience, the bitterness of mistakes and joy of Eureka. Throughout the course of evolution, manifesting itself in various forms, these features always evolved in parallel, mutually complemented each other, providing rapid progress, and sometimes forced humanity to roll back.

The economic systems that were created and managed by man over the past 12 thousand years are in a state of transformation, trying to satisfy the individual needs and demands of society as efficiently as possible. Over time, evolutionary transformations of socio-economic systems affect all levels of scientific and empirical analysis: from households to state levels. In the end, it becomes obvious that some 'strings' are formed and permeate these evolutionary transformations over time. Various scientists and professionals have developed different approaches to the analysis of the mentioned 'strings' when conducting horizontal analysis, but the list of scientists who carried out the vertical analysis is rather limited. And the conduct of a comprehensive study within the framework of a research chronotopic cone for all levels, ranging from an individual (household) to a state was not carried out earlier properly (Fig. 1).

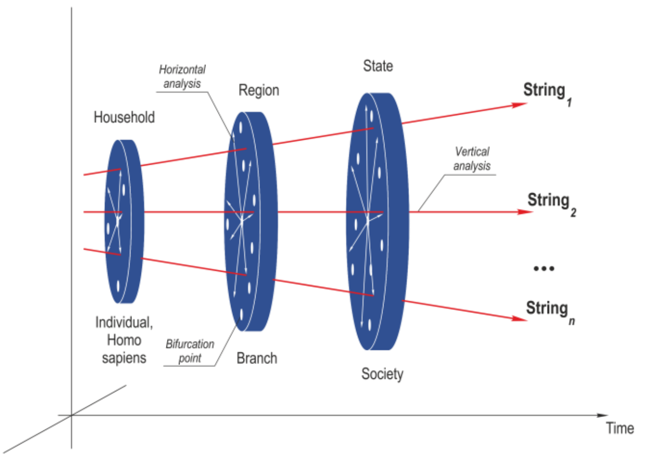

Fig. 1. The logic of research.

Over time, it becomes obvious that the key areas of analysis of the bifurcation points emergence and development are concentrated at two levels of scientific abstraction and practical analysis - the level of the individual and the state level. According to this approach authors present the results of human (Homo sapiens) socio-economic transformations with the definition of the main characteristics of bifurcation points, as well as the identification of key parameters of the transformation of the socio-economic system at the state level in terms of the most favorable conditions for its development, which are determined by Global Innovation Index, Global Competitiveness Index, Doing Business Index.

II. Methodology and Research Design

A. Literature Review

Today, the role of knowledge in economic development is increasing, outpacing the importance of factors of production and natural resources. Understanding the role of knowledge and the ability to produce new knowledge, the ability to apply them in favor of man and humanity becomes one of the urgent tasks of modern scientific thought.

However, so far, economic thought does not always have a proper understanding of the changes that take place. Obviously, the shortage of accumulated baggage of new ideas is reflected and it makes almost impossible to find new strategies for civilization development. The value of knowledge in the modern economy has not been given an adequate explanation yet either how or in what conditions knowledge is created and are commercialized within the market circulation.

The earliest studies on this subject were generally philosophical and were associated with the works of ancient Greek scholars: Xenophon [1], Plato, Socrates [2] and Aristotle (IV-III BC) [3].

Subsequently, with the separation of epistemology - the theory of knowledge - into a scientific branch in 1854, the concept of knowledge got acquired an interdisciplinary character and at the present stage is organically included in the subject field of studying social, humanitarian, natural and even technical sciences. During the evolution of knowledge, which was initially considered at the individual level as an abstract epistemological category, it has transformed into a key factor of corporate and national competitive advantage [4].

Despite the fact that the category of 'knowledge' is rather semantically large, it has clear semantic boundaries. In some studies between knowledge and concepts such as information, competence, innovation, there are no clear conceptual boundaries and they are used synonymously as a result [5].

In the book "Personal Knowledge" M. Polanyi [6] mentioned that there is, in fact, no clear boundary between codified and implicit knowledge and suggested that they have been viewed as boundaries of a continuum. Thus, implicit knowledge can be described as an excellent form or perfect component of human knowledge which complements the explicit knowledge.

Polanyi's popularization of the concept is associated with the emergence and development in the 1970s of a new discipline - the sociology of scientific knowledge, which studies sociological factors that determine the cognitive aspects of scientific work. H. Collins, one of the founders of the discipline, argued in his article "The TEA set: tacit knowledge in scientific networks" in 1974: "An important point is that the transfer of skills is not done through written instructions [7].

On the basis of H. Collins' article, the sociologist of scientific knowledge there were identified two models of knowledge production:

1) algorithmic includes the generation and transmission of information in explicit form;

2) inculturation emphasizes the decisive role of implicit knowledge in the process of scientific research.

In support of the thesis about the interdisciplinary nature of knowledge, we should note that they were used by the economics of the second half of the twentieth century as a methodological basis for the solution to the crisis caused by the critique of the basic preconditions of the neoclassical direction ('mainstream economics'), despite the alleged inappropriateness of the mentioned previously models to solve economic problems.

The results of the conceptual analysis make it possible to conclude that the category of "knowledge" is not semantically identical to the other concepts mentioned previously and therefore the synonymous use of these concepts in the framework of scientific research is inappropriate. For example, between the concepts of "information" and "knowledge" the following basic difference is noted: while knowledge directly depends on the cognitive ability of the individual, information in the form of structured and formatted data remains passive and inert until the moment of association with knowledge, which is necessary for its interpretation and processing [8].

Knowledge in the works of D. Bell [9] and M. Castells [10] is a set of organized statements about facts and ideas, which constitute valid judgments about experimental results transmitted using any communication intermediary in a semantic form.

As we can see, these definitions have dramatically excellent semantic content, which is expressed in different ways of obtaining knowledge (empirical, theoretical), its presentation (in the form of judgments, facts, information, skills) and transfer (through the mediator, experience, education). Given the fact that knowledge is a definitive category, for its adequate terminological description, it seems advisable to use the method of structural-genetic analysis and synthesis, which makes it possible to highlight individual parts of the object, to identify their main properties and relationships.

As has been noted by B. Johnson and B. Lundvall, the modern economy is more than aware of the importance of knowledge and learning. The new theory of development and the new theory of trade suggest the existence of a stable relationship between the knowledge base increases and the growth of productivity [11].

The inclusion of knowledge in the production process of a social product involves significant costs. The use of knowledge means its transformation into a product form, technology, qualification, a new quality of the organization. The end effect is expressed in the growth of labor productivity, lower costs, revenue growth, and competitiveness.

Historically, there are three stages of social progress: pre-industrial (agrarian), industrial and post-industrial (innovation) types of society. This gradation is based on three parameters: the main productive resource, the type of production activity, the nature of the basic technologies (Table 1).

The transition from one type of society to another is carried out by an evolutionary rather than a revolutionary way through the removal of existing contradictions, the deepening of the complexity of society, and the complication of social structure. Continuation of the industrial way of managing is seen not only through the introduction of technological innovations but also in the development of global transformational processes as a single entity that affects society.

Many anthropological and archaeological studies indicate that the course of human history has identified three major revolutions. It began with a cognitive revolution, about 70 thousand years ago, which has become the first barrier of natural selection for Homo sapiens, which he successfully overcame and Homo neanderthalensis, Homo altaensis and others representatives of the Homo genus as a dead end of evolution.

The agrarian revolution took place 10-12 thousand years ago, significantly accelerated progress and gave humanity the benefit of farming, the gradual abandonment of hunting and gathering, but on the other hand, it doomed to slave dependence on crops, primarily wheat and rice.

The scientific revolution took place about 500 years ago did a significant impact on the life of not only at the individual but the planet level. The tragedy of Hiroshima and Nagasaki, in vitro fertilization, space exploration, ozone holes, and the Great Pacific garbage patch are a far from the full list of the results of the human knowledge evolution.

TABLE I. THE MAIN CHARACTERISTICS OF SOCIETY

Social parameters	**Type of society**		
	Pre-industrial (agrarian)	***Industrial***	***Post-industrial (innovation)***
The main production resource	land (raw material)a	energy	knowledge (informa-tion)
Type of production activity	[extraction]	[fabrication]	[processing]
The nature of the basic technologies	labor-intensive	capital-intensive	high-tech
Social basis	interaction of a human with nature	the interaction of a human with the transformed nature	human interaction
Community forms	simulating other people's actions	mastering the knowledge and capabilities of past generations	inter-personal interactions

a. *[9]*

In our study, the authors attempted to identify some analogies in the analysis of a civilized chronotope: domesticated wheat as a result of the agrarian revolution and the digitalization phenomenon based on the comprehensive penetration of Internet technologies, which is inherent in the scientific revolution in general and the Fourth industrial revolution in particular.

Wheat did not guarantee people a comfortable life even. The existence of a peasant in this sense is more difficult than the fate of a hunter-gatherer. The ancient people fed on dozens of species of plants and animals, and therefore could survive in the famine years, even without having supplies of one way or another canned food. If the livestock of any animal was reduced or some kind of plant disappeared, people gathered other species of plants or hunted other animals. Peasant communities until recently fed on a limited set of domesticated plants. In a number of regions, it was the only plant - wheat, potatoes or rice. Torrential rains, a flock of locusts or a fungus that mutated and managed to infect this plant, led to the wholesale death of farmers - thousands, tens of thousands have died.

Peasant life brought people as a society protection from wild animals, rain and cold. But for each person individually, the disadvantages outweighed the merits. Wheat produced far more calories per unit area than all previous food sources, and sapiens began to multiply exponentially but not new knowledge. Approximately 13 thousand years BC, when people fed on wild plants and hunted wild animals on the territory of the Jericho oasis (southeast of modern Palestine), a roaming group of about a hundred individuals could feed. About 8.5 thousand years BC, when the wheat fields came to be replaced by wild plants, the oasis also supported the lives of thousands of people, but already significantly cramped, half-starved and aggressive with a smaller (narrower) volume of knowledge.

The agrarian revolution is one of the controversial events in history. Some scientists claim that it has led humanity to the path of progress and prosperity. Others are sure that it was the point of nonreturn, humanity has chosen the path leading into the abyss. It was a point of bifurcation: Homo sapiens renounced kinship with nature and rushed towards the anthropogenic progress, which is characterized by alienation and laziness.

Was this event the beginning of a new flexible labor revolution that provides independence and new opportunities for anyone? Of course. The development of science, the commercialization of innovations and their distribution are social processes that unfold as ideas, values, interests and social norms are generated and circulated in various contexts. As a result, it becomes difficult to determine the full social impact of new technological systems: there are many intertwining components that make up modern human society, as well as many innovations that are somehow created based on the interaction of these components.

III. RESEARCH RESULTS

Since the global economic crisis, value added in the information and communication technology (ICT) sector as a whole has decreased in the countries with different economic development levels in line with total value added. Within the ICT sector, however, value added in digital services and in computer and electronics manufacturing has decreased while it has increased in information technology services and remained constant in software publishing. These contrasting trends, which are being reflected in ICT employment, are expected to continue in the coming years as the share of venture capital investment in ICTs – an indicator of business expectations – is back to its 2000 peak. The ICT sector remains a key driver of innovation, accounting for the largest share of developed economies business expenditure on research and development and for over one-third of total patent applications worldwide [12].

Data-driven innovation, new business models, and digital applications are changing the workings of science, governments, cities, and sectors like health and agriculture. Policies to support digital innovation tend to focus on innovation networks, access to finance, and data (re-use), but pay less attention to investment in ICTs, knowledge-based capital, and data analytics. The effects of the digital transformation manifest in job destruction and creation in different sectors, the emergence of new forms of work, and a reshaping trade landscape, in particular for services. In response, many governments are reviewing labor laws and trade agreements.

From the outset, two technological pillars, digitization, and interconnection, have been driving the digital transformation, complemented by a growing ecosystem of inter-related technologies. Digitization is the conversion of an analog signal conveying information (e.g. sound, image, printed text) to binary bits. Although still costly to digitize or collect, information can be represented in a universal manner, and it can be stored as data. Digital data can be used – processed, stored, filtered, tracked, identified, duplicated and transmitted – infinitely by digital devices without degradation, at very high, speeds and at negligible marginal cost. The Internet has led to growing interconnections that allow this to occur globally. In contrast, processing and disseminating analog information is slow and the variety of formats (e.g. paper, film reel, magnetic tapes, etc.) severely limits links, combinations, and replication. In short, digitization reduces physical constraints to information sharing and exploitation.

Digitization and interconnection have been empowered by exponentially growing computing power, with the number of transistors per square inch in an integrated circuit has doubled every 18 to 24 months, or a 100-fold improvement in a decade, for nearly 50 years (Moore's law). This growth is well illustrated by the mainstreaming of the smartphone since 2007 and is further accelerated by computing delivered via the cloud as a service. Combined with constant mobile connectivity, a wide range of new products, applications and services have emerged over the past decade, forming a growing ecosystem of technologies and applications, which, through increasing use by individuals, firms, and governments, is driving the digital transformation.

As part of our study, the trends presented undoubtedly have an impact on human life, but the relationship with the indicators of the competitiveness of countries and the effectiveness of doing business in them. The results are not so straightforward (Fig. 2).

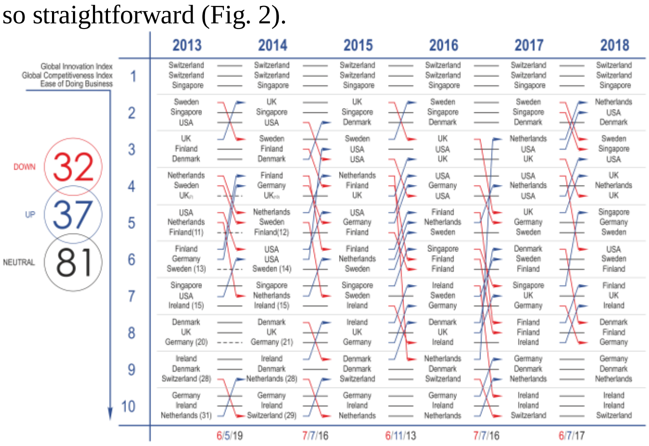

Fig. 2. Top-10 countries in Global Innovation Index ranking (2018) comparing with the dynamic of Global Competitiveness Index and Ease of Doing Business [12, 13, 14]

The following conclusions are obvious:

First, there is no straightforward relationship between the Global Innovation Index, the Global Competitiveness Index and the Doing Business Index (with the exception of Switzerland and Singapore), even taking into account the innovation lag, it is not possible to unequivocally argue that the degree of penetration of innovations (primarily in digital form) is not provided and does not guarantee the growth of competitiveness of the state that absorbs them.

Secondly, over the past 6 years, in the top ten countries in the ranking of the Global Innovation Index, there were 32 downward iterations, 37 ascending iterations and 81 - neutral. This indicates a significant uncertainty in the direction of further transformations and the need to establish dependence using the methods of quantitative analysis.

Thirdly, the conditions that ensure the leadership of countries in terms of the Global Innovation Index and the Global Competitiveness Index are not significant for the same countries in terms of the Doing Business Index, namely, the leaders are in the top ten in business freedoms, which may indicate the methods of hidden protectionism in the sphere of technological security of the state.

IV. Conclusion

Access to digital networks provides the technical foundation for the digital transformation of the economy and society but does not by itself necessarily ensure effective use. Other factors also need to be addressed, notably skills. Effective use of digital technologies requires a wide range of skills, including information and communication technology (ICT) specialist skills, generic ICT skills and complementary skills such as information processing, self-direction, problem solving and communication.

Effective use also requires firms to take into account in their decision-making and operational processes the specific risks related to the use of digital technologies, particularly with respect to digital security (e.g. theft of trade secrets, disruption of operations, reputational damages, financial losses, etc.) and privacy protection. It is also crucial that governments encourage organizational change, including investments in data and other knowledge-based capital, to realize the full potential of the digital transformation. A lack of firm dynamics, which can lead to the co-existence of poorly performing firms with very low levels of ICT use and star performers, is another important contributor to effective use.

There is broad recognition that the digital economy has a great potential to enhance productivity, incomes and social well-being. At the same time, there is growing concern that successive waves of investments in digital technologies have contributed to job losses, wage stagnation, and increasing wage inequality.

Looking back, it is important to note that major technological innovations have always been accompanied by extensive transformations in the labor market. By increasing labor productivity, innovation enables the production of more goods and services with less labor, thus leading to the possibility of technological unemployment in certain sectors or occupations. At the same time, innovation creates new employment opportunities in different industries and in newly created markets.

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