Digital transformation and convergence effect as factors of achieving sustainable development

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Digital transformation and convergence effect as factors of achieving sustainable development

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Abstract. The paper introduces the term "digital (neural network) economy", which reveals the content of the processes of digital transformation of the national and world economic systems that are currently going on and makes it possible to form the methodological basis for further research in this field. It is shown that at the technological level the processes are accompanied by NBIC convergence of (nano-, bio-, information and cognitive) clusters of the digital economy, which generates synergy effects. The new structure of the modern economy is being formed. The building blocks of today's economy are: systems of the circular economy, clusters, network, business incubators, and technology platforms. The economic contents and the essence of the structure of the national economy are shown and the directions for its transfer are found out. It has been concluded that in the time of digital economy, as a result of network convergence, synergy effects of converged regional clusters appear. It has been found out that with a growing number of converged clusters of information spaces, the entropy inside them is stably going down. The paper reveals the content of the digital concept, defines the general principles, criteria and indicators of sustainable development. In order to characterize sustainable development, a number of indicators are used. They can be considered at different hierarchical levels: global, national, regional, local and industry-specific ones. The features of the "green economy" developing in the time of digitalization of the world and national economic systems are looked into. Given these features, a model of the regional concept has been developed and proposed. The model embraces sustainable development and organizational and economic mechanisms, which can be used to measure the efficiency of its implementation in the time of transfer to the digital (e-neural network) economy.

1. Introduction

The historical process and development of human civilization has acquired a qualitatively new essence and special dynamism. Indeed, today, in the XXI century the experience accumulated by mankind bears evidence that spontaneous development of society lasting for many centuries threatens to lead us to a global ecological and socioeconomic crisis, which endangers the entire human civilization. The current situation of the planet Earth shows that mankind cannot keep on considering the environment and socioeconomic development independently from each other [1],[2].

The 1990s saw the beginning of the qualitative transformation in all spheres of human society due to its transfer to the information network development stage [1], to the sixth technological paradigm of the e-neural network economy. Today a neural network transformation of the structure of the world

and national economy is taking place. A principally new type of competition – global innovative hyper-competition – is emerging. At the same time, cutting-edge revolutionary technologies in the field of neural networks have ensured a breakthrough for implementing the hypercompetitive advantages of the leading countries in the middle-run period [3].

These specific features together form the goals and objectives of the present research in terms of optimization and rationalization of management actions to be taken in various fields of the economy. Quite frequently, these actions, due to some limitations, do not bring about the desired effect, which is caused by the lack of the possibility of correcting them operatively and flexibly in the dynamically changing conditions and increasing innovative hypercompetition. There is a problem of insufficient promptness, flexibility and efficiency of managerial decisions and procedures used by the state and regional authorities in the time of transfer to the hypercompetitive digital economy, which often entails the reducing competitiveness both of an individual enterprise and the entire industry. It should be highlighted that there is a scientific problem, confined in the absence of a single methodological approach in scientific literature to the formulation of the neural network paradigm and management of the national, industry-specific and regional infrastructure in the time of the digital neural-network transformation of the entire world economic system.

Dealing with such problems in the context of public administration, it is reasonable that the object of this study should be defined as information space in the age of the digital economy. The subject of this study is the processes of structural transformations and network convergence of the informatization sector and corresponding institutions regulating the digital economy. The purpose of this research is to form and determine the regularities, common for the developing economic system in the time of transfer to the digital economy, and, on this basis, to develop a management model for processes emerging in the course.

2. Research Methodology

In the time when neural network information technology is rapidly developing, a new quality of the economy emerges. It can be called digital, electronic neural network economy (e-neural network economy), which is characterized by the emergence of a lot new laws, mechanisms, functional and regulatory institutions, qualitatively new processes, products, services and effects of the e-neural network economy.

One of the main manifestations of the developing digital e-neural network economy is the transfer of commodity circulation into a digital environment. Today the number of mobile services provided by economic agents is growing considerably, which is expressed by traffic volume on a global scale. This process represents a fundamental trend in the age of the digital economy, which transforms the traditional life style and the notion the economic agents have about the mechanisms forming and developing the economic system. In particular the report made by the GSMA Association on the mobile economy [4] with a reference to the Cisco traffic forecast on the global mobile data market says that within 2015-2020, the total annual growth rates of the global mobile traffic are expected to be 40-50%, while by 2020 the mobile traffic will be 9-10 times bigger than in 2014, as shown in Figure 1.

The studies [3, 5] demonstrate that the NBIC-convergence, which underlies the digital economy institutions, has the qualities of a synergy effect from the interacting and converging structures of the economic system. In particular, a growing number of information systems in a cluster and an increasing number of clusters, participating in the convergence process, result in a bigger synergy effect because there are more links between the corresponding information systems both inside and outside the information space.

The synergy effect can be calculated in the same way as the economic effect, since in the context of public funding, the specifics of the fiscal legislation do not make it possible to increase considerably the budget for developing the informatization sector and the amount of public funding every year is comparable. Thus, the number of implemented services is:

$$nS = \sum_{i=1}^{k} Serv_i \times x_i \quad , \tag{1}$$

where:
x_i is the specific weight of the current service in the cluster of the information space,
$Serv_i$ is the given services,
k is the number of clusters.

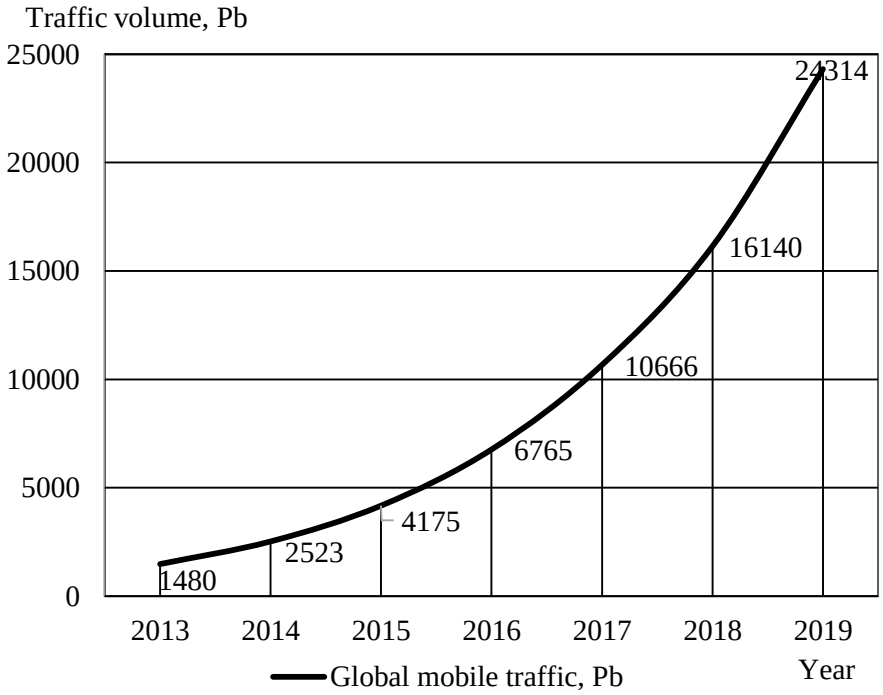

Figure 1. Growth in global mobile data traffic.

In these conditions, we consider the e-neural network economy as a global electronic network socioneuromorphic system, which has an integrated, complexly arranged multi-tier structural and functional organization and whose institutional matrix includes integrated network multi-tier communities of producers, consumers, intermediaries and managers, as well as planning, coordinating, regulating and supervising institutions providing for diverse e-neural network effects, introduction of hypercompetitive advantages and protection of rights for new neuro-intellectual property items [3]. In particular, Figure 2 illustrates a dependence diagram of the numbers of services and numbers of clusters in the information space in comparison with the data for a similar number of clusters in the digital economy.

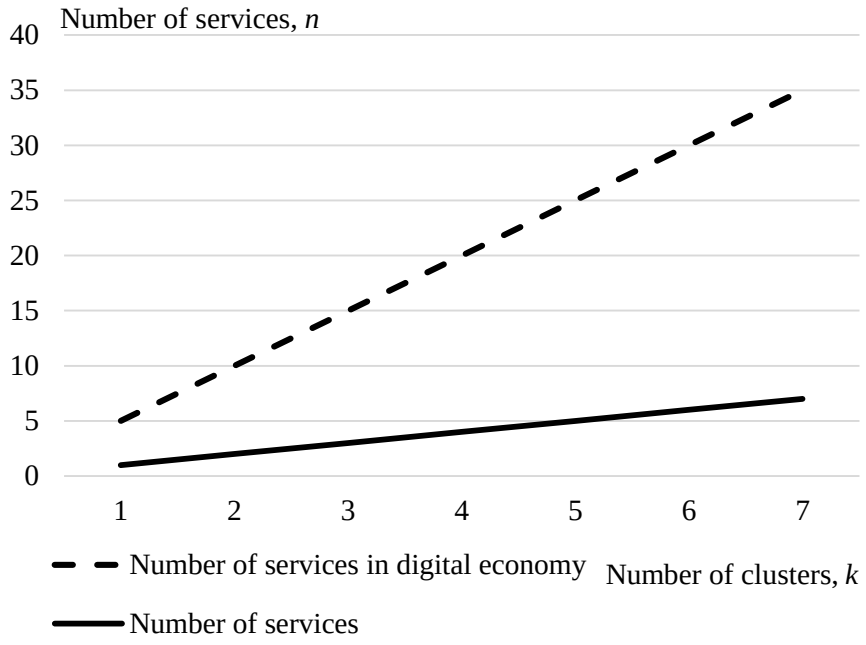

Figure 2. Number of services in digital economy clusters.

3. Research Results

The document called “Transforming our world: the 2030 Agenda for Sustainable Development” adopted at the UN Sustainable Development Summit in New York contains a comprehensive action plan and 17 sustainable development goals [6], with five of them being related to the preservation of the existing eco-system. We consider the model within the sustainable development concept given the ranking of the goals and objectives of economic agents by the ecologic efficiency criterion of their economic activities [3].

In our opinion, the concept of “green” economy supplements the concept of sustainable development. A growing number of scientists agree that sustainability largely depends on the development of the “green” economy. Since energy and transport pollute the environment a lot, energy modernization is the basis of the “green” economy, with alternative energy and growth of intellectual systems of energy distribution being its core. Developing renewable sources of energy does not only concern the power economy. It is also the matter of the environment and future of the civilization.

In this context, the model, developed by the authors, uses the methodology relying on the activities which involve intellectual technologies. It analyzes how individuals and/or their groups interact with physical or digital intellectual items in order to identify the gaps between the current and expected level of certain competences so that recommendations will be automatically produced for further educational and research activities and this gap can be gradually filled in.

Given the above specifics, for a certain level of competence S, the model is to be used when the event of physical stimulus E_i maximizes the probability that the learner will change their level of competence for level S'. Therefore, the model gets activated by physical events in combination with a probability of change in competences. Formally, this relation is determined as follows:

$$\arg\max_i P(S \to S' | E_i), \tag{2}$$

Moreover, the probability that the learner will obtain the level of competence S' because of stimulus E_i, will be strictly greater than the probability that S will independently change its state,

namely:

$$P(S \to S' | E_i) > P(S \to S'), \tag{3}$$

The above formulas are simultaneously aimed at identifying new physical stimuli, which are able to increase the current level of competences in the field of “smart city” to a higher level. In this environment, the hardware consists of sensors, connected to the Internet, to physical objects and data transfer to web-applications, which collect and process the data. The result of this physical and virtual convergence depends on the participation in this environment using relevant strategies. Thus, the developed model uses the relevant equipment, interfaces and applications for visualization of physical phenomena in certain situations.

Considering the examined features of the information space, it would be reasonable to develop a conceptual convergence model using entropic methods of knowledge management, processed in convergent regional information spaces. In particular, taking into consideration the structure of the information space of the executive government bodies in St. Petersburg and given the number of moduli in the information systems, based on the data of the Register of St. Petersburg State Information Systems [7], it is possible to identify the groups of information system clusters with similar features, forming synergy effects from interaction, which was discussed in earlier studies [3, 5].

It should be noted that the elaboration and development, recently taking place in many countries all over the world, of promising neural-network projects, which have been given state support and financing, leads to a sustainable innovation growth and emerging of a diversity new digital and network effects [8-14].

Taking into account the used entropic approach and the formulas (1) and (3), we obtain that the specific entropy of a cluster given the synergy effect achieved in the process of digital convergence will be calculated as follows:

$$H(X)/\Delta S = -\sum_{k=1}^{n} p_k \log_2 p_k \Big/ nk^4, \tag{4}$$

It should be noted that during the convergence process, no growth is observed, but entropy reduces, and its character is damping, as it can be seen in Figure 3 (calculated for 2 clusters of the systems). This synergy effect occurs also as a result of convergence of a certain number of information spaces and clusters. It was identified that, according to the observed pattern, when the number of converged clusters of information spaces is growing, the entropy within them is stably reducing [15].

These specifics allow us to specify numerically the convergence effects that have been found out and to evaluate the impact of the continuing structural transformations of the economic system so as to increase the efficiency of its management. At the same time, the entropy, which reduces in the course of these processes, suggests that the processes of regional informatization are managed more efficiently.

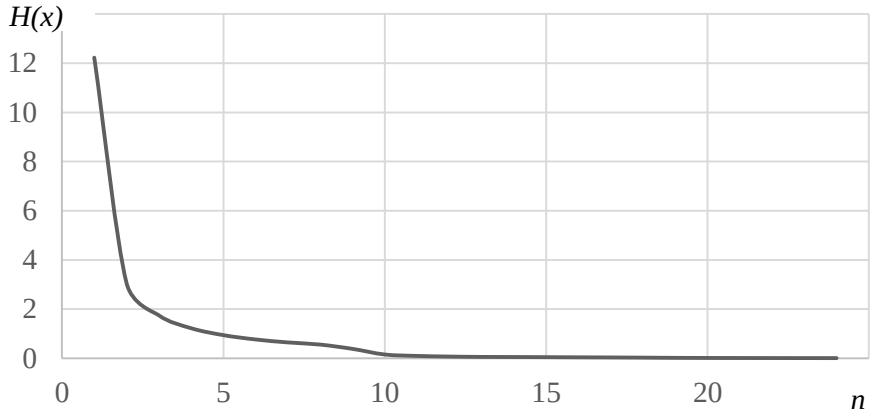

Figure 3**.** Decaying decrease in entropy during convergence

4. Conclusion

The facts considered allow us to conclude that the newest technological revolution of the neural network is developed. It results in the formation of the integrative mega-network “NeuroNet”, whose technological nucleus includes global, digital, network, and hybrid computer-socio-neuro-morphous interfaces [16]. The core of this industrial revolution is networking, digitalization and cybernetics, industrial Internet, the Internet of Things, robotics, three-dimensional design and printing [17]. Today the global digital technology is seen as a powerful catalyst of the world labor productivity.

The effective introduction of the “green economy” strategy is related to the launch and effective operation of the innovative environmental development mechanism [18]. The most advanced green, energy-saving technologies, environmentally-friendly energy technologies and based on the innovations and breakthrough technologies of the XXI century [19]. In the green economy, green value added should be considered. It is created in sustainable sectors and affects the value of the gross domestic product [20]. So, it is logical to conclude that the digital economy is an information network economy, based on innovations and environmentally-friendly technologies, ensuring sustainable growth and decent working and living environment for future generations.

Thus, the research study demonstrates, from the perspective of the interdisciplinary approach the growing role of the digital economy mechanisms in the development of the global socioeconomic structure and the global digital economy institutions, which is the main factor of structural transformations in the world economic system, transforming the traditional model of interaction between economic agents at the level of households and at the level of national economies and providing the population with the opportunity to obtain products and services in a more convenient and environmentally-friendly way comparing to the traditional economic system. Thus, not only the world economic system is transforming, but also the mindset of people and political thinking of the government, which, given the identified synergy effects, ensures further expansion of the digital economy on the global level, supporting this trend in the long-term.

5. Further Research

In further research a generalized model of the digital economy development should be built given the paradigm of the world economic system restructuration and an interdisciplinary approach to managing informatization processes at the inter-industry level. The changing role and the concept of technological infrastructure of the occurring permutations should be considered in terms of the NBIC convergence underlying the transfer to the sixth technological paradigm, examined in the context of the e-neural development pattern of the economic system.

One of the consequences of this model should be its application for managing the informatization sector of a region, which is very important, having regard to modern trends in using high-tech industries in the national economy. Developing this eco-system will make it possible to ensure the

convergence of activities of the state power and regional economy industries [21]. The suggested approaches must help to increase the efficiency of management both at the regional and federal levels, and stimulate public support of government actions aimed at ensuring sustainable and favorable socioeconomic development [22].

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