ATLANTIS PRESS
Advances in Economics, Business and Management Research, volume 83
2nd International Scientific Conference on 'Competitive, Sustainable and Safe Development of the Regional Economy' (CSSDRE 2019)

Principles of cross-sectoral network interaction between structures in the digital economy

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***Abstract* — The article shows the results of the research in the area of cross-sectoral network interaction of structures in the digital economy. The research sums up the analysis of the up-to-date practices of digital twins management in Russia and worldwide and enlarges on the effects of digital twins employed in such economic sectors as automotive industry, healthcare, education, culture, trade, transport and agriculture. The emphasis is made on the big data becoming the major active of modern business. Moreover, they are the data connected within a certain network that may add to the value of a company. The eleven basic principles of cross-sectoral network interaction of structures in the digital economy have been elicited as such reflecting the concept of adding value to business: the principle of consistency; the principle of synergy; the principle of the electronic exchange quality in terms of data and documents exchange in the form of business operations between the structures from different sectors; the principle of automated control; the principle of digital design of management processes; the principle of horizontal and technological cooperation between the partners within the network; the principle of continuous training of staff in the area of digital innovations; the principle of SDM client oriented approach; the principle of procedure standardization; the principle of cross-cultural digital communications; the principle of socially responsible partnership. Conditioned by the rapidly developing digital communications, cross-sectoral cooperation is marked by the transition from the rigid hierarchical structures to the flexible horizontal network structures capable of swiftly adjusting the configuration of their links to the new designs of technologically advanced partnership.**

Keywords — digital economy, digital twin, cross-sectoral interaction, principles, effects

I. INTRODUCTION

Development of the digital economy appears to be a national priority in Russia, the major goal being to set up at least 10 national companies holding the leading positions and remaining the high-tech enterprises developing cross-cut technologies and managing digital platforms that work on the global market and generate a system of startups, research teams and companies in different sectors of economy.

The basis of the new paradigm in digital design and simulation of global competitive product of new generation is considered to be by and large in making smart digital twins. As the scientists interpret the term today, a digital twin is a hierarchic system of mathematical models, computation methods and programming services allowing for the synchronization in real time between the state of a real lasting process, or a system, and its virtual copy [1-3]. According to chief analytics officer Gartner – M. Halpern, "a digital twin is not just a 3D-model, but a virtual model of an 'object'. Every material thing gets at least one unique twin. It is hard to provide integrity of the development processes, systems engineering and digital twins' production [4].

As Deloitte estimates, the global market of digital twins technologies will have grown up to 16 billion dollars by 2023 whereas the turnover of the technologies market forming the basis of this process (the Internet of Things (Iot) and computer-based education in particular) is expected to double by 2020 [5]. Therefore, as a result of the rapid wide-spreading use of double twins in various sectors of industry, cross-sectoral network interaction of structures in the digital economy requires particularly close attention.

II. MATERIALS AND METHODS (MODEL)

The study in the area of cross-sectoral network interaction between the structures in the digital economy presupposes systemic and network approach to simulating the structures that manage implementation of digital twins in the traditional sectors of industry.

III. Results and Discussion

A new paradigm of digital design and simulation driven by smart digital twins is created as a result of computerized simulation and optimization on the basis of smart big data. In fact, a digital twin has little in common with a regular 3D geometrical model or simple mathematical calculations that are widely used in industry and often (though, wrongly) associated with digital design and simulation [5].

Making 'smart' simulations requires managing the two key sets of problems [6]:

– use of complex multidisciplinary mathematical models with a high level of adequacy to the real materials, constructions and physical and mechanical processes as such governed by the equations of mathematical physics. Such models allow for the aggregation of all the knowledge accumulated over the period of designing, producing and using a product;

– development of the key competences of 'smart' model making: customization, systems engineering, multilevel matrix of targets and restraints related to resources (time, financial, technological, procedural and others); validation of 'smart' models; 'digital' certification.

Implementation of digital twins technology is a serious project which may require solid investments and their preliminary pay-off estimate. Nevertheless, according to Deloitte's latest research, this technology keeps gaining more and more popularity at a rapid pace in a number of sectors of economy, including aerospace industry, automotive industry, retail trade, healthcare, 'smart' cities design, etc. [7].

The conceptual architecture of making digital twins is based on 6 major stages [8]:

– Making a digital twin. This stage requires rigging the physical process with a great number of sensors measuring critical sections of the key process and other subprocesses. There are two kinds of measurements: operating measurements related to the criteria of the physical performance of the equipment; ecological (or external) measurements that have an impact on production operations, such as ambient temperature, atmospheric pressure and humidity level. Such measurements can be transformed into protected encoded digital messages and later transferred to a digital twin.

–Network communications. This stage presupposes permanent communication in the real time mode that provides for the coordination between the physical process and the digital platform. Network communications remain one of the most important challenges in producing a digital twin.

– Data aggregation. At this stage the data are uploaded into the data deposit, processed and prepared for further analysis. Data aggregation can be performed either on the physical hardware or in the cloud.

– Data analysis. At this stage data are analyzed and visualized. Use of the advanced analytics platforms and technologies allows analysts to develop iteration models that can generate ideas and elaborate recommendations for decision-making.

– Differences identification. The analysis results in the dashboards resuming the differences available between a digital twin and its physical counterpart (as per a single measurement or several ones); thus the changes and corrections to be made become conspicuous.

– Action. This stage is dedicated to the elimination of the discrepancies between a digital twin and its physical counterpart. Such procedures are carried out via decoders in the intelligent systems of data management that renew the data supply chains depending on the human interference. Such interaction finalizes the closed-loop link between a physical object and its digital twin.

Table 1 shows sectoral effects of digital twins use in a number of economic sectors.

As it has been reported by Huawei [9], a large-scale development of digital technologies will have a direct impact on changing the perception of traditional factors providing for the competitiveness of a company. The introduction of digital technologies makes a core change in the global economy system organization, in the operational model of a company, consumer power, structures of economic sectors and role of the governments while it also increases cost effectiveness and explores new opportunities on the market. Even the most traditional sectors of economy are becoming more open for the new methods of big data analysis in order to obtain new knowledge and take efficient management decisions. The big data is acquiring the status of a key asset in modern business. Hereafter, it is important to understand that only the data bound within a network can add to a company value.

Bearing in mind the importance of developing the innovative preventive approaches to the management of economic structures in the digital economy conditioned by the cross-sectoral network interaction, it goes without saying that elaboration of the principles of the network interaction between the structures within different sectors of economy appears to be a major scientific mission. Being one of the key categories of the management science, principles synthesize the objectivity of the economic laws and management patterns as well as the characteristic features of the real management practice. Thus, in this study the principles of cross-sectoral network interaction of structures in the digital economy are understood as the aggregate of the key rules of performance, basic regulations and norms of behavior the management of the companies is guided by when working on adding value to their businesses in the conditions of digital economy.

TABLE I. – EFFECTS OF DIGITAL TWINS USE IN A NUMBER OF ECONOMIC SECTORS

Economy sector	Effects of digital twins use
Automotive industry	Use of digital twins for the purpose of boosting new machines model design. Digital twins and simulations reduce the need for making costly real prototypes for the aerodynamic tests and trial runs, which consequently reduces the time spent on a new automobile production by 30%.
Public and municipal administration	Elimination of the problems connected with inter-departmental cooperation, access to the data neglected by the traditional statistics but necessary for decision-making. Better transparency, reduced corruption and superior quality of cooperation on the levels government – citizens and government – businesses.
Healthcare	Setting up libraries displaying realistic models of cardiac performance and performance of other human organs. Doctors can consult and address the models every time they need to have a better understanding of their patients' condition in real time.
Education	Expansion of the educational space due to the development of the digital environment (producing electronic textbooks, establishment and development of educational platforms, growing number of mass open-access online courses, development of distant education).
Culture	Digitization of cultural heritage. Accumulation of the highly sought data and setting up digital platforms that would contribute to the spread of the information in the sphere of culture and art. Making innovative cultural content.
Trade	Use of the information from the sensors on the shop equipment in the supermarket chains in order to create digital twins of the real trading platforms, which would allow the managers to check the availability of goods on the shelves in real time and test efficiency of the selling areas design.
Transport	Use of digital twins to simulate supply chains and production processes at the production facilities for the purpose of better management of the material supply.
Agriculture	Automatic performance of the maximum number of agricultural processes as a result of making a virtual (digital) simulation of the whole production cycle and interconnected links of the value creation chain. Taking urgent action to prevent losses in case there is a registered threat of bad crop.

Drawn on the basis of [7]

The list below is comprised of the basic principles of cross-sectoral network interaction of structures in the digital economy that reflect the idea of adding value to business:

1) the principle of consistency which presupposes establishment of a collaborative network of the information and communication links between the structural elements of the management system that provide for the integrity and sustainable functioning of the network as a single socio-economic and digital system;

2) the principle of synergy that characterizes adding to the company value on the basis of cross-sectoral network interaction by means of big data management, analytical procedures, cloud computing, the Internet of Things, virtual reality, artificial intelligence and computer-assisted learning;

3) the principle of horizontal and technological cooperation between the partners within the network that marks spanning of the administrative boundaries and advanced pace of data exchange;

4) the principle of the electronic exchange quality in terms of data and documents exchange in the form of business operations between the structures from different sectors that defines a better quality and data integrity as well as omnichannelisation;

5) the principle of automated control that presupposes encouraging the responsible representatives of the company to gradually turn down management of the current operations in the company's performance;

6) the principle of digital design of management processes defines the idea of a functioning hardware complex of electronic data exchange complying with the features of a specialized data exchange system and providing for a high level of data security;

7) the principle of continuous training of staff in the area of digital innovations that presupposes continuous involvement of the staff in the processes of digital literacy improvement;

8) the principle of SDM client oriented approach that presupposes satisfaction of the company's clients' needs in the conditions of the rapidly changing digital environment (SDM-clients: social, digital & mobile clients);

9) the principle of procedure standardization that presupposes having more freedom in the economic processes;

10) the principle of cross-cultural digital communications that is based on the idea of establishing efficient and mutually intelligible (for all the communicators) communications in the digital environment;

11) the principle of socially responsible partnership that presupposes continuous improvement of business practices and joint efficiency with the purpose of developing shared social and ecological responsibility.

One of the basic principles of cross-sectoral network interaction between structures in the digital economy is the principle of horizontal and technological cooperation between the partners within the network that marks spanning of the administrative boundaries and advanced pace of data exchange. It is noteworthy that with the rapid advance of digital communications and lean production, the economic power shifts from the rigid hierarchal structures towards the participants of flexible horizontal networks capable of adjusting the configuration of their links according to the new projects and joint production of new innovative goods [10]. Among the companies the leadership is taken over by the enterprises with minimal hierarchy and maximal organization mobility which allows having the benefits of the dynamic network environment.

Development of digital platform is the core of the cross-sectoral interaction in the digital economy. In the economics theory [11, 12] digital platforms are not solely interpreted as technological systems equipped with their own code and interface, but also as such that along with offering a range of products and services allow different kinds of users to find one another and exchange resources, which results into creating new common assets – new products, services, technologies, enterprises, etc. Such exchange of resources differs from the traditional market transactions and requires the presence of a platform operator (developer) who provides the tools for the coordination of communication and successful exchange transactions between users [13].

Creation of common assets is possible due to the collaboration of economic agents and its network effects with the additional benefits for all the actors of the network [10]. Thus, the users of the platform can be considered as the participants of a single collaborative network acting not only as consumers, but also as producers and suppliers of the complimentary kinds of assets, including innovative ideas and technologies. Due to the network interaction of users, such platforms assist businesses in achieving economic diversity and improving innovative performance [10].

It is worth mentioning that the above aggregated principles of cross-sectoral interaction between structures in the digital economy reflect the basic ideas of organizational structures development under network management.

IV. Conclusion

The analysis of the up-to-date foreign and Russian practices of digital twins management allowed studying the contents of the effects of the digital twins use in such sectors of economy as automotive industry, healthcare, education, culture, trade, transport and agriculture. Conditioned by the rapidly developing digital communications, cross-sectoral cooperation is marked by the transition from the rigid hierarchical structures to the flexible horizontal network structures capable of swiftly adjusting the configuration of their links to the new designs of technologically advanced partnership. The basic principles of cross-sector network interaction between structures in the digital economy have been outlined as such reflecting the basis of adding value to businesses and include: the principle of consistency; the principle of synergy; the principle of the electronic exchange quality in terms of data and documents exchange in the form of business operations between the structures from different sectors; the principle of automated control; the principle of digital design of management processes; the principle of horizontal and technological cooperation between the partners within the network; the principle of continuous training of staff in the area of digital innovations; the principle of SDM client oriented approach; the principle of procedure standardization; the principle of cross-cultural digital communications; the principle of socially responsible partnership. In the further research, the elicited principles will serve the foundation for building the concept of the cross-sectoral interaction between structures in the digital economy.

Acknowledgment

The reported study was funded by RFBR according to the research project № 19-010-00346.

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