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Системный анализ процессов виртуализации цифровой экономики

Виртуализация социально-экономических процессов выражается в развитии различных видов экономической деятельности в компьютерной сети Интернет, являющейся инфраструктурой современной экономической системы, катализатором глобализационных процессов и основным средством коммуникаций компьютеров, информационных систем различного назначения и сложности и людей. Исследование теоретико-методологической проблемы системного анализа процессов виртуализации в цифровой экономике обусловлено важностью определения структуры виртуализации как совокупности взаимосвязанных производств, потреблений, рынка и финансов в Интернете. Элементы системы объединяют виды экономической деятельности, к которым относятся предпринимательство в Интернете, информационная и интеллектуальная деятельность. Изучение данной проблемы осуществлялось с использованием эмпирических методов познания структуры системного анализа процессов виртуализации в цифровой экономике наряду с применением наукометрических методов обзора методологии образовательного процесса для подготовки кадров цифровой экономики и повышения их квалификации как предтечи проектирования процессов производства, потребления, рыночных и финансовых процессов, протекающих в цифровой среде.

Проведенные исследования позволили получить научные результаты в сфере структуризации социально-экономических процессов виртуализации, а именно: предложена дихотомия процессов виртуализации в цифровой экономике с учетом фактора образования; выявлены положительные и отрицательные последствия виртуализации для экономики и общества в целом.

В ходе исследований мы пришли к выводу, что системный анализ процессов виртуализации в цифровой экономике базируется на развитии образовательной компоненты и отражает среду процессов виртуализации, включающую цифровые платформы, которые, во-первых, формируют глобальную инфраструктуру мировой экономики; во-вторых, способствуют развитию предпринимательства; в-третьих, обеспечивают производственные, потребительские, рыночные и финансовые функции и корпоративное управление; в-четвертых, являются источником сетевых внешних эффектов, создающих новые социальные и экономические проблемы. Перспективой дальнейших исследований является разработка модели оценки влияния структуры процессов виртуализации на экономический рост в цифровой экономике.

Ключевые слова: цифровая экономика, виртуализация, системный анализ, социально-экономические процессы

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System analysis of digital economy virtualization processes

The virtualization of socio-economic processes is expressed in the development of various types of economic activities in the Internet computer network, acting as the infrastructure of the modern economic system, a catalyst for globalization processes, and the main means of communication between computers, information systems of various purposes and complexity, and people. The study of the theoretical and methodological problem of digital economy virtualization processes is due to the importance of determining the structure of virtualization as a set of interconnected industries, consumption, markets, and finance on the Internet. The elements of the system combine the types of economic activities, which include entrepreneurship on the Internet, as well as information and intellectual activities. The study of this problem was carried out using empirical methods of cognition of the structure of the system analysis of digital economy virtualization processes, along with the use of scientometric methods for reviewing the methodology of the educational process for training digital economy personnel and improving their qualifications as a precursor to the design of production processes, consumption, market and financial processes occurring in a digital environment.

The conducted studies make it possible to obtain scientific results in the field of structuring the socio-economic processes of virtualization, namely: a dichotomy of virtualization processes in the digital economy is proposed, taking into account the factor of education; the positive and negative consequences of virtualization for the economy and society as a whole are identified.

It was concluded in the course of the study that the system analysis of digital economy virtualization processes should be based on the development of the educational component and reflect the environment of virtualization processes, including digital platforms, which, first, form the global infrastructure of the world economy; second, they contribute to the development of entrepreneurship; third, they provide production, consumer, market and financial functions and corporate governance; fourth, they are a source of network externalities that create new social and economic problems. The prospect for further research is the development of a model for assessing the impact of the structure of virtualization processes on economic growth in the digital economy.

Keywords: digital economy, virtualization, system analysis, socio-economic processes

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Introduction

The concept of virtualization emerged in the late 1960s and early 1970s when IBM made simultaneous work on the same system and running multiple applications possible for multiple users. Virtualization includes the replacement of real objects and actions with their images and relationships, constantly available for operation, and affects two main aspects: 1) the virtualization of society: traditional institutions prescribe doing real things and real actions, but people instead work with virtual objects – images, which makes social institutions a part of virtual reality; 2) virtualization of social institutions, including the economy, politics, and culture. Virtualization uses a variety of software applications for e-learning, business communications, social networking, computer simulation, and manufacturing and organizational management.

Virtualization has a dual nature: it is both a system consisting of separate, interconnected elements and a process that occurs both in each element and in the system as a whole. The system analysis of virtualization processes as the evolution of elements of a socio-economic system and types of economic activity made it possible to identify the patterns of development of the system itself, as well as the features of its external environment. Norbert Wiener, the founder of cybernetics and system analysis, was the first to look for the common in living organisms and artificial systems [50]. Stafford Beer developed the ideas of cybernetics as a science of management and applied them to management decision making in industry and government.

The authors hereof propose a system approach, which includes the definition of the object, subject, and purpose of research. This study considers the socio-economic system in the process of its transformation into the virtual environment of the Internet computer network. The object is a traditional socio-economic system; the subject is virtualization as a complex process, and the purpose is to determine the features of the transformation of the elements of the socio-economic system and types of economic activities associated with virtualization processes. The authors consider the socio-economic system as a coherent structure of education, production, consumption, exchange, and finance, and the types of activities that connect the elements of this structure are entrepreneurship, information, and intellectual activities, which also include the translation of knowledge and technology. This socio-economic structure and the connections between its elements form a system that exists in the virtual environment of the Internet, and the mutual influence of the virtual and real economic systems is confirmed by the development of the digital economy.

Materials and methods

The study of the theoretical and methodological problem of system analysis of digital economy virtualization processes was carried out using the following set of scientific methods:

- the empirical methods of cognition of the structure of digital economy virtualization processes;
- the scientometric method for reviewing the methodology of the educational process for training digital economy personnel and improving their qualifications

- as a forerunner of the design of production, consumption, market, and financial processes in the digital environment;
- the dichotomy method for structuring socio-economic processes, system analysis of digital economy virtualization processes;
- the method of system analysis for the development of a systematic methodology for studying the educational component in the study of the virtualization processes environment.

Results

The structure of the virtualization process

The process of added value creation in the digital economy is more dependent on virtual assets such as brands than on traditional tangible assets. The image of a political candidate, created in a virtual environment, is becoming critically important, and political parties and other organizations neglecting this fact increasingly lose in the struggle for power. The promotion of goods or services on social computer networks determines the cultural value and impact of scientific or artistic projects to a greater extent than their actual artistic or scientific significance. In terms of the transition of communication processes to the network, the virtualization of all spheres of socio-economic life, including social institutions, takes place in the information society. Social institutions influence the economic behavior of market agents who make decisions related to the purchase, investment, and promotion of goods and services. Communication functions are fundamental in the activities of a virtual enterprise, especially in the context of increasing information flows.

A digital economy is a socio-economic activity mediated by software and provided by a telecommunications infrastructure [40]. It also includes the social sphere, represented on the Internet in the form of e-healthcare, e-learning, as well as smart homes and buildings using the Internet of Things.

The main virtualization technologies in the transition to the digital economy are: cloud technologies targeted at all consumers, including businesses and individuals; the Internet of Things; network interaction on the Internet and universal automation, which allows the implementation of models of individual consumption of information, knowledge, physical goods, and services. These technologies transform all elements of the economy and make global virtualization possible.

Figure 1 shows the virtualization environment with its constituent structures and processes. The environment is the Internet computer network acting as an economic and infrastructural component, its social component and means of communication and information processing – mobile communications and computers of all capacities and purposes. Information is a flow of information that, having passed through the education system, becomes knowledge, materializes itself in technologies, including information technologies, which are the basis of the digital economy. The digital economy, being the top of the pyramid as the most advanced socio-economic system from a technological point of view, at the same time is the environment for the development of not merely virtualization processes, but for other new and poorly studied socio-economic processes and phenomena.

Figure 1 The environment of virtualization processes and their hierarchy in the digital economy

Virtualization of education

The knowledge translation process has always been considered as an informational activity covering the teacher and the student, but with the emergence of information learning technologies, a computer appeared as a teaching tool between the subject (teacher) and the object of learning (student), and since then, in the early 1980s, the process of virtualization of education has occurred [1]. The teacher sets the task, develops the content of the educational material and teaching methods; the computer implements the methodology, adapts the content to the individual characteristics of the student; the student acquires knowledge, abilities, and skills. The whole chain reflects the technological process of acquiring a new educable quality and is called information learning technology. "Information learning technology is the process of preparation and translation of information to a student through a computer" [1, p. 7].

Virtualization processes in education are extremely slow. Back in 1994, the authors hereof outlined a large program for the use of information technology in school education, including the educational databases containing extensive reference material, the content of which is verified in accordance with rigorous scientific theories. Such bases can be multi-level, designed for a quick acquaintance (definition and examples), and can have a form of textbooks and monographs on the subjects of the natural-mathematical and humanitarian cycles of the school course and areas of training in higher educational institutions. In addition to standardizing content, such databases should be free for users, supported by the state,

in contrast to widespread electronic libraries, for which educational institutions must pay a fee, otherwise, students and teachers are deprived of the opportunity to use them. Expert systems for educational purposes make it possible to classify objects by their fragments and relate primarily to biology, botany, zoology, medicine, and geology. Such systems have not appeared in educational institutions; moreover, they are used very selectively in real science and practice. Even medical diagnostics, albeit preliminary, is carried out only with the participation of a person, although expert systems are used in the world, for example, for the analysis of fluorography data. Expert training systems, in addition to their applied, subject purpose, also diagnose the learner's knowledge, manage learning and enable the learner to try him/herself in the role of an expert by changing or adding to the knowledge base the rules linking the known facts and thereby obtaining new knowledge.

As it was shown in [1], in the study of any subject, its virtualization can be used to one degree or another, instructing special programs to conduct research of processes and systems, imitating their behavior in various conditions, avoiding the risks of real experiments. The development of such programs is highly labor-intensive; therefore, professionals in the field of pedagogy and information systems should deal with them and implement them along with textbooks and computer equipment. Special software should allow working both individually and in groups, developing complex projects with the distribution of developer roles, simulating the remote work of real design organizations. The system approach to the content of education as a whole allows avoiding both repetitions and scattering of information about the object of study in the sections of the course and other courses, it is better to organize interdisciplinary connections and the practical orientation of education.

It is the difficulties in the creation of simulating programs for the main number of academic subjects that led to the fact that most researchers of modern virtualization processes in education consider technical issues, paying attention to computer science, information technology, and programming in particular. For example, teachers from the National Technological University of Argentina describe the possibilities of deploying mobile virtual laboratories for student experiments, in which the physical components of information systems are replaced by logical devices and logical network services. At the same time, they call the learning processes in such environments “paravirtualization”, since they allow complete simulation of the work with real computers and networks. Students can communicate between two, four, or six nodes of a simulated network, quantify resource consumption by virtual machines, test services under study, access and interact with a remote graphical virtual machine desktop using free software [6].

Karlov considers virtualization processes in education through studying the information security of computer systems, taking into account the educational aspects of training young personnel for science, production, and solving social problems. He considers virtualization as a way to isolate the user from the physical characteristics of computing resources (processors, servers, operating systems, networks, applications, etc.) and notes its enormous importance and benefits in the field of education since it makes it possible to increase its efficiency, reduce the costs, make it broader and more easily accessible [21].

Other virtual technologies in education and training include various special environments, giving the possibility to solve the problems related to administration, work with databases, business, and economy. Kliment notes that the virtualization of the education sector remains a poorly researched area since there are no developments in which the systematization of opportunities would be carried out and the prospect of using information technologies in the field of education and training was outlined, which would allow raising this social

sphere to a new qualitative level [24]. There are two main areas of virtualization. The first area concerns the creation of an infrastructure in educational institutions and in the mobile application environment using the cloud. The second area includes virtual laboratories, a virtual educational environment. Various simulators of this kind create real situations for teaching decision-making, interactive whiteboards, cloud services, various kinds of special interfaces and programs and special gadgets that allow solving practical problems not only in an educational institution but also outside it, including also control of the formed skills of students [12]. However, according to the researchers, such developments remain mostly at the level of projects or prototypes and are not widely used. It is required to develop education using virtualization and to study the very processes of virtualization in education because the pedagogical and organizational innovations that can be reproduced in any educational institution lie at the intersection of these two directions.

To create pedagogical conditions, an educational virtual infrastructure is being formed, which includes electronic textbooks with imitation capabilities, programs and augmented reality devices, and mobile applications. Kaunas University of Technology has created an educational infrastructure that allows students and teachers to access virtual desktops and applications via the Internet, simulating work in computer labs and performing tasks while at home, which is especially important during a pandemic [33].

Practical training of personnel, immersing it in an environment at the early stages of learning, including the work with various applications: mobile versions of Internet enterprises, such as mobile commerce and mobile advertising, and businesses such as mobile health, mobile education, smart homes, and IoT buildings, is crucial for the digital economy, which is a socio-economic activity mediated by software and provided by a telecommunications infrastructure. However, long-term prosperity in the digital economy requires the ability to transform, create an ecosystem of these applications and services around their network and software platforms [49]. This kind of training is especially effective not merely for the subjects of the natural and mathematical cycle, for the training of technical specialists, but for raising their qualifications [45]. The most popular are the training environments for IT specialists since this area is most convenient for virtualizing training, but a number of problems arise here. Studying special courses that require intervention in the settings of computers and their operating systems can lead to their partial failure since students can incorrectly or incompletely complete the task. The imitation and virtualization of objects of activity without the use of real physical devices are especially important here [26]. This approach makes it possible to combine the study of the course on the operation of information systems and computer networks [17] with information security issues [32], to pose and solve the problems and limitations of virtualization, to identify additional opportunities and advantages of virtual technologies, as well as to form the appropriate skills among students [52].

The speed of change in the digital economy and the need for the constant professional development of specialists do not leave time for writing traditional textbooks and publishing them in paper form. Here, cloud technologies come to the aid of teachers and students, making it possible to place software and instructions for its use in one repository, the so-called "educational clouds" that solve hardware and software problems for a specific educational process and institution [56]. Such services and methods of their use can significantly reduce the need for physical resources, increase the effectiveness of training and provide unique opportunities for individual assessment that would not be available with physical computers in laboratories, as well as simulate new business models for enterprise management [51].

The processes of virtualization of education have acquired particular importance in terms of the spread of distance learning due to the pandemic. Distance learning is gaining popularity for a number of reasons, in addition to the forced limitation of contacts: first, the students are under constant supervision, they are forced to complete tasks and study theoretical material; second, they can study at a convenient time and at an individual pace; third, the construction of a personal road map based on the test results allows one to achieve an understanding of the essence of the subject being studied and not just a superficial acquaintance. Modern interactive telecommunication technologies, such as video conferencing, forums, and chat rooms, allow communication in synchronous and asynchronous ways, allowing students, teachers, scientists, and researchers to be part of the online community, collaborate on projects, exchange information, and obtain knowledge in a way different from the traditional one [43].

Computer games are beginning to play a new, educational role since the skills of quick reaction in the control of dynamic objects are required in the control of drones and in the training of appropriate operators. Moreover, digital versions of traditional, physical games are created, while the psychological and pedagogical concepts of their traditional versions are preserved, these concepts are associated with modern elements of game design [42].

In addition to the educational effect, virtualization of education saves significant funds required for the production of printed products, as well as for the development of amateurish author's educational programs and their methodological support. Often such developments are not supported by scientific research and pedagogical experiments and are of dubious benefit if they do not harm the holistic scientific worldview of students. This is especially true for the humanities, philosophy, history, and cultural studies. It should be noted that there are still no complex multimedia materials devoted to the work of a famous writer (including texts, illustrations, video, and audio accompaniment), scientist, public figure; multimedia data made it possible not only to accompany the relevant training courses but also to play an educational role, including patriotism. Modern students of a young age, and even the older generation, would be more interested in familiarizing themselves with such materials on their gadgets than in a library with paper carriers, which are becoming increasingly archaic for them.

Production virtualization

Production virtualization is the use of powerful information systems that control all processes, from product development to marketing; such information systems are called digital platforms. Business virtualization means replacing its physical infrastructure with electronic infrastructure, which is a dynamic business environment. Business process virtualization affects the coordination of employees' work, personnel management, the use of information technology to optimize costs and profits. In terms of a cybernetic system, production can be viewed as a "black box" with input and output, and the entire automated production system is a sequence of such "boxes" that must work without interruption. Platforms in the digital economy support not only one enterprise but also other enterprises in the industry, as well as enterprises in related industries, suppliers, distributors, and all participants in the supply chain. Therefore, the main task of the platforms is to manage the entire production and distribution system for each product. Business process virtualization includes the following components: electronic interaction, intellectual property of an enterprise, a knowledge base of an enterprise, software applications for data processing and analysis, e-commerce, data protection tools, as well as a new approach to management,

outsourcing, and network communications, including network logistics. The need for virtualization is recognized at all levels of management of economic objects [3], which is also due to the requirements of Industry 4.0 [31] associated with the reduction of life cycles of innovative products and full control of each stage of development, manufacture, operation, and disposal. Nowadays, almost all companies invest in information technology, which allows them to produce innovative products, promote them in the market, and be at the forefront of competition. At the same time, the role of data processing centers increases, which allows saving computer resources and Big Data processing [8]. According to [5], “virtualization of the data center is the process of matching the available resources with the actual needs of the services offered, the transition from physical servers to virtual servers, sharing and providing servers, networks, storage and applications”. For example, “virtualization with Intel Technology is the latest in enterprise information processing technology. Intel works closely with VMware, XenSource, Jaluna, Parallels, RedHat, Novell and other developers” [9].

Young's research shows that the inclusion of remote work in the company's business model has the following advantages: it increases productivity by 67%; reduces costs by 59%; provides access to more qualified personnel by 39%; improves staff turnover and employee health by 37% and 25%, respectively [54].

Virtualization processes are supported by the new telecommunications industry, which, on the one hand, is itself a structure of industrial communications, and on the other hand, the infrastructure of the digital economy. The telecommunications industry provides services, but these services must also be provided by the manufacturer as requested by consumers. This means that modern smartphones using fast mobile communication must collect data about users, their needs and requests and, as necessary, send the request to the network for counter processing by the relevant organizations. Cloud services, mobile applications, and voice-controlled home devices are examples of new data generation interfaces that provide intelligent, personalized services. The catalyst for these processes is the integration of 5G communication technologies and the Internet of Things into Industry 4.0 [41], and cognitive management technologies allow making error-free decisions and saving natural and human resources [14]. Fog computing associated with processing data from IoT sensors also allow an intelligent approach to resource allocation and saving strategies [46]; the same problem is solved by cloud computing with centralized processing of production data [48]. Based on data from a survey of 931 enterprises, the researchers [15] showed that a comprehensive solution to industrial, social, and environmental problems in the production of a product could increase the company's productivity and its overall efficiency in terms of flexibility, design, delivery, and quality. Smart strategies are being developed for enterprises, representing an intelligent economy of a closed cycle (circular economy) [25], which allows the use of secondary raw materials for the production of new products.

Virtualization is fundamentally changing the processes of enterprise management, creating associations coordinated on the Internet [19]. It also changes the behavior of the enterprise in the market, since it is no longer driven by demand, but develops new proposals, delegating the authority of marketing research and sales to the control center. Network virtualization is the key for enterprises to thrive in the digital economy [40].

The digital economy contributes to sustainable socio-ecological and economic development; virtualization of production contributes to saving resources and preserving the natural environment, energy distribution, replacing non-renewable resources with their counterparts created using information technology in a virtual environment [23].

Consumption virtualization

Consumption is also being virtualized. Virtualization processes in consumption are bi-directional: on the one hand, Internet users consume content that producers and sellers offer them in the form of advertising or information products in the form of texts, audio, and video, and, on the other hand, the consumer generates, requests and participates in the provision of information services. In this case, the consumption of information can be passive or active. Passive consumption of an information product does not allow changing its content, while active consumption affects the sequence of data output to the user, for example, computer games or the learning process. Comments of consumers who have bought a product or service allow other consumers to obtain objective information about this product before purchasing; these comments also help manufacturers to improve the quality of their products.

Consumers are also changing their pricing behavior on the Internet, as the Internet allows quick searches and comparisons of various available products/services and their prices [18]. The change in price behavior lies in individual choice, conditioned not only by a rational but also by a value approach, conditioned by an emotional factor. This is especially facilitated by the mobile websites of online stores [4].

Market virtualization

There are many studies of virtual markets and the mechanisms and features of their functioning [30]. The authors hereof distinguish the following characteristics of the Internet market as an element of the structure of virtualization processes. First, the exchange product is information products, many of which represent an image of a real material product. The information products market includes the e-commerce market, the payment system market, the online advertising market, and the software market. Second, an online store or an online auction can be an exchange site. Third, the virtual marketplace encompasses areas such as Internet banking, retail, and services. Fourth, according to the classification of “seller-buyer” interaction, the B2B (business-to-business), C2C (consumer-consumer), and B2C (business-consumer) markets can be distinguished. The following are the segments of the virtual market: the auction market, commodity market, service market, credit market, financial market, labor market, capital market, innovation market, natural resource market, education market, and insurance market.

In virtual markets, there is a unique online product – an information product with the following characteristics: the ability to accumulate and grow due to search engines choosing it from various sources; ease of use and the ability to influence the consumer with its content; various forms of presentation (text, image, audio, and video); high processing speed [44]. The information product also has a dual character, since it is also an information service.

A special segment of virtual markets is the P2P (peer to peer) market, which is a decentralized computer network, whose participants can directly transfer data to each other. This market has evolved due to the emergence of cryptocurrencies and the ability to sell bitcoins or other cryptocurrencies to each other without a data center [13].

There are at least two types of competition in virtual markets [27]. The first type of competition is the competition for goods and services that takes place between firms and organizations on the Internet. The second is the competition of search engines (platforms), due to which users can see these companies in the list of answers to their queries [16]. In traditional markets, there is no such double competition; it is unique to the Internet.

Virtualization processes have embraced businesses at all levels, from transcontinental corporations to individual entrepreneurs, and have fueled global competition in virtual markets. This fact forces all companies to revise their business processes and stimulates the development of innovations [11].

Financial virtualization

Financial virtualization processes can be divided into three levels. The first level is the emergence of electronic payments, plastic bank cards, and Internet banking. The second level is financial markets, online currency and securities trading. The third level is cryptocurrency mining (production or creation) and related blockchain technology.

Internet banking is the generic term for remote banking technologies that provide access to accounts and transactions at any time and from any computer connected to the Internet. The consumer uses his or her own browser to perform operations; he or she does not need to install the client part of the system software. The advantages of Internet banking are as follows: 1) an entrepreneur can manage his or her account from anywhere in the world at any time, using Internet technologies in banking; 2) banks do not have to create expensive branches; it is enough to build a branch computer network; 3) in the near future, each user will be able to create their own home bank; 4) there is a 10-12-fold reduction in the cost of banking operations. All over the world, there is a decrease in the demand for cash, but a fairly large number of citizens still prefer it, fearing the risks of electronic payments [37].

Bitcoin is the first currency to gain value without being a conventional product that meets needs and is not backed by existing currencies. Currently, bitcoin is considered an innovative tool for global trading. The possibilities of bitcoin are enormous; it has evolved from a local payment system into a large-scale network covering many payment transactions in many developed countries of the world. Cryptocurrency is an integral part and product of corporate finance capital and the global financial market. An important characteristic of cryptocurrencies, of which there are currently several hundred, is their capitalization – the total market value of coins in circulation. The market capitalization of bitcoin at the beginning of January 2018 approached 300 billion USD, and in November, the capitalization of bitcoin exceeded 342 billion USD, and the market price of one bitcoin was almost 19 thousand USD (in 2010, a year after entering the market, 1 bitcoin cost 0.50 USD).

Blockchain technology based on distributed data storage and organization of direct connections between agents of the financial market, on the one hand, makes transactions safe and transparent, but, on the other hand, takes the cash flow out of the control of the state. However, blockchain technologies create the conditions for reducing or eliminating corrupt behavior in the financial sector, as they can serve as an evidence base and ensure the transparency of transactions. The emergence and spread of blockchain and cryptocurrency technologies threaten the existence of traditional financial institutions such as banks and exchanges, which are inherently speculative intermediaries, and their services will not be in demand in the new society based on trust.

Functions and activities in virtualization processes

Entrepreneurship and business

Virtual enterprises engaged in e-commerce, production and processing of information have become widespread. They work on the Internet and have no tangible assets.

One of the first scientific definitions of e-commerce, which eventually became classic, was given in 1996 by Vladimir Zvass, professor of information systems and management of

informatics at Columbia University, editor-in-chief of the *International Journal of Electronic Commerce*: “E-commerce is the dissemination of business information, relationships in the business environment and business agreements over telecommunication networks. In today's business environment, the operational boundaries between firms have become transparent because these boundaries have been an obstacle to entrepreneurship and joint intra-firm and intra-firm business processes. Consequently, e-commerce includes trade relationships and agreements between companies, as well as general processes that support trade within individual firms” [57]. From the authors’ point of view, the most adequate definition of e-commerce was given by American scientists Kalakota and Whinston: “the purchase and sale of information, goods and services through computer networks” [20].

The French economists Youssef and Ragni in their monograph “New Models of Economics, Organization and Coordination” point to the need for correct differentiation of activities in computer networks and highlight three main problems of the new reality. First, the differences between e-commerce and traditional commerce should be defined, as well as the components, included in the new commerce from existing activities. Second, it should be defined whether the accounting in electronic commerce should be performed only on the World Wide Web, or all possible networks can be included. Third, the distinction should be made between traditional and e-commerce [55].

The analysis of classification signs shows that e-commerce is not only trade on the Internet, but also such forms of existence of firms and corporations, which have now become a qualitatively new form of business. Here is the definition of e-business given by the consulting company PricewaterhouseCoopers: “E-business is the integration of systems, processes, organizations, chains that create value and shape markets, they use the Internet and related technologies and concepts. E-commerce is only a part of e-business, substantially limited to marketing and sales processes” [39]. E-business includes information production, logistics, financial transactions, brokerage, consulting, network management, and e-commerce.

E-commerce is only part of a virtual business; many organizations and firms create their digital counterparts in a virtual environment, while new models of management of organizational and cyber-physical systems appear [22], including using cloud technologies [29], which allow employees quick access to information resources, as well as address information security issues [2]. However, data protection creates added value in the transmission and storage of information, including by providers, programmers who create anti-virus programs and counter cyberattacks with their help, while the value chain includes stakeholders with different responsibilities in the market of information products and services [53].

Information technologies increase the competitiveness of firms, which is especially true for the construction industry, introducing building information modeling technologies from the design stage of buildings to their construction and operation [38]. The unification of small and medium-sized construction enterprises in a business network creates a favorable environment for the development of healthy competition and, most importantly, stimulates the introduction of modern technologies that can significantly reduce the innovation and technological gap in relation to the world's best practices, improve the administrative environment and give them the opportunity to strive for the availability and reliability of their financing, to develop the infrastructure and service component [47].

Information activity

Information activity is bi-directional, thus one and the same subject can be a producer and consumer of an information product. Firms, organizations, corporations, regional and

municipal governments have their own image on the Internet [34]. In social networks, people shape their image. The creation of an image can be considered as the development and promotion of an information product. The consumer is looking for the necessary data and for this action, he or she must know how the Internet works, be able to form a request, make a choice from a large amount of information provided.

New types of information activities have emerged related to the development of digital economy technologies: Big Data processing, fog and cloud computing, additive technologies. This requires the producers and consumers of the information product to have modern competencies and constant professional development.

Intellectual activity and artificial intelligence

Intellectual activity is the creation of new knowledge, carried out in the framework of research and development, and its main share is in the field of computers, including the development of software, databases, and telecommunications.

The processes of virtualization of intellectual activity have given rise to two phenomena: network and artificial intelligence. Networked intelligence makes it possible to use the Internet to collectively create an intellectual product, distribute tasks among participants and collect results together. This is how complex projects develop, participants communicate via the Internet, being in different geographic locations.

Artificial intelligence is an information technology that allows simulating human thinking on a computer. Artificial intelligence systems make it possible to build human-machine communications in natural language, create expert systems that can make professional decisions using the knowledge of specialists in this field, recognize and classify objects, and manage complex objects and systems, including robots as well. Thus, virtualization has embraced such an important and complex area of human activity as management.

The development of 5G communication networks will make it possible to use the broadband Internet and the capabilities of artificial intelligence systems for business management [35], create new business models that allow implementing breakthrough production technologies, combining intelligent operations and supply chain management [10]. The use of new economic and mathematical models [28], including the methods of fuzzy logic and multi-agent modeling, also makes it possible to improve the management processes of virtual business, reduce the number of errors in decision making, entrusting it to information technologies [36].

Virtualization externalities

Externalities are external manifestations of the results of activities; this term is most often used for negative consequences. Virtualization processes have mainly positive effects, which include the following: first, changes in technology reduce the cost of market activities and the cost of communication and search, change consumer behavior, aggregation and data processing; second, technological change is driving economic change such as the scale of operation, individualization, and innovation. Also, individual production by customer orders – customization – is developing.

The most severe negative effect of virtualization processes is crime in computer networks and cyberattacks, which lead to the theft of funds from bank accounts, personal data of citizens, and business disruptions. The negative consequence of virtualization of slightly less severity is Internet addiction, and the last place in the rating of negative effects is occupied by such an effect as a distorted view of the real world in young consumers of information products.

Discussion

The study of the theoretical and methodological problem of system analysis of virtualization processes in the digital economy is due to the importance of determining the structure of virtualization as a set of interconnected industries, consumption, markets, and finance on the Internet. Production virtualization processes considered by the authors on a systematic basis develop the ideas about the integration of 5G and IIoT technologies in Industry 4.0, substantiated by Sasiain et al. [41]. System analysis of virtualization processes is based on the widespread use of information technology, reflecting the prospects for changes in the production landscape of firms. At the same time, according to Gillani et al. [15], a systematic methodological approach to the analysis of multilevel virtual processes is required for linking digital transformations in technological, organizational, and ecological contexts. However, in the authors' opinion, the contexts indicated by scientists reflect virtualization processes mainly at the micro-level. In this regard, in the virtualization of economic activities, the authors distinguish entrepreneurship and business, information activities, intellectual activities, as well as artificial intelligence. At the same time, in the process of virtualization, the educational component as an intellectual activity of a person is transformed into computer systems of artificial intelligence.

Conclusion

The system analysis of socio-economic virtualization processes in the digital economy has shown that they have a complex hierarchical structure. The first level includes the main components – education as a training system, production, consumption, markets, and finance. The second level contains complex subsystems for each of these elements, which can be detailed. The third level is formed by individuals or institutional groups engaged in certain economic activities with the consumption of information products and services. Virtualization has a dual nature: it is a system consisting of separate, interconnected elements and a process that occurs both in each element and in systems as a whole at the same time.

The main types of activities that have been virtualized include: knowledge and technology translation processes, e-business, information and intellectual human activity, transforming into artificial intelligence systems. The environment of virtualization processes is the Internet computer network, which, first, forms the global infrastructure of the world economy; second, it promotes the development of entrepreneurship; third, it provides production, consumer, market and financial functions and corporate governance; fourth, it is a source of network externalities that create new social and economic problems. The Internet segment is represented by social networks that form the processes of information and knowledge production, affecting the formation of human capital and intellectual activity. The digital economy itself as a socio-economic system acts not only as a technological top of the hierarchy but also as an environment for the implementation of the functions of all its components.

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