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ECONOMIC POLICY

Forcing the Digital Economy: How will the Structure of Digital Markets Change as a Result of the COVID-19 Pandemic

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Abstract—Could the forced digitalization of multiple spheres of human life caused by the coronavirus pandemic lead to radical changes in the global and Russian economies? How and to what extent have ubiquitous lockdowns affected the digital transformation? The new model of the digital economy growth, formed during the ongoing crisis, actually contributes to the accelerated development of secondary digital infrastructure (platforms and artificial intelligence technologies) through the creation of mass markets, the noticeably higher consumption in the field of ICT services, and the redistribution of a significant part of resources from other sectors. However, this digital forcing, within the framework of which traditional industries were placed in a deliberately losing situation due to artificially created circumstances, is taking place during a fundamental structural crisis of the global economy. Therefore, unlike the technological revolutions of the past, this one will have serious objective limitations associated with narrowed opportunities for the development of the primary digital infrastructure, without which extensive development of digital services and markets is impossible. In addition, further implementation of the adopted model of building a digital economy, based on the collection and processing of big data, is fundamentally impossible outside globalization processes and implies a significant imbalance between the new "world technological center" (the United States and China, who, however, are in a state of trade war) and the "world technological periphery." For most other countries, including Russia, it means the need to "fit" into one of the two currently possible peripheral contours of the global digital transformation.

Keywords: digital economy, digital transformation, digital platforms, artificial intelligence, COVID-19 pandemic, coronavirus, microelectronics, ICT, 5G networks

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One of the visible results of the COVID-19 pandemic outbreak in early 2020 was a sharp acceleration in the development of a large group of ICT and online services. Ubiquitous lockdowns and, in fact, forced self-isolation of the population contributed to the explosive growth of online services, distance education, remote employment, and the advancing technological replacement of all types of labor (from manual to intellectual).

In these conditions, it has been commonly stated that the epidemiological crisis created favorable conditions for a historically unprecedented phenomenon designated as a "disrupt" (revolutionary transformation), when in real time one can observe the breakdown of the existing structure of the global economy and even a change in the socio-economic formation (which used to take decades and centuries). This disrupt is carried out through the forced "manual" transfer of humanity to a new digital society or even the world order. It became a commonplace during a pandemic to view the ongoing processes as a sharp acceleration in the formation of a comprehensive digital ecosystem. However, for the first time such an ecosystem was mentioned at the World Economic Forum in Davos back in 2009 as a new paradigm for accelerated economic growth in response to the global financial crisis of 2008–2009 [1].

The purpose of this paper is to investigate to what extent such assumptions are substantiated and whether "coercion to be online" triggered by global quarantine and forced social disunity can radically accelerate digital transformation and lead to a total transformation of the global economic and financial systems. It seems that the answer is not so obvious and in fact quite ambiguous.

Let us start the investigation by considering an issue that is very important in this context, namely, *what exactly* is meant by the "digital economy" (hereinafter, DE)? Based on the statement that the DE in reality means the construction of a global digital infrastructure, we will further analyze current capabilities of the ICT and microelectronics sector to generate high growth rates, as well as new mechanisms for expanding and creating markets using platform tech-

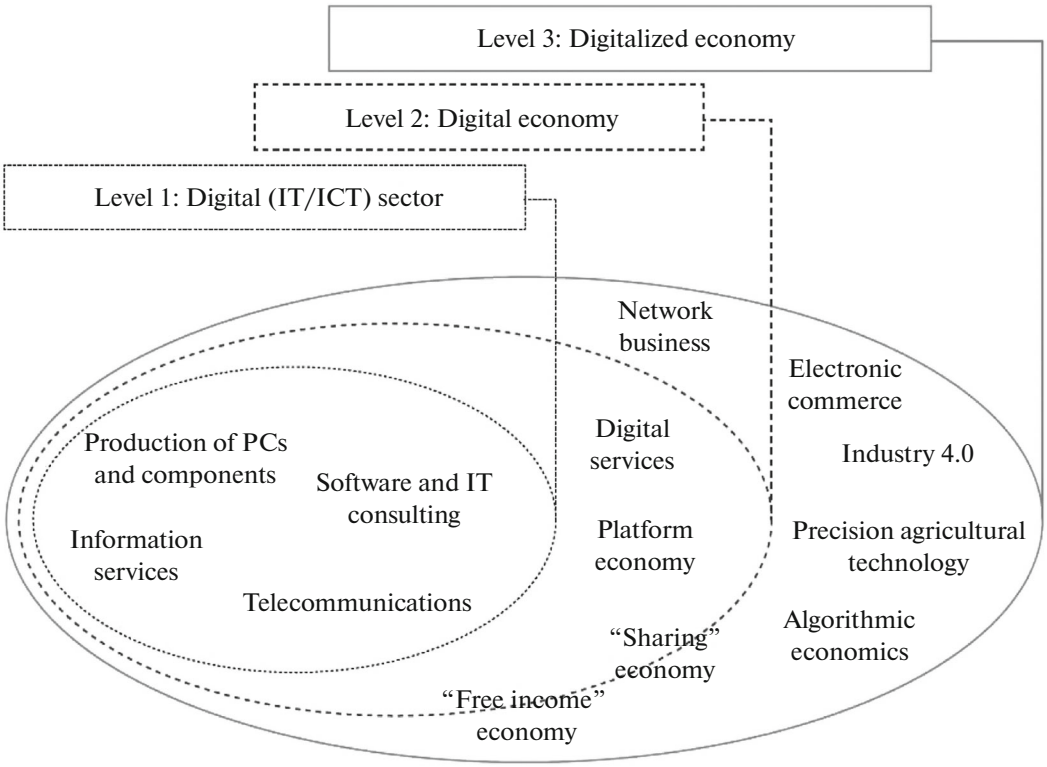

Fig. 1. Three levels of the digital economy according to the classification adopted by UNICTAD. Source: [2, p. 6].

nologies and artificial intelligence. This will make it possible to substantively answer the question of what problems of the global DE project could be solved by the COVID-19 pandemic and what could not. Now we will show that, on the one hand, the response measures undertaken in most of the world's leading economies to the pandemic have created very favorable conditions for the flow of investments into the DE, as well as the formation of new mass markets (including social) of services by removing restrictions on access to and the use of personal data of citizens. However, on the other hand, the economic crisis, sharply aggravated by the global quarantine, has dealt a serious blow to the "material core" of the DE. The general decline in public demand and investment opportunities of enterprises amid the crisis create prerequisites for slowing down the development of basic (primary) digital infrastructure, without which the explosive growth of ICT services based on platform technologies is likely to be limited.

What we call digital economy and what it is. First, it is necessary to determine what is meant by the DE in current scientific discourse, how this concept has evolved to date, and how it relates to economic reality. The current definition of the DE, considered by the UN as basic [2], includes three levels (Fig. 1):

1. "Core of DE," or "the digital sector," which refers to the definition of the sector for the production of electronic products and the provision of ICT services, which was introduced in 1998 by the OECD [3].

2. The DE itself, which covers, in addition to the digital sector, those spheres of activity that would not appear or could not exist without the use of ICT technologies.

3. Digitalized economy: those types of economic activities that existed before the widespread use of ICT technologies, but which are increasingly using digitized data in organizational processes.

As part of the evolution of the DE concept, the basic definition was supplemented with elements of the second and third levels (with the exception of the e-commerce sector, which can be easily estimated and was taken into account in statistics from the very start), including the ICT sector (which existed before the DE), gradually over the past 20 years. However, most of these elements emerged in the early 2010s. After the crisis of 2008–2009, the problem of DE development gradually started to come to the fore on the international agenda. Most of the authors studying the problem of the DE's contribution to the growth of the world economy have abandoned attempts to localize this phenomenon in favor of its maximally broad interpretation [4]. By 2019, in the official documents of the OECD, the concept of digital economy was replaced by the concept of digital transformation [5]. This led to numerous statistical distortions (for example, a part of

the real economy for which the Internet serves only as a place for concluding commercial transactions is referred to the DE) and the need for widespread use of subjective, expert assessments and all kinds of ratings and indices designed to assess some components of the DE not amenable to accurate measurement and accounting.

As a result, now, depending on the definition used, the size of the DE, according to UNCTAD estimates, is from 4.5 to 15.5% of world GDP in 2019 [2, p. 26]. Attempts to estimate the direct contribution of the industries outside the "core of the DE" to GDP end up expanding the DE with activities that have nothing to do with it, first of all, expenses of companies and households for goods purchased via the Internet, which in some methods reach 80–90% of the estimated volume of the Internet economy [6].

This kind of statistical manipulation is mainly aimed at demonstrating high growth rates of the DE, which is necessary within the hype cycle to attract investors to this sector. A similar picture could be observed in the 1990s in the field of ICT, and in the first half of the 2000s in connection with the development of nanotechnology [7]. Meanwhile, a really significant contribution to GDP is still made mainly by the core of the DE in the form of ICT, while secondary services built on its basis, although they significantly change people's daily life, as well as production and technological processes, only have an auxiliary function from an economic point of view. They are able to accelerate economic growth during the period of general economic recovery but have not yet demonstrated the ability to generate growth on their own [8].

Can the ICT and microelectronics sector generate high growth rates? One of the key elements in the discourse on digitalization is the assertion that ICT, together with its secondary extensions in the form of a complex of digital services, has the potential to generate the same high growth rates of the world economy as in the middle of the 20th century. Indeed, the 1950–1990 were characterized by a rapid technological breakthrough in the production of electronic equipment, which started, like most technological innovations, with defense orders [9]. However, the main factor in the transformation of electronics into a general-purpose technology with the broadest field of application and capability of generating a whole tree of new technologies was its successful commercialization due to its ability to satisfy basic human needs and form a huge consumer market [10].

Moving from cutting-edge exclusive wares and luxury goods in the 1980–1990s to mass consumer markets in the 2000s, digital devices and mobile networks reached almost 100% penetration and almost completely exhausted their potential for extensive growth. However, with the advent of smartphones and high-speed data transmission technologies, the sector of electronic services has developed rapidly, for which the ICT hardware, including mobile networks and terminals of access to these networks (smartphones, tablets, and other mobile devices), has become a necessary *basic infrastructure*.

For a while, the new model for the development of ICT hardware markets was successfully supported through various marketing and technological measures, forcing consumers to change smartphones and other electronic devices as often as possible. However, such a model, which worked well as the world economy was growing in the early 2000s, after the crisis of 2008–2009 began to falter, and in the second half of the 2010s also started to exhaust its potential. The profits of companies manufacturing electronics and computer equipment have grown at a relatively low rate in recent years and do not cover capital expenditures on research and development (R&D), which are growing much faster. So, in the period from 2010 to 2017, the average volume of such costs for large ICT companies amounted to 13.6% of revenue, or about 21% of GVA, which is 10–11% more than the profit received [11].

Meanwhile, in order to maintain high growth rates of any high-tech industry, it is necessary to ensure a regular change of generations of products and to improve manufacturing technologies. For this, such industries need to maintain not only a consistently high share of R&D expenses in the cost of manufactured products but also high profitability, sufficient for regular reinvestment in R&D in the required volume. The sector of traditional ICTs is no longer fully meeting these requirements. This is due not only to the saturation of markets and the lower consumer demand but also due to reaching the technological barriers in the field of microelectronics, which no longer allow so rapidly changing of generations of processors, increasing their computing power, and most importantly reducing costs.

The main economic component of the model for rapid growth of microelectronics was the so-called Moore's law, which implies that over time semiconductor products become cheaper to manufacture, as their crystal area decreases. However, in recent years this law has actually ceased to work. With the transition from design standards for the production of microcircuits using 28-nm technology to 20 nm, the cost of a single transistor hardly decreased, but the cost of developing a technological process increased. In addition, the growth in operating costs of modern microelectronic industries began to be largely determined by the increased energy consumption, which now exceeds the energy consumption of many automobile plants [12].

After reaching technological production standards of 14 nm and less, microchips started to become more expensive. Although formally due to the higher density of transistors on a chip the cost of a single transistor continues to decrease, the relative cost of final products in comparison with their performance will increase due to the large percentage of defective plates when using thinner technological processes.

It is important to note that the crisis in the microprocessor market began in 2019. According to the TrendForce report, revenue growth for semiconductor manufacturers stopped at the beginning of 2019 due to weakening demand in most end markets, including smartphones [13]. According to the Semiconductor Industry Association, at the end of 2019, the revenue of microelectronics manufacturers decreased by 12.1% to $412.1 billion. The same estimate (a 12% drop) was given by Gartner at the end of 2019 [14].

From a technological point of view, in the coming years the situation will only get worse: specialists in the field of microelectronics believe that the further development of the semiconductor industry may sharply slow down or even completely stall when trying to master the norms of the technological process less than 5 nm, since the transition to "atomic" norms of the technological process introduces physical limitations that cannot be overcome with the help of lithography and modern photomasks [15]. Thus, the objective technological limit of the development of conventional silicon microelectronics and the core of the DE in the form of traditional ICTs will be reached in the foreseeable future. The development of alternative, fundamentally new technologies that can replace silicon crystals and ensure the continued growth of computing power at the same pace will require tremendous investments in R&D and technical reequipment of production facilities.

Digital platforms, artificial intelligence, and a new mechanism to expand and create markets. Launched after 2009, the concept of the DE as a new modernization project was intended, in fact, to reverse these negative trends and to create additional space for the growth of the semiconductor industry and traditional ICT markets in general at the existing level of technology *through the formation of new mass markets*. Such markets are based on the so-called digital platforms: high-tech communication platforms on which the entire complex of economic relations between economic entities is implemented and which, depending on the purpose of their activity, perform various kinds of functions [16, p. 11]. In other words, a platform is an artificial environment, built on the basis of ICT infrastructure, for the interaction of people and electronic devices, within which traditional services can be provided (taxi aggregators Uber and Yandex, product platforms Rolls Royce and Spotify) and fundamentally new products and services can be created (Google and Android, Apple and IOS, and the whole complex of services and infrastructure built around them for the development and sale of software by third-party developers; industrial platforms GE and Siemens).

Common to all these completely different types of platforms is the principle of their operation, which is built around the problem of extracting, registering, storing, processing, and using huge amounts of data, which, in fact, turn into a special type of raw material and can perform a number of important functions [17, pp. 35–88]:

—Train algorithms to work correctly and maintain their competitive advantage.

—Allow coordinating the work of employees and hire external contractors in the outsourcing mode.

—Help optimizing the production processes and make them more flexible.

—Transform products with low trade margins into services with high margins.

By accumulating and processing data and extracting useful information these data contain, platforms gradually form the basic "ecosystem" in which the entire industry operates. At the same time, some of the platforms are also building extensive infrastructure for their existence and extensive development, making massive investments in the creation of their own production facilities. Such platforms own not only information, "they become the owners of the infrastructures of society" [17, p. 85].

The most important element of the DE, formed around the platforms, are artificial intelligence (AI) technologies. In the context of this study, AI will mean not algorithms for mechanization of typical mental activity or the so-called expert systems (based on logical programming) that were booming in the 1980s but advanced machine learning algorithms, especially the development of deep learning methods and reinforcement learning based on neural networks. A fundamental feature of these AI technologies is the ability of the system to self-learn, which necessarily requires huge amounts of data and their constant generation [18].

According to most experts working with AI technologies, at the moment deep learning is the only fundamental innovation in the field of AI, which is used for active development of basic functional AI applications (pattern recognition, speech recognition, planning, and dispatching) [19]. Then, on this basis, specialized AI applications are created for specific sectors of the economy (predictive analytics in the field of financial services, trade, and insurance; monitoring of physiological parameters and diagnostics of diseases by X-rays in the field of health care; monitoring of social activity in the field of public administration). Combined with a system of platforms that provide a constant flow of new data, AI technologies have the potential to form a whole tree of products and services that meet basic needs of people and thus create massive and rapidly growing markets in the field of education, healthcare, governing, industrial organization, etc.

In the meantime, it is important to note that the data that platforms and AI work with involve recording, registration, and physical media. Any unit of recorded data needs a sensor that can receive it, recognize it, and read it, as well as an appropriate infrastructure for transferring these data to a processing center,

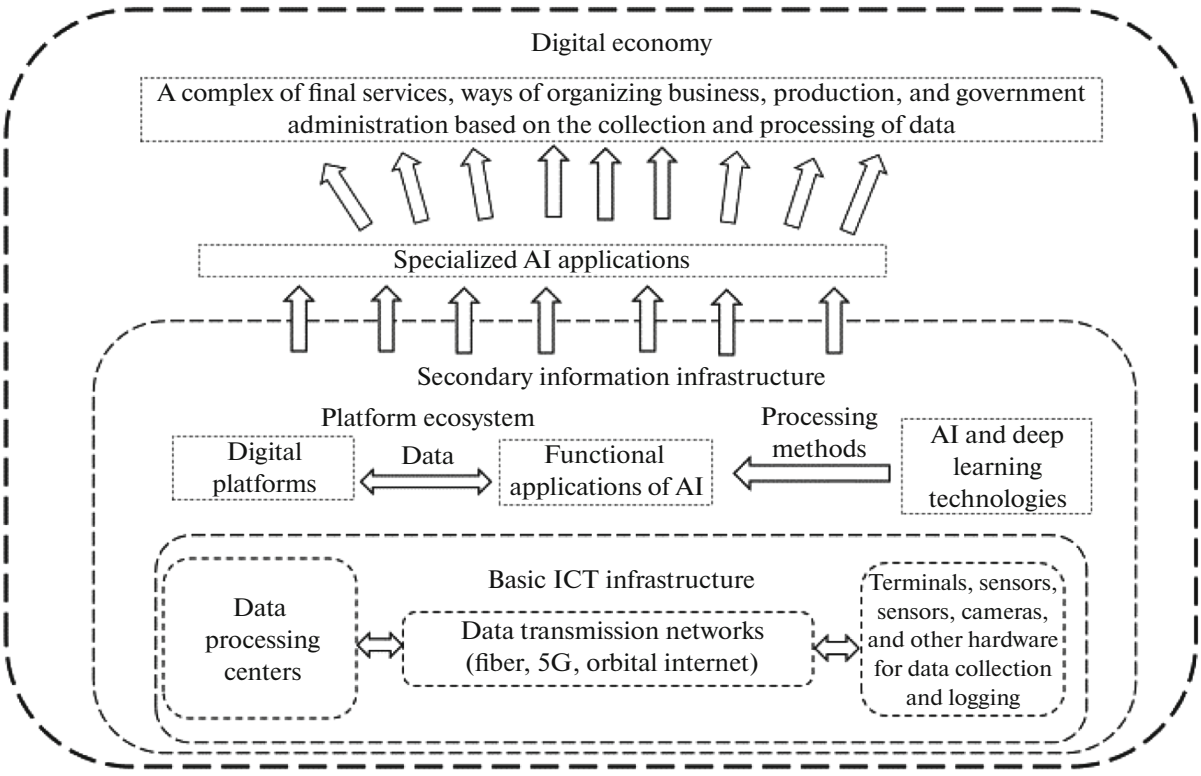

Fig. 2. Diagram of the organization of DE as a complex of products and services based on the collection, transmission, and processing of big data.

storage systems for accumulating collected data, and huge computing power for processing and AI training.

The creation of all this physical (or, in other words, *primary*) infrastructure, including new-generation 5G mobile data networks, without which efficient exchange of information between billions of sensors and data centers will be impossible, will create huge new markets for traditional products of ICT and microelectronics. However, the creation of such a primary basic infrastructure will require a huge amount of investment. In fact, the widespread launch of DE development programs by governments of most countries means the creation of this primary infrastructure by states, at the expense of state budgets [11].

Thus, the current concept of the DE actually means digitalization of all spheres of the economy and social life, which, in turn, denotes the widespread creation of *digital infrastructure* (in industry, services, social sphere, public administration, and entertainment and leisure fields). Such a digital infrastructure has two levels: *basic* (*primary*) ICT infrastructure (terminals for collecting and recording data, data transmission networks, and centers for data accumulation and storage) and *secondary* information infrastructure (platforms, modern AI technologies, and functional AI applications) (Fig. 2).

We believe that in order to assess the real impact of the coronavirus pandemic on digital markets, it is necessary to distinguish these two levels of digital infrastructure: the basic hardware level and the secondary level associated with the collection and processing of large amounts of data. The key statement is that the lockdown, self-isolation of the population, and the resulting forced digitalization that affected a number of economic sectors and areas of human life have generated a serious additional impulse for the development of the secondary level and the complex of digital services based on it. Meanwhile, the primary infrastructure in the form of the ICT core received a tangible blow, and the recovery from it cannot be expected any soon, especially in the context of the economic crisis exacerbated by the response measures against the pandemic and the freezing of investment projects.

What problems of the global DE project could the COVID-19 pandemic solve? The modernization project of digital transformation launched more than ten years ago, despite massive support from international development institutions, governments of developed and developing countries, and large corporations, did not lead to the expected economic effect. The share of the DE, even taking into account Internet commerce and all the statistical manipulations to artificially expand this sector, according to the most optimistic

estimates, is not higher than 15% of the world's gross output. The indirect effects of positive impact on GDP growth attributed to digital technologies due to productivity growth in other industries are still difficult to account for and have not been unequivocally confirmed.

Surveys of large companies from various industries, conducted by McKinsey and Gartner shortly before the outbreak of the pandemic, as well as Intel/EMC studies, showed that only a tenth of companies completely switched to a digital business model, and these are mainly companies in the retail sector. Others see multiple organizational, technical, personnel-related, and most importantly financial obstacles to the digital transformation of their business. Moreover, research shows that there is growing doubt and skepticism about digital technology among CEOs around the world, and platform-based benchmark digital companies such as Uber, Google, and Airbnb are no longer perceived as role models and are not valued by investors as high as in 2017–2018 [20].

DE growth in various countries was rather slow, so even such industry leaders as the head of Alibaba Jack Ma until recently believed that the transition to a new type of economy would take more than a dozen years [21]. It seems that the main reason for this is that *platform technologies*, having formed a secondary level of the global digital infrastructure, nevertheless, have *not yet been able to create truly mass markets* based on their services. They have significantly transformed the service sector, mainly affecting the entertainment industry, as well as creating a number of additional services and activities that do not satisfy basic needs of people and do not generate much added value. In the context of general economic growth, platform business models help gaining additional benefits and accelerating the development of certain types of business (for example, trade), but they were unable to generate such growth on their own under conditions of the general economic slowdown after the global financial crisis of 2008–2009.

Meanwhile, the coronavirus pandemic has had a powerful stimulating effect on a range of ICT service segments. So, the codirector of the Veon holding K. Terzioğlu believes that the COVID-19 pandemic "contributed to the ten-fold acceleration of the digitalization of the global economy" [22]. It is expected that the forced introduction of the general population to online services and the transition to remote work, which were previously perceived as something optional but with the introduction of quarantine measures became necessary, will radically and for a long time transform spheres of trade, education, health care, entertainment, public services, and even manufacturing. In particular, rapid growth was observed in the field of all kinds of online services: video streaming, delivery platforms, collaboration services, video broadcasts, education, entertainment, games, and contactless payment systems.

So, for example, the number of customers of the Zoom video conferencing platform in the two months of the pandemic has increased fivefold and the value of shares has doubled. The giants of ICT and the platform industry rushed to seize such a promising market that became mass overnight: a class action lawsuit was filed against Zoom with charges of violating the privacy law, which crashed the company's shares, and its place was immediately taken by Microsoft Teams and Skype from Microsoft and Hangouts Meet from Google. Another example is the explosive growth of contactless payment services and e-commerce. As of mid-April 2020, revenue growth for the largest US online retailers was 68% YoY, while online ordering globally increased by 146% YoY [23].

However, the main thing here is that social distancing measures and WHO recommendations were partially able to solve the main problem of the global digital transformation project: *to organize a forced flow of funds and investments from traditional sectors of the economy to the ICT sector.* As a result, while all the traditional areas of production in the first quarter of 2020 are experiencing a record drop in production and investors are dumping shares of industrial giants (for example, aircraft corporations), the ICT industry juggernauts are reporting explosive growth in revenue and the number of customers.

So, in just three months of 2020, the value of Amazon shares increased by 23.6%, and the company set a new record for market capitalization, more than $1.23 trillion. According to Americans for Tax Fairness and the Institute for Policy Studies, representatives of key ICT corporations earned the most from the pandemic: Amazon CEO J. Bezos, $34.6 billion; Facebook founder M. Zuckerberg, $25.3 billion; Microsoft creator, B. Gates, $8 billion; Oracle cofounder L. Ellison, $7 billion [24].

Removing barriers to access to mass markets for social services. A truly large potential market for services based on Big Data processing technologies using AI methods is in the social sphere, which satisfies basic needs of people in health care, education, and public services. At the same time, such technologies can come to this sector *only with the help of the state*, because until recently there were multiple obstacles to their mass introduction: legal, socio-cultural, and psychological. *Legal obstacles were crucial*: these are restrictions on working with personal data of citizens, the lack of a legislative framework that determines the nuances of interaction in the digital environment, etc. That is why global development institutions promoting the global digitalization agenda, such as the World Bank, have developed a whole set of recommendations for governments of developing countries. The main recommendation is the creation of a favorable regulatory framework and the removal of legal barriers, in particular, for cross-border data transfer [25].

One of the main outcomes of the pandemic is the *removal of a significant part of these barriers* (under the pretext of combating the spread of the virus): this allows platform technologies and data processing

methods using AI to obtain and use personal data of citizens and create mass markets for social services.

So, for example, during the period of quarantine restrictions in Russia, a full set of laws was adopted that provide a legal basis for the commercial and governmental use of personal data and their processing[1]. Aggregators, social networks, banks, mobile operators, and operators of payments, cameras, and retail cash registers obtain a legal opportunity to establish a database exchange and create a single information platform for launching any social services on its basis. This will lead to the consolidation of the digital sector, which previously existed as separate islands in the corporate and government segments, and will significantly facilitate the flow of investment and the formation of new mass markets. For example, the new legislative framework can be used as the basis for implementing the unified federal digital platform for interaction of citizens and businesses with the state Gostech, the draft of which was presented by Sberbank in early 2020. Its platform can be used to organize services for renting state property, medical insurance, and obtaining compulsory medical insurance certificates; all processes regarding the management of state property can also be transferred to the new platform. The market for such services in Russia is estimated at 20 billion rubles annually [26].

A similar but larger-scale project received a powerful impulse for development in the United States. Amid and under the pretext of the pandemic, Governor of New York E. Cuomo, in collaboration with former Google CEO E. Schmidt, who headed the government commission on the development of telemedicine and broadband Internet access during the quarantine period, and with the support of the Defense Innovation Board and the National Security Commission on Artificial Intelligence proposed to ensure the accelerated introduction of digital technologies in various spheres of human life. It basically means combining the financial and technological capabilities of private ICT companies with those of the state to form markets that provide a whole range of digital services [27].

Apparently, AI technologies will be able to develop very dynamically after the pandemic, primarily because in combination with platform solutions for collecting Big Data this is the only fundamental innovation in the ICT field at the moment that can potentially form massive and quickly growing markets. However, these technologies will be able to radically transform the world economic system and social sphere only if there is a well-developed material ICT infrastructure (the primary level of digital infrastructure). Meanwhile, the COVID-19 pandemic and the accompanying global economic crisis could deal a tangible blow to the prospects for its construction.

Problems of the development of primary digital infrastructure during the crisis. Under conditions of the pandemic, the microelectronics manufacturing sector suffered almost as badly as other industries. Quarantine measures in the PRC in early 2020 led to partial and complete shutdowns of Chinese factories that manufactured products for the largest technology companies around the world. This disrupted supply chains and resulted in a shortage of components for electronics manufacturing around the world. As early as in February 2020, global smartphone shipments decreased by 38% compared to the same period in 2019. At the end of the first quarter, smartphone sales decreased by 17% compared to the fourth quarter of 2019 [28].

The disruption of supply chains at all levels makes it difficult to supply new computers from the PRC to the markets of developed countries, whose hardware requirements for mass telecommuting and remote learning have increased dramatically. As a result, the market for personal computers and laptops is now characterized by a significant gap between supply and demand. Shipments for the 1st quarter of 2020 (53.7 million units) were 8% below the level of 2019, while the demand for laptops and workstations has increased significantly [29].

If we consider the statistics of the ICT market over the past year and a half, we can see that the crisis in such basic areas as the production of ICT equipment and electronics *began long before the pandemic and the collapse in oil prices* in early 2020. The growth of the sector for manufacturing of ICT equipment and digital devices seriously slowed down as early as in 2019 (Fig. 3, Table 1).

As can be seen from the above data, the decline in revenue from sales of equipment and telecommunication services began in 2019, and even before the start of the pandemic the growth was not expected to resume in 2020. The forecast made during the pandemic suggested an even greater drop, with the largest decline affecting the ICT hardware sector. The only segment that will grow is cloud services: Gartner predicts growth by 19%, in particular, cloud video conferencing by 24.3% and cloud telephony by 8.9% [30].

The global epidemiological crisis has demonstrated that the existing microelectronics production system with several large microchip manufacturing centers, to which all manufacturers of final products are oriented, and supply chains tied to the PRC is *physically unable to cope with the explosive growth in demand* for electronic products. Moreover, this problem was explicit even before the start of the pandemic, and its main reason was the abovementioned difficulties in the technical reequipment of microprocessor factories for the production of chips using new, thinner technologies. So, AMD, which orders 7-nm crystals for its processors from the Taiwanese company TSMC, faced a massive delay in the order execution back in September 2019. And the shortage of Intel processors associated with the technical reequipment of factories for 10 nm began all the way back in 2018 and has not yet been overcome [31]. Thus, the possibility of a further

[1] Federal Law of 08.06.2020 N 168-FZ On the Unified Federal Information Register Containing Information on the Population of the Russian Federation and Federal Law of 24.04.2020 N 123-FZ On Conducting an Experiment to Establish Special Regulations in Order to Create the Necessary Conditions for Development and Implementation artificial intelligence technologies in the constituent entity of the Russian Federation—the city of federal significance Moscow and amendments to Articles 6 and 10 of the Federal Law, On Personal Data.

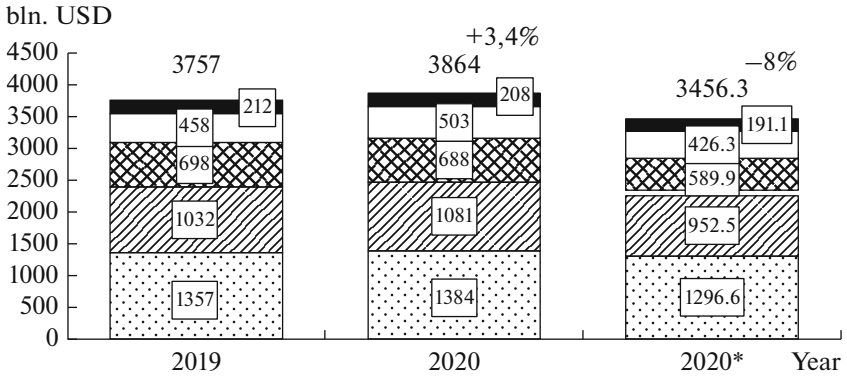

Fig. 3. Gartner forecast regarding the development of individual segments of the ICT market for 2020 before and after the coronavirus pandemic: ⊡ telecommunications services; ▨ ICT services; ⊠ production of ICT equipment; □ software development; ■ data center services

Source: [30].

large-scale increase in the production of microcircuits and final products based on them, which should form the basic level of the DE infrastructure, may be under threat.

Development of the other two basic elements of the primary level of the digital infrastructure, namely, data transmission networks and data processing centers, also faces serious problems. The surge in Internet traffic fueled by the use of digital interactive entertainment during quarantine has increased the load on networks so much that concerns have arisen in some countries about the robustness of telecommunications infrastructure. In mid-March 2020, the EU turned to streaming services with a call to reduce the quality of broadcasted content so as not to overload networks [32].

In the meantime, maintenance of the potential communication system between sensors, cameras, and other devices at the basic level of the global digital infrastructure requires a significantly larger increase in bandwidth than the load on networks during a pandemic. According to IDC estimates, the traffic generated by IoT devices will grow by an average of 28.7% per year and will increase up to 79.4 zettabytes per year by 2025 (1 zettabyte is 10^{21} bytes), and the total amount of stored and processed data will reach 175 zettabytes by 2025. Currently, data centers are capable of storing and processing only about 20 zettabytes per year [33]. With such traffic growth rates, two problems will arise simultaneously: the need to dramatically increase the capacity of data centers and the bandwidth of data transmission networks.

The problem of fast, reliable, and secure networks for huge volumes of traffic can become even more severe. Now data transmission is carried out not only through mobile networks but also using fiber-optic cables connecting continents and countries. Physical disruption (for example, as a result of sabotage or natural disaster) even of a few such fiber-optic lines can lead to the complete collapse of globally functioning digital services, which is especially dangerous in the case of widespread development of payment systems and digital security systems. The solution to such a critical vulnerability could be satellite broadband Internet. Two companies tried to develop it before the pandemic: OneWeb and SpaceX (Starlink project). Both the projects were developing extremely slowly

Table 1. Results of 2019 and forecast of growth/decline of individual ICT sectors before and after the start of the COVID-19 pandemic (%, compared to the previous year)

ICT sector	Results of 2019		Forecast for 2020	
	estimate for January 2020	estimate for May 2020	made in January	updated made in May
ICT sector as a whole	**0.5**	**1**	**3.4**	**−8**
Telecommunications	−1.1	−1.6	1.5	−4.5
ICT services	3.6	3.8	5	−7.7
Production of ICT equipment	−4.3	−2.2	0.8	−15.5
Software development	8.5	8.8	10.5	−6.9
Data center services	−2.7	0.7	1.9	−9.7

Source: [30].

(OneWeb planned to complete the launch of satellites no earlier than 2023 and Starlink by 2027), since they required enormous investments. The Starlink project is estimated at $10 billion, while OneWeb was able to raise about $3.3 billion, but in March 2020 it filed for bankruptcy. So, one cannot expect rapid implementation of these projects under conditions of falling investment activity in the context of the new global economic crisis.

The pandemic is also characterized by serious problems with the development of 5G mobile communication networks, which must provide sufficient capacity, reliability, and data transfer speed in the networks that connect elements of the primary ICT infrastructure for the adequate operation of all related digital services. 5G development projects in many EU countries were suspended in early 2020, and one of the formal reasons was the fact that cell towers were physically destroyed because of the information about their supposedly harmful effects on health and the association with the spread of COVID–19 [34]. The real reason is the US trade war with China, which has become a key center for the development and production of 5G technologies. Fierce competition between the United States and China for control over new generation communication standards and technologies began back in 2019 and was conducted mainly by "nonmarket methods." So, under political pressure from the United States, most EU countries and the United Kingdom have denied Huawei the right to supply the equipment for the construction of 5G networks.

At the same time, the main problem for the spread of infrastructure of the new generation of mobile communications is the *need for significant investment resources* due to technical features of the construction of 5G networks (stations should be installed much denser than for the 4G standard). Thus, the total investment in the development of mobile networks around the world in the next five years is estimated at 1.1 trillion dollars, of which about 80% accounts for 5G networks [35, p. 2]. At the same time, as of 2019, the costs of passing ever-increasing traffic through the networks of telecom operators were not covered by revenues from traditional services. This gap grew steadily even before the start of the pandemic, and in the postpandemic period it will continue to increase, which will not allow providing the necessary volume of investments in the construction of new networks [11]. According to the results of the 1st quarter of 2020, companies leading in manufacturing of 5G technologies and construction of 5G networks realized that the planned investments would have to be postponed indefinitely. In countries where the deployment of new generation networks was only expected, auctions for frequencies for 5G were suspended or postponed to later dates [36].

In May 2020, the Ministry of Telecom and Mass Communications of Russia proposed to save 1.5 billion rubles which was planned to be spent in 2020 on works on clearing the frequencies for the construction of the new generation infrastructure. A significant cut in funding could lead to a sharp slowdown in the deployment of 5G networks. So, instead of 20 thousand base stations of the fifth generation, only five thousand can be produced by 2024. In addition, on May 14, 2020, the Security Council of the Russian Federation refused to give operators frequencies in the range of 3.4–3.8 GHz for the construction of 5G networks, as they are used by the Ministry of Defense and Roskosmos, and proposed as an alternative frequencies in the range of 4.8–4.99 GHz, for which there are *no international standards and certified equipment yet*. All these financial and technical difficulties do not allow the rapid deployment of the new generation networks, especially in those countries that, at the time of the outbreak of the pandemic and the economic crisis, still lacked the adequate infrastructure. However, those countries, first of all, China, where 5G networks were deployed back in 2018–2019, following the COVID–19 pandemic, received a tremendous advantage in the further development of both the levels of digital infrastructure and related products and services[2].

Conclusions. The currently generally accepted model of digital transformation, which implies the construction of a global digital infrastructure, requires *creation of favorable conditions for the formation of new mass markets* both for the traditional ICT and microelectronics sector and for digital platforms and AI technologies. The COVID–19 pandemic has partially solved this problem. In the conditions of forced social isolation and retarded economic processes around the world, various services provided via the Internet, which were previously perceived as a pleasant, useful, and convenient but only an optional addition, have become *essential needs*. This is one of the key conditions for the successful formation of mass markets. The rapid growth of the client base and revenue in certain segments of DE, as well as the growth of capitalization of leading digital companies, became natural.

The need to create a physical basis (primary level) of digital infrastructure can potentially generate huge additional demand for traditional ICT and microelectronics products, that is, ensure the further intensive development of these industries on the basis of existing technologies and taking into account the existing technological limitations. At the same time, due to the high costs that are required to create the basic level of digital infrastructure, its construction within the framework of the global DE project is generally

[2] At the end of March 2020, China had 198 thousand 5G base stations, and the number of users of the fifth generation communication network exceeded 50 million. By 2025, the total investment in the formation of a 5G network is estimated at 1.2 trillion yuan, and the volume of all investments in the industry could reach 3.5 trillion yuan [37].

entrusted to governments: they must raise significant budgetary funds to solve this problem. However, the new global economic crisis that began even before the pandemic (apparently already in the fall of 2019), which was aggravated by the quarantine measures adopted everywhere to fight the spread of infection, creates significant problems for the development of the basic level of digital infrastructure. A serious drop in GDP, industrial production, and budget revenues, coupled with the need to adopt large-scale sets of anti-crisis measures aimed at supporting key industries, as well as sectors of the economy most affected by the lockdown, raises the question of *actual possibilities of state funding* for DE projects.

Therefore, "forced digitalization" as a key result of quarantine measures introduced in connection with the COVID-19 pandemic is so far expressed in the fact that most of the developed and largest developing countries of the world were forced to speed up the digitalization of the social sphere and public administration, *to take legislative measures* in order to facilitate access to personal data of citizens, and *to introduce special tax and legal regimes* that allow securing the preferences created by the lockdown for the accelerated development of the DE.

The digital transformation model promoted by international development institutions and ICT giants suggests that added value will be redistributed to the digital services and software sector (the secondary level of digital infrastructure). The pandemic has *actually strengthened the monopoly position of ICT companies*, owners of digital platforms and AI technologies, securing their position at the highest level of the economic pyramid and ensuring that investments flow in their direction. Platform-based digital services (mainly in the areas of online commerce, distance learning, telecommuting, conferences, etc.) *received a significant portion of resources* redistributed from other, traditional industries and sectors of the economy that became unprofitable overnight. Such processes, as a rule, occur during periods of industrial and technological revolutions and took place both in the 19th century and throughout the 20th century. However, back then the process of destruction of ineffective industries occurred in a natural way, gradually over many decades under the influence of objective economic processes. The uniqueness of the digital forcing caused by the quarantine lies in the fact that a number of traditional industries are *forcibly placed in deliberately losing conditions*, which were created artificially due to the global lockdown. A similar role in the history of humankind was played by *war*, the results of which consisted in cardinal changes in the existing economic and financial system of the world.

* * *

As borders and access to markets are commonly closed and manufacturing and supply chains are disrupted as a result of quarantine measures, the expert and scientific community has been widely discussing in the press the statement that the pandemic is a big nail in the coffin of globalization. However, this statement, which seems obvious only in appearance, is difficult to agree with.

First, the main beneficiaries of the pandemic, platform and AI technologies, which received a powerful impulse for accelerated growth, by their very nature require a constant influx and generation of a huge amount of data for further development. This inevitably leads to *monopolization of markets*: the more data, the better the product; the better the product, the more data can be collected [17]. This means that *as many countries as possible should get involved in digitalization processes*, creating a basic digital infrastructure and digitally transforming their governing system, healthcare, social sphere, etc. In other words, *the formation of a secondary level of digital infrastructure*, on which new digital services can develop and new digital markets can be created, is *possible and necessary only on a global scale*. One of the leaders of the ICT industry K. Terzioğlu directly expresses this opinion: "perhaps the coronavirus is a kind of call for the world to unite again around one platform for free trade and accelerating globalization... the coronavirus has proven that the Internet and networks represent the main element required for existence of communities, countries, people, and businesses" [22].

Second, the existing system of almost monopolistic control over the primary (microelectronics and 5G technologies) and secondary (platforms and AI technologies) levels of the digital infrastructure, dominated by transnational corporations of the PRC and the United States, does not leave developing countries, including Russia, a chance to maintain economic independence in the course of digitalization processes, forcing them to use technologies from one of these countries that are technological leaders in the field of the DE. Thus, it is obvious that only a *global* digital transformation can lead to the formation of a new "technology center" and a new "technological periphery." Another leader of the digital industry, Kai-Fu Lee, speaks eloquently about this: "the rest of the countries may have large populations, but they do not have AI technologies... And so they have no choice but to become data providers for American or Chinese AI companies... This will turn them into unapproachable leaders... Most countries simply will have no choice but to become a vassal state of the United States or China: I give you my data... and in return you help feed the poor in my country..." [38].

It seems that there is *merging of the financial and technological capabilities of private ICT companies with the administrative resource, repressive apparatus, and budgetary capabilities of states* for the formation of a fundamentally new management system, within which some functions, including power (fiscal, banking,

administrative, medical) ones, will be delegated to automated systems that make decisions based on deep analysis of large data sets about all types of human activity. Since the ICT giants will have control over these systems, states will in fact lose their subject status (they will retain it only formally) and this will *allow resuming the project of globalization of the world economy*, but at a higher level. The COVID–19 pandemic has clearly shown that in China this scheme of merging between private digital corporations and the state apparatus is *already being implemented*. The creation of powerful lobbying institutions in the United States seeking to increase government spending on financing developments in the field of DE and the construction of the corresponding basic technological infrastructure (5G networks and the Internet of Things) began even before the pandemic and was a response to the success of Chinese companies that in recent years, with the support of the state, collected a huge amount of data on all types of activity of the PRC population. The need to stop the spread of infection by all means and prevent the development of new pandemics creates potentially favorable conditions for the implementation of this scheme in other countries or even at the global level.

However, this pathway for development of events is not definitive. The *logic* of globalism and monopolization of digital infrastructure and markets ultimately suggests that there must be only one leader. Meanwhile, the threat of the continuation of the COVID-19 pandemic and the emergence of other pandemics, a new global economic crisis, which has already been rushed to be declared the worst recession since the Great Depression, the trade war between the United States and China, as well as the struggle for leadership in global markets and within the framework of creating new projects of global trade and investment unions introduce significant uncertainty into the *actual* processes of globalization. The possibilities of such or an alternative path of development (the disintegration of the world into several economically and technologically autonomous regions) remain open.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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