

Digitalization and Sustainable Development: the New COVID-19 Challenge Requires Non-standard Solutions

Cyfryzacja i zrównoważony rozwój: nowe wyzwanie związane z COVID-19 wymaga niestandardowych rozwiązań

Oksana Polishchuk*, Tetiana Kulinich**, Nataly Martynovych***,
Yuliia Popova****

**National Aviation University, The Management Technologies Department,
Lubomyra Husara Avenue, 1, 03058 Kyiv, Ukraine*

E-mail: oksana.polishchuk@npp.nau.edu.ua, ORCID: 0000-0001-5263-3262

*** Lviv Polytechnic National University, Department of Organizational Management,
S. Bandery Str., 12, 79013 Lviv, Ukraine*

E-mail: tetiana.v.kulinich@lpnu.ua ORCID: 0000-0003-0110-7080

**** University of Modern Knowledge, Department of Economics and Management,
Velyka Vasylkivska street, 57/3, 03150, Kiev, Ukraine*

E-mail: k.martinovich81@gmail.com, ORCID: 0000-0001-9884-6052

*****State University of Infrastructure and Technologies,*

Department of Business Logistics and Transportation Technologies,

Kyrylivska street, 9, 04071 Kyiv, Ukraine

E-mail: yuli-p@ukr.net, ORCID: 0000-0002-5246-1349

Abstract

The spread of COVID-19 contributes to changing economic, environmental and social reality around the world. One of the significant consequences of the current pandemic can already be called the accelerated introduction of digital technologies in various fields. Against this background, the article is devoted to the theoretical and analytical substantiation of the feasibility of reorienting traditional production and management systems in the context of COVID-19 to digital ones. It has been proven that digitalization, sustainable development and COVID-19 are new challenges generated by human activity that require non-standard solutions. A composition of non-standard digital solutions is proposed to overcome the problems associated with COVID-19, ensuring sustainable development, allowing to launch new business models capable of smoothing post-Covid consequences and bringing the world economy onto a trajectory of sustainable economic growth.

Key words: sustainable development, Sustainable Development Goals, digitalization, digital technologies, COVID-19

Słowa kluczowe: zrównoważony rozwój, Cele zrównoważonego rozwoju, cyfryzacja, technologie cyfrowe, COVID-19

1. Introduction

In 2015, with the adoption by 193 UN member states of 17 Sustainable Development Goals (SDGs) until 2030, a turning point in the development of future generations took place. As a result of this event, the discussion of a new model of socio-economic development that meets the challenges of modernity and aspirations for a more just, prosperous and environmentally friendly world was actualized. However, in the presented report *Transforming our World: The 2030 Agenda for Sustainable Development* (2015) digitalization was not mentioned, despite the

fact that most experts in the field of management, business, finance, environmental management, sustainable development agree that digital transformation is not only a tool for achieving sustainable development goals, but also a driver of structural changes in various industries, the main game-changer of the world economy of the XXI century.

So, the leading consultants of Gartner Inc note that *digitalization is a new model of sustainable business development, covering personnel, business processes, things, scalable globally for the whole world through the use of information technology, the Internet, assuming effective personal service for everyone, everywhere and always* (Inter Systems Experts, 2021). eMarketer experts believe that *digitalization is a process involving a global increase in the share of robotic production and automation of many life processes of humanity as a whole, contributing to the formation of sustainable development* (Global Ecommerce Forecast 2021, 2021). According to Rockwell Automation Vice President Mark Bottomley, who has made a significant contribution to the development of various industries across Europe, *sustainable development is becoming an increasingly relevant part of the social agenda, which makes it a critical topic for business and industry. Digitalization allows industries not only to reduce the amount of harmful waste, but also to effectively redistribute resources, increase productivity and create safer, more attractive working conditions for employees* (Rockwell Automation, 2019).

The COVID-19 Pandemic, which has shown the critical importance of digital technologies in the fight against poverty, environmental, economic and social risks, improving the quality of life of people, etc., has contributed more actively to the digitalization of the economies of the countries of the world, while exposing the problem of digital inequality and digital divides. Based on what has been said, digitalization is rightly considered a tool for implementing the sustainable development goals, and COVID-19 is a new challenge requiring non-standard solutions.

2. The purpose of the article

The purpose of the study is to formalize the theoretical and analytical aspects of digitalization under the conditions of COVID-19 and to develop non-standard solutions for ensuring sustainable development based on digital technologies.

3. Methodology

The study was based on the use of general scientific methods (in clarifying the essence of digitalization), as well as statistical, comparative and graphical analysis (in substantiating hypotheses and dependencies).

When forming the author's vision regarding the meaning of the category *digitalization*, the scientific statements of the following authors were summarized: H. Albach, B. Berthon, E. Brynjolfsson, M. Jeon, M. Jeong, D. Ernst, B. Kahin, M. Knickrehm, S. Markovitch, T. Mesenbourg, H. Meffert, N. Negroponete, T. Niebel, A. Pinkwart, R. Reichwald, Z. Xiang, D. Fesenmaier, D. Tapscott, P. Willmott, K. Schwab, L. Halkiv, O. Karyi, I. Kulyniak, S. Okhynok, S. Markovitch, P. Willmott, M. Knickrehm, P. Daugherty, N. Martynovych, E. Boichenko, O. Vivchar, N. Myskova, O. Popovych, O. Kasianenko, A. Galkin, Y. Popova, E. Chuprina, D. Shapovalenko.

When substantiating hypotheses and dependencies, the article sequentially verifies four logically interrelated hypotheses: 1) digitalization is a necessary condition, a driving force of sustainable development, 2) the COVID-19 pandemic has contributed to the acceleration of digitalization, 3) the COVID-19 pandemic has negatively affected digitalization 4) digitalization is an effective tool for making non-standard sustainable development decisions in the context of COVID-19, describing the relationship of the analyzed indicators (passenger turnover by air transport, revenues from air transportation, the number of commercial flights, the growth rate of the offer of carrying capacity, aircraft load, the volume of CO₂ emissions into the atmosphere, the volume of electronic sales, the dynamics of downloaded applications for remote work, the world level of falling tourist flow, the number of trips in absolute terms, etc.).

When establishing the relationship between digitalization, COVID-19 and sustainable development, quantitative and qualitative indicators are compared, reflecting positive and negative results and their impact on changing overall well-being.

The statements and conclusions are based on the analysis of official statistical data of various international organizations and companies, such as the United Nations Conference on Trade and Development, International Institute for Applied Systems Analysis (IIASA), Rockwell Automation, International Air Transport Association, Eurostat, World Meteorological Organization, World Tourism Organization, FreightWaves, Global Carbon Project, Pacvue, for 2019-2020 and partly 2021.

4. Findings and Discussion

4.1. Digitalization and sustainable development in the context of COVID-19

An analytical review of the study results of the symbiosis of digitalization, sustainable development and COVID-19, as well as the challenges generated by these phenomena, requires clarification of some theoretical aspects, in particular the essence of the digitalization category.

A review analysis of previously conducted scientific studies by various authors, such as H. Albach, B. Berthon, E. Brynjolfsson, M. Jeon, M. Jeong, D. Ernst, B. Kahin, M. Knickrehm, S. Markovitch, T. Mesenbourg, H. Meffert, N. Negroponte, T. Niebel, A. Pinkwart, R. Reichwald, Z. Xiang, D. Fesenmaier, D. Tapscott, P. Willmott, K. Schwab et al., allowed us to establish that the category *digitalization* appeared in 1995. This term was first used by a Greek-American computer scientist from the University of Massachusetts, the founder of the One Laptop per Child Association, who studied digital economics, Nicholas Negroponte (Negroponte, 1995). However, scientific circles started talking more actively about digitalization after Klaus Martin Schwab announced the Fourth Industrial Revolution at the World Economic Forum in Davos in 2016, noting that *economic growth and well-being for everyone is our common goal, and digital technologies will play the main role therein* (Schwab, 2016).

It should be noted that in the works of the authors presented above, digitalization is considered as a result of the natural evolutionary process of economic and social development, which includes computer, information and communication technologies. Agreeing with this opinion, we consider it appropriate to visualize this statement (Fig. 1).

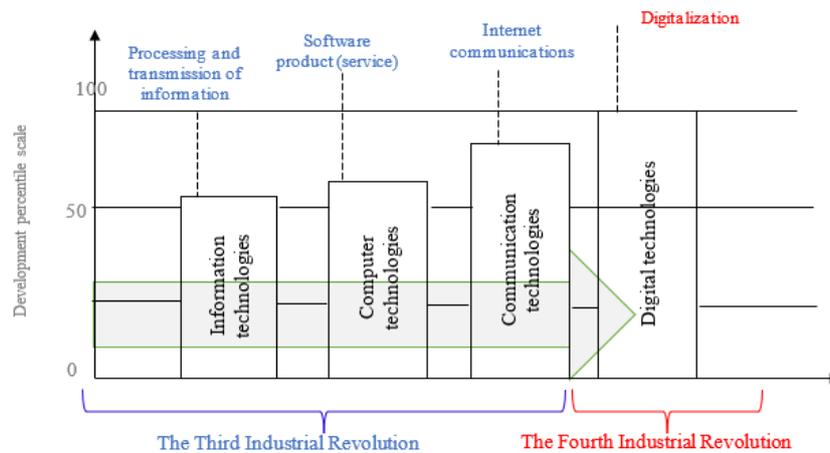


Figure 1. Conceptual vision of the periodization of the formation of digitalization, compiled by the authors on the basis of generalization (Negroponte, 1995; Schwab, 2016)

From (Fig. 1) it follows that information, computer and communication technologies belong to the Third Industrial Revolution, digital technologies – to the Fourth one. The method of measuring the level of development in percentiles is explained by the fact that this scale allows unifying the results of both statistical and empirical studies (polls, marketing research, expert opinions) and presenting them in a generalized form. In this regard, we came to the conclusion that digital technologies are an obligatory component of digitalization, and digitalization, in fact, is the process of introducing digital technologies into all spheres of society (The compact Oxford English dictionary: complete text reproduced micrographically, 1991). This point of view is reflected in the research of the vast majority of scientists in various scientific fields.

Thus, R. Tapscott understands digitalization as revolutionary changes in business models based on the use of digital platforms, which lead to a radical increase in market volumes and competitiveness of companies (Tapscott, 1998).

In the studies of Ukrainian economists L. Halkiv, O. Karyi, I. Kulyniak, S. Okhynok, digitalization is considered as a *new model of business development, a new paradigm of accelerated economic development* based on such processes as globalization, transformation, integration (Halkiv, 2020).

S. Markovitch, P. Willmott define digitalization as the process of digitizing all information (and even material) resources (creating digital copies) and the formation of network interaction platforms in order to obtain a predictable and guaranteed result for any control impact (Markovitch, Willmott, 2014).

M. Knickrehm, B. Berthon, P. Daugherty argue that digitalization is a phenomenon caused by the rapid development of information technologies, microelectronics and communications in most countries of the world (Knickrehm, Berthon, Daugherty, 2018).

Relying on the statements of R. Tapscott, L. Halkiv, O. Karyi, I. Kulyniak, S. Okhynok, S. Markovitch, P. Willmott, M. Knickrehm, B. Berthon, P. Daugherty, as well as based on the conceptual vision of the periodization of the formation of digitalization (Fig. 1), it has been established that digitalization should be understood as integration processes taking place at the level of companies, industries, affecting all spheres of society. In addition, we came to the conclusion that digitalization is the core of the digital economy, which the authors understand as a system of economic, social and cultural relations based on the application and use of computer, information and communication and digital technologies.

All of the above gives grounds to assert that digitalization is a conductor of economic, environmental, social, cultural and other changes that affect the life of an individual and society as a whole, and also becomes a necessary condition, a driving force for sustainable development. A similar point of view is reflected in the studies of N. Martynovych, E. Boichenko, O. Vivchar, N. Myskova, O. Popovych, O. Kasianenko, focused on the formation of the educational level of the population of Ukraine under the conditions of the information society. The authors note that it is necessary to move to a new level of progress based on renewable sustainability, the implementation of which can be ensured through digitalization, which in turn will allow the formation of a new personality focused on the system of environmental values, and not on the values of consumer society (Martynovych, 2019).

This thesis is confirmed by the analysis presented by UNCTAD, according to which, over the past decades, the relevance of the introduction of digital technologies in industry, agriculture, engineering, construction, real estate services, small and medium-sized businesses, financial and other spheres has increased significantly. Accordingly, for the period of 2010-2020 the number of Internet users increased from 1.6 billion to 4.1 billion (the prevalence rate increased from 23 to 54%); the number of smartphones, that just started to appear on the market in 2007-2008, reached 3.2 billion by 2020, while global Internet traffic increased from 4 thousand to 100 thousand GB per second. Over the period 2015-2020, the volume of e-commerce revenue in the world has grown more than 2.5 times, reaching \$3.5 trillion (UNCTAD, 2020). All this testifies to an unprecedented technological breakthrough, as well as to the fact that the prerequisites for transferring key processes to a digital environment and ensuring their continuity have already been formed.

The COVID-19 pandemic contributed to the acceleration of digitalization. This is stated, among other things, in the report of the United National Conference on Trade and Development *The COVID-19 Crisis: Accentuating the Need to Bridge Digital Divides*, according to which of the six main digitalization trends, three are directly related to quarantine: remote work and the use of technology communication; changing consumer habits; negative impact on some digital platforms (UNCTAD, 2020). As we can see, along with the positive impact of COVID-19 on digitalization, there is also a negative one, which requires additional attention and the development of non-standard solutions, which are presented below. Thus, the author's reasoning and analytical argumentation give grounds to assert that digitalization is one of the conditions for ensuring sustainable development.

This point of view was reflected in several reports of 2019-2020 at once. In particular, the problems of digitalization in connection with the implementation of the sustainable development goals were discussed in detail in the reports: *Digital revolution and sustainable development: challenges and prospects* within the framework of the *World in 2050* initiative; *UNCTAD Report on the Digital Economy 2019* and *The Covid-19 Crisis: Accentuating the Need to Bridge Digital Divides*; the report of the UN High-level Group on Digital Cooperation *Time of Digital Interdependence* (TWI 2050, 2019; UNCTAD, 2019, 2020; UN, 2019). The general thesis of the expert opinions reflected in these reports is that digitalization potentially contributes to the implementation of the SDGs in three main directions (Table 1).

Table 1. The main directions of SDG implementation based on digitalization, compiled by the authors on the basis of generalization (TWI 2050, 2019; UNCTAD, 2019, 2020; UN, 2019)

Result	SDG
<i>1st direction</i>	
Digitalization accelerates the process of transition from an environmentally hazardous business model to a circular economy	
Reduction of environmental risks, creation of additional jobs in the <i>green</i> sectors of the economy	Improving the standard of living of society around the world, especially in developing countries. Ensuring a healthy lifestyle and promoting well-being for everyone at any age.
<i>2nd direction</i>	
Digitalization contributes to social integration, reducing inequality of opportunities, literacy development, as well as increasing financial inclusion	
Internet connectivity in developing countries. Gaining access to financial resources for people living in developing countries through various mobile applications. Electrification of developing countries and reduction of the cost of Internet traffic Popularization of norms and values protecting human rights through the Internet	Reducing the inequality of access to the Internet for residents of the countries of the world. Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all
<i>3rd direction</i>	
Transition of the world economy to sustainable ecological development	
While regulators are not keeping up with the pace of development of the digital revolution and the greening of the global economy, however, digitalization has a high potential to reduce anthropogenic impact on the environment.	Ensuring the availability and rational use of water resources, access to affordable, reliable, sustainable and modern energy sources for all. Promoting the fight against climate change and its consequences.

Thus, tabular data allow us to conclude that sustainable development is becoming an increasingly relevant part of the social agenda, which makes it a critically important topic for business and industry. Digitalization allows industries not only to reduce the amount of harmful waste, but also to efficiently redistribute resources, increase productivity and create safer, more attractive working conditions for employees.

4.2. Digital management technologies: Aviation and COVID-19

Aviation is one of the industries in which the digitalization of business processes is proceeding at the most active pace. This trend of technological transformation is due to the twenty-year growth in demand for air transportation (Fig. 2), which is associated with the development of tourism, which has had a positive impact on the aviation industry, as well as minimizing costs and the risk of human error. However, despite the prospects of the aviation industry, the coronavirus pandemic has had a devastating impact on its development worldwide. Thus, for the period of 2019-2020, there was a decrease in global revenue in passenger kilometers (RPKs) by 66%, which is comparable to the level of global air traffic in 1998 (Fig. 2).

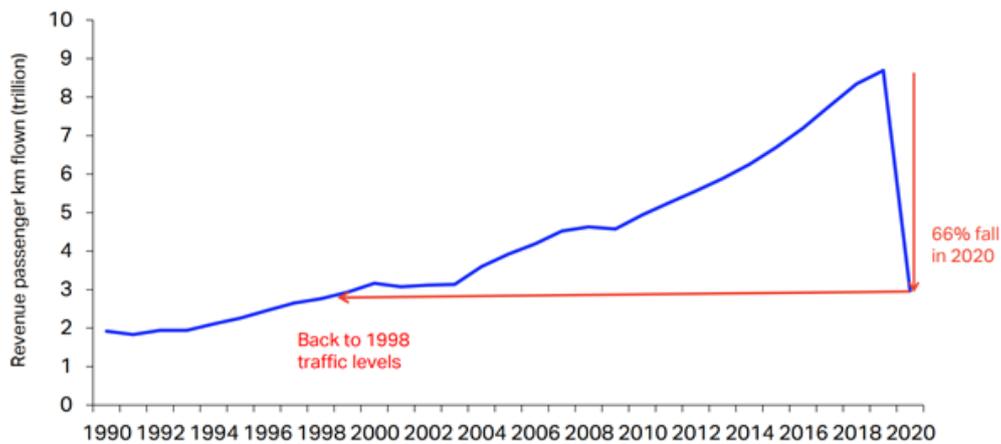


Figure 2. Dynamics of passenger turnover by air transport for 1990-2020, in trillion PCM (IATA, 2020)

The IATA Annual Review 2020 report on the devastating impact of COVID-19 on the aviation sector reads as follows: *In 2020, the COVID-19 pandemic was the strongest shock to air transportation and the aviation industry since World War II. Even the terrorist attacks of September 11 and the global financial crisis of 2007-2008 were not so dramatic from an economic point of view* (Fig. 3).

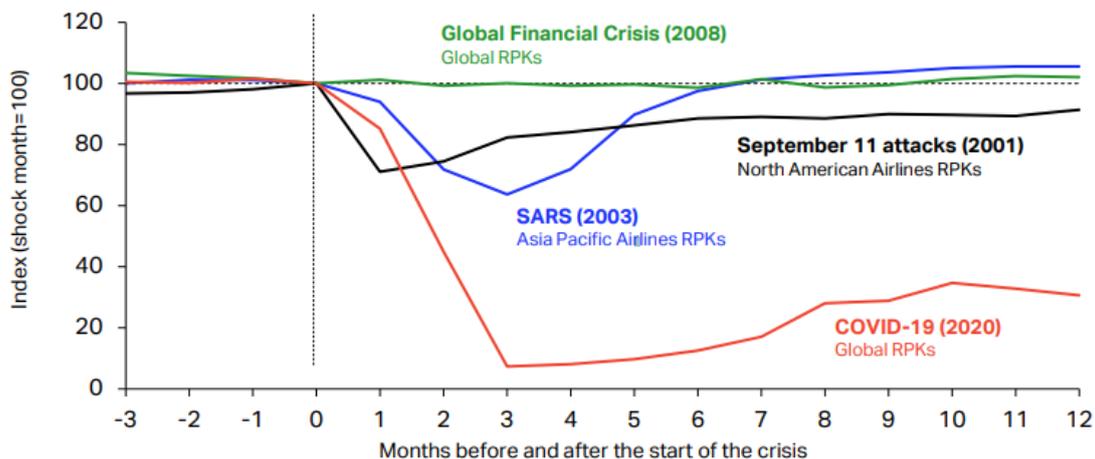


Figure 3. Comparative evaluation of the shock index, (shock month=100) (IATA, 2020)

The decrease in passenger turnover, of course, had a negative impact on airline revenues. So, if before the COVID-19 pandemic (2018-2019), the revenues of air carriers were at the level of \$ 600 billion. By the end of 2020, their total incomes have decreased three times, which is comparable to 1993 (Fig. 4).

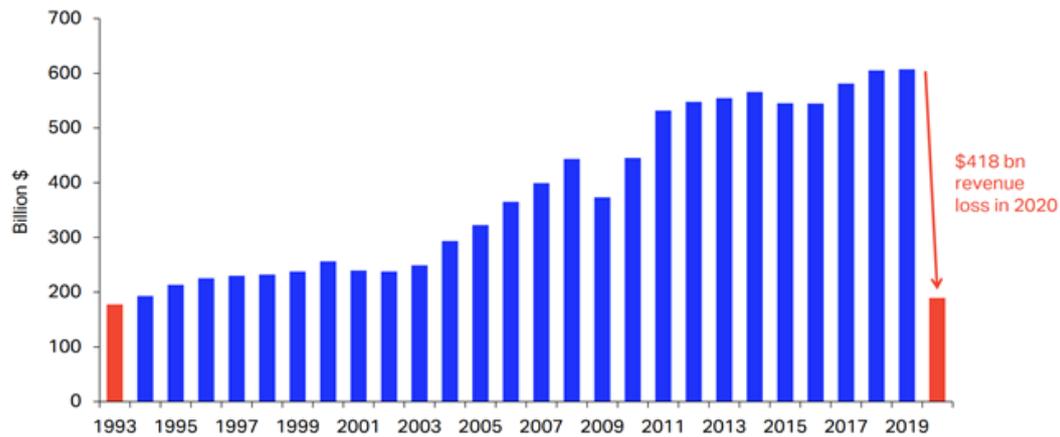


Figure 4. Dynamics of income from air transportation 1993-2020, (IATA, 2020)

The domestic aviation market of China suffered the most, which literally in three months (February-April 2019) decreased by 94% compared to the previous year, but closer to 2020 it has already recovered by 60% (IATA, 2020). Unlike the Chinese market, the European one is recovering very slowly. According to Eurostat, there were no significant signs of air travel recovery in the first months of 2021. So, in January 2021, the decline was 68% of the level of 2019, in February -73%, and in March -71%. In April, the reduction of flights was estimated at 70%. Despite the fact that in August 2021, the number of commercial flights to the EU increased by 48% compared to August 2020, this is still much lower than the *pre-pandemic* level (-31% compared to August 2019). (Eurostat, 2021).

Flight statistics at the largest European aviation hubs show a similar picture: Paris de Gaulle Airport and Amsterdam Airport handled 67% less flights, Frankfurt Airport 65% less, and Munich Airport 81% less. The decline in Barcelona was 79%, in Madrid -66%, in Rome -76%, in Vienna -76%, in Dublin -86% and Copenhagen -81% (Eurostat, 2021).

Despite the magnitude of the negative impact of the pandemic, quarantine measures have also brought positive results from the point of view of sustainable development. Thus, according to the analytical reviews of the logistics company Freight Waves, for the period 2020-2021, along with a decrease in the growth rate of the supply of carrying capacity, the loading of aircraft increased, which contributed to an increase in the profitability of airlines from cargo transportation, thereby leveling the negative effects of rising costs, for example, fuel. The highest load rates are observed in Europe (89.0%) and Latin America (85.3%) (FreightWaves, 2021).

In addition, the coronavirus pandemic has led to a record decrease in CO₂ emissions into the atmosphere, causing a *greenhouse effect* and, as a result, global warming. Thus, in the Global Carbon Project studies, it is noted that for 2020-2021, the volume of CO₂ emissions worldwide, it decreased by 2.4 billion tons (7%), which is significantly more than the previous record figures of the end of World War II – 0.9 billion tons and at the peak of the global financial crisis – 0.5 billion tons (GCP, 2021).

However, despite the presence of positive aspects, their share in the total volume is insignificant, which gives grounds to assert that COVID-19 is a global challenge requiring non-standard solutions. This is also evidenced by the forecasts of international analytical centers, according to which the restoration of international passenger traffic will be carried out at a very slow pace. It is expected that in 2021, the volume of international traffic will still represent only a small fraction of pre-crisis indicators and will not fully recover until at least 2023 (Global Ecommerce Forecast 2021).

Therefore, digital technologies and digitalization in the existing reality, according to the author (O. Polishchuk), are an effective tool for making non-standard decisions. For example, due to the digital revenue management technology *Revenue Management*, airlines, under the conditions of dynamic pricing of services, have the opportunity to differentiate services clearly according to customer requests in a short period of time. In addition, this technology allows you to create a client profile once, create personal offers, services and tariffs, as well as make changes and additions at any time if necessary. Attribution of passengers and the formation of personal profiles through the sale of additional services contribute to an increase in the volume of aviation retail and increase competitiveness.

As a tool to combat the consequences of a COVID challenge, we also consider it advisable to use online services that allow you to book a flight from any place in the shortest possible time without unnecessary risks of infection. Among the most popular digital technologies for online booking of air travel, OneTwoTrip, Online, Aviasales metasearch, Kauak (service for booking air tickets for international flights), Travelocity, Rozetka.Travel (popular in Ukraine) can be distinguished.

In the context of a pandemic, the so-called *customization* is becoming increasingly relevant in the passenger air transportation market, which involves the interaction of airlines and aircraft manufacturers in the process of cabin

layout. Thanks to the digital technologies of virtual (VR, virtual reality) and augmented reality (AR, augmented reality), it becomes possible to reproduce a full-scale mock-up of a custom version of the aircraft cabin, and then form a projection of the future design solution and test all the elements until the final assembly of the cabin. Thus, airlines can not only assess the prospects for the development of the air fleet in the medium and long term, but also manage the existing fleet of aircraft in real time in order to work out solutions for the configuration and retrofitting of the cabin.

The trends and directions of development of the global passenger air transportation market outlined above indicate that, under the conditions of current restrictions on air travel due to COVID-19, the aviation industry should show flexibility and adaptability, since the modern world, even after the end of the pandemic, will never be the same. The onset of the Fourth Industrial Revolution, combined with new challenges, dictate different rules, which are based on digitalization. Based on this, not only aviation, but the whole of humanity (present and future generations) needs to be integrated into the transformed reality of sustainable development.

4.3. Digital management technologies: management, economics of organizations and COVID-19

Speaking about digitalization in the context of management, it should be noted that it affects absolutely all spheres of society and industries, enterprises of various forms of ownership and activities, organizations, processes. Digital technologies can be aimed at management and leadership; negotiations and sales; management psychology; formation of critical thinking and personal growth; improvement of managerial qualifications, etc. Digital management technologies require new approaches to the organization of management, including flexible methodologies for project development and management; the creation of mental maps and the use of a single collective information space, etc.

Along with the urgent need to use digital technologies in management on the way to the implementation of corporate digitalization, a number of problems arise related to the unwillingness of managers, employees, consumers to integrate into the digital space, to rebuild their thinking on the course of global sustainable development.

Therefore, digitalization of management of both the enterprise and the state is, on the one hand, a challenge emanating from the external environment, and on the other, creates additional competitive opportunities in the context of the COVID-19 pandemic, against which significant transformations have taken place, leading to one of the deepest economic recessions in the world over the past 100 years. At the same time, the poles in the development of trade and services have shifted, the structure of employment has changed, etc.

On the basis of all that has been said, it follows that COVID-19 had not so much a negative impact, but rather contributed to a change in realities, redirecting the traditional foundations and understanding of production, sales, consumption, education. This fact is also noted in the reports of international organizations. In particular, the Digital economy report united nations conference on trade and development, 2019 talks about changes in consumer habits, expressed in an increase in electronic sales. For example, in the USA in the period of 2019-2020, there was an increase in online sales in the field of food delivery, pet food. Significant growth affected some items of medical products. According to Pacvue, sales of hand antiseptics and antibacterial soap have increased (Pacvue).

According to analytical studies of The COVID-19 Crisis: Accentuating the Need to Bridge Digital Divides over a ten-day period (mid-January – early February 2020), there was an increase in the volume of food products of the Chinese online retailer JD.com by 215% to 15 thousand tons (compared to the same period last year) (UNCTAD, 2020).

Changing habits due to COVID-19 will also be discussed at the upcoming 24th session of the UNWTO General Assembly (Marrakesh, Morocco, November 30 – December 3, 2021). The agenda notes that *The pandemic has revealed the importance of multimedia communications within the new reality. The current shift towards digitalization, as a result of which the habits of viewers and users are changing, and the consolidation of strategies for shifting the focus to mobile devices have accelerated since the pandemic broke out* (UNWTO, 2021).

Another area in which there has been a sharp increase in user activity over the period of 2019-2020 is streaming services. The closure of theaters, cinemas and schools to quarantine, helped attract a new audience to streaming services and video hostings such as Netflix, HBO, YouTube, etc.

Due to the spread of COVID-19 in the world, more and more people began to work remotely using video conferencing services and messengers. The demand for the use of programs such as Microsoft Teams, Skype, Cisco's Webex and Zoom has increased. Since the end of January 2020, China has seen a significant increase in the use of remote work services such as WeChat, Tencent and Ding (Fig. 5).

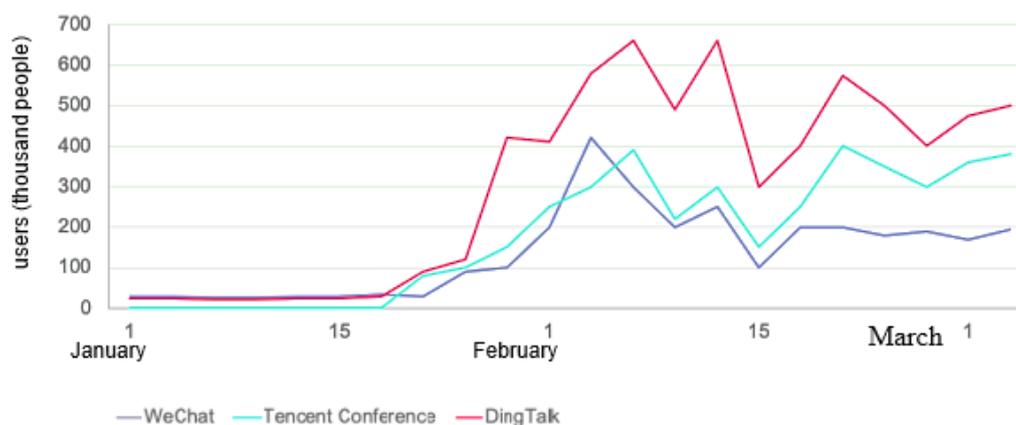


Figure 5. Dynamics of downloaded applications for remote work in China 2020 (Sensor Tower, 2020)

Digital tools and online trainings allow teachers to stay in touch with students. Digital technologies have also played a positive role in the activities of the International Organization for Migration. For example, in Belgium and France, under the conditions of the pandemic, they began to use online platforms on which citizens must register if they find themselves in a difficult situation. In Slovakia, consular offices offer a geolocation service via a SIM card in order to contact their citizens and provide them with the necessary information.

The use of online platforms stimulates the development of cloud technologies for data storage and analysis, increases the demand for renting various services of technology companies such as Amazon Web Services, Microsoft, Tencent and Alibaba.

As mentioned earlier, experts also note the positive effects of COVID-19 on the environment, which are manifested in reducing greenhouse gas emissions, improving water quality, reducing noise, improving air quality and, in some cases, restoring wildlife (GCP, 2021). At the same time, in the studies of atmospheric experts from the World Meteorological Organization, it is noted that the *positive impact* from the suspension of economic activity on the level of CO₂ in the atmosphere during a pandemic is extremely small, since the overall picture is made up of annual emissions and represents the entire volume accumulated since the pre-industrial era. On this scale, reductions in emissions in one particular year are unlikely to have an impact on global atmospheric carbon dioxide levels (WMO, 2021). Despite the presence of visible social and economic and environmental benefits obtained during the quarantine, scientists around the world note that during the same period of 2019-2020, the amount of household and medical waste increased, exacerbating the previously acute problem of waste recycling with the disposal of personal protective equipment.

Tourism in general and some digital platforms, mainly in the field of transportation and travel, such as Uber, Lyft, Didi Chuxing (transportation services), Airbnb, Booking.com (housing rental services) suffered significantly from COVID-19. This trend reflects the general decline in the travel and tourism industries during the pandemic (Fig. 6). Thus, according to UNWTO analytical data, in 2020 the number of international arrivals decreased by one billion or by 74% compared to 2019.

Regionally, the Asia-Pacific region suffered the greatest damage from the pandemic in tourism, since the strictest travel restrictions were in effect there -84% (300 million) international arrivals. In the Middle East and Africa, there was a decline of -75% (UNWTO, 2019, 2020).

Europe lost 70% of the tourist flow in 2020, while the European continent recorded the largest drop in the number of trips in absolute terms compared to 2019 -500 million. In the North and South America, the decrease in the number of foreign tourists was 69% (UNWTO, 2019, 2020). The global nature of the COVID-19 consequences in tourism industry, as well as the relevance of sustainable development, is evidenced by the upcoming 24th session of the UNWTO General Assembly (Marrakesh, Morocco, November 30 – December 3, 2021), in which (4. Thematic session: *Innovation, Education and Rural Development to Build Back Better*), issues of restarting tourism through innovation, based on digital technologies, and education for future generations will be discussed (UNWTO, 2021).

The studies of the European Union Agency for Cybersecurity have also established both positive and negative effects of COVID-19 on digital processes and components of sustainable development. The analytical report notes that, on the one hand, the growth of electronic sales contributed to the acceleration of the digital transformation of enterprises, medium and small businesses, accounting for 99% of all companies in Europe, forced to expand their online presence in order to survive under the current conditions. On the other hand, published opinion polls have shown that about 41% of Europeans are concerned about the security of online payments (EUAC, 2020).

In addition, COVID-19 has demonstrated the existing stratification both between countries and within them. According to UNCTAD's analytical data, the least developed countries are experiencing certain limitations in various areas, which are associated with the lack of Internet, which ultimately slows down digitalization. Using the example of education, it is possible to demonstrate more clearly the existing digital divide between states and students.

Thus, according to the Program for International Student Assessment, in countries such as Denmark, Slovenia, Norway, Poland, Lithuania, Iceland, Austria, Switzerland and the Netherlands, 95% of students can use a home computer, while in Indonesia this figure is only 34%. Among low-income states, more than 75% do not offer any form of distance learning, while those that do offer it, cover only 36% of residents with Internet access (PISA, 2021).

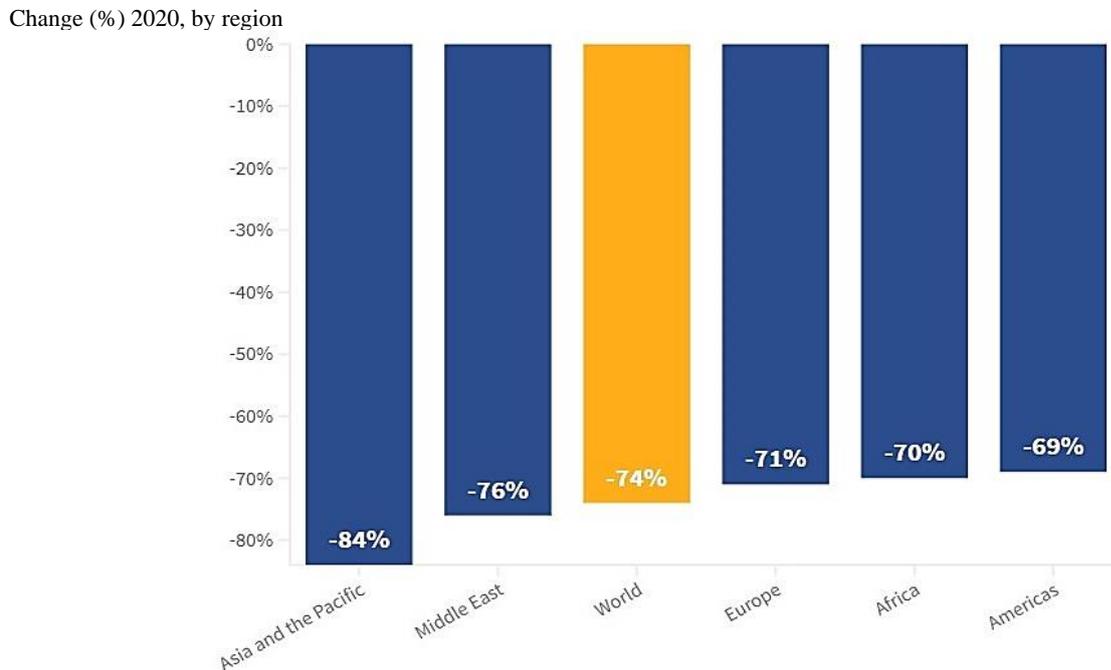


Figure 6. The level of decrease in the tourist flow in the world during the pandemic (UNWTO, 2020)

Summarizing what has been said, it should be noted that despite the efforts of the world community to jointly research the origin, behavior, and global influence of the virus, answers to many questions will be received and made public much later. Only one thing is clear, the symbiosis of digitalization, sustainable development and COVID-19 are new challenges generated by human activity that require non-standard solutions.

In this regard, the composition of non-standard digital solutions to overcome the problems associated with COVID-19, ensuring sustainable development, is presented below (Table 2).

Thus, the presented trends will allow launching new business models that can smooth out the post-covid consequences and put the world economy on a trajectory of sustainable economic growth. At the same time, digitalization is a key tool for achieving Sustainable Development Goals.

5. Conclusion

Based on the results of the research, there are theoretical and applied foundations of digitalization under the conditions of COVID-19 are formed in this article, as well as non-standard solutions for ensuring sustainable development based on digital technologies are developed.

1. As a result of a review analysis of previously conducted scientific research in the field of digital transformations, it was found that digitalization is the result of a natural evolutionary process of economic and social development, which includes computer, information and communication technologies, which made it possible to deepen the terminological apparatus of the economy and to approach the consideration of applied problems in a substantive way.
2. As a result of generalization of theoretical and analytical data, it is proved that digitalization is a conductor of economic, environmental, social, cultural and other changes affecting the life of an individual and society, as well as a necessary condition for sustainable development, which made it possible to identify the main directions of the implementation of the SDGs based on digitalization.
3. Comparative analysis of statistical indicators for the period of 2019-2020, made it possible to prove that the COVID-19 pandemic contributed to the acceleration of digitalization, as well as the fact that along with the positive impact of COVID-19 on digitalization, there is also a negative one, which gave reason to assert that the symbiosis of digitalization, sustainable development and COVID-19 are new challenges generated by human activity that require non-standard solutions.

Table 2. Non-standard digital solutions for sustainable development in the context of COVID-19, compiled by the authors according to (IDC's, 2021, Gartner, 2020)

5-year trend (2020-2025)	10-year trend (2020-2030)
<p style="text-align: center;">Accelerated transition to cloud technologies</p> <p>Transition of enterprises of various industries to cloud digital models in order to remain competitive.</p>	<p style="text-align: center;">Composite business architecture</p> <p>The transition of enterprises of various industries to a modular flexible business architecture model (<i>packaged</i> business services, data factories, private 5G networks and embedded AI, etc.), allowing organizations to move from rigid traditional planning to a flexible response to rapidly changing business needs, which creates opportunities for the introduction of innovative approaches, reduces costs and improves partnerships.</p> <p style="text-align: center;">Algorithmic trust</p> <p>The transition of enterprises of various industries to algorithmic models of trust, since enterprises and organizations can no longer fully trust management bodies and their place is taken by algorithms that ensure the confidentiality and security of data, track their origin and confirm the identity of people and things (SASE, Secure Access Service Edge), as well as by responsible and explainable AI, that is, an algorithm with traceable stages.</p> <p style="text-align: center;">Silicon-free technologies</p> <p>The transition of enterprises in various industries to carbon technologies, involving the use of new materials with expanded capabilities instead of silicon, the physical stock of which is being depleted, which make it possible to make technologies more compact and faster.</p> <p style="text-align: center;">Formative artificial intelligence</p> <p>The transition of enterprises in various industries to formative AI, which is able to change dynamically in order to respond to the situation, adapt over time to technologies that create new models for solving specific tasks (<i>small data</i> and self-monitoring training).</p> <p style="text-align: center;">Digitalization of personality</p> <p>These are the technologies of the future that integrate with people, which means that there are more and more opportunities to create digital versions of a person. These digital doubles of people can exist both in physical and virtual space, which can be used for identification, access, payment and immersion analytics. However, such an interface also represents an additional vulnerability that can be used by attackers. Among other technologies, one can note the <i>health passport</i> and digital doubles of a citizen.</p>
<p style="text-align: center;">Transition to autonomous digital operations</p> <p>The transition of enterprises of various industries to cloud ecosystems as a basic structure that will expand the capabilities of resource management and real-time analytics.</p>	
<p style="text-align: center;">Peripheral computing</p> <p>The transition of enterprises in various industries to peripheral computing and business models that will take into account changes in office work and work at home related to the pandemic, which will allow for faster and more efficient response to changing needs.</p>	
<p style="text-align: center;">Intelligent digital workspace</p> <p>The transition of enterprises of various industries to an intelligent workspace, which will allow employees to work more efficiently both on their own and on joint projects.</p>	
<p style="text-align: center;">Digital legacy of the pandemic</p> <p>Transition of enterprises of various industries to a sustainable digital infrastructure. This non-standard solution is associated with the technical debt that arose due to forced migration to the cloud space during the quarantine period, so enterprises of all industries will continue to look for opportunities to create sustainable digital infrastructures.</p>	
<p style="text-align: center;">Opportunistic expansion of digital opportunities</p> <p>The transition of enterprises in various industries to subscription models involving the acquisition of at least one startup to develop a new or adapt an existing technology.</p>	
<p style="text-align: center;">Reassessment of relationships and services</p> <p>The transition of enterprises of various industries to optimal digital strategies due to the transformation of demand, supply, logistics, etc.</p>	
<p style="text-align: center;">Eco-sustainability</p> <p>The transition of enterprises in various industries to eco-sustainable methods of doing business, based on the reuse of materials in supply chains, ensuring a zero carbon footprint and reducing energy consumption.</p>	
<p style="text-align: center;">People are still of paramount importance</p> <p>The transition of enterprises of various industries to the use of crowdsourcing and professional development/retraining of employees, the development of digital teams or DevOps groups, due to digitalization.</p>	
<p style="text-align: center;">Internet behavior</p> <p>The transition of enterprises in various industries to digital technologies for monitoring behavioral phenomena and managing data that affect them, involving face recognition, location tracking and big data, etc.</p>	
<p style="text-align: center;">Mesh network technology in cybersecurity</p> <p>The transition of enterprises of various industries to the mesh network technology, which allows getting access to any digital assets, regardless of where the asset is located or the person himself, while ensuring the security of information that is being attacked due to digital assets going beyond the firewall, especially when using cloud technologies and remote work.</p>	

- On the basis of general scientific methods, statistical, comparative and graphical analysis, a composition of non-standard digital solutions to overcome the problems associated with COVID-19 has been formed, ensuring sustainable development, which allow launching new business models capable of smoothing out the post-covid consequences and putting the world economy on a trajectory of sustainable economic growth.

References

1. EUAC, 2020, <https://www.enisa.europa.eu/news/enisa-news/tips-for-cybersecurity-when-buying-and-selling-online> (21.09.2021).
2. EUROSTAT, 2021, *Commercial air transport in August 2021: in recovery*, <https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210914-1> (21.09.2021).
3. Freight Waves, 2021, <https://www.freightwaves.com/airforwarders-freightwaves> (21.09.2021).
4. GALKIN A., POPOVA Y., CHUPRINA E., SHAPOVALENKO D., 2019, Interaction of logistics 4.0 and Consumer Oriented Marketing Using ICT, Proceedings of the 33rd International Business Information Management Association Conference *IBIMA 2019: Education Excellence and Innovation Management through Vision 2020*, 33: 6751-6760.
5. GARTNER, 2020, *Trends Drive the Gartner Hype Cycle for Emerging Technologies*, <https://www.gartner.com/smarter-with-gartner/5-trends-drive-the-gartner-hype-cycle-for-emerging-technologies-2020> (20.09.2021).
6. Global Carbon Project, 2021, <https://www.esgenterprise.com/esg-solution/sustainability-environment/> (22.09.2021).
7. Global Ecommerce Forecast, 2021, <https://www.emarketer.com/content/global-e-commerce-forecast-2021> (14.09.2021).
8. HALKIV L., KARYY O., KULYNIK I., OHINOK S., 2020, Modeling and Forecasting of Innovative, Scientific and Technical Activity Indicators Under Unstable Economic Situation in the Country: Case of Ukraine, *Communications in Computer and Information Science*, (11) 58: 79-97.
9. IATA Annual Review, 2020, https://www.iata.org/contentassets/c81222d96c9a4e0bb_4ff6ced0126f0bb/iata-annual-review-2020.pdf (18.09.2021).
10. IDC, 2021, IDC's Technology Trends For 2021, <https://www.idc.com/getdoc.jsp?containerId=US46942020> (20.09.2021).
11. Inter Systems Experts, 2021, On technologies for accelerating digital transformation: interviews with TAdviser, <http://www.tadviser/index.php/> (11.09.2021).
12. International Institute for Applied Systems Analysis (IIASA), 2019, *Initiative Report TWI 2050 «The Digital Revolution and Sustainable Development: Opportunities and Challenges. The World in 2050»*, <http://pure.iiasa.ac.at/id/eprint/15913/1/TWI2050-for-web.pdf> (12.09.2021).
13. KNICKREHM M., BERTHON B., DAUGHERTY P., 2018, *Digital Disruption: The Growth Multiplier*, https://www.accenture.com/_acnmedia/PDF-4/AccentureStrategyDigitalDisruptionGrowth-Multiplier.pdf (15.09.2021).
14. MARKOVITCH S., WILLMOTT P., 2014, *Accelerating the digitization of business processes McKinsey*, <http://www.mckinsey.com/business-functions/digitalmckinsey/ourinsights/accelerating-the-digitization-of-business-processes> (15.09.2021).
15. MARTYNOVYCH N., BOICHENKO E., VIVCHAR O., MYSKOVA N., POPOVYCH O., KASIANENKO O., 2019, Formation of Educational Level of the Population of Ukraine in the Conditions of Formation of Information Society, *International Journal of Engineering and Advanced Technology (IJEAT)*, 9 (1): 6406-6410.
16. NEGROPONTE, N., 1995, *Being Digital*, Knopf, Paperback edition, 1996, Vintage Books.
17. Pacvue, 2020, <https://www.pacvue.com/> (23.09.2021).
18. PISA, 2021, <https://www.oecd.org/pisa/> (21.09.2021).
19. Rockwell Automation, 2019, <https://www.rockwellautomation.com/en-gb/company/news/press-releases/markbottomley-andphilh-20190506-1233.html> (07.09.2021).
20. SCHWAB K., 2016, *The Fourth Industrial Revolution*, Eksmo, Moscow.
21. Sensor Tower, 2021, <https://sensortower.com/> (30.09.2021).
22. TAPSCOTT D., 1998, *Digital Economy*, McGraw-Hill, New York.
23. *The compact Oxford English dictionary: complete text reproduced micrographically*, 1991, 2nd ed., Clarendon Press, Oxford.
24. UN, 2015, *Transforming our world: the 2030 Agenda for Sustainable Development*, <https://sdgs.un.org/2030agenda> (24.09.2021).
25. UN, 2019, *The Age of Digital Interdependence. Report of the UN Secretary-General's High-Level Panel on Digital Cooperation*, <https://digitalcooperation.org/wp-content/uploads/2019/06/DigitalCooperation-report-web-FINAL-1.pdf> (12.09.2021).
26. UNCTAD, 2019, *Value Creation and Capture: Implications for Developing Countries. Digital Economy Report 2019*, https://unctad.org/en/PublicationsLibrary/der2019_en.pdf (12.09.2019).
27. UNCTAD, 2020, *The Covid-19 Crisis: Accentuating the Need to Bridge Digital Divides*, <https://unctad.org/web-flyer/covid-19-crisis> (12.09.2021).
28. UNCTAD, 2019, *Digital economy report 2019 value creation and capture: implications for developing countries*, https://unctad.org/system/files/official-document/der2019_en.pdf (21.09.2021).
29. UNCTAD, 2020, *The Covid-19 Crisis: Accentuating the Need to Bridge Digital Divides*, https://unctad.org/en/PublicationsLibrary/dtinf2020d1_en.pdf (23.09.2021).
30. UNWTO, 2021, *General assembly twenty fourth session*, <https://www.unwto.org/ru/event/general-assembly-twenty-fourth-session> (21.09.2021).
31. UNWTO, 2019, *Statistics 2020*, <https://www.unwto.org/ru/node/10067> (21.09.2021).
32. World Meteorological Organization (WMO), 2021, Governance, <https://public.wmo.int/en/about-us/governance> (21.09.2021).