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A Review of the Impact of the Digital Transformation on the Global and European Economy

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Abstract

The paper aims to present digital transformation as a process that has been taking place in the digital economy and the European Union's economy in recent years and its impact on changes in the economic and social sphere. As a starting point, this paper considers the importance of advanced technology products in the global production and trade in the global and European economy, including information and communication technologies, which constitute the primary basis for the development of the digital economy.
The paper shows that leading technologies can allow sustainable development goals (SDGs) to be achieved faster and more effectively. It is necessary to eliminate the persistent, significant income differences between developing and highly developed countries and disparities in access to the use of innovative solutions (including social innovation).

Keywords: transformation, digital economy, advanced technology products, global economy, European Union

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Introduction – The position of advanced technology products in global and European exports

Technology is a crucial factor that influences economic competitiveness in the global and European economies. High-tech industries are booming in international trade,[1] and their dynamism helps improve performance in other sectors. Investments in research, development, innovation, and skills, which are essential for economic growth and the development of the knowledge-based economy, are a key EU policy area.

In the period 2015–2018, ***advanced technology products***[2] had a relatively stable share in the total global exports of the 75 countries surveyed,[3] amounting to more than 18%, with a slight decrease in this share in 2018 compared to the previous year – from 18.75% to 18.47% (Table 1).

Table 1. Analysis of the export of advanced technology products for 75 countries, considering 10 product groups (including group 891: arms and ammunition), USD billion, %

YEAR	2015	2016	2017	2018
Export of all products	15 026,6	14 634,6	16 063,3	17 538,6
Export of advanced technology products	2 804,2	2 738,1	3 011,2	3 238,6
Export dynamics (previous year = 100%)	100,00	97,64	109,97	107,55
Export dynamics (2015 = 100%)	100,00	97,64	107,38	115,49
The share of exports of advanced technology products in the export of all products	18,66	18,71	18,75	18,47
Export dynamics (previous year = 100%)	100,00	100,25	100,19	98,51
Export share dynamics (2015 = 100%)	100,00	100,25	100,45	98,95

Note: The number of countries depends on the availability of data for ten selected product groups; all data for the group of selected countries.
Source: UN COMTRADE database.

Table 2 presents the analysis of the export of advanced technology products for 26 European Union (EU) countries (excluding Romania and Slovenia due to a lack of data), considering 10 product groups.[4] Based on these results, we can conclude that throughout the analyzed period of 2015–2018, the value of exports of advanced technology

1 See Table 1.

2 Excluding group 891: arms and ammunition.

3 Own study – data according to UN Comtrade database. Calculations of export trends of advanced technology products in selected countries of the world and the European Union in 2015–2018 – according to the UN international commodity nomenclature – *Standard International Trade Classification, (SITC) Rev.3 for High-Skill and Technology Intensive Manufactures, which include the goods of section 5, divisions 75; 76; 87; 88 and groups: 776; 792; 891; 892; 896; 897* – The Least Developed Countries Report 2014 UNCTAD, *Growth with structural transformation: A post–2015 development agenda*, https://unctad.org/system/files/official-document/ldc2014_en.pdf (accessed: 1.08.2018) p. XII. The surveyed countries in this study are 75 countries of the world that reported their data on the export of technologically advanced goods to the UN Comtrade database.

4 Excluding group 891: arms and ammunition.

products in the EU systematically increased, reaching a peak in 2018 of USD 732.5 billion. The dynamics of their exports in 2018, compared to 2015, rose to the level of 115%. It should be noted, however, that although the share of the analyzed products in the trade of the surveyed EU countries (excluding Romania) was characterized by an upward trend in 2015–2017, it decreased in 2018, from 12.26% to 11.90% (Table 2).

The share of exports of advanced technology products in EU exports in the analyzed period was approx. 6 percentage points lower than the share of this product group in the world trade. This resulted i. a. from the growing position of mainly Asian countries in the production and export of goods with a higher degree of processing and technology content. According to the European Innovation Ranking, published by the European Commission in 2019, South Korea and Japan's positions deserve particular attention (European Commission 2020b; see also: Komisja Europejska 2019).

Table 2. Analysis of the export of advanced technology products for 26 selected European Union countries*, considering 10 product groups (including group 891: arms and ammunition), USD billion, %

YEAR	2015	2016	2017	2018
Export of all products for 27 selected countries	5 143,0	5 148,1	5 637,9	6 155,2
Export of advanced technology products	637,0	643,8	691,0	732,5
Export dynamics (previous year = 100%)	100,00	101,06	107,33	106,01
Export dynamics (2015 = 100%)	100,00	101,06	108,47	114,99
The share of exports of advanced technology products in the export of all products	12,39	12,51%	12,26	11,90
Export share dynamics (previous year = 100%)	100,00	100,96	98,01	97,11
Export share dynamics (2015 = 100%)	100,00	100,96	98,95	96,08

Note: all data for the group of selected countries.

* No complete data for Romania and Slovenia
Source: UN COMTRADE database.

Export of advanced technology products

In 2019, the EU–27 countries exported almost a quarter of advanced technology products to the United States (24.7%), followed by China (11.7%) and the United Kingdom (11.0%). Exports increased from €188 billion to €382 billion between 2009 and 2019, which meant an average annual growth rate of 7.4%. Among the six largest partners of the EU–27, exports to the United States increased the most in absolute terms, from €36 billion to €94 billion, while exports to China showed the highest average annual growth rate (12.9%).

Pharmacy represented the most considerable value in the export of advanced technology products in 2019 (€91.7 billion). It was also the group with the highest average annual growth rate (12.9%) between 2009 and 2019. Growth rates above 5% were also

observed in the export of aerospace (9.4%), scientific instruments (7.6%), and electrical machinery (5.8%). Lower growth rates were recorded in the groups of computers and office machines (2.2%), non-electric machinery (2.9%), chemistry (3.1%), armament (3.8%), and electronics-telecommunications (4.9%). In 2019, pharmacy was the most important group of high-tech products in EU–27 exports to the United States, Switzerland, Japan, and Russia. The USA was the leading partner in EU–27 exports in as many as seven categories, including electronics-telecommunication (next to China). In exports to Great Britain, computers and office machines was the leading product group (based on Eurostat 2021).

The 2019 trade deficit with China was mainly due to deficits in electronics-telecommunications (-€48 billion) and computers and office machines (-€39 billion). The trade surplus with the UK was broken down into more groups, the four largest of which were pharmacy (€4 billion), electronics-telecommunications, scientific instruments, and computers and office machines (all three €3 billion). In the case of the United States, there was both a large deficit in aerospace (-€14 billion) and an even more significant surplus in the group of pharmacy (€18 billion) (Eurostat 2021).

Summary:

- The production of advanced technology products in the EU showed a marked increase from €288 billion to €337 billion between 2008 and 2018.
- Between 2015 and 2018, the value of export of advanced technology products in the EU grew steadily, reaching the apogee in 2018 of €732.5 billion. The 2018 dynamics of exports, compared to 2015, increased to the level of 115% (similar to the analyzed global export of 75 world countries). The share of advanced technology products in the EU was stable at approx. 12%.
- The largest part, almost a quarter of the export of advanced technology products from EU countries, was sent to the United States, and then to China and Great Britain (approx. 11%). The export increased from €188 billion to €382 billion in the analyzed decade, corresponding to an average annual growth rate of 7.4%.
- There was a relatively large deficit in the EU trade in advanced technology products with China. The second partner for which the EU recorded a trade deficit was Vietnam, while a trade surplus with the United Kingdom, the United States, and Russia was observed.

The impact of digital technologies on economic and social development

Digitization has transformed economic activity worldwide in recent years, thanks to radically reduced costs of collecting, storing, and processing data and significantly increased computing power.[5]

5 Own study based on: UNCTAD 2017b; 2018a, pp. 1–30; 2019.

UN reports show the scale of new opportunities that the development of the digital economy allows, including assistance to smaller companies in developing countries in accessing the global market, which allows for more effective integration with the global market and creates new opportunities to generate income. Information and communication technologies (ICT), e-commerce, and new digital applications are used to promote entrepreneurship, including women's empowerment as entrepreneurs and traders, and to support creative and innovative production activities and create attractive new jobs. Also, mobile and digital solutions contribute to facilitating financial integration. Through access to the Internet, small companies in developing countries may have a chance to access various services "in the cloud" and obtain funding for their activity on Internet platforms.

However, UNCTAD (United Nations Conference on Trade and Development) experts say that many developing countries, particularly the Least Developed Countries (LDCs), are still too poorly prepared to take advantage of the many opportunities that digitization presents. There is also a risk that digitization will increase polarization and worsen income inequality, as significant gains in labor productivity can be mainly generated by a narrow group of highly skilled professionals (UNCTAD 2019). High dynamics of development are typical of economies that largely use internet platforms, where operation brings significant benefits, especially to first contractors. Indeed, the top four companies in the world (by market capitalization) – Apple, Alphabet (Google), Microsoft, and Amazon – are closely linked to the digital economy (based on UNCTAD 2017a). There are also concerns about how data flows are used in the context of privacy and online security issues. The rapid pace of evolution of the digital economy results from technologies and innovations that have developed over several decades and are becoming increasingly common. High-speed broadband access to increasing computing power, storage, and lowered ICT hardware and data management costs have facilitated the digitization process. The key technologies underpinning the growing digital economy are advanced robotics, artificial intelligence, the Internet of Things (IoT), cloud computing, big data analytics, and three-dimensional (3D) printing.

Global digital platforms have taken many steps to strengthen their competitive position, including acquiring potential competitors and expanding into new markets. The most important achievements are the acquisition of LinkedIn by Microsoft and WhatsApp by Facebook. Alphabet (Google) and Microsoft have invested in telecommunications equipment, buying Motorola and Nokia, respectively. Major platforms have also made other significant acquisitions in the retail, advertising, and marketing industries, entering the non-residential real estate markets. Other steps include strategic investment in research and development (R&D) and lobbying in national and international decision-making circles. At the same time, strategic partnerships between multinational enterprises (MNEs) in traditional sectors are explored. For example, Walmart cooperates with *Google* to use Google Assistant; Ford and Daimler joined Baidu on the Apollo platform; Google has built the Android Automotive plat-

form with Volvo and Audi. Intel and Facebook are working together to develop a new Artificial Intelligence.[6]

The economic geography of the digital economy does not follow the traditional North-South division. It is consistently led by one highly developed and one developing country: The United States and China. These two countries account for 75% of all blockchain patents,[7] 50% of global IoT spending, and over 75% of the global public cloud computing market. These two countries hold 90 percent of the world's 70 largest digital platforms' capitalized market value. Europe's share is 4%, while Africa and Latin America together have only 1%. The seven 'super platforms' – Microsoft, Apple, Amazon, Google, Facebook, Tencent, and Alibaba – account for two-thirds of the total market value. Therefore, in many digital technologies, the rest of the world, especially Africa and Latin America, lag far behind The United States and China (UNCTAD 2019, p. 3).

The diversified pace of development of the digital economy in different regions of the world

In 2015, the global production of ICT goods and services accounted for around 6.5% of global gross domestic product (GDP), and approximately 100 million people are employed in the ICT services sector alone. The export of ICT services increased by 40% between 2010 and 2015. Global e-commerce sales in 2015 reached USD 25.3 trillion, 90% of which was in the form of business-to-business e-commerce and 10% in the form of business-to-consumer (B2C) sales. UNCTAD estimates that B2C cross-border e-commerce was worth around USD 189 billion in 2015, which corresponded to 7% of total B2C e-commerce. Sales of robots also peaked, and the worldwide shipments of 3D printers more than doubled in 2016 to over 450,000, approaching 6.7 million in 2020. Global Internet access in 2019 had increased 66-fold compared to 2005.

At the same time, it is important to monitor the geographic structure of the online business. Although the number of Internet users increased by 60% between 2010 and 2015, more than half of the world's population remained offline. Broadband Internet in developing countries, if available, is relatively slow and expensive, limiting businesses' and individuals' ability to use it productively. Only 16% of the world's adult population used the Internet to pay bills or purchase goods. And while more than 70% of the population in several developed countries has already purchased

6 UNCTAD 2019, pp. 6–9.

7 *Blockchain* is a decentralized and dispersed database in an open-source Internet network with a peer-to peer (P2P) architecture without central computers and without a centralized place of data storage, used for recording individual transactions, payments, or accounting entries, encoded using cryptographic algorithms. In fact, *blockchain* is a kind of decentralized and dispersed register of transactions, or in other words, it is a decentralized transaction platform in a dispersed network infrastructure. *Blockchain* is a public and open register that can be accessed by anyone, Rochowicz 2018; see also: UNCTAD 2019, p. 6.

goods and services online, the equivalent share in most LDCs was only 2% (UNCTAD 2017b, pp. 1–2).

Meanwhile, most micro, small, and medium-sized enterprises (MSME) in developing countries are still poorly prepared to take advantage of the digital economy. Small businesses tend to use the Internet to sell online much less frequently than large companies. Only 4% of all 3D printers are used in Africa and Latin America. The use of robots is also very limited in most developing countries, except for some countries in Asia where they are used quite widely. As the digital economy evolves, there is a greater need to ensure that as many people and companies as possible in developing countries can benefit from the digital economy.

Depending on the definition of the digital economy, estimates of its size range from 4.5 to 15.5 percent of global GDP. In terms of value-added estimates in the ICT sector, the United States and China together account for almost 40%. However, in terms of GDP share, this sector is the largest in Taiwan, Ireland, and Malaysia. Global employment in the ICT sector increased from 34 million people in 2010 to 39 million in 2015, with computer services accounting for the largest share (38%). The share of the ICT sector in total employment increased from 1.8% to 2% over the same period (UNCTAD 2019, pp. 15–17).

Digital technologies have a significant impact on the development of the Micro, Small, and Medium-sized Enterprises (MSME) sector, especially in developing countries. It means they have a chance to present their offer on the digital platform and better access to the global market. It allows companies to reduce costs, streamline their supply chain, and more easily sell products and services worldwide.

The ability of countries and businesses to use new digital resources has become a key determinant of competitiveness. However, the overall impact of digitization can vary widely between countries and economic sectors. This makes it increasingly important for governments to provide them with a sufficient supply of skilled workers with strong cognitive, adaptive, and creative abilities necessary to operate modern devices in the ICT sector.

In developing the digital economy, the need for international cooperation in today's world is increasing, mainly to prevent adverse effects leading to the widening of digital divides and the generation of even bigger income inequalities.

Digitization creates many new opportunities for entrepreneurs and businesses, as well as benefits for consumers. An example of this is the global development of e-commerce. Consistency with international commitments such as the 2030 Agenda for Sustainable Development requires international efforts to ensure that no country is left behind in the digital transition.[8]

8 For more on this topic, see UNCTAD 2018b.

The growing role of e-commerce

Although e-commerce is an integral part of the developing digital economy, its effects are still difficult to measure. The development of global e-commerce illustrates how the increased use of ICT is reshaping production and trade, which significantly impacts developing countries. Official statistics on leading e-commerce markets, including business-to-business and business-to-consumer e-commerce, show that global e-commerce has reached USD 25.3 trillion.

China has become the world's largest e-commerce market for individual customers (USD 617 billion), followed closely by the United States (USD 612 billion). The United States, on the other hand, has the largest B2B market worth more than USD 6 trillion and is far ahead of Japan (USD 2.4 trillion) in this respect. No developing or transforming economy, except China, was placed in the top ten e-commerce markets in 2015 (UNCTAD 2018b, pp. 1–3).

The business-to-business segment currently has the largest share in the e-commerce market, while the business-to-consumer segment is growing rapidly. In fact, in most developing and transition countries, online shoppers make up a small fraction of all internet users. Unlike social networks, where activity rates are relatively high among Internet users in developing countries, the percentage of Internet users engaging in e-commerce is much lower. It may reflect limited purchasing power and inhibiting factors such as a lack of confidence and limited purchasing possibilities, including the lack of local language content and unsatisfactory level of delivery and payment services (UNCTAD 2018b, pp. 1–3).

The 2017 value of global e-commerce was estimated at USD 23.8 trillion, based on a revised methodology. The value of global B2B e-commerce in 2018 was USD 21 trillion, representing 83% of all e-commerce, comprising both sales on online market platforms and electronic data interchange transactions. B2C e-commerce was valued at USD 4.4 trillion, up by 16% from 2017. Cross-border B2C e-commerce sales amounted to USD 404 billion in 2018, representing an increase of 7% over 2017. The United States continued to dominate the overall e-commerce market, remaining among the top three countries by B2C e-commerce sales, alongside China and the United Kingdom. Together they had more than 1.4 billion people shopping online in 2018 (UNCTAD 2020).

The idea and concept of the European Union's Digital Single Market

On May 20, 2010, the European Commission published a report entitled "A new strategy for the single market – at the service of Europe's economy and society" to supplement the Europe 2020 strategy. The purpose of this document was to identify the need to develop a comprehensive strategy for the European Single Market, covering all the policies con-

cerned, including **digital policy**. The report also identifies several initiatives to support the Single Market by removing significant barriers to its operation. The Commission's report and the resolution of the European Parliament of May 20, 2010, on bringing the single market closer to consumers and citizens (Rezolucja Parlamentu Europejskiego w sprawie przybliżenia jednolitego rynku konsumentom i obywatelom 2010) provided the basis for the Communication entitled "Towards a Single Market Act", in which the Commission put forward a series of measures to boost the EU economy and create jobs (Komunikat Komisji do Parlamentu Europejskiego, Rady, Europejskiego Komitetu Ekonomiczno-społecznego i Komitetu Regionów 2010). With reference to its Communication of January 11, 2012, entitled "A coherent framework for building trust in the Digital Single Market for e-commerce and online services" (Komunikat Komisji do Parlamentu Europejskiego, Rady, Europejskiego Komitetu Ekonomiczno-Społecznego i Komitetu Regionów 2012), the Commission published in June 2012 a Communication on "Better Governance for the Single Market" (Komunikat Komisji do Parlamentu Europejskiego, Rady, Europejskiego Komitetu Ekonomiczno-Społecznego i Komitetu Regionów 2012b), which proposed focusing on sectors with the highest growth potential, including network sectors (e.g., energy and telecommunications). In October 2012, the Commission presented a second set of proposals called the Single Market Act II . It included 12 core actions that focused on the four main drivers of economic growth, increasing employment and confidence: integrated networks, cross-border mobility of citizens and businesses, the digital economy, and actions to strengthen consistency and enhancing consumer benefits (Komunikat Komisji do Parlamentu Europejskiego, Rady, Europejskiego Komitetu Ekonomiczno-Społecznego i Komitetu Regionów 2012c).

On May 6, 2015, the Commission adopted the Digital Single Market Strategy based on three pillars: 1) providing consumers and businesses with easier access to digital goods and services across Europe; 2) creating appropriate and equal conditions for the functioning of digital networks and innovative services to flourish; 3) maximizing the growth potential of the digital economy.

The Digital Single Market Strategy aims to address several challenges of digitizing European society, but its overarching goal is to facilitate cross-border e-commerce in the EU. It is broadly in line with the European Parliament's long-promoted initiatives to achieve the Digital Single Market, which essentially removes national barriers to online transactions.

The authors of the document entitled "Contribution to economic growth: The European Digital Single Market. Economic benefits for citizens and businesses. A study commissioned by the IMCO Commission, the European Parliament", identified around €177 billion in potential annual economic gains (in current euro value) from the full implementation of legislative measures introduced or envisaged to be adopted. It corresponded to 1.2% of current (2017) GDP, based on European Commission estimates (Scott Marcus, Petropoulos, and Yeung 2019, pp. 8–12).

However, the Digital Single Market Strategy primarily aims to strengthen the EU in many ways. Most of the benefits of implementing this strategy come from (1) sup-

porting the digital single market or (2) further promoting the digitization of the EU. It is foreseen that the cross-border electronic ordering of both physical and virtual goods and services in the Digital Single Market would be as easy and cost-effective as at the national level. Likewise, many e-government services, including health and business start-up services, would be as easy and cost-effective cross-border as domestically. Thus, the benefits of the single market can lead to lower prices, broader choice possibilities, and greater convenience for consumers, economies of scale, and increased competitiveness of the EU compared to global trading partners.

A fully implemented Digital Single Market can contribute to the better use of digital technology than is currently the case in the EU. High-speed broadband, mobile services (5G), artificial intelligence, robotics, big databases, machine learning, the Internet of Things, cloud computing, and blockchain technology are likely to play transformative roles in the EU economy and society. Comprehensive digitization of the EU is expected to increase productivity, lower transaction costs, increase the innovativeness of products, services, and processes, and make the EU more competitive in the global market.

Therefore, the EU's transformation through digitization depends on adopting a range of technologies, such as artificial intelligence, robotics, big data, machine learning, the Internet of Things, and blockchain. Most estimates of future global benefits amount to trillions of euros per year; thus, the EU is potentially on the verge of a truly transformational change.

The cumulative benefits of adopting the legislation proposed under the Digital Single Market Strategy result from two different but overlapping dimensions: the benefits of the single market and the benefits of digitalization (Scott Marcus, Petropoulos, and Yeung 2019, pp. 11–12).

The idea behind the Digital Single Market is essentially to remove all national restrictions on internet transactions. The idea is based on the single market concept: to eliminate trade barriers between the Member States to increase economic prosperity and create "even closer ties between the peoples of Europe." This idea was then transformed into the concept of the internal market, defined as "an area without internal frontiers within which the free movement of goods, persons, services, and capital is ensured". The European Commission has also published conclusions that explain the rationale behind the future single market concept for online platforms (Komunikat Komisji do Parlamentu Europejskiego, Rady, Europejskiego Komitetu Ekonomiczno-Społecznego i Komitetu Regionów 2016).

Therefore, the Single European Digital Market is a market in which the free movement of people, services, and capital is ensured. Also, natural persons and enterprises can easily access and engage in online activities under fair competition conditions and a high level of consumer and personal data protection regardless of their nationality or place of residence.[9]

9 Articles 4(2)(a), 26, 27, 114 and 115 of the Treaty on the Functioning of the European Union (TFEU); see also: Ratcliff, Martinello, and McGourty 2021.

The concept of digitization of the European industry

To ensure a fair, open, and secure digital environment, the European Commission has identified three main emerging challenges:

- ensuring that online platforms can continue to benefit the economy and society,
- developing the European economy based on widely available databases (Big Data),
- protecting Europe by addressing cybersecurity challenges.

Europe's industry digitization tools can help companies, researchers, and public authorities make the most of new technologies by combining national and regional initiatives and boosting investment through strategic partnerships and networks.

The industry is one of the pillars of the European economy, as the manufacturing sector in the EU comprises 2 million enterprises, 33 million jobs, and 60% growth of productivity. The world is on the brink of a new industrial revolution, driven by next-generation information technologies such as the Internet of Things (IoT), cloud computing, databases (big data), robotics, and 3D printing. It opens new horizons for the industry to become more efficient and capable of producing innovative products and services. It is estimated that the digitization of products and services could generate over €110 billion in annual revenues for the European economy over the next five years.

The European industry is strong in digital sectors such as automotive electronics, security, and energy markets, telecommunications equipment, business software, and laser and sensor technologies. Europe also has world-class research and technology institutes. However, high-tech sectors face severe competition from other parts of the world, and many traditional industries and small and medium-sized enterprises (SMEs) are lagging. There are also significant differences in digitization between EU regions (European Commission 2020a, n.d.).

Financing the EU digitization program

It is estimated that the EU digitization program should mobilize up to €50 billion in public and private investment for the digitization of industry, including:

- €37 billion of investment for digital innovation.
- €5.5 billion of national and regional investment in digital innovation hubs.
- €6.3 billion for the first production lines of next-generation electronic components.
- €6.7 billion for the European Cloud Initiative.

The European Commission is also planning to build the European Big Data Economy. The initiative aims to enable the best use of the potential of digital data for the benefit of the economy and society. To achieve this, the Commission intends to unlock the potential for reusing different types of data and facilitate free movement across borders to realize the idea of a European Digital Single Market.

The *data economy* value in the EU amounted to over €285 billion in 2015, which represents over 1.94% of EU GDP. Due to the annual growth rate of 5.03%, this value grew to €300 billion, representing 1.99% of GDP in 2016. If put in place in time, the favorable political and legislative conditions would make incentives to invest in ICT. The European data economy's value could then rise to €739 billion by 2020, reaching 4% of total EU GDP.

Promoting the reuse of public data and publicly funded data is also planned.

The public sector in the EU is one of the most data-intensive (and database-driven) sectors in the global economy. Huge amounts of data are stored, known as public sector information, which can be reopened, depending on the national access systems. The reuse of this data can contribute to the growth of the European economy, artificial intelligence development, or help address societal challenges.

On January 22, 2019, negotiators from the European Parliament, the EU Council, and the Commission agreed on the revised directive. The newly adopted Directive on Open Data and Public Sector Information aims to:

- Identify (through an implementing act) a list of high-value data sets, such as geospatial or statistical data, to be made available free of charge. These datasets have high commercial potential and can accelerate the emergence of EU-wide value-added information products and services and the development of artificial intelligence;
- Stimulate the publication of dynamic data and the use of APIs (application programming interfaces);
- Limit the exceptions that currently allow public authorities to charge higher than the marginal dissemination costs to reuse their data.[10]

Assessment of the need for further action on accessing and reusing private-sector data

In its Communication "Towards a Common European Data Space", the Commission defines several principles that need to be considered for data sharing to be successful for all parties involved, between enterprises (B2B – Business to Business) and between enterprises and Governments (B2G – Business to Government).

The European Commission has identified as the key goals:

- Ensuring fair and competitive markets for IoT objects and products and services that rely on non-personal data generated by dedicated devices. The Commission proposes several draft rules that companies should consider when drafting their contracts.
- Helping public authorities access and reuse private sector data to guide policy decisions or improve public services.

10 Own study based on: European Commission n.d.

It also believes that adhering to the principles set out in the Communication would support the provision of private-sector data on preferential terms.

The European Commission discusses with stakeholders to assess whether these principles and possible codes of conduct in B2B and B2G data-sharing agreements are sufficient to achieve their goals and take appropriate action if needed.

Removing data location restrictions: the free flow of data

The free flow of data means the freedom to process and store data in electronic format anywhere in the EU. This is essential for the development and use of innovative data technologies and services. Consequently, the Free Flow of Non-Personal Data Regulation is the cornerstone of the Common European Data Space. This regulation introduces the principle of the free flow of non-personal data across borders into EU law, thus establishing the free movement of non-personal data as is done by the General Data Protection Regulation.

In addition to the free flow of non-personal data in the EU, the measures announced in "Towards a Common European Data Space" will unleash the full power of the EU data economy and contribute to the competitiveness of European businesses by modernizing the *online services market*.

The Digital Single Market Strategy supports *open science and open access to scientific results*. The aim is to provide European science, industry, and public authorities with access to excellent digital infrastructure – *supercomputers and databases*.

The European Commission invests in world-class ICT research and innovation to boost economic growth and job creation. It encourages the creation of innovative public-private partnerships to stimulate innovation in Europe, while the research funding programs under "Horizon 2020" provide opportunities to promote excellence in ICT research.

The digital infrastructure offers researchers easy and controlled online access to facilities, resources, and collaboration tools, providing them with ICT capabilities for data processing, connectivity, data storage, and access to virtual research environments. New digital tools for scientific collaboration through Open Science make research more efficient, transparent, accessible, and effective.

The Commission is also working on initiatives to stimulate innovation in Europe by strengthening the ICT ecosystem and supporting European researchers, businesses, and entrepreneurs. It also invests in new technologies with forward-looking ideas and long-term research.

Robotics technologies help Europe maintain and develop a competitive manufacturing sector with millions of jobs; they also offer new solutions to societal challenges, from good aging to health, intelligent transport, security, energy, and the environment.

However, there are still some barriers to the functioning of the Digital Single Market, and the EU is seeking further harmonization, including:

- fragmented national tax systems,
- separate national markets for financial services, energy, and transport,
- e-commerce rules, standards, and practices differing in individual EU countries,
- complex rules regarding the recognition of professional qualifications (European Commission n.d.).

Conclusions

In conjunction with efforts to eliminate the persistent gaps between developed and developing countries in their access to existing innovative solutions, the use of leading technologies may allow more effective achievement of the SDGs.

Supporting these new ideas is linked to the prospect of finding solutions for sustainable development that are better, cheaper, faster, and easy to use. It is beneficial to link the impact of technological progress with the progress in ICT, including in low-income economies, which, in terms of improving the condition of the environment, is visible based on the effects of the development of the renewable energy sector. However, new technologies often raise concerns, especially among policymakers, about societies' ability to adapt to the changes they cause, which often causes concern and even hostility towards certain technological developments.

The rapidly accelerating pace of development in recent years (2014–2017) and the adoption of new technologies in recent decades were mainly due to: a) the emergence of digital platforms – particularly the Internet; (b) the cumulative nature of technological changes; c) the convergence of technologies into new combinations; d) significant cost reductions.

The purpose of these changes is primarily to increase the key potential for achieving the sustainable development goals according to UN Agenda 2030.

Big Data Analytics (Big Data) can help manage or solve critical global problems, create new scientific breakthroughs, improve human health, and streamline decision-making by delivering real-time information streams. The Internet of Things makes it possible to monitor and manage the processes and activities of connected objects and machines, and more effectively monitor the world of nature, animals, and people. These two technologies have important applications in healthcare, agriculture, energy, water, and quality management, as well as in monitoring development indicators to measure progress towards the SDGs. Governments should, therefore, consider developing strategies to use these technologies for their development goals.

Artificial Intelligence is capable of image recognition, problem-solving, and logical reasoning that are sometimes beyond human capabilities. Artificial intelligence, especially when combined with robotics, also has the potential to transform production processes and economic activities, especially in the manufacturing industry. The same is true of 3D printing, which enables faster and cheaper production of smaller quantities of complex products and components and rapid iterative prototyping

of new products. In addition to potentially reducing CO_2 emissions by eliminating the need to transport elements, 3D printing can also benefit healthcare, construction, and education.

Rapid advances in biotechnology allow for the precise analysis of the human genome and the study of genes in medicine, enabling personalized treatment under specific conditions in conjunction with artificial intelligence and big data analysis. They also allow for the genetic modification of plants and animals.

Nanotechnology – i.e., the production and application of materials on an infinitely small scale – has important applications in the water supply (water purification), energy-saving (storage of batteries), agriculture (precise agrochemical substance release management), ICT sectors, in the miniaturization of the size of electronic components, and in medicine (drug delivery mechanisms). Renewable energy technologies enable electricity provision in remote and isolated rural areas inaccessible to centralized grid systems. Drones can revolutionize the supply of materials, facilitate precision farming, and replace people in hazardous tasks. Inexpensive custom satellites will soon be available to more developing countries and their businesses and universities, enabling them to monitor yields and environmental damage.

The new EU Research Framework Program – Horizon Europe 2021–2027 – foresees a continuation of activities that were already present in Horizon 2020, such as ICT innovations for SMEs in the manufacturing sector. The European Commission has proposed allocating €100 billion from the EU budget, while the European Parliament and EU Council reached a provisional agreement in spring 2019 on the principles and financing of Horizon Europe.

Activities aimed at companies cooperating with Digital Innovation Hubs (DIHs) to experiment and test innovative digital solutions to improve their operation are becoming very important here. Organizations participating in pre-investment test experiments will be eligible for funding. European DIHs that integrate science, business, public institutions, and NGOs will participate in these projects, as will other types of DIHs or knowledgeable organizations.

After 2020, the European Regional Development Fund (ERDF), through inclusion in the EU's Smarter Europe Program, can also support the construction and modernization of DIHs, especially in the purchase of hardware, infrastructure, and software, in providing services to SMEs and the sector public, etc., provided that their objectives are to: (i) increase research and innovation capacity and the uptake of advanced technologies; (ii) allow citizens, businesses and governments of the Member States to reap the benefits of digitization; (iii) enhance the growth and competitiveness of SMEs by building local innovation ecosystems; or (iv) develop skills for smart specialization, industrial transformation, and entrepreneurship. The area of operation of digital innovation hubs usually covers the local economy. A prerequisite for ERDF investments in DIHs is that they will be re-mentioned in the partnership agreements and operational programs used to manage funds in EU regions.

New to the future ERDF program is also encouraging interregional investment through the new INTERREG Innovation Investment Facility. It means that several regions (possibly from different Member States) may also decide to jointly invest in Digital Innovation Hubs in the near future.

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Przegląd wpływu transformacji cyfrowej na gospodarkę światową i europejską

Celem artykułu jest prezentacja rozwoju transformacji cyfrowej jako procesu mającego miejsce zarówno w gospodarce cyfrowej jak i w gospodarce Unii Europejskiej w ostatnich latach i jej wpływu na przekształcenia w sferze ekonomicznej i społecznej. Jako punkt wyjścia do rozważań w tym artykule przyjęto znaczenie pozycji towarów zaawansowanych technologicznie w produkcji i handlu światowym w gospodarce globalnej i europejskiej, w tym szczególnie technologii informacyjnych i komunikacyjnych, stanowiących podstawową bazę do rozwoju gospodarki cyfrowej.
W artykule wykazano, że wykorzystywanie wiodących technologii – w połączeniu z działaniami mającymi na celu wyeliminowanie utrzymujących się znacznych różnic dochodowych między krajami rozwijającymi się i wysoko rozwiniętymi oraz różnic w dostępie do korzystania z innowacyjnych rozwiązań (w tym innowacji społecznych) – może pozwolić na szybsze i skuteczniejsze osiągnięcie celów zrównoważonego rozwoju.

Słowa kluczowe: transformacja, gospodarka cyfrowa, produkty zaawansowane technologicznie, gospodarka światowa, Unia Europejska

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