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# Digital Integration and Green Economy for the Transition to Industry 5.0

Joanna Kotowicz-Jawor*
Halyna Matviienko**

ABSTRACT

The purpose of the article is to study the integration of digitalization and the Green Economy, identifying the characteristics of their combination and development, and generating recommendations to achieve a positive synergistic effect and to accelerate the transition to Industry 5.0. The article is dedicated to the combination of Green Economy and digitalization, which leads to the emergence of completely new features in the Economy. The relevance of the topic is determined by the fact that the use and development of human capital, the Green Economy and digitalization can have an important synergistic effect with the emergence of new characteristics, with both positive and negative consequences, and affect the achievement of the goal. sustainable development. Research methods: analysis and synthesis, abstraction and generalization, a systematic approach to the analysis of the Green and Digital Economy, economic-statistical and mathematical analysis. The article identifies the fundamental risks of the digitalization of the Economy, being the main ones: the depletion of limited resources, electronic waste, the deepening of asymmetric development.

KEY WORDS: Industry 5.0, digitalization, raw materials, e-waste recycling, Green Economy, asymmetric development.

*The Institute of Economics Polish Academy of Sciences, Warsaw, Poland. ORCID ID: https://orcid.org/0000-0002-4511-9107. E-mail: Joanna.Kotowicz@inepan.waw.pl

**V. I. Vernadsky Taurida National University, Kyiv, Ukraine. ORCID ID: https://orcid.org/ 0000-0002-5265-8379. E-mail: matviienko.halyna@tnu.edu.ua

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# Integración digital y Economía verde para la transición a la Industria 5.0

RESUMEN

El propósito del artículo es estudiar la integración de la digitalización y la Economía verde, identificando las características de su combinación y desarrollo, y generando recomendaciones para lograr un efecto sinérgico positivo y acelerar la transición a la Industria 5.0. El artículo está dedicado a la combinación de Economía verde y digitalización, que conduce a la aparición de características completamente nuevas en la Economía. La relevancia del tema está determinada por el hecho de que el uso y desarrollo del capital humano, la Economía verde y la digitalización pueden tener un importante efecto sinérgico con el surgimiento de nuevas características, con consecuencias tanto positivas como negativas, y afectar el logro del desarrollo sostenible. Métodos de investigación: análisis y síntesis, abstracción y generalización, un enfoque sistemático para el análisis de la Economía verde y digital, análisis económico-estadístico y matemático. El artículo identifica los riesgos fundamentales de la digitalización de la Economía, los principales de los cuales son: el agotamiento de los recursos limitados, los desechos electrónicos, la profundización del desarrollo asimétrico.

PALABRAS CLAVE: Industria 5.0, digitalización, materias primas, reciclaje de residuos electrónicos, Economía verde, desarrollo asimétrico.

## Introduction

The world economy is going through unprecedented times of complete transformation due to significant uncertainty related to the global climate outlook and geopolitical security. Such a situation presupposes the use of entirely new measures and tools to achieve sustainable development and the construction of fundamentally new public management mechanisms, expanding cooperation between countries and widening a long-term sustainable development program. The combination of the green economy and digitalisation implies the appearance of entirely new characteristics of the economy, which allow us to evaluate the role of society, the market, enterprises, and technologies in a new way and change the worldview of humanity.

Sustainable future development directly depends on achieving sustainable development. The transformation to Industry 5.0 can be simplified and reduced in time with the help of new technologies and digitalisation. Nowadays, most daily actions and results

depend on innovative digital technologies (Maria E. Mondejar, Ram Avtar. 2021). Achieving Industry 5.0 is possible only due to the use and development of human capital and digitalisation, the artificial intelligent use and combination of which can have a significant synergistic effect with the emergence of new features that can have both positive and negative effects and will affect on well-being and social protection.

## 1. Results and discussion

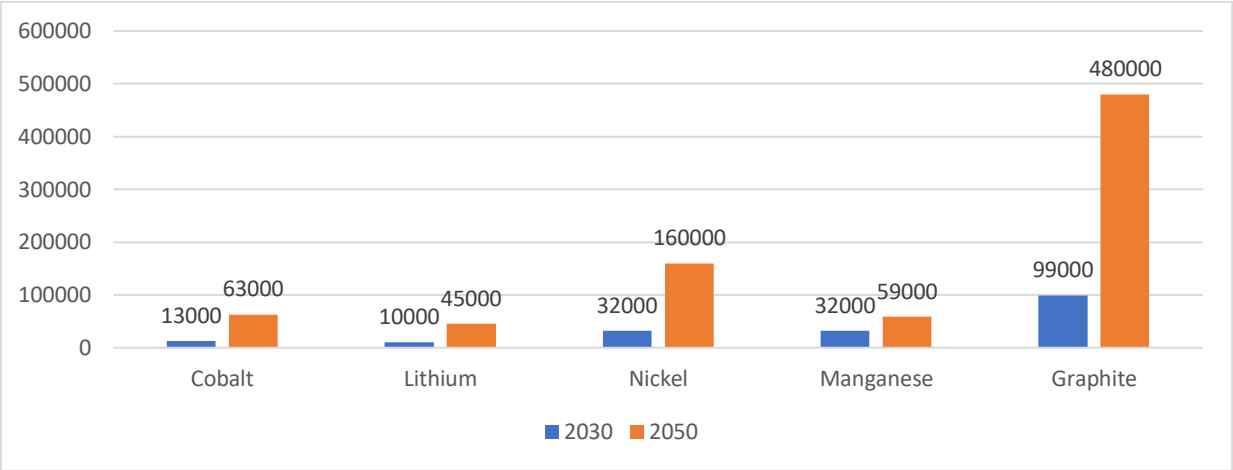
Digitalisation and the transition to a green economy significantly change business models and necessitate the introduction of innovations and the exchange of knowledge and information between countries. The development of digitalisation brings a new set of tools and mechanisms to the economy, which need to be aligned and balanced to ensure green sustainable development. Geospatial data is becoming a core element of real-time modelling and forecasting systems. The development and support of satellite data also have a wide range of applications in almost all sectors of the economy. It is advisable to build mature data platforms both at the country level and between organisations. That will help to effectively exchange information and scientific developments and not duplicate them.

The development of such areas as artificial intelligence and big data will allow better policymaking and more informed decisions with great benefits for society and the economy. There is a close relationship between making informed decisions based on data and achieving sustainable development. (Ardito., 2018).

The implementation of digitalisation and green economy also has adverse effects, which must be minimised through the right policy:

1. Electronic device production and distribution exhausts limited and rare resources and create electronic waste that is difficult to dispose of or upgrade. A significant change in resource flows and an increase in demand for raw materials (lithium, cobalt, copper, tungsten) are predicted (Lewicka, Ewa, Katarzyna Guzik, and Krzysztof Galos. 2021). Global demand for raw materials such as lithium, cobalt, copper, tantalum, tungsten and rare earth metals is expected to grow, reflecting the increased use of ICT. The same situation arises in green technologies when alternative energy requires practically unavailable elements in Europe, which significantly increases dependence on other countries. (European Commission, 2020).

Figure 1. Materials for batteries for renewables (LDS, tonnes)




Source: European Commission (2020)

The EU produces only 1% of all raw materials for batteries. China and Africa and Latin America provide 74% of all battery raw materials. Therefore, there are risks of an increase in current prices of raw materials, which are necessary to support the development of new production facilities in the long term. In the supply chain for wind generators, the highest risks exist at the raw material stage. The EU provides only 1% of the raw materials for wind energy. Energy systems built on clean energy technologies are fundamentally different from systems powered by traditional hydrocarbon resources. Green energy requires a significant amount of minerals, most of which are rare and not produced in the EU. (Figure 2)(IEA, 2021).

For robotics, 44 raw materials are relevant, of which the EU produces only 2%. On the other hand, the EU is the leading player of processed materials and robotics assemblies, respectively 21% and 41% of the world supply (UNCDAT, 2020).

Therefore, it is necessary to ensure an adequate and sustainable supply of raw materials from global markets and the effective use of resources and the supply of "secondary raw materials" through processing. From the point of view of the value of raw materials for the development of ICT, the transition to a circular economy is a necessary condition. It is also expedient to identify new mining and processing sites by restoring and supporting exploration activities and the mining industry.

2. Most electronic devices become obsolete much earlier than their "useful life", and it is almost impossible to upgrade or use them further due to a lack of design and rapid technological change (Rui Wang, Qi Zhang, Lu Zhan, Zhenming Xu, 2022). In 2019, the most

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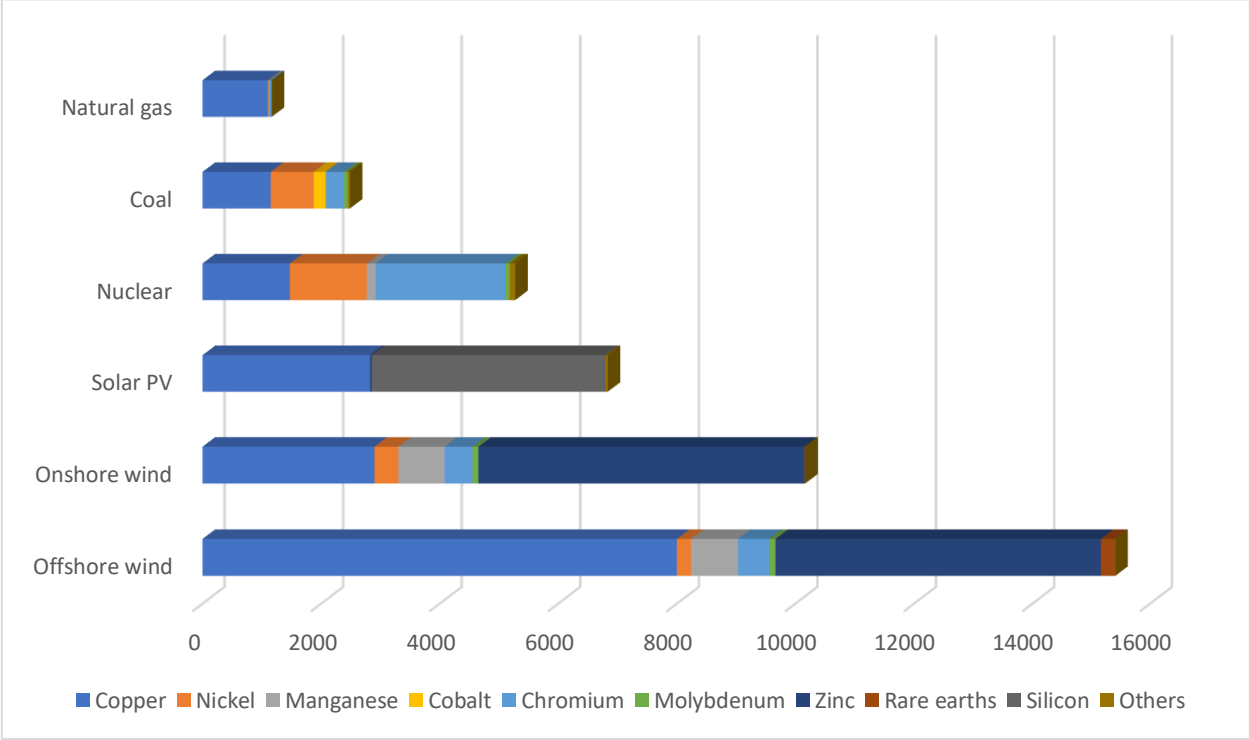
significant amount of electronic waste was generated in Asia (24.9 million tons), America (13.1 million tons) and Europe (12 million tons). In 2019, only 17.4 per cent of e-waste was officially collected and recycled (The Global e-waste statistics partnership, 2020). In the EU, the percentage of e-waste recycling is, on average, 42.1%. Poland increased the percentage of e-waste recycling from 13.9% (in 2009) to 39.1% (2019), but in the last three years, this percentage has had an unstable trend over the years and fluctuated significantly. In 2019, the average volume of electrical and electronic waste collected in EU member states was 10.0 kg per inhabitant.

Figure 2. Minerals used in clean energy technologies compared to other power generation sources

kg / MW




Source: IEA (2021)

Because of such trends, it is necessary to consider the complete recycling cycle and the possibilities of upgrading electronic devices at the development stage. Electronic products are better designed on a modular basis for easy replacement of parts for modernisation. It is also advisable to develop a network of service centres that can repair and ensure the functionality of an electronic product for an acceptable price since now it is often not economically viable to repair some products and sometimes it is cheaper to buy new ones.

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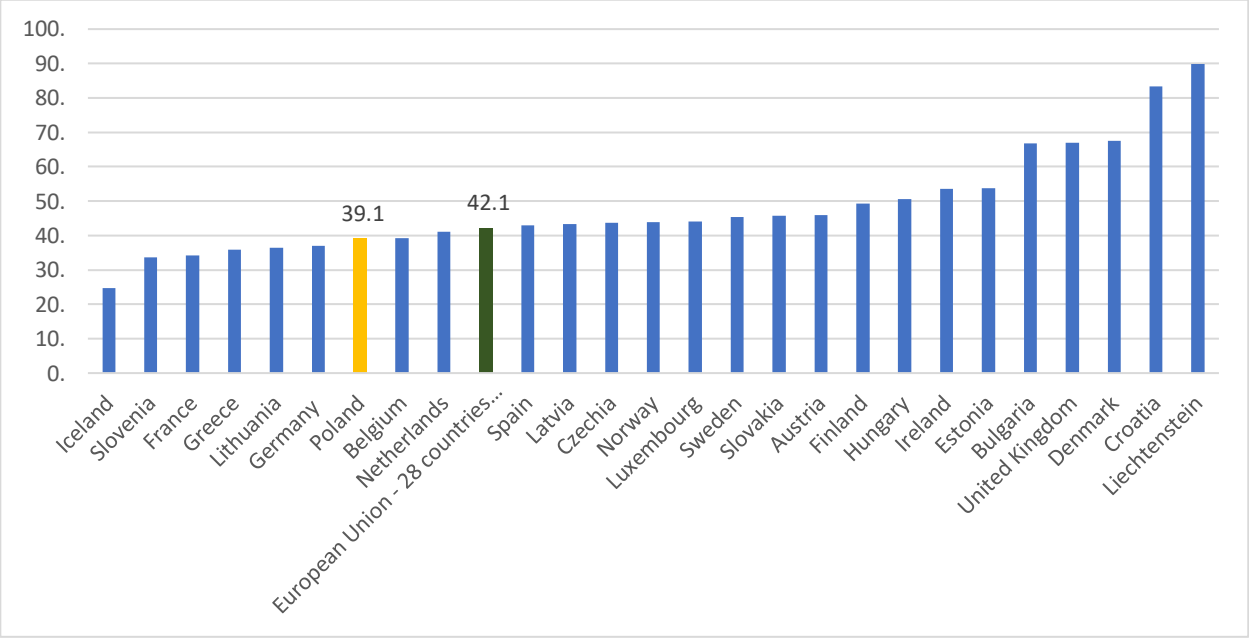
Through the development of legislation in the field of eco-design, the European Commission aims to promote durability, reusability, maintainability of products, improvement of resource efficiency and reduction of environmental impact. The main task is to maximize the percentage of recycling of electronic devices and reuse of rare metals. Resource losses during the life cycle and recycling processes of ICT devices can be minimized through proper design, technology and public policy (Digitalization and natural resources, 2021). E-waste management is one of the central topics in Europe due to the large number of metals involved and the great rarity of these metals in Europe. Therefore, it is advisable to change the technical standards to facilitate the recycling of electronic products, taking into account these goals at the design stage. For this, the Directive on ecological design (2005/32/EC) and the Directive on waste electrical and electronic equipment (WEEE) (2002/96/EC) were introduced in the EU, which also need to be improved and supplemented according to the requirements of the time.

Figure 3. The recycling rate of e-waste %




Source: Eurostat 2021

3. Many next-generation technologies, such as fiber optics and RFID, have no recycling potential until 2035 (Marscheider-Weidemann et al., 2016). Therefore, closing resource cycles on the basis of innovative activity and the introduction of a circular economy is the need of the time. There is also a need for more research on the environmental impact of

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alternative energy, some of which, when considered over their full life cycle, have a significant negative impact on the environment.

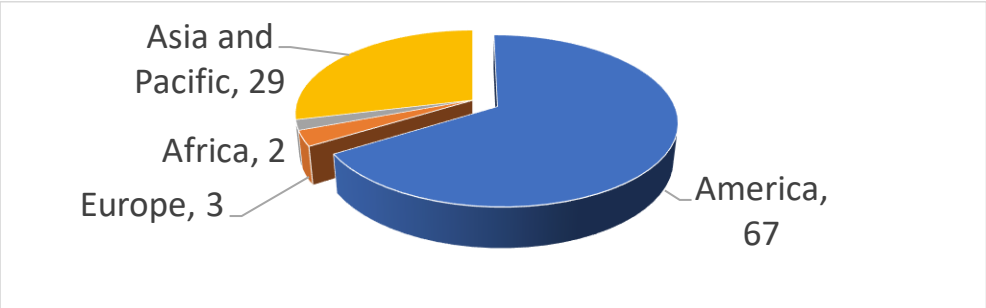
An increasingly digitized economy will consume not only raw materials, but also a lot of energy. Artificial intelligence (AI) systems, which are becoming increasingly common in the digital economy, are particularly energy-intensive.

As AI becomes more complex, expect some models to use even more data. This is a problem because data centers consume an incredible amount of energy. As the number and volume of data processing centers grow, they can become one of the largest consumers of energy, and can have a significant impact on the environment.

It is already necessary to put the issue of carbon footprint or energy consumption of AI on the agenda. The issue of digital waste is also acute now, up to 90% of digital data is not used. According to Tech Target, about 90% of data is never accessed three months after it is first stored. According to a 2018 report by the Active Archive Alliance, up to 80% of all digital data is never accessed or reused after storage. According to IBM, 90% of all sensor data collected from IoT devices is never used. (Gerry McGovern, 2020).

4. The deepening of asymmetric development due to the uneven application of technology and information, unequal access to data deepens poverty and social inequality. China and the United States, two countries that have played a leading role in the ICT sector and digital business from an early stage, account for 96 (as recently as 2019, this figure was 90%) percent of the market capitalization. On the other hand, Europe accounts for only three percent of the market capitalization, while Africa and Latin America together account for two (UNCTAD, 2021).

Figure 4. Share in total value, by region (%)




Source: UNCTAD, 2021

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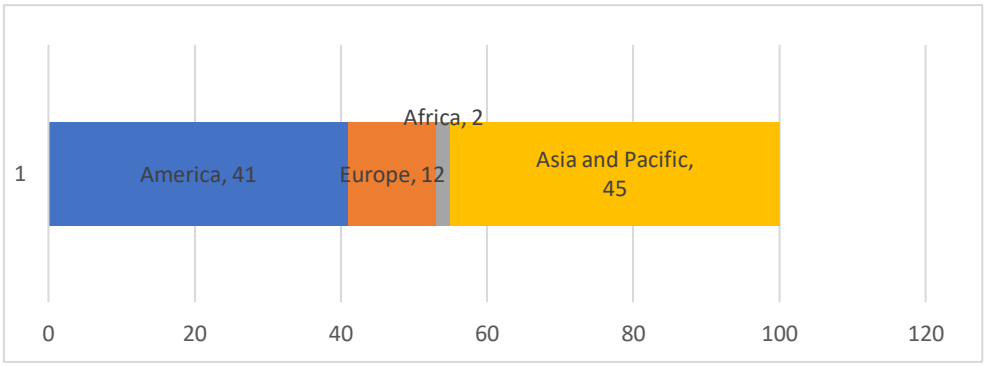
If we consider the Number of top 100 platforms, by region, the largest number of platforms are concentrated in America – 41 and China – 45. In Europe, the largest platforms are 12 (Adyen, Autol, Checkout, Delivery Hero, Edenred, Hellofresh, Farfetch, Klarna, Spotify, Just Eat T. Yandex). Thus, 86 of the 100 largest platforms in the world are located in America and Asia.

Figure 5. Number of top 100 platforms, by region




Source: UNCTAD, 2021

5. Due to the unevenness of digital development, there is a need to recognize the complex trade-offs between efficiency, which generally requires more and more international coordination (especially in policy development and cooperation in the field of scientific research, which requires digital solutions and databases), and fair distribution of benefits and costs. The political and economic consequences of such an uneven distribution require further research. Therefore, reliance on the countries of digital leaders may increase, which will weaken political will.

6. Regulation of data use is important because user data is key to the participation of Internet companies in the processes of management and targeted marketing. Since the 2016 US election, there has been increased scrutiny and public debate about how social media and internet platforms manage user data and can manipulate opinion based on collected data about user preferences and psychological profiles. All this creates serious problems for democracy and political life.

7. Data security, vulnerabilities of critical infrastructure, cloud databases are currently still vulnerable to cyber attacks. According to PwC surveys and Allianz Risk Barometer research, cybercrime is one of the biggest business threats. Businesses need to develop and implement new mechanisms to combat cybercrime. Currently, cyber security is one of the

DOI: https://doi.org/10.46925//rdluz.40.13

national security priorities, and there is an increasing demand for the development of cyber security principles and frameworks, incentives for strengthening cyber security, and a training system. (PWC, 2021). In 2021, the average number of cyber attacks and data breaches increased by 15.1% compared to 2020.

A business survey found that the convergence of digital and physical systems, such as IoT devices, has increased security risks. In addition, 41% of executives believe that their security initiatives are not keeping pace with digital transformation and new technologies. In 2021, cybercrime cost US companies more than $6.9 billion, companies experienced 50% more attempted cyberattacks per week, and only 43% of businesses are financially prepared for cyberattacks in 2022 (Forbs, 2022a). Almost 80% of attacks against nation-states target government institutions, non-governmental organizations (NGOs) and think tanks. Small and medium-sized businesses are especially vulnerable to cyber attacks. According to the Accenture Cost of Cybercrime Study, 43% of cyber attacks target small businesses, and only 14% of SMBs are prepared. 30% of small businesses consider phishing attacks to be the biggest cyber threat. 83% of SMBs will not be financially able to recover from a cyber attack. The insurance business is already developing cyber liability insurance services, but 91% of small businesses do not use these services. Ransomware cost the world $20 billion in 2021. This figure is expected to grow to $265 billion by 2031 (Forbs, 2022b). According to forecasts, the situation regarding cyberattacks will deteriorate even more in the coming years. That's why cybersecurity analysts are the most in-demand profession in the industry right now.

8. A radical change in the labor market and requirements for employees. Regeneration of the labor force requires large-scale investments in the labor market and retraining, changing educational programs, which already mostly do not meet the requirements of the times. If the curricula in educational institutions are not changed, there may be a labor shortage in many sectors in the near future. The development of the green economy requires renewable energy project managers on the market. Different sectors of the economy will feel the impact of automation and digitalization and the labor market in different ways. The development of technology poses a threat to the existence of many professions, but the emergence of new ones is expected. It is predicted that 75 million current occupations could be replaced, while 133 million new ones could be created during this time.

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It is expected that in 2022 up to 58% of working hours will be performed by people and 42% by technology (machines and algorithms) and this percentage will increase every year. The share of highly skilled jobs has increased by 25% over the past 2 decades. Employment in the manufacturing sector decreased by 20%, while in the service sector it increased by 27% (OECD, 2022). The main skills, and competencies that will be demanded by employers will be analytical thinking, active learning, technological design, creativity, critical thinking, persuasion, negotiation, resilience, emotional intelligence and leadership (WEF, 2022a). Therefore, it is advisable to rethink the inclusive education system, focus training on developing skills necessary for success, develop creativity in students, and self-development in education. Close cooperation with employers is necessary for the development of individual, specific skills. (WEF, 2022b). Now, due to the mismatch of the labour market with modern requirements, the creation of jobs is slowing down, and the reduction is accelerating. Companies estimate that, on average, approximately 40% of employees will need reskilling within six months or less, and 94% of business leaders report that they expect employees to acquire new skills while on the job. Such a massive change in personnel approaches requires assessing the value of human capital in the company's assets and developing a strategy for its development. (WEF, 2022b)

AI mostly complements the work of high-skilled workers and primarily replaces low-skilled workers, which could further increase income inequality and eliminate increased investment in education.

Modern transformations in the labour market have created new challenges with which politicians continue to struggle. Employees may need retraining or advanced training. Policies and institutions will play a key role in ensuring that all workers can successfully navigate a changing labour market (OECD.AI, 2022).

An important step in the development of the circular economy is the introduction of digital labelling (e-labels), which allows you to track the product at all stages of the life cycle, which helps to implement the concept of zero-waste production. Appropriate implementation of smart audit and complete collection of information on waste and resource use at all stages. Special development of digital platforms and industrial and cluster symbiosis is also necessary (Kerdlap 2020).

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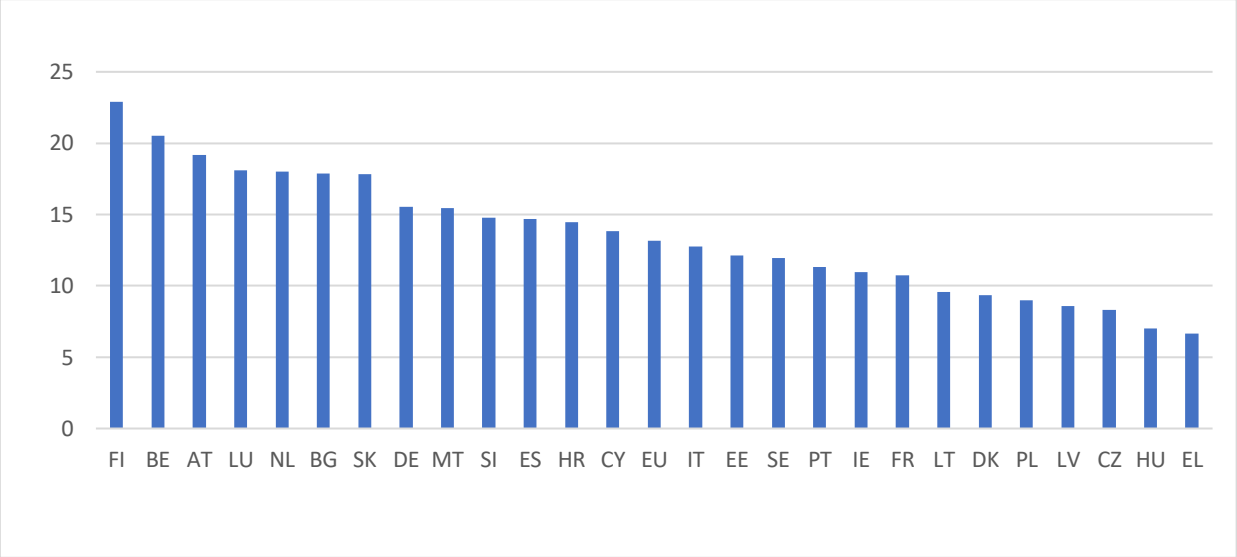
Many countries have already implemented e-labelling schemes (representing 56% of the world economy). The European Union, on the other hand, still relies solely on physical markings on devices. Some businesses in the EU use RFID. Thus, 22% of Finnish enterprises use RFID, a high level of which is also used in Belgium, Austria, Luxembourg and the Netherlands (Figure 6).

Figure 6. Enterprises using Radio Frequency Identification (RFID) technologies (Percentage of enterprises) 2017




Source: Digital Agenda 2022a

Almost every fourth enterprise in Denmark uses artificial intelligence technologies. In Poland, this percentage is only 2.86%. On average, the percentage of enterprises in 2021 that will use AI was 7.91%. (figure 7).

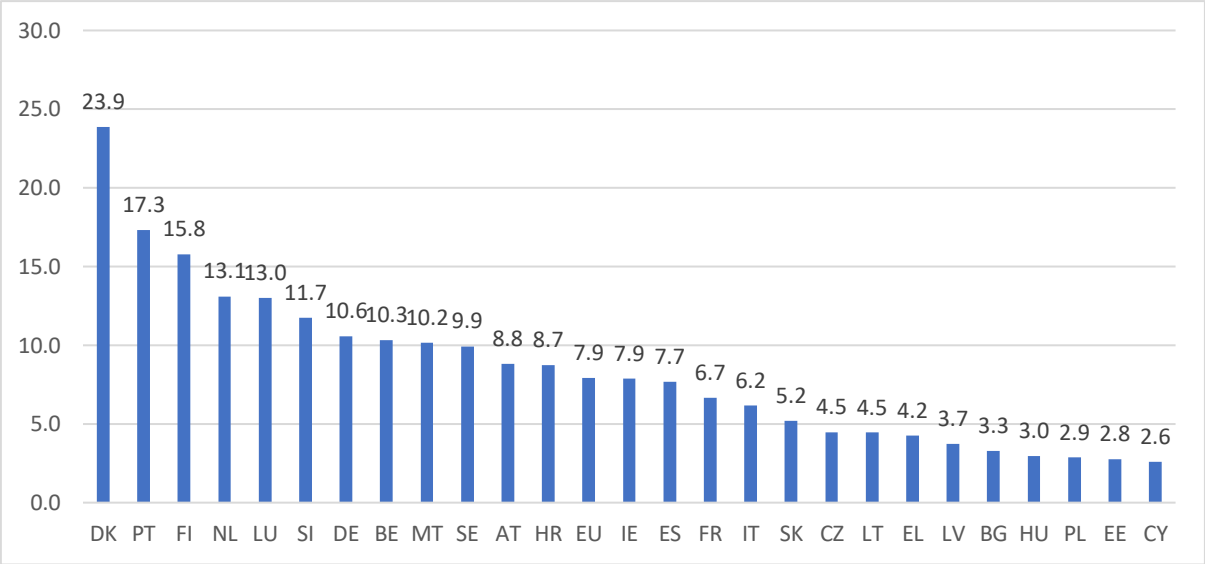
Most of the enterprises that analyse big data in their work are in Malta (30%), in the Netherlands, Denmark, Belgium, and Ireland (Figure 8).

In the European Union, there is a significant gap in digitalization between countries, and investments in ICT are much smaller compared to other large economies, only 2% share of ICT investments in GDP estimated in the EU. While the United States and Japan invest almost 3.5% of their GDP in ICT

Countries such as the USA and China invest the most in AI, which accounted for 65% of all investments in AI in 2022 (Figure 9).

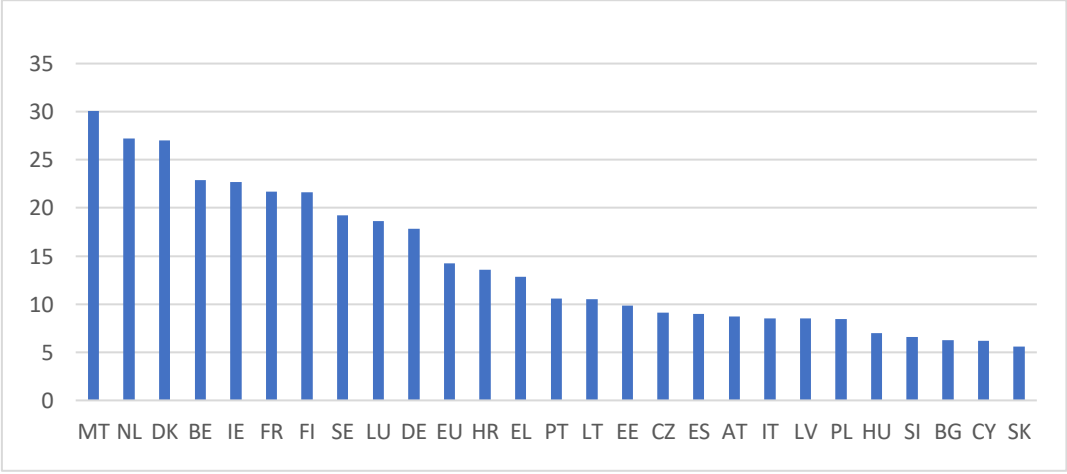
The digitalization gap is also reflected in the average R&D intensity of the ICT sector itself in the European Union compared to its key international competitors. Importantly, the European Union is also characterized by significant differences in the intensity of digitization within the Union, between regions, sectors and individual companies. Therefore, reducing such gaps is very important for future sustainable development

Figure 7. Enterprises using AI technologies, Percentage of enterprises, 2021




Source: Digital Agenda 2022b

Figure 8. Enterprises analysing big data (2020), the Percentage of enterprises




Source: Digital Agenda 2022c

The integration of digitalization, artificial intelligence and the Internet of Things provides significant synergistic effects and new opportunities. But such large disparities in

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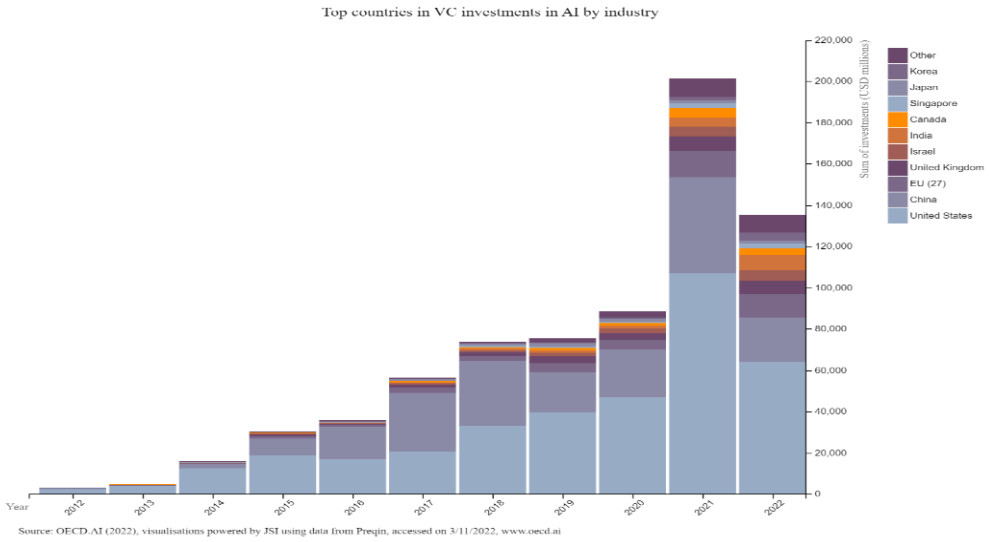
the use of technology between EU countries can exacerbate uneven development and the digital divide.

Figure 9. Top countries in VC investments in AI by industry




Source OECD.AI, 2022

There are also challenges and influences on democratic processes. Using personalisation algorithms to search for information creates "echo chambers" in which people see only information that matches their views and virtually no alternative information. In addition, the level of depression increases with the significant use of social networks, which negatively affects economic development and human productivity. Cultural globalisation also occurs when one culture dominates and local traditions are lost. (Hunt et al., 2018).

Adaptability and application of modelling and artificial intelligence promotes self-organization and stability of the entire system and decentralize decision-making (Oztemel and Gursev, 2020). There are also changes in management systems at the state and enterprise levels, which causes changes in the organizational and functional structure. Transformation to agile governance is already taking place at the state level. The principles of which fully meet the requirements for the formation of a digital environment and reduce risks when making decisions. Digitalization weakens executive power and strengthens grassroots power. Agile governance focuses attention on goals and how to implement them, on innovations in management that are as important as technological innovations (World Economic Forum, 2021).

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Digitalization has a particularly high potential in the field of energy and energy efficiency. Development of systems for modeling energy consumption based on combinations of many factors (weather forecast, social behavior, work schedules and production cycles of energy-consuming enterprises). Integration with large energy consumers and their consumption plans has significant potential. The time has come for decentralized (modular) energy systems based on renewable energy sources. Automatic distribution of energy production between producers, especially those who use green energy (small producers). Also, the integration into such decentralized systems of the Internet of Things and energy management strategies will help to more accurately and effectively manage the supply and demand for energy. But in order to achieve these goals, the interaction of all participants and government bodies is important, to complement each other's actions and reduce the duplication of functions. At the same time, with the help of digital technologies and big data, enterprises can monitor energy consumption and emissions in all production lines in real time, and implement effective energy saving and emission reduction strategies. With the right institutional policies and digitalization, effective energy management and the development of a green economy are possible.

Digital technologies make it possible to quickly transition and implement the principles of a green and circular economy by implementing:

- increasing information about the product at all stages of its life cycle. Examples of digital technologies that reduce information asymmetry include digital passports that allow tracking of a product's journey from design to completion of the life cycle. They improve the understanding of the composition of used products and facilitate their recycling and increase the potential for reuse;

- reduce transaction costs associated with finding customers and suppliers. Examples of digital technologies that reduce transaction costs include digital platforms combined with artificial intelligence and blockchain, which help create a transparent and reliable information source for secondary materials and thus facilitate the exchange of raw materials between different sectors and industries. Asset exchange platforms integrated with IoT, big data, cloud computing and AI enable the generation of data on market supply and demand for assets;

- large-scale use of blockchain and artificial intelligence requires energy-intensive data processing. But at the same time, its use makes it possible to reduce information and digital gaps between interested parties. The introduction of a digital product passport makes it easier to obtain control over materials throughout the entire cycle. From the manufacturer's point of view, digital passports also make it easier to get information. Digital labels can also be used in smart city systems, attaching them to garbage containers allows you to optimize the time of garbage removal and improve logistics. Real-time data stored and processed in the cloud and shared between the cloud, trucks, containers and processing plants. (Aclima, 2020).

Sustainability must be considered and implemented at a systemic level, implementing the principles of sustainable coding, taking into account environmental, social and economic factors.( Trusova et al., 2021).

With the development of standards and indicators of the impact and measurement of digitalization on sustainability, since it is digitalization that is a key factor in changes in both the economy and societies, and with the right approach, opportunities can be maximized and risks minimized. There is an increasingly close interaction between people and technologies. It is advisable to embed systems of human values and norms and digitization (WBGU, 2019). Therefore, TWI2050 proposes to initiate local, national and global dialogues on the development and implementation of relevant norms and values of the Digital Anthropocene (TWI2050. 2020).

Thus, the integration of digitalization and the green economy can provide a significant synergistic effect and accelerate the transition to Industry 5.0, but it is advisable to consider the following features to avoid and reduce risks:

1. The need to reform education and form new competencies.

2. Development of science, human capital, people-centeredness. Digitalization should increase sustainability, develop convergence between human and artificial intelligence (European Commission 2022a).

3. Modernize management systems at all levels by introducing Agile management.

4. Development of technologies to overcome diffuse negative impacts on the environment.

5. Develop sustainability in the digital future.

6. Institutional support should play a major role in strengthening the ability of enterprises to engage in environmental innovation.

7. Appropriate development of completely new systems and mechanisms in such areas as "green" procurement, assessment and certification of "green" products, transformation of innovative achievements, "green" technologies, development of the market of "green" technologies and systematic change of financial and tax policy to support innovations "green" technologies, to increase returns from green technology innovations and stimulate the development of green technologies at enterprises.

## Conclusion

The transition to Industry 5.0 is associated with the process of multi-level transformation of the economic and socio-technological system aimed at increasing its environmental sustainability and social justice. New requirements for the development of the economy require a multidisciplinary approach to innovation, which affects almost all aspects of human life.

Now, more than ever, sustainable development requires the building of a strong global coalition of experts on sustainable development and digital technologies, which will help shape a shared vision of the future, develop standards and goals, prioritize investments and resources, systematically align digital transformation with the plan for sustainable development, while increasing dematerialization human activity.

The EU needs a fast and effective digital transformation that will help solve climate and environmental problems, strengthen social cohesion and increase competitiveness. But it is necessary to take into account that new technologies also cause a number of challenges that must be solved, including an important reassessment of the role of the state, business and the construction of new institutional systems.

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