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DIGITAL TECHNOLOGIES IN ADVANCING THE GREEN ECONOMY OPPORTUNITIES FOR GLOBAL BUSINESS AND FINANCIAL STABILITY

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Abstract. The development of the green economy has gained popularity due to the alarming increase in the consumption of natural resources, which has prompted the international community to create a new paradigm of economic activity in line with the sustainable development strategy. An equally important issue was the rapid development of digitalisation and its implementation in all areas of activity. The study therefore focused on the impact of digitalisation on the development of the green economy. The *purpose* of the study was to identify the positive and negative aspects of the impact of information technologies on the achievement of the principles of the green economy. The research methodology included methods of analysis, synthesis, systematisation, logical comparison and generalisation of results. Based on the analysis of the literature, it was found that there is no clear difference between the concepts of green economy and sustainable development. The *primary objectives* of sustainable development, as outlined in the Decree of the President of Ukraine, were subjected to thorough analysis. Furthermore, the key challenges hindering the attainment of these objectives, largely attributable to the ongoing war, were meticulously identified. The following conclusions were drawn: among the problems in achieving sustainable development goals, social, economic, political, environmental and organisational problems were identified. These included the growing economic crisis, the danger to people's lives, the destruction of infrastructure, the increase in unemployment, the number of internally displaced persons, the damage to the environment, education and entrepreneurship caused by active hostilities, the occupation of territories and rocket attacks. An investigation was conducted into the means of digitalisation that could be utilised to overcome the aforementioned issues. The following areas were examined: digital marketing, the development of online platforms for the purpose of searching for specialists and partners, educational, social and medical programmes, robotic demining of territories, applications for predicting energy efficiency and environmental friendliness of enterprises, and others. In addition, the negative aspects of the impact of information technologies on achieving sustainable development goals were identified. These include the growth of cybercrime, the security of personal data and financial transactions, the increase in the use of energy resources, and the growth of electronic waste. A proposal was made to improve the formula for determining the green economy development coefficient by determining the coefficients of digitalization productivity, the use of natural resources, and energy efficiency.

Keywords: digital economy, digital technologies, financial security, green economy, international business.

JEL Classification: Q20, Q57, L86

1. Introduction

In the modern world, the economy is constantly growing through increased supply and demand in the marketplace. However, as the well-being of the population increases through the satisfaction of needs, the amount of natural resources used also increases. In some cases, the depletion of environmental resources has reached critical levels, resulting in climate change and the degradation of the atmosphere, soils and water bodies, with adverse effects on the populations of these regions through deterioration in health, access to fresh water and weather conditions. Despite the critical impact on individual territories, the entire ecosystem is also suffering, with the negative changes becoming increasingly apparent. The adverse environmental impact caused by human activities has

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led to the emergence of the "green economy" paradigm, which aims to satisfy consumer needs while preserving the environment. However, the concept of a green economy is not limited to environmental aspects, as it encompasses social, economic, political and organisational factors that ensure the well-being of the population.

Another challenge of modern times is the spread of digitalisation in economic activities. Information technologies have been implemented to some extent in all industries and areas of life. On the one hand, the development of new technologies expands the possibilities for co-operation and communication; on the other hand, there is a risk of irrational and inappropriate use of digitalisation. This is due to a lack of awareness of the characteristics of different types of technology. At the same time, it is important to understand whether digitalisation contributes to the implementation of the goals of the green economy or, on the contrary, hinders it. It is imperative to ascertain the mechanisms and types of technologies that should be implemented in activities and which should be eschewed. In the context of international co-operation, digitalisation engenders new possibilities and obfuscates boundaries for manufacturers and entrepreneurs, thereby promoting investment attraction and expanding the marketing space. However, there are risks associated with cybersecurity, limited knowledge of the features of technologies and financial transactions. Simultaneously, in the context of achieving the objectives of the domestic green economy, it is imperative to consider the repercussions of a full-scale invasion. This invasion has engendered novel challenges in achieving these objectives and necessitates an evaluation of the potential of digitalisation to address the challenges associated with war.

2. Literature Review

The term "green economy" was first coined in 1989, and since then it has gained significant popularity, particularly following the launch of the Green Economy Initiative by the United Nations Environment Programme (UNEP) in 2009 and the adoption of the Green Growth Declaration by the Organisation for Economic Co-operation and Development (OECD). However, there remains a lack of consensus regarding the fundamental principles of the green economy, as well as the distinction between the terms "green economy", "green growth" and "sustainable development". This is mainly due to the widespread use of these concepts in different sectors and at different levels. What these concepts have in common is the importance of maintaining a high level of economic performance while taking into account environmental and social aspects and minimising negative environmental impacts (Merino-Saum et al., 2020).

The green economy is seen as an alternative vision for future development that encompasses the economic, social and environmental well-being of society (Soderholm, 2020). Soderholm (2020) emphasises the need for continuous and radical technological change, rather than incremental change, and highlights the role of government and policy-making in achieving the goals of the green economy. The work also describes a comprehensive approach to the design of policies, pilot projects and the implementation of technologies that require cross-interaction between sociologists, natural scientists, engineers, managers and politicians as one of the effective mechanisms for the development of the green economy.

In the majority of works, the green economy is regarded as a component of sustainable development, which fosters the establishment of an ecologically sustainable economy. Its efficacy is predominantly evaluated through mathematical calculations of coefficients and indices. An illustration of such an index is the Pigouvian index, which stabilises the ecosystem at a sustainable level of zero and enables the assessment of the negative impact of enterprises through a negative value (Mikhno et al., 2021). The practical implementation of the Pigouvian index entailed the introduction of an environmental tax, the amount of which is proportional to the degree of environmental pollution caused by the enterprise (Manta et al., 2023). The introduction of the environmental tax has been demonstrated to encourage industries to adopt environmentally friendly technologies. This, in turn, has been shown to result in a reduction in profits whilst concomitantly exerting a positive impact on greenhouse gas emissions (Mardones et al., 2022; Cadoret et al., 2020). Researchers are also refining existing mathematical models and developing coefficients for calculating the effectiveness of environmental projects, taking into account the economic, social, political, and environmental impacts on achieving sustainable development (Mikhno et al., 2021).

In order to achieve the objectives of the green economy, it is essential to formulate a sustainable development strategy that takes into account all the relevant influencing factors and evaluates potential risks. A pivotal factor in determining economic activity is digitalisation, given that, in the contemporary era, no industry exists that does not utilise information technologies. A considerable body of research has been dedicated to the role of digitalisation in the development of international business. The improvement of access to customers and partners, communication, and marketing to meet market requirements is facilitated by information technologies.

However, alongside the new opportunities presented by digitalisation, there are risks associated with information security, difficulties in remote regulation, and digital interdependence (Luo, 2022).

Cybersecurity, as a major challenge of digitalisation, protects personal data and financial transactions. Cybercrime causes more than 100 billion USD in losses every year and requires highly qualified professionals and significant investments to ensure a high level of protection (Moller, 2023). At the same time, the issue of remote management remains relevant, as it is influenced by different socio-cultural, political and financial characteristics of countries and requires personnel who understand the specificities of the region (Ferreira et al., 2021; Lou, 2022). Often, international companies ignore this issue and select trusted employees who do not understand the specifics of managing in another country. This tactic inevitably leads to conflict, staff turnover and reduced profitability of local operations. The digital interdependence of companies arises from the influence of one part of the company on the whole, where crises in small branches affect the operation of the whole company, leading investors to carefully study the markets of the countries in which they plan to operate.

Another challenge of digitalisation is the need for skilled human resources, as many managers, especially in small enterprises, lack sufficient knowledge to implement information technologies for internationalising the enterprise and entering the international market (Pereira et al., 2022; Reim et al., 2022). This has led to the emergence of digital companies that help in the selection of technologies for business internationalisation and in the search for customers or partners in the international market (Vadana et al., 2021). Globalisation and the internationalisation of business have also contributed to the spread of corruption, even in countries where it has almost been eradicated, due to differences in the culture of economic relations in different countries, where in some countries improper benefits are part of economic partnerships and are not considered illegal (Lee et al., 2024).

The researchers examined the role of digitalisation in achieving green development, mainly through a review of the literature on the topic, and identified gaps in research on digitalisation, specifically the impact of big data and artificial intelligence on achieving the UN's 2030 Agenda for Sustainable Development (Castro et al., 2021). Castro et al. (2021) advanced the argument that a considerable number of studies on digitalisation and the green economy were of a superficial nature and narrowly focused. The digitalisation of businesses was a popular research vector, with analyses focusing on the development and modernisation of enterprises. However, the benefits of implementing digital technologies were not obvious to the owners of small and medium-sized enterprises, who were reluctant to invest in the development of information technology because they did not understand the benefits (Irimiás & Mitev, 2020).

A substantial corpus of research on digitalisation and green economy development attests to the pertinence of the topic. Nevertheless, the majority of studies have concentrated on the discrete analysis of digitalisation, specifically its impact on business profitability. Conversely, the examination of the direct impact of information technologies on the development of the green economy has received scant attention (Pangarso et al., 2022). Consequently, ascertaining the extent to which digitalisation impacts green development is both timely and necessary.

The objective of the present study was to ascertain the impact of digitalisation on the realisation of the principles of the green economy.

3. Materials and Methods

A review of the extant literature revealed lacunae in the research on the relationship between digitalisation and the green economy. An analysis was conducted of Ukraine's challenges in implementing sustainable development goals due to the war, with the results summarised in Table 1. Following the identification of the challenges associated with the achievement of green economy objectives, solutions employing information technologies were proposed. The data is summarised in Table 2. An analysis of coefficients was conducted for the purpose of determining the effectiveness of green economy implementation. This analysis resulted in the proposal of an improved formula for the implementation of information technologies.

4. Results

In order to ascertain the impact of digitalisation on the development of the green economy, an analysis was conducted of the success of green economy implementation in Ukraine, with a view to identifying issues that require resolution. Prior to the war, the President of Ukraine promulgated the Decree "On the Sustainable Development Goals of Ukraine until 2030" on 30 September 2019 (No. 722/2019), which provided for the adaptation of the global SDGs, including the green economy, as proclaimed by the UN resolution of 25 September 2015. The objectives encompassed social, economic and environmental measures. Table 1 provides a concise overview of the objectives and the challenges associated with their realisation, taking into account the ongoing war in the country.

Table 1

Challenges to achieving the Sustainable Development Goals in Ukraine

No.	Sustainable development goal	Challenges to achieving the goal
1	No Poverty	Deepening of the economic crisis, increased spending on the Armed Forces of Ukraine, rising inflation, increased tax burden due to the military tax, and rising unemployment.
2	Zero Hunger	Restrictions on access to food and water in areas where active hostilities are taking place, mining and shelling of agricultural land, and the danger of harvesting.
3	Good Health and Well-being	Direct threat to the life and health of the population as a result of shelling, restricted access to medical and health facilities and sports grounds in dangerous regions and during air raids, constant psychological stress due to fear of war.
4	Quality Education	Shelling of schools and higher education institutions. Lack of full-time education in the frontline areas, reduction in the number of hours of study due to anxiety.
5	Gender Equality	Restrictions on the rights of men of military age to travel abroad, restrictions on the rights of citizens during curfews.
6	Clean Water and Sanitation	Violation of sanitary conditions due to shelling, destruction of pumping systems, shelling of infrastructure, lack of electricity.
7	Affordable and Clean Energy	Shelling of energy infrastructure facilities, electricity shortages that lead to power outages for consumers and businesses, and rising electricity costs, especially for businesses.
8	Decent Work and Economic Growth	The economic crisis, suspension of business operations, and rising unemployment.
9	Industry, Innovation and Infrastructure	Shelling of infrastructure, roads, enterprises, research institutes, lack of funds for innovative developments.
10	Reduced Inequality	Reduced social assistance, an increase in the number of internally displaced persons in need of housing, labour and social benefits, and growing social injustice.
11	Sustainable Cities and Communities	Reduced security due to indiscriminate rocket attacks, low level of inclusive transport and ramps in cities, and deteriorating air quality due to combustion products after shelling.
12	Responsible Consumption and Production	The war caused many businesses to go bankrupt, and some were forced to relocate, losing equipment and skilled staff.
13	Climate Action	Increase in the number of fires, military waste, and greenhouse gas emissions, including due to the widespread use of generators.
14	Life Below Water	Mining of the Black Sea, rocket attacks on ports, oil leakage due to damage to ships, destruction of the Kakhovka HPP, which became a local environmental disaster, damage to the Dnipro and Kyiv HPPs.
15	Life on Land	Destruction of forests, soil, and agricultural land in the frontline regions, and mining of fields.
16	Peace, Justice and Strong Institutions	Increased burden on state institutions due to the large number of internally displaced persons in need of social and legal assistance, as well as the restoration of lost documents. High level of corruption and prevalence of bureaucratic procedures.
17	Partnerships for the Goals	Shifting the focus of international diplomacy to war, assistance in providing weapons, loans and a peace plan.

Source: compiled by the authors based on the Decree of the President of Ukraine "On the Sustainable Development Goals of Ukraine until 2030" of September 30, 2019 No. 722/2019

As demonstrated in Table 1, the realisation of sustainable development goals poses a considerable challenge even for economically developed countries. The ongoing war has given rise to novel and intricate challenges for Ukraine, necessitating the implementation of prompt solutions. Obstacles to environmental initiatives include pollution caused by military waste, combustion products, and explosive materials. The social challenges experienced by the region are manifold. These include increasing poverty and social inequality, as well as a significant number of internally displaced persons. Reduced access to food and drinking water, and disruption to working and living conditions due to damage to infrastructure, including housing and utilities, are also present. The political and economic problems experienced by the region are driven by rising inflation, economic crisis, unemployment, and corruption.

A thorough investigation was conducted into the manner in which digitalisation affects the resolution of the aforementioned challenges in achieving sustainable development goals, international co-operation, and financial security. The results of this investigation are presented in Table 2, which details the challenges to achieving sustainable development goals and the methods for overcoming them through information technologies.

As demonstrated in Table 2, digitalisation has been shown to have a positive impact on the SDGs that were identified as challenges in Ukraine during the war. However, it should be noted that the potential of information technologies also extends to international

Table 2
Opportunities for digitalisation to overcome challenges in achieving the Sustainable Development Goals

Challenges in achieving the sustainable development goals	Information technology
Economic crisis	Stimulation of economic development through the entry of local businesses into the international market through digital marketing, search for partners through online platforms, and remote communication with partners and potential customers.
Unemployment	Creation of an online platform with vacant positions, recruitment using information technology, analysis of databases of potential employees, and the possibility of remote work.
Extraction of forests and agricultural land	Application of robots for demining, creation of a map with the geolocation of mined, contaminated and possibly explosive areas.
Restrictions on access to education	Online platforms for learning, testing, and completing tasks remotely.
Psychological stress due to fear of war	Online psychological support, online psychological practices.
Limited access to electricity, water	Creation of chatbots with schedules of electricity and water supply outages.
Air raid alert	Creation of online maps with the geolocation of shelters, applications with air raid alerts.
Need for social assistance for internally displaced persons	The ability to fill out online social security forms using chatbots and step-by-step instructions, electronic queues at administrative service centres, and the creation of a platform with housing and job offers.
Deterioration of air quality due to shelling and fires	Development of an app with air quality information, air pollution notifications and recommendations for an action plan in case of air pollution.
Insufficient support for people with disabilities	Creation of applications with notifications about transport schedules with a ramp, a chatbot that helps plan the best route for people in wheelchairs, and an online guide for people with visual impairments. Simplified access to services through online consultations, submission of documents and financial transactions. Possibility of remote work.
Ensuring the transition to sustainable consumption and production models	Building models to automatically calculate business efficiency, including energy efficiency, resource use and environmental performance.
Loss of documents	Digital application Diia with the availability of basic documents.
Bureaucracy and corruption	Creation of electronic queues, the possibility of submitting documents through unified registers, and restrictions on live communication between citizens and businesses and officials.
Decreased attention of international diplomacy to the development of the green economy	Engaging international partners through remote communication to train entrepreneurs and restore production and infrastructure facilities in accordance with the principles of the green economy.

Source: compiled by the authors

co-operation and improves access to financial transactions. Furthermore, digitalisation has enhanced communication and created borderless marketing, which has the effect of reducing the number of trips and flights needed for in-person meetings. In addition to these benefits, the possibilities for banking operations have increased, allowing money transfers to be completed in a matter of minutes.

However, it is important to note that the rapid implementation of information technologies can be associated with a number of risks. These include data leaks from company databases, leaks of clients' data, potential hacker attacks, and financial security issues such as errors in financial transactions and their prolonged resolution and transaction protection. The increased use of information technologies has resulted in a reduction in the workforce that previously performed these functions, which poses a threat of rising unemployment.The use of information technologies is also energy-intensive. However, it is imperative to calculate a company's efficiency coefficient for software use according to its needs to improve energy efficiency.

In order to assess the development of the green economy, the formula calculation by Mikhno et al. (2021) was considered. This formula takes into account the index of the implementation of environmental technologies and scientific developments in enterprises, as well as the social welfare index. The latter considers the amount of taxes and social payments related to temporary or permanent disability. The natural resource coefficient, which includes implementing green technologies for air, water, and soil purification, is also considered. The corruption coefficient is a measure of political influence, with economic well-being determined by the ratio of GDP per capita to the GDP per capita of the country with the highest figure globally. Despite this indicator being multifactorial, it does not provide an objective assessment. For example, when calculating the environmental indicators of enterprises, only the number of enterprises that implement environmental technologies is considered. In contrast, the quality coefficient according to the enterprise's activities is not considered.

It is recommended that an energy efficiency coefficient be incorporated, defined as the ratio

of electricity consumed in a given current period to that of the preceding period. In a similar vein, it is advised that the digitalisation efficiency and natural resource utilisation coefficients be ascertained. In order to evaluate the efficacy of information technology utilisation, it is imperative to monitor diverse categories of IT, thereby determining the productivity coefficient, particularly by evaluating favourable outcomes concerning the costs of maintaining the technology. It can thus be concluded that companies are not required to utilise all the most recent tools available on the IT market; rather, they are at liberty to select products that meet the individual needs of their business. Consequently, an objective assessment of green economy implementation can be achieved by calculating coefficients that determine the dynamics of changes in production processes over a given period.

5. Discussion

A review of the extant literature revealed the relevance of the concepts of green economy development and sustainable development. However, the ambiguity between these terms prompted an equational analysis of the concepts to facilitate an understanding of the challenges in achieving SDGs and the digitalisation methods that help address them. The majority of contemporary studies have examined digitalisation and the green economy separately, although when studying digitalisation, they identified a positive impact on achieving specific green economy goals. For instance, Desyatnyuk, Krysovatyy, Ptashchenko, and Kyrylenko (2024) demonstrated the advantages of digitalisation in increasing accessibility to banking operations for the population, regardless of their place of residence. However, they emphasised the need to improve financial literacy among the public and ways to protect personal data, as the availability of services without knowledge of security increased the risk of fraud. In their 2024 study, Krysovatyy, Ptashchenko, Kurtsev and Arutyunyan (2024) emphasised the potential of digitalisation to facilitate the realisation of inclusive economic objectives, notably by enhancing accessibility to administrative and banking services remotely via online banking platforms and government websites. Dethine, Enjolras and Monticolo (2020) identified the development of information technologies as a critical factor in the internationalisation and growth of businesses. This development requires investments in technology and the training of qualified personnel, as each enterprise needs a customised set of information technologies tailored to its specific operations. Leal Filho et al. (2023) expounded on the potential advantages of digitalisation for environmental modelling, public health, biodiversity support, and initiatives focused on enhancing Earth's prosperity.

Concurrently, Niehoff (2022) advanced the argument that digitalisation is business-oriented, employing conventional business models and does not encourage adherence to sustainable development principles. Desyatnyuk, Naumenko and Lytovchenko (2024) emphasised the necessity of enhancing cybersecurity standards to ensure digital financial security, whilst simultaneously addressing the escalating issues of energy consumption and electronic waste. Malik and Froese (2022) identified corruption risk as a salient negative aspect of digitalisation. In addition, Palumbo (2022) highlighted the phenomenon of depersonalisation of workplaces and social-organisational injustice. Ahmadova et al. (2022) posited that digitalisation is associated with environmental changes following an inverted U-shaped curve, whereby moderate implementation of information technologies has a positive effect on environmental indicators. Conversely, excessive digitalisation has a detrimental effect. This lends support to the validity of the formulae proposed for calculating the efficiency coefficients of digitalisation dynamically and according to the needs of the enterprise.

6. Conclusions

Following a comprehensive review of the extant literature, it was determined that the distinction between the green economy and sustainable development remains indistinct. Consequently, the development of the green economy was contemplated within the overarching framework of the sustainable development strategy. A meticulous examination of the impediments to the green economy's progression in Ukraine was undertaken, leading to the identification of the repercussions of the armed conflict on the implementation of the sustainable development principles enshrined in the UN resolution. The study identified various challenges, including social, economic, environmental, political, and organisational issues, stemming from active combat and missile strikes, that hinder the achievement of these objectives. Social challenges included rising unemployment, internally displaced persons (IDPs), social injustice, threats to life and constant stress. Economic problems included rising inflation, additional tax burden due to the introduction of military service, rising energy prices, closure of businesses due to the security situation and lack of skilled labour. Environmental factors included pollution of the atmosphere, soil and water by combustion products, mines and explosives, fuels and other harmful substances. The organisational and political challenges experienced by the country at this time included bureaucracy, corruption, an increase in the burden on state

structures, and the redistribution of budget funds with an emphasis on military needs.

A number of proposals were made with a view to resolving the challenges that had been identified. These proposals involved the use of information technologies, including digital marketing, online platforms for searching for specialists and partners, educational, social and medical programmes, robotics for demining territories, and programmes for calculating the energy efficiency and environmental friendliness of enterprises, etc. Simultaneously, the negative aspects of the widespread implementation of digitalisation for the development of a green economy were identified, including the risk of personal data leakage, cybercrime, the danger of financial transactions, increased energy costs and electronic waste. Suggestions were made for improving the formula for determining the effectiveness of green technology implementation based on digitalisation productivity, energy efficiency, and natural resource utilisation coefficients.

Author contributions

All authors have contributed equally.

Conflict of interest

The authors declare that there is no conflict of interest.

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