


## Article

# How the Digital Economy Is Revolutionizing Marketing Management and Driving Sustainable Development

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**Abstract:** E-business, based on information, communication, and digital technologies, is a component of the digital economy. Furthermore, it is characterized by active development, determining the currently spreading changes in the traditional economy. The purpose of this study is to determine the impact of the digital economy on the realization of sustainable development goals and the transformation of the concept of marketing management. The following research methods were used in the study: historical method—to study the evolution of marketing management concepts; statistical analysis—to study aspects of the digital economy; correlation and regression analysis—to identify the relationship between the level of digitalization and key indicators of sustainable development and marketing management; systematic approach to consider digitalization, sustainable development and marketing as interrelated components of a single system. The article presents the relationship of sustainable development goals with the need to improve approaches to marketing management in the context of digitalization. The objectives include UN goal number 8: “Decent Work and Economic Growth”, number 9: “Innovation and Infrastructure”, and number 12: “Responsible Consumption and Production”. The paper examines the evolution in approaches to understanding marketing management in the twentieth and twenty-first centuries. Correlation and regression analysis is used to identify how digitalization affects certain factors and how these factors contribute to it. The paper analyzes the dynamism of the formation and development of the worldwide digital economy, establishes the relationship between its components, and examines their impact on the ecosystem. The dynamics of the number of Internet and social media users in the world is analyzed and the changes in global e-commerce revenue and digital advertising expenditures are estimated. The positive consequences and opportunities that arise in the digital economy are presented. The authors emphasize the transformation of the marketing management concept with regard to the goals of sustainable development. Marketing strategies and directions in state policy for regulating the impact of the digital economy on the environment, taking into account the goals of sustainable development, are proposed for business entities.



Academic Editor: Fabrizio D’Ascenzo

Received: 28 November 2024

Revised: 26 January 2025

Accepted: 28 January 2025

Published: 30 January 2025

**Citation:** Sak, T.; Mylko, I.; Ivashko, O.; Chulipa, I.; Wołowiec, T.; Sokołowska-Woźniak, J. How the Digital Economy Is Revolutionizing Marketing Management and Driving Sustainable Development.

*Sustainability* **2025**, *17*, 1130.

<https://doi.org/10.3390/su17031130>

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**Keywords:** sustainable development; e-business; SDG 8; SDG 9; SDG 12; digital economy; marketing management; digital marketing

## 1. Introduction

The digitalization of the economy is intensifying, and more and more socio-economic spheres are undergoing changes. It is worth noting that this process has had a positive impact on sustainable development, as the digital economy is conducive to innovations and active transition in the digital space. This can lead to the solution of environmental, social, and economic threats.

Marketing management is particularly important in ensuring business success in the digital economy. Digital transformation has changed the way companies interact with their customers, develop products, and achieve long-term goals. Because of the new demands of society, the economy, and the regulatory environment, current marketing management goes beyond traditional practices to include sustainability strategies and innovative approaches as part of a global strategy to achieve the UN Sustainable Development Goals.

The purpose of our study is to determine the impact of the digital economy on the achievement of sustainable development goals and the transformation of the marketing management concept.

Such sustainable development goals as Sustainable Development Goal number 8: “Decent Work and Economic Growth”, number 9: “Innovation and Infrastructure”, and number 12: “Responsible Consumption and Production” can be achieved through the digital economy [1]. Companies should develop marketing management systems that comply with the principles of ethical production, equal opportunities, and proper working conditions. Companies should also implement policies to develop products that meet environmental standards, organize production with less waste, and use circular business models. The marketing management system should include the formation of a marketing information system to understand climate risks and create conditions for the introduction of environmental innovations.

The digital economy is based on the use of digital technologies, the constant search for innovations, and the qualitative transformation of economic activities that ensures economic growth. In particular, mobility and Internet connectivity facilitate access to cyberspace for businesses and individuals, promote new forms of doing business, and reduce transaction costs. Although the increasing amount of information in the world is difficult to manage, it is also a key factor in the economy and a profitable asset of digital business. AI tools simplify the processing of large amounts of information and the automation of operational processes, while also increasing companies’ efficiency and reducing costs [2].

A unique ecosystem is emerging in society to support the development, distribution, and interaction of innovations and digital technologies. This ecosystem ensures the spread of these technologies, creating a network effect where the actions of one participant influence the value of a product or service for others. The use of new digital tools requires the acquisition of skills, raising society’s level of education and awareness, and the creation of computer networks. The acceleration of economic processes expedites management decision-making, which necessitates changes in the concept of marketing management regarding total digitalization and prioritizing sustainable development [3].

The unresolved problem is quantifying the influence of key factors driving the digitalization of the economy on marketing management’s relationship with the environment, the need to develop marketing strategies to transform business models, and state policy to regulate the digital economy’s impact on the environment with regard to the goals of sustainable development.

## 2. Literature Review

In this context, special attention should be given to the marketing management system, which Philip Kotler and Kevin Lane Keller describe as the art and science of selecting target markets and obtaining, retaining, and growing customers through the creating, delivering, and communicating of superior customer value. Co-creation of value between consumers and businesses, as well as the importance of generating and sharing value, have become an emphasis in the development of modern marketing thought [4]. The American Marketing Association offers the following formal definition: Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offers that are of value to consumers, customers, partners, and society as a whole [5].

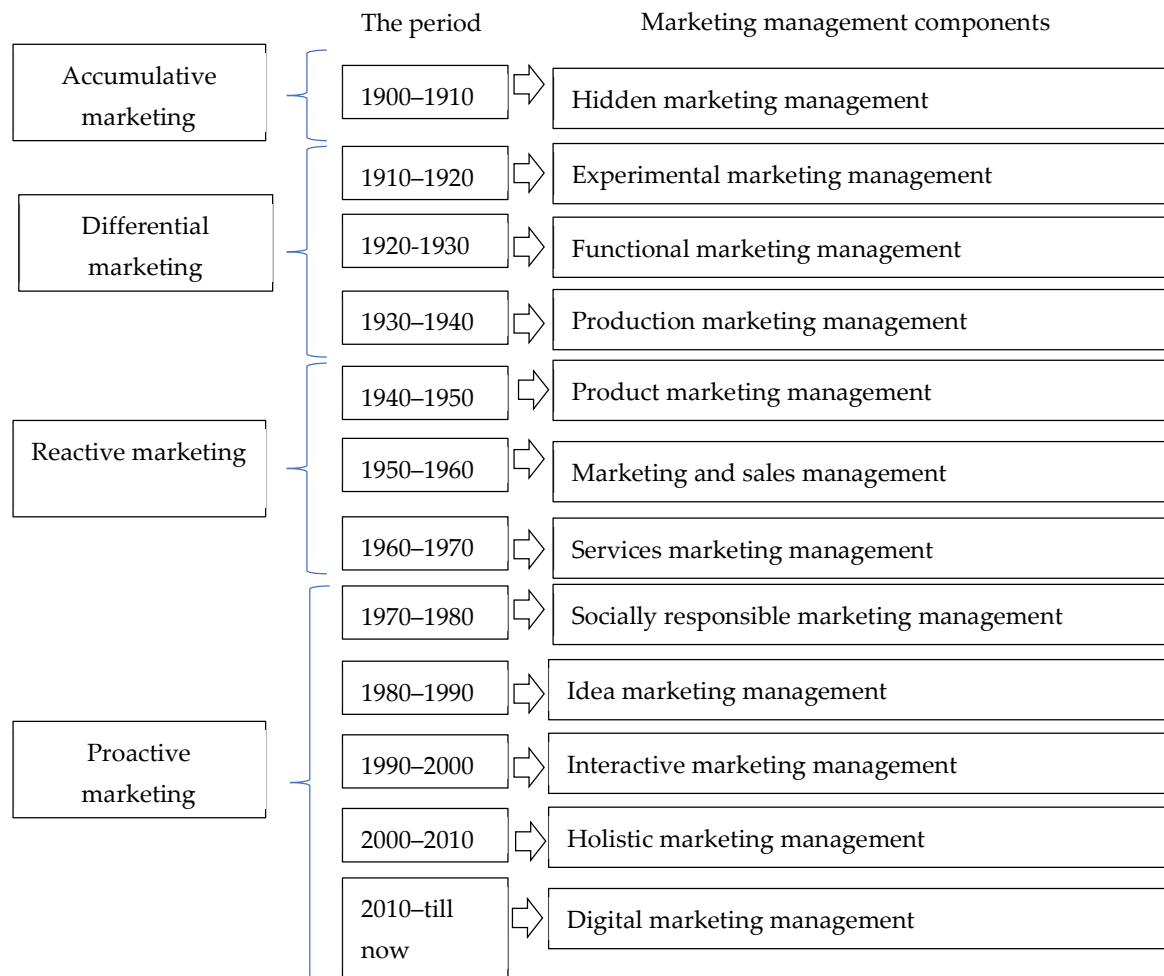
Peter Drucker highlights how management and marketing are inextricably linked. Drucker's theories are widely accepted in management and marketing literature; it was he who first proposed the idea that the customer should be the primary objective of business. According to Drucker, "creating customers is the only accurate definition of the purpose of business". Additionally, "a business enterprise has two basic functions: marketing and innovation, since its purpose is to create a customer". "Marketing is not only much broader than sales; it is not a specialized activity at all", Drucker writes in his book *The Practice of Management*, indicating that he equates marketing with business. It includes the entire company. It is the entire company as seen from the standpoint of its profitability, or, more specifically, from the viewpoint of the customer. As a result, marketing should be approached with consideration and accountability in every aspect of the business [6].

Consider how the concepts of marketing management have changed in the twentieth and twenty-first centuries. Some scholars believe that the prerequisites for the emergence of marketing management appeared in the fourth to the third centuries BC, which were characterized by the emergence of the first methods of influencing the consumer. This period (the pre-scientific period) lasted until the first half of the nineteenth century. The second stage—from the first half of the nineteenth century to the first half of the twentieth century—was the formation and development of marketing concepts and the introduction of the term "marketing" into the official business vocabulary. The third stage began in the 1950s and continues to this day. At this stage, marketing management is formed. Marketing principles are applied to enterprise management, the main focus is on the consumer, and maximum customer satisfaction is achieved by combining marketing and enterprise management systems [7].

The development of marketing management has undergone qualitative transformations that can be divided into the following periods:

- The accumulative period, which lasted until the first part of the twentieth century and was characterized by the accumulation of knowledge in marketing and management
- The differential period (1900–1910), when the two areas of marketing and management were separated
- The reactionary period (1950s–1960s) was marked by the emergence of marketing management
- The proactive period (from the 2000s to the present) which is defined by the active practical application of marketing management, creation of preferences and expectations, new segments, and new generations of consumers [8].

Figure 1 shows the interconnection and transformation of marketing management components in a historical context, reflecting the accumulation of knowledge and practical experience.



**Figure 1.** Transformation of marketing management concepts in terms of the amount of accumulated knowledge \*. \* Source: own elaboration.

A more detailed chronology of the evolution of the concept of marketing and its content is presented in the scientific work of Gary J. Brunswick [9].

At the beginning of the twentieth century, marketing and management began their formation. For the manufacturer, it was the way in which he dispensed his product, distributing it to customers through various sales channels. Marketing is a distinct form of economic production and an operation that determines the value of the product being distributed, while also serving as a key element in the economic distribution process [10]. These are the years of hidden marketing management and the accumulation of knowledge through experience.

The period of the 1920s–1940s can be called the era of differential marketing, marked by the formation of experimental, functional, and production marketing management concepts. In addition to selling, the scope of marketing expanded to include promoting ideas about products that would make consumers desire them and create a willingness to pay the price set by the seller. Marketing management began incorporating research, forecasting, and planning [11]. Much attention was paid to improving production and intensifying the promotion of goods without much differentiation by markets and consumers.

The period of the 1950s–1970s is the era of reactive marketing, within which the product, sales, and service marketing concepts were developed. Marketing management began to be viewed as an economic process through which goods and services are exchanged. This process is formed on the basis of coordinated actions, the ultimate goal of which is to move goods from places of production to places of final use in order to maximize consumer

satisfaction [12]. During this period, Kotler's interpretation of marketing from the point of view of management appeared: "the analysis, organization, planning and control of the firm's resources that influence customers, resources, and firm policy in order to meet the needs and desires of selected consumer groups for profit" [13].

In the 1980s and 2000s, marketing came to be defined as the process of managing efforts in a dynamic and socially responsible environment to facilitate exchange relationships, aligning the organization's capabilities and resources while maximizing customer satisfaction [14].

There is a shift from the use of more passive (reactive) methods of marketing management aimed at adapting to changes in the business environment to the use of proactive approaches that enable the formation of desired trends through the widespread use of interactive tools [15]. In practice, the whole range of marketing tools has begun to be used for each separately developed program. The emergence of a new market—the market of ideas—led to the creation of a legal framework for the protection of intellectual property rights. The emergence of a unique product—ideas within creative industries—led to the creation of a new market and the development of the concept of marketing management for ideas. The need to establish an information and communication system within the enterprise led to the development of the concept of interactive marketing management.

The idea of the holistic concept of F. Kohler and K. Keller is an attempt to build an effective marketing system for enterprises across various industries and markets. This system integrates elements of a socially responsible concept, components of internal and integrated marketing, and a subsystem for establishing and managing relationships with other business entities [16].

In the 2000s, the process of digitalization of society began, which led to the emergence of new digital business models, digital channels for approaching customers, and tools for promoting products in the digital environment. This became a prerequisite for the formation of digital marketing management. Today, digital marketing is a general term for the marketing of goods and services that uses digital channels to attract and retain customers [17]. Models of brand management have begun to emerge, one of which is the Brand Asset Valuator model. BAV is a tool used to assess the value of a brand by measuring its status and strength; it helps companies understand how consumers perceive their brand compared to competitors. This has a significant impact on the accuracy of decisions made [18,19].

However, the transformation of the concept of marketing management continues, given the shift from a market orientation to a sustainability orientation, as environmental and social issues accompanying digitalization processes become more acute. The digital economy has negative consequences in addition to positive impacts. For these reasons, marketing management should take into account the clear interconnection of the value creation process with social and ecological systems [20].

### 3. Materials and Methods

To establish the cause-and-effect relationships between the results of the digital economy and the factors that contribute to its development, we used the method of correlation and regression analysis [21–23].

The digital economy is accompanied by significant spending on digital advertising and an increase in the number of Internet and social media users. Our initial hypothesis is that there is a close relationship between the number of Internet and social media users and the growth of digital advertising spending. In turn, the average number of devices and connections significantly affects the growth of e-waste per capita.

During analysis, we took into account the following variables:

- number of Internet users;
- number of users of social networks;
- the amount of spending on digital advertising;
- average number of devices by region;
- average number of connections by region;
- electronic waste per capita by region.

Let us assume that the relationship between the variables—the number of Internet and social media users and the growth of digital advertising spending—is described by a linear multivariate regression equation:

$$y = b_0 + b_1x_1 + b_2x_2, \quad (1)$$

where  $y$  is the cost of digital advertising in billions of dollars;  $x_1$  is the number of Internet users in millions of people;  $x_2$  is the number of social network users in millions of people;  $b_0$  is the free term of the regression equation;  $b_1$  and  $b_2$  are the coefficients of the regression equation that characterize the quantitative impact on the resulting indicator of a change in the value of the relevant factor indicator per unit of its measurement.

The relationship between the attributes—the average number of devices and connections and the growth of e-waste per capita—is described by a linear regression equation:

$$z = a_0 + a_1x_3, \quad (2)$$

where  $z$  is the amount of e-waste per capita in kg per person;  $x_3$  is the average number of devices and connections;  $a_0$  is the free term of the regression equation;  $a_1$  is the coefficient of the regression equation that characterizes the quantitative impact on the resulting indicator of a change in the value of the relevant factor indicator per unit of its measurement.

To build regression models, the authors of the study collected an array of digital data. Using the Excel statistical data analysis package, the authors present a general view of the models that reflect the real situation.

#### 4. Results

In this study, we sought to analyze the dynamism of the formation and development of the digital economy and to establish the relationship between its components and their impact on the ecosystem.

More than 66% of all people on Earth now use the Internet, and according to the latest data, the total number of users worldwide is 5.35 billion [24] (Figure 2). Over the past 12 months, the number of Internet users has grown by 1.8%, with 97 million new users since the beginning of 2023 [25].

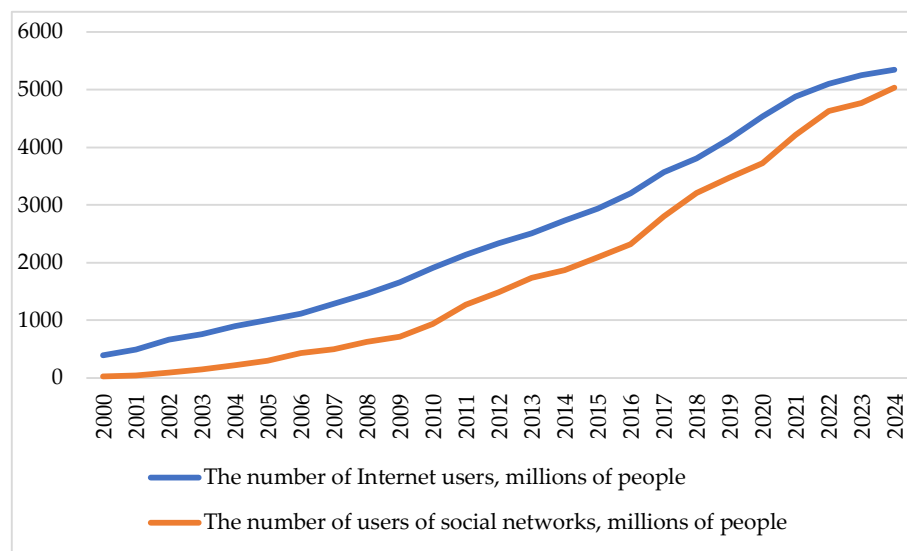
At the beginning of 2024, the number of unique mobile phone users was 5.61 billion. The latest data from GSMA Intelligence show that 69.4% of the world's population now uses mobile devices, and the global number has grown by 138 million (+2.5%) since the beginning of 2023 [26].

The analysis shows that the identities of active social media users have surpassed 5 billion, with the latter figure equivalent to 62.3% of the world's population. Over the past year, the total number grew by 266 million, resulting in an annual growth rate of 5.6% (Figure 2).

E-business, which is based on information, communication, and digital technologies and is a component of the digital economy, is characterized by active development, determining changes, and spreading which today changes the traditional economy, transforming it from a resource-consuming economy to a resource-creating economy. The digital transformation of the economy involves:



- A change in the model of economic management from program-targeted to program-projected;
- Penetration of digital technologies into the spheres of economic structure, traditional markets, social relations, and public administration;
- Formation of more efficient economic processes supported by digital infrastructures that change the main sources of added value and the structure of the economy;
- Transfer of the function of the primary mechanism for economic development to institutions based on digital models and processes.



**Figure 2.** Number of Internet and social media users in the world \*. \* Source: own elaboration based on the data to the report *Digital 2024* [25].

The digital economy is a network of social relationships driven by electronic technologies, infrastructure, services, and data analysis tools, aimed at maximizing production, distribution, exchange, and consumption while advancing socioeconomic development. One of the top priorities on a worldwide level is increasing the proportion of the digital economy and speeding up GDP development through digitalization [23].

The study of aspects of the digital economy and indicators for assessing the state of the economy and society is relevant for the development of transformation policies in line with the goals of sustainable development. Advances in technology and new opportunities for digitalization of the economy give impetus to improving assessment methods and indicator systems.

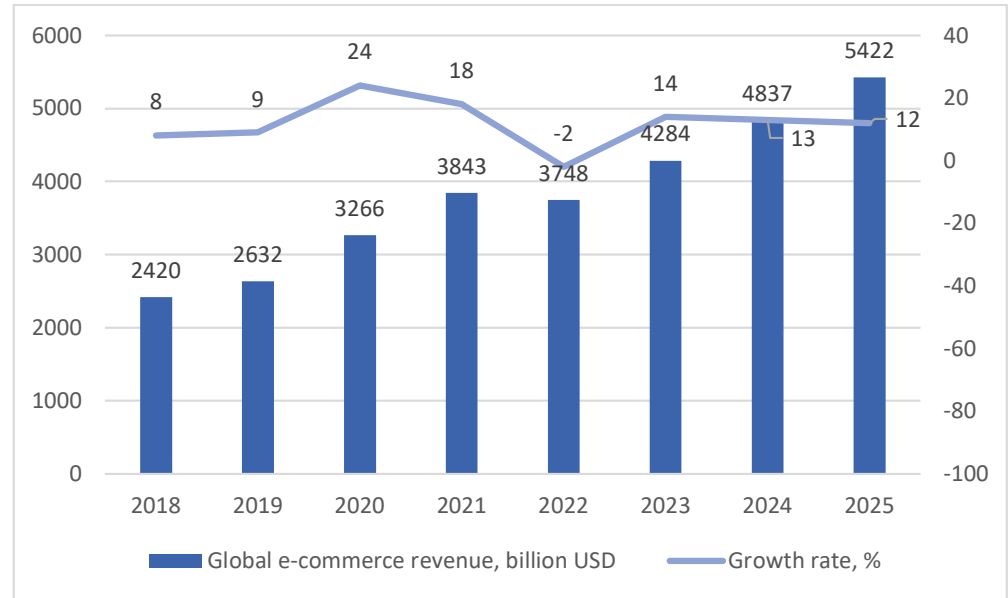
Many organizations' business practices have undergone significant changes as a result of digital transformation, which is the process of implementing digital technology to increase productivity and efficiency.

After the boom caused by the global COVID-19 crisis, e-commerce is now in a stabilization phase and is characterized by an increase in factors contributing to uncertainty. For example, global events such as the full-scale Russian–Ukrainian war, inflation, and supply chain difficulties point to a global recession and slow down the performance of many major e-commerce players (Figure 3).

Although 2022 was a difficult year for e-commerce, subsequent periods have been characterized by global revenue growth.

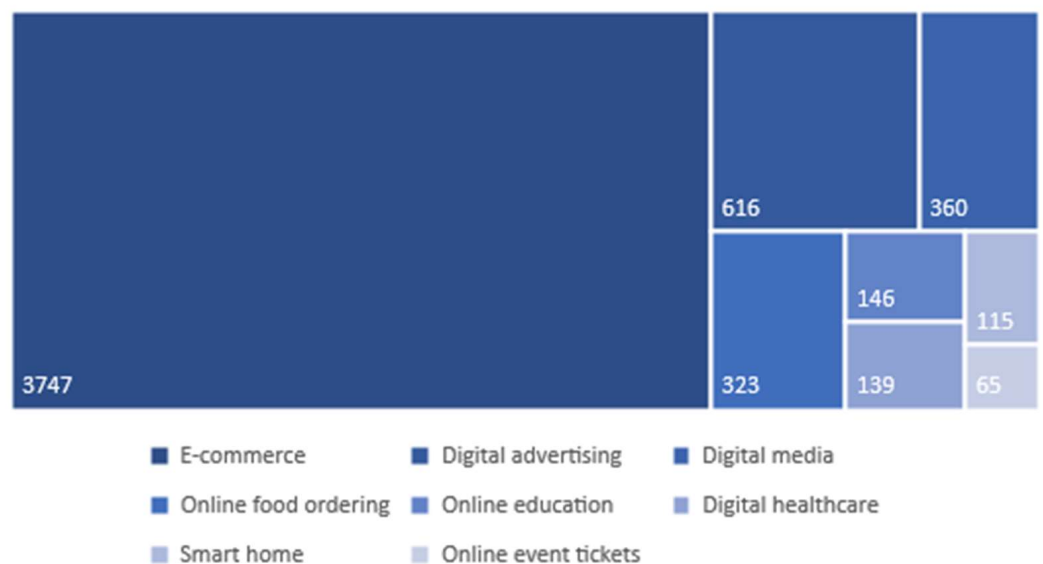
The e-commerce market is evolving as fast as it is expanding. One of the consequences of rapid innovation in this space is the emergence of an ecosystem that reduces friction in the value chain. These interconnected platforms, which are still being developed by a handful of companies, continue to attract interest among venture capitalists. In particular,

social commerce and payments platforms have significant potential to shape the future of e-commerce. As the line between the physical and digital worlds blurs every day, technologies such as blockchain, artificial intelligence, augmented and virtual reality, cryptocurrency payment platforms, and 5G are transforming consumer shopping into an increasingly seamless experience in the meta-universe [24].



**Figure 3.** Global e-commerce revenue in billions of US dollars and growth rate \*. \* Source: own elaboration based on the data [25].

E-commerce continues to hold the largest share of the digital economy (more than 67%) despite the chaotic global developments of 2022. Figure 4 shows the revenue-generating structure of the digital economy’s primary markets in 2022.



**Figure 4.** Revenue of selected markets of the digital economy in 2022, billions of US dollars \*. \* Source: own elaboration based on Statista Digital Market Outlook [27].

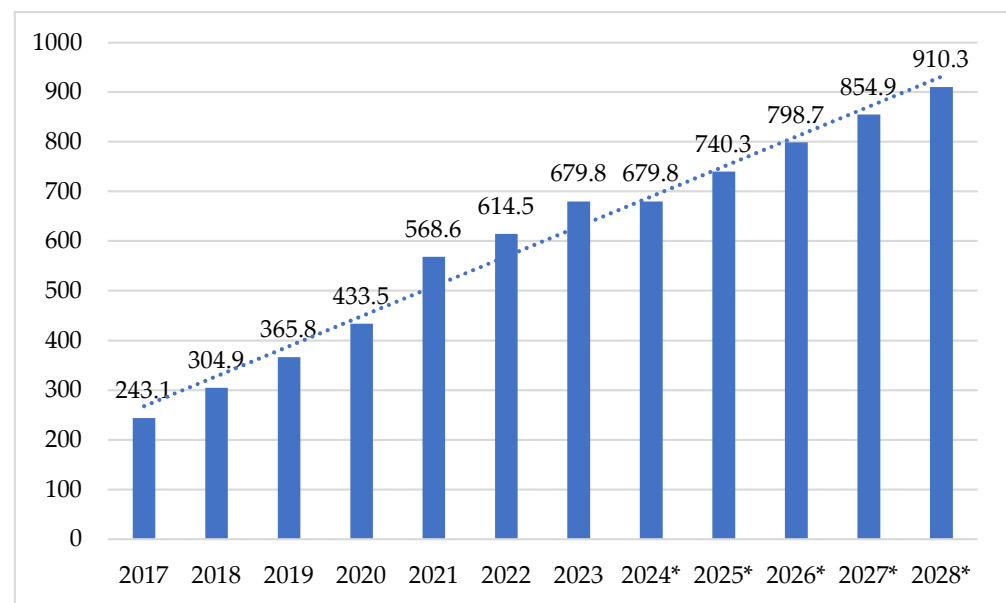
A total of 11% of the economy is created mainly by digital advertising. Every year, its share increases. The advertising and marketing industries have long supported one another. Despite the present economic downturn, market research indicates that the worldwide



advertising sector will expand by 5.3% in 2024. Businesses allocated 9.5% of their income to marketing as of 2023 [28,29].

Over the past seven years, the online marketing market has grown several times—for example, global spending on online marketing increased by about 2.8 times in 2023 compared to 2017.

Marketing and advertising are key components of business development. As the number of internet users grows year on year, many brands have increased their digital marketing spend to reach more consumers (Figure 5).



**Figure 5.** Spending on digital advertising in the world, billions of dollars \*\*. \* forecast data. \*\* Source: own elaboration based on the data of Statista Digital Market Outlook [30].

Research shows that the global digital advertising market is currently valued at USD 740.3 billion. This includes advertising through online channels such as audio, search, banners, and influencer marketing. It is projected to grow by 8.9% from the USD 679.8 billion spent in 2023, reflecting a slight slowdown from the previous year when growth reached 10.6%. It is clear that search advertising will continue to dominate the online advertising market with projected spending of USD 306.7 billion this year, accounting for 41.4% of the total.

The largest year-on-year growth from 2017 to 2024 occurred in 2021, when spending grew by 31.2% year-on-year. The surge in digital advertising spending in 2021 was the result of the economic recovery from the COVID-19 pandemic, a shift in business priorities to selling through online channels, changes in consumer habits, and technological advances. This was a turning point for the digital advertising market, strengthening its key role in marketing strategies.

Experts predict that, despite a minor downturn, the online advertising sector will continue to expand over the coming years. Global digital marketing spending is projected to grow by 7.9% in 2025 to USD 798.7 billion. In 2026 and 2027, an average growth of about 6.8% is expected, bringing total spending to USD 910.3 billion. By 2028, this figure is expected to reach USD 965.6 billion [30].

Let us present a sample of statistical data for correlation and regression analysis in Table 1 to build the actual model (1).

**Table 1.** Outputs for correlation and regression analysis.

Years	The Number of Internet Users *, Millions of People	The Number of Users of Social Networks *, Millions of People	Spending on Digital Advertising **, Billions of Dollars
2017	3568	2804	243.1
2018	3808	3212	304.9
2019	4148	3478	365.8
2020	4534	3726	433.5
2021	4880	4214	568.6
2022	5098	4632	614.5
2023	5250	4770	679.8

Source: own elaboration based on data of \* Statista Digital Market Outlook [30], \*\* Digital 2024 [25].

For the analysis, we took a sample of data for 7 years (2017–2023). It is clear that a small sample size and the remoteness of statistical data in time reduce the accuracy of correlation and regression analysis, but the reason for this is the difficulty of obtaining such data.

Using the Excel statistical data analysis package, a regression model was built and the corresponding coefficients were calculated. The analysis revealed that the factors  $x_1$ —the number of Internet users in millions of people—and  $x_2$ —the number of users of social networks in millions of people—are highly collinear, i.e., interdependent. This explains why we excluded one of the factors, the number of Internet users, from the model.

The linear univariate model has the following form:

$$y = -400.182 + 0.224x_2. \quad (3)$$

Let us provide an economic and mathematical interpretation of the results of the regression analysis (Table 2). The coefficient of multiple correlation indicates a very strong relationship, highlighting the dependence of the output indicator on the factors included in the model. The coefficient of determination is 98%, i.e., 98% of the changes in the output variable are determined by the influence of the input variables.

**Table 2.** Interpretation of regression analysis results for model (3).

Regression Statistics *		ANOVA				
Multiple R	0.994262682	df	SS	MS	F	
R Square	0.988558281	Regression	1	162,756.2749	162,756.2749	431.9972627
Adjusted R Square	0.986269937	Residual	5	1883.765118	376.7530235	
Standard Error	19.41012683	Total	6	164,640.04		
Observations	7					

	Coefficients	Standard Error	t Stat	p-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	−400.1816817	41.96453788	−9.536187028	0.000214574	−508.0549605	−292.3084029	−508.0549605	−292.3084029
x2	0.224007742	0.010777612	20.78454384	$4.77408 \times 10^{-6}$	0.196303009	0.251712475	0.196303009	0.251712475

\* Source: own elaboration, calculated on the basis of the initial data in Table 1.

The next step is to check the built model for adequacy, which requires comparing the data obtained with the Fisher’s table criterion. In our case, the calculated value of the criterion is higher than its tabular value. Therefore, the built model fully reflects the relationship between digital advertising spending and the number of social media users.

Analyzing the model, we can say that with an increase in the number of social media users by one unit, digital advertising spending increases by 0.224 units. This direct correlation can be explained by the fact that the larger the number of social media users is, the

more expedient it is to advertise on the Internet, as it is possible to promote products to the target audience.

Digital technologies and their infrastructure are heavily dependent on natural resources. Thus, the constant growth in the production and use of devices, as well as the increasing demand for water and energy, is causing increasing environmental damage. For example, the production and consumption of digital devices, data centers, and information and communication technology (ICT) networks account for 6% to 12% of global electricity use.

Developing countries experience the most severe environmental consequences of digitalization while benefiting less from its economic advantages. These nations often export raw materials with minimal added value and import high-cost digital devices, alongside an escalating volume of electronic waste. Geopolitical disputes over access to critical mineral resources, especially in these regions, further exacerbate the situation.

The digital economy continues its rapid expansion. By 2023, annual smartphone shipments surpassed 1.2 billion, more than double the volume recorded in 2010. The number of Internet of Things (IoT) devices is expected to grow 2.5 times by 2029, reaching 39 billion units. Additionally, data from 43 countries, representing three-quarters of global GDP, reveal a 60% increase in e-commerce sales between 2016 and 2022, culminating in USD 27 trillion in sales [29].

However, this rapid expansion imposes substantial environmental burdens. Digital technologies demand extensive resource consumption. For instance, producing a 2-kg computer necessitates approximately 800 kg of raw materials, while manufacturing a single smartphone requires about 70 kg of resources.

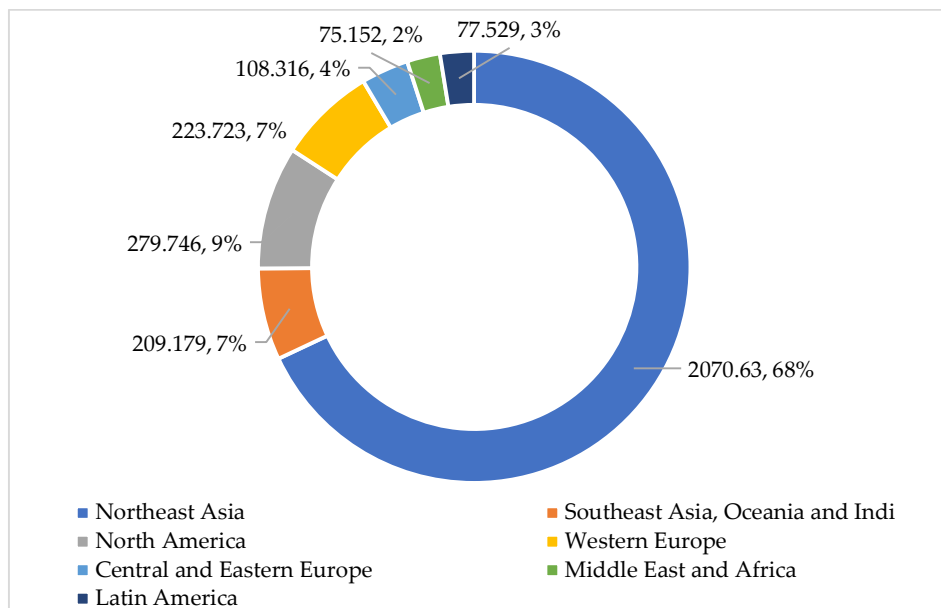
The manufacturing stage alone accounts for up to 80% of greenhouse gas (GHG) emissions associated with smartphones, making it the most environmentally impactful phase. Nevertheless, the entire lifecycle of digital devices and ICT infrastructure, including e-commerce operations, contributes to environmental degradation.

Electronic waste is increasing at a pace that outstrips recycling efforts. Between 2010 and 2022, waste from screens and small IT devices grew by 30%, reaching 10.5 million tons. Improper disposal of this waste not only pollutes ecosystems but also poses significant health risks.

The growing demand for data processing, transmission, and storage—driven by emerging technologies like blockchain, artificial intelligence (AI), 5G networks, and IoT—further intensifies emissions. In 2020, the ICT sector contributed between 0.69 and 1.6 gigatons of CO<sub>2</sub> equivalent, accounting for 1.5% to 3.2% of global greenhouse gas emissions [31].

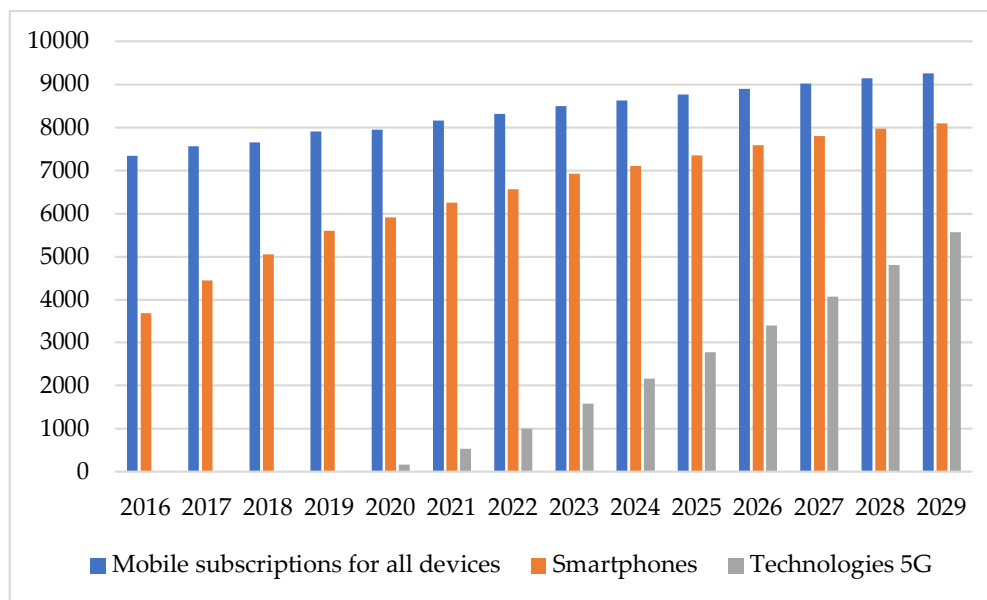
Addressing these challenges requires comprehensive policy reforms, technological advancements, and collaborative action among policymakers, businesses, and consumers. Key measures include transitioning to circular business models, optimizing energy efficiency in logistics, adopting eco-friendly packaging, and promoting more sustainable consumption practices. In 2023, the use of IoT devices with cellular connectivity increased significantly, demonstrating the high rate of adoption of these technologies in different groups of countries. The data presented in the UNCTAD report, based on Ericsson Mobility Visualizer analytics, allows us to analyze the spread of IoT technologies depending on the level of development of economies and their digital infrastructure (Figure 6).

Countries with a developed digital infrastructure have a much higher level of use of IoT devices with cellular connectivity compared to developing countries. This is due to the availability of technology, better integration of IoT into business models, and a wider range of applications in industry and everyday life.



**Figure 6.** IoT devices with cellular connectivity, by country group in 2023, millions of connections \*. \* Source: own elaboration based on the data of United Nations Conference on Trade and Development (UNCTAD), report Ericsson Mobility Visualizer—Mobility Report [32].

The number of IoT devices is projected to grow sharply amid the boom in the digital economy. By the end of 2029, the number of 5G subscriptions is expected to reach 5.6 billion, accounting for more than 50% of all mobile subscriptions. 5G technology is expected to become the dominant technology in terms of subscriptions by 2028 (Figure 7).



**Figure 7.** IoT devices with cellular connectivity in 2016–2029 by device and technology, millions of connections \*. \* Source: own elaboration based on the data of United Nations Conference on Trade and Development (UNCTAD), report *Ericsson Mobility Visualizer—Mobility Report* [32].

In the second quarter of 2024, the number of 5G subscriptions grew by 161 million, bringing the total to more than 1.9 billion. Meanwhile, the number of 4G subscriptions continued to decline, with the total number falling by 25 million as more users migrate to 5G. The total number of 4G subscriptions is about 5.2 billion, which corresponds to about 60% of all mobile subscriptions [33].

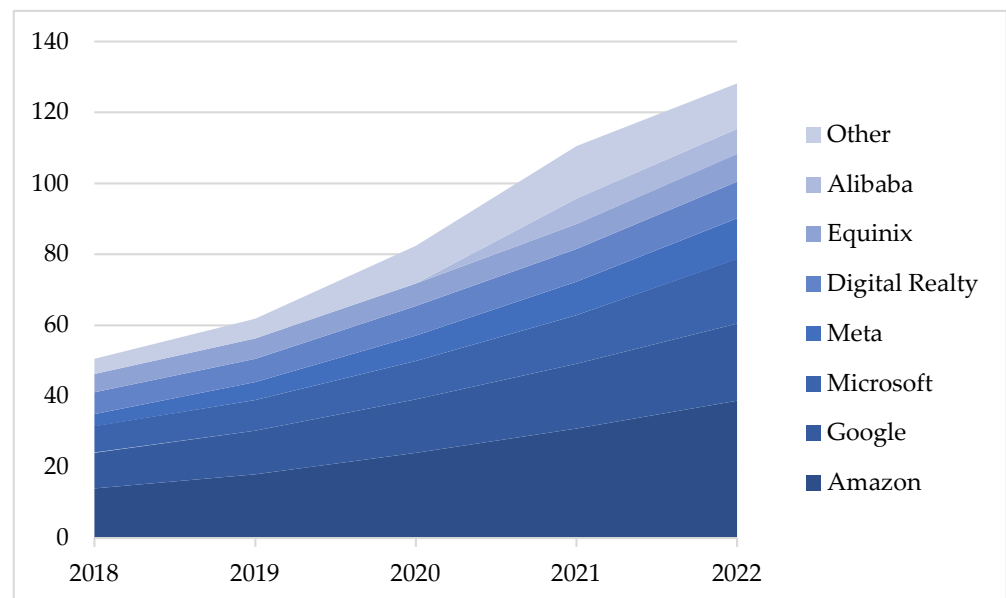
Increased energy and water consumption due to digitalization is a pressing issue. From 2018 to 2022, the electricity consumption of the 13 largest data center operators more than doubled. In 2022, global data center electricity consumption was equal to the amount consumed by France—460 terawatt hours (TWh) [29].

According to the International Energy Agency, this consumption may increase to 1000 TWh by 2026 [34].

This growth could put additional strain on local power grids. For example, in 2020, data centers in Singapore consumed about 7% of the country's electricity, and in Ireland, this figure reached 18% in 2022 [35].

Cryptocurrencies also cause significant energy consumption. From 2015 to 2023, global energy consumption of bitcoin mining increased 34 times, reaching 121 TWh.

The demand for water in digital infrastructure is steadily increasing, a worrying trend in a world where nearly two billion people remain without access to clean drinking water. In 2022 alone, Google's data centers and offices consumed over 21 million cubic meters of water. Emerging technologies, such as generative artificial intelligence, are further intensifying this demand due to their reliance on server cooling systems, which require substantial water resources (Figure 8).



**Figure 8.** Annual electricity consumption by selected data center operators, terawatt-hours, 2018–2022 \*. \* Source: own elaboration based on the data of United Nations Conference on Trade and Development (UNCTAD), report of companies [29].

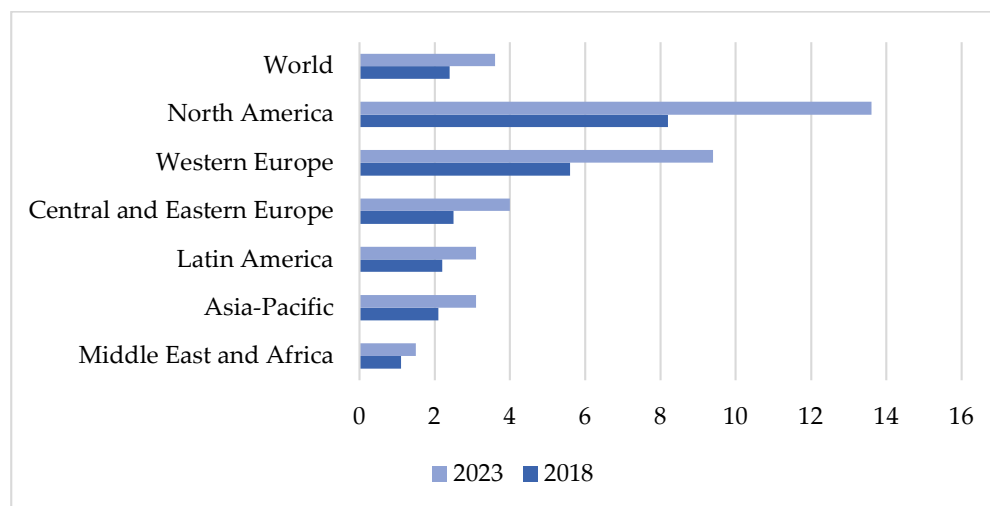
To solve these problems, joint efforts by technology companies and governments are needed to improve energy efficiency and reduce water consumption.

All major data center operators are showing a steady increase in electricity consumption, which is a consequence of digitalization, data growth, cloud technologies and new digital platforms.

Technology giants (Amazon, Google, Microsoft) are showing the largest growth in consumption, indicating an increase in their role in the global digital infrastructure.

There is a significant increase in devices per capita in developed countries (Figure 9).

North America and Western Europe have seen the highest growth in the average number of devices and connections per capita, reflecting their high level of digitalization. In contrast, regions such as the Middle East and Africa are lagging behind in terms of growth, although they are gradually improving their performance.



**Figure 9.** Average number of devices and connections per capita, by region, 2018 and 2023 \*, \* Source: own elaboration based on the data of United Nations Conference on Trade and Development (UNCTAD) calculations based on data from Cisco [36].

All regions have seen an increase in the number of devices per capita, indicating that digitalization is a global process that is reaching all parts of the world, although the pace of this process may vary. There is a significant gap between developed regions (North America, Western Europe) and less developed regions (Middle East and Africa). Developing countries disproportionately shoulder the environmental burdens of digitalization while gaining limited economic advantages. Table 3 provides regional data on electronic waste, revealing that these nations produce less than 1 kg of digital waste per capita, in stark contrast to 3.25 kg per capita in developed countries. In the least developed nations, this figure drops to just 0.21 kg.

**Table 3.** E-waste by region.

Region	Inhabitants		E-Waste Generated <sup>1</sup>				E-Waste Documented as Formally Collected and Recycled <sup>2</sup>			
	Millions in 2010	Millions in 2022	kg per Capita in 2010	kg per Capita in 2022	Million kg in 2010	Million kg in 2022	Million kg in 2020	Million kg in 2022	Collection Rate 2010 (%)	Collection Rate 2022 (%)
Africa	1040	1408	1.6	2.5	1640	3551	1.9	25	0.1	0.7
Americas	918	1021	9.9	14.1	9068	14,427	3149	4328	34.7	30.0
Asia	4168	4677	3.2	3.4	13,259	30,147	1030	3568	7.8	11.8
Europe	733	742	13.3	17.6	9739	13,076	3780	5593	38.8	42.8
Oceania	36	44	12.6	16.1	452	707	-	292	-	41.4
World	6896	7893	5	7.8	34,157	61,908	7961	13,807	23.3	22.3

<sup>1</sup> Electronic waste (e-waste) refers to the quantity of electrical or electronic products discarded within a country during a specific reporting year, prior to any processes of collection, reuse, treatment, or export. <sup>2</sup> Officially collected e-waste includes waste gathered in compliance with environmental protection laws specifically addressing e-waste. This category also encompasses e-waste that is collected domestically but subsequently exported and treated according to the regulatory standards of the destination country. Source: own elaboration based on the Global e-Waste Monitor (GEM) report.

A significant portion of electronic waste from developed countries is exported to developing regions, where formal systems for waste collection and recycling are often insufficient. In 2022, only 7.5% of electronic waste in developing countries was officially collected, compared to 47% in developed nations.

While the world's population grew from 6.896 million in 2010 to 7.893 million in 2022, an increase of about 14.5%, e-waste production increased much faster—from 34.157 million tons in 2010 to 61.908 million tons in 2022, an increase of almost 81%. This shows that the increase in technological consumption is far outpacing population growth.



The amount of e-waste per capita increased from 5 kg per person in 2010 to 7.8 kg per person in 2022, which also confirms the rapid increase in the consumption of electronic devices. The largest increase per capita was observed in Europe (from 13.3 to 17.6 kg) and America (from 9.9 to 14.1 kg).

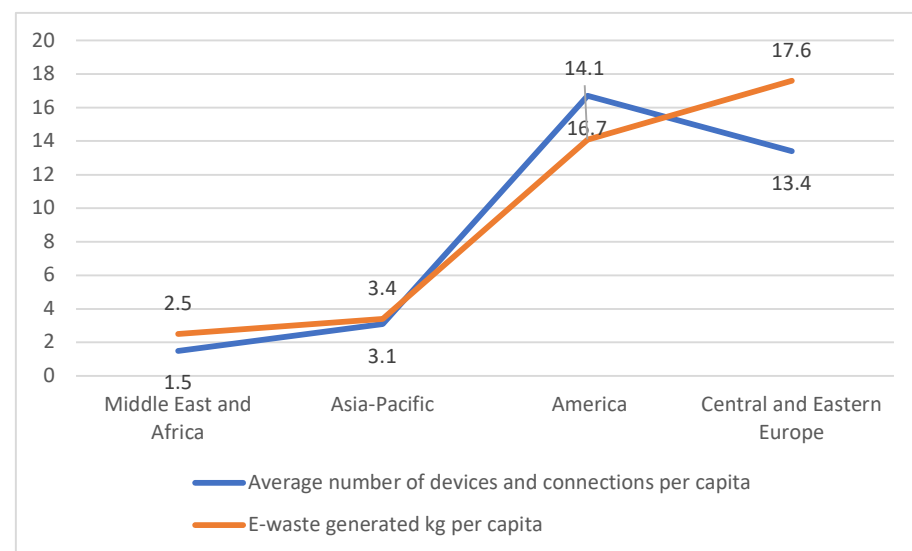
Africa has the lowest e-waste production per capita (2.5 kg per person in 2022), but its recycling rate is extremely low—only 0.7% of e-waste was documented as recycled in 2022.

Europe has the highest e-waste production per capita (17.6 kg in 2022), but also demonstrates the highest recycling rate—42.8% in 2022.

While the total volume of e-waste has increased, the global recycling rate has decreased from 23.3% in 2010 to 22.3% in 2022. This means that recycling rates are not keeping pace with the growth in e-waste production.

Despite increasing recycling rates in some regions, such as Europe and Oceania, the global e-waste problem remains extremely serious. There is a need to significantly improve the efficiency of e-waste disposal and recycling in all regions, especially in Africa and Asia, where the lowest recycling rates are observed.

A graphical representation of the relationship between changes in the amount of e-waste per capita and the number of devices (connections) is shown in Figure 10.



**Figure 10.** Average number of devices and connections and e-waste generated per capita by region \*. \* Source: own elaboration, calculations based on the United Nations Conference on Trade and Development (UNCTAD) data from Cisco [36], Global e-Waste Monitor (GEM) report [37].

The sample of statistics for the correlation and regression analysis is presented in Table 4 to build the actual model (2).

**Table 4.** Inputs for the correlation and regression analysis for model (2).

Region	Average Number of Devices and Connections per Capita	E-Waste Generated kg per Capita
Middle East and Africa	1.5	2.5
Asia-Pacific	3.1	3.4
America	16.7	14.1
Central and Eastern Europe	13.4	17.6

Source: own elaboration, calculations based on the United Nations Conference on Trade and Development (UNCTAD) data from Cisco [36], Global e-Waste Monitor (GEM) report [37].

For the analysis, a selection of data was taken by regional division of the world's countries.

Using the Excel statistical data analysis package, we built a regression model and calculated the corresponding coefficients.

The linear one-factor model has the following form:

$$z = 0.9417 + 1.2307x_3. \quad (4)$$

The economic and mathematical interpretation of the results of the regression analysis is presented in Table 5. The coefficient of multiple correlation indicates a very strong relationship, highlighting the dependence of the output indicator on the factors included in the model. The coefficient of determination is 98%, i.e., 98% of the changes in the output variable are determined by the influence of the input variables.

**Table 5.** Interpretation of regression analysis results for model (4).

Regression Statistics *		ANOVA					
Multiple R	0.931714022		df	SS	MS	F	
R Square	0.86809102	Regression	1	150.1276609	150.1276609	13.16196997	
Adjusted R Square	0.802136529	Residual	2	22.81233907	11.40616953		
Standard Error	3.377302109	Total	3	172.94			
Observations	4						

	Coefficients	Standard Error	t Stat	p-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1.230651997	2.814618749	0.4373	0.704622683	−10.87967505	13.34098	−10.8797	13.34098
x <sub>3</sub>	0.941711585	0.259571774	3.6279	0.068285978	−0.175135617	2.058559	−0.17514	2.058559

\* Source: own elaboration, calculated on the basis of the initial data in Table 4.

The verification of the built model (4) is adequate to the data, since the calculated value of the Fisher's criterion is greater than its tabular value. Therefore, the model fully reflects the relationship between e-waste and the number of devices and connections.

Analyzing the resulting model, we can say that with an increase in the number of devices and connections per person, e-waste increases by 1.2307 kg per person on average in the world. Such a direct and close relationship can be explained by the fact that device generations are changing rapidly, users often change their devices, and e-waste is growing significantly. Therefore, the problem needs to be addressed immediately.

Investments in recycling technologies and waste management systems are critical to ensuring a sustainable future, given the rapid growth of e-waste.

The manufacturing phase of digitalization imposes significant environmental costs on developing countries rich in critical minerals. The extraction and processing of these raw materials frequently result in environmental degradation, pollution, and heightened competition for essential local resources, such as water, among mining operations, agriculture, and households.

These nations also face disproportionate impacts from climate change while lacking the necessary resources to leverage digital technologies for mitigating its effects. Bridging the growing digital environmental inequalities requires coordinated international action to promote equitable practices. Key measures include fostering sustainable mining methods, enhancing digital infrastructure, curbing the illegal export of electronic waste, and strengthening the capacities of developing countries.

To address the environmental challenges of digitalization, a transition toward a circular and inclusive digital economy is essential. This approach involves adopting sustainable

practices across the entire digital lifecycle—from design and production to usage and disposal—while ensuring fair distribution of economic benefits.

Currently, the digital economy generates excessive waste, a problem worsened by programmed obsolescence, where product lifespans are deliberately shortened for technical, functional, or psychological reasons. Despite the growing need for circular practices, only 7.2% of the global economy is currently circular, with this percentage declining due to increased material extraction and consumption.

As of 2022, merely 22.3% of global electronic waste was officially collected, with even lower collection rates in developing countries, highlighting the urgent need for more sustainable and equitable waste management systems.

## 5. Discussion

The digital economy is characterized by the widespread use of digital technologies to create value and increase efficiency [38]. Marketing management in this context involves the use of digital tools to better understand consumer behavior, predict market trends, and increase customer engagement. The introduction of new technologies, such as AI-powered chatbots, augmented reality (AR) in advertising, and blockchain for secure transactions, has redefined the role of marketing. Effective marketing management ensures the successful integration of innovations into the company's operations.

Marketing management in the digital economy increasingly combines innovation with sustainable development. For example, artificial intelligence-driven tools are used to optimize energy consumption in manufacturing, and blockchain improves traceability in environmentally friendly sources. These technologies not only increase efficiency, but also meet consumer demands for ethical and environmental practices.

In the context of environmental management and societal expectations, marketing management is increasingly focused on promoting sustainable development. This involves creating strategies that align business goals with sustainable practices to benefit both companies and the planet [1].

A company's marketing management system based on the principles of sustainable development should include the following elements:

- market segmentation, selection of target audiences, taking into account sustainable needs—environmental friendliness and responsibility;
- brand positioning through the achievement of sustainable development goals, which involves the implementation of environmental and social communication messages in its communication strategies [18];
- implementation of innovative business models that allow for more efficient use of resources and customer engagement;
- creating a management system based on the principles of transparency and trust in establishing communication with consumers through the use of reporting according to GRI (Global Reporting Initiative) and SASB standards.

Despite the obvious benefits of sustainable marketing management, companies face several challenges: High costs of implementing environmental initiatives, lack of understanding by consumers of the real value of such products, and a shortage of professionals who understand the mechanism of implementing the principles of sustainable development in the company's marketing management.

The main management initiative should be the spread of sustainable marketing, a concept of marketing activities aimed at creating and selling products or services that have a minimal negative impact on the environment. The main goal of environmental marketing is to satisfy consumer needs in a way that promotes sustainable development, preserves

natural resources, and obtains environmental, social, and economic benefits [39]. The key elements of environmental marketing are:

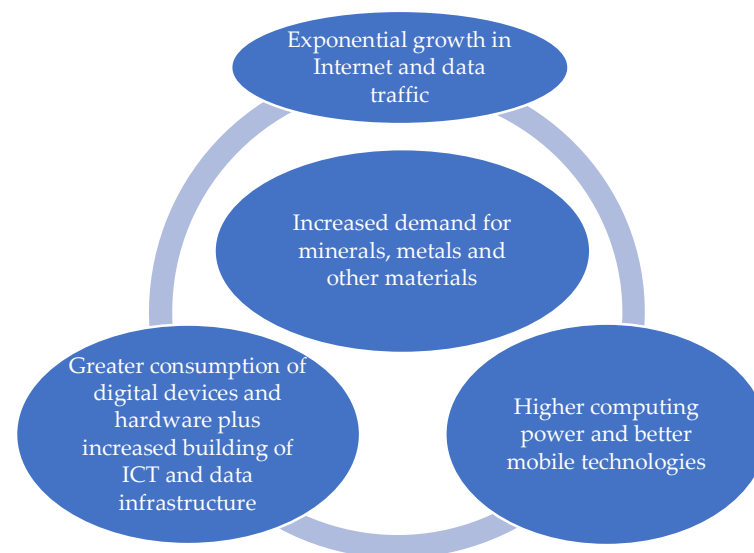
- product environmental friendliness (use of environmentally friendly materials, energy-saving technologies, biodegradable packaging, etc.);
- ethics—transparency in production and communication, consideration of social and environmental standards;
- brand positioning through the formation of a “green” image through responsibility for environmental issues.

By optimizing resource utilization and reducing waste, businesses can lower costs and create new market opportunities. Sustainable practices can also lead to technological innovations that benefit people and the planet [25].

Transitioning to sustainable digitalization demands that regions with excessive device consumption reduce their usage, creating space for under-connected areas to advance their digital infrastructure and foster development.

Achieving this goal requires coordinated efforts involving governments, businesses, consumers, and civil society. Effective and inclusive solutions must draw on a wide range of perspectives to address the challenges equitably and holistically.

Digitalization has an impact on the growth of material consumption, as it requires significant resources to produce digital devices and infrastructure (Figure 11).



**Figure 11.** The impact of digitalization on consumer trends and spending. Source: own elaboration, based on data from the *Digital Economy Report 2024* [29].

The main aspects of the identified dynamics include:

- The demand for mobile and network devices, computers, servers, data centers, and related infrastructure is growing every year. The production of such technologies requires a large variety of materials, including rare earth metals, copper, lithium, and other minerals.
- Dynamic pace of technological upgrades and the emergence of a new generation of digital technologies leads to an increase in the consumption of materials for more powerful components and new types of infrastructure. For example, 5G technologies require the installation of new base stations and other network solutions.
- The development of the Internet of Things (IoT) leads to the mass production of new connected devices used in industry, transportation, smart homes, etc. This also increases the material costs of producing and maintaining this infrastructure.

- The amount of data is growing exponentially due to the proliferation of digital services and technologies. To store and process these data, larger and larger data centers are being built, which require materials for servers, cooling and infrastructure support.
- Increased use of materials leads to an increase in the environmental burden associated with the extraction of resources, production of electronic devices and their disposal. The growing amount of e-waste is becoming a problem that is being addressed through the transition to a circular economy, more efficient use of resources, and recycling.

Thus, digitalization, in general, significantly affects the consumption of materials, which poses new challenges for both the economy and the environment [39]. The digitalization of the economy, more specifically, has both positive and negative impacts on the achievement of sustainable development goals (Table 6).

**Table 6.** Impact of economic digitalization on achieving the Sustainable Development Goals.

Sustainable Development Goals	Positive Impacts of the Digitalization of the Economy	Negative Impacts of the Digitalization of the Economy
SDG 8: Decent work and economic growth	<ul style="list-style-type: none"> <li>• Creation of new jobs in IT, e-commerce and digital marketing;</li> <li>• Increasing labor productivity with the help of digital technologies;</li> <li>• Remote work provides an opportunity to employ people in different regions and people with disabilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Job losses due to automation in traditional industries;</li> <li>• Uneven access to technology between countries, which may increase economic inequality.</li> </ul>
SDG 9: Innovation and infrastructure	<ul style="list-style-type: none"> <li>• Stimulating innovation and developing new platforms, services and digital products;</li> <li>• Investing in digital infrastructure to optimize business processes;</li> <li>• Increasing access to knowledge and educational opportunities through online education and digital ecosystems.</li> </ul>	<ul style="list-style-type: none"> <li>• Uneven development of digital infrastructure between countries and regions, which deepens digital inequality;</li> <li>• High costs of creating and maintaining digital infrastructure.</li> </ul>
SDG 12: Responsible consumption and production	<ul style="list-style-type: none"> <li>• Digital platforms enable businesses to transparently demonstrate information about environmental responsibility, for example, through product labeling and sustainability reports;</li> <li>• The growing popularity of platforms for the secondary sale of goods (Vinted, OLX), which promotes the reuse of resources.</li> </ul>	<ul style="list-style-type: none"> <li>• Increase in e-waste due to the short life cycle of electronic devices;</li> <li>• Excessive use of resources for the production of digital goods (rare metals, plastic), which worsens the state of ecosystems;</li> <li>• Digital advertising of increased consumption, which forms impulsive purchases instead of conscious consumption.</li> </ul>

Source: own elaboration.

## 6. Conclusions

The practical recommended steps include:

- (1) directions of state policy to regulate the impact of the digital economy on the environment.
- (2) directions for transforming marketing strategies in the context of achieving sustainable development goals.

The digital economy significantly transforms the concept of marketing management, fostering sustainable business practices and innovation. The shift from market orientation to a focus on sustainable development in marketing management is accompanied by the adoption of digital tools such as the Brand Asset Valuator, which enhances the precision of strategic decision-making. Digital technologies contribute to addressing environmental, economic, and social challenges by integrating sustainable development goals into business processes. At the same time, the digital economy exerts a substantial impact on the ecosystem, including increased electronic waste, energy resource consumption, and greenhouse gas emissions. These factors necessitate a comprehensive approach to managing digital processes.

In accordance with the outlined negative impacts, transformations in marketing are needed in the context of achieving the sustainable development goals, namely:

- The use of digital tools to create new jobs in marketing, such as digital campaign management, data analysis, and the development of sustainable brand development strategies;
- Adaptation of educational programs for training marketers in new competencies required in the digital age;
- Integration of digital technologies into marketing strategies: use of AI, big data, CRM systems to improve business efficiency;
- Promotion of environmentally friendly consumption through brand communications, focusing on durability, and the reuse or recycling of the product;
- Use of environmental principles in digital advertising with a focus on compliance with the requirements for the disposal of digital devices and changing consumer behavior towards sustainable consumption.

The proposed transformations will allow businesses to more effectively overcome the challenges of the digital economy, integrate sustainability values into their operations, and promote global environmental and social responsibility. Accordingly, changes should be made in both business marketing strategies and government programs and projects.

A sustainable approach to marketing strategies will help companies achieve economic efficiency, improve their reputation, raise consumer awareness, and reduce their environmental impact. Accordingly, marketing strategies should be based on:

- Using digital data to forecast demand. Big Data analysis allows for better forecasting of consumer needs to avoid overproduction, reducing resource consumption and having a positive impact on the environment;
- Environmental transparency—focusing on a product’s environmental friendliness, recyclability, energy savings, or other environmental benefits;
- Optimization of digital marketing channels, which will help reduce the amount of unnecessary digital advertising that consumes resources by focusing on personalized approaches.

The state policy of regulating the impact of the digital economy on the environment should include the following main areas:

- Legislative regulation of e-waste:
  - Establishment of standards for companies on the use of electronic equipment and digital devices;
  - Introduction of tax incentives for companies that invest in recycling and environmental technologies;
  - Introduction of “take-back” programs, which require companies to ensure that they collect equipment at the end of its useful life.
- Stimulating the energy efficiency of digital infrastructure:
  - Introducing energy efficiency standards for server centers, such as mandatory use of renewable energy;
  - Ensuring carbon emissions reporting for large digital companies;
  - Providing grants and subsidies to companies that implement innovative energy-efficient solutions.
- Development of technologies for the secondary use of resources:
  - Creating an infrastructure for the reuse of digital device components;
  - Support for research into new environmentally friendly materials for the production of digital equipment.
- Implementation of educational programs to raise public and business awareness of the responsible use of digital technologies and equipment recycling;



- Deepening international cooperation by harmonizing policies and developing common standards for recycling and reducing the environmental impact of digital technologies.

In order to transform the marketing management system, taking into account the need to achieve such sustainable development goals as Sustainable Development Goal number 8: “Decent Work and Economic Growth”, number 9: “Innovation and Infrastructure”, number 12: “Responsible Consumption and Production”, we recommend the following measures:

- Digital transformation of business on the basis of sustainable development and transition to a circular business model;
- Involvement of more partner companies in data collection and publication of sustainability reports;
- Developing or updating a sustainable development strategy, in particular for attracting and retaining talent, ensuring gender equality, implementing greenhouse gas emission reduction initiatives, and other measures aimed at mitigating environmental impact;
- Involvement of partners in environmental initiatives [40].

Given the study of the positive and negative consequences of expanding the boundaries of the digital economy, it is worth emphasizing the transformation of the concept of marketing management. The modern concept should be based on the goals of sustainable development, i.e., minimizing the harmful impact on the environment and maximizing the opportunities that humanity receives from the latest technologies.

Therefore, the state policy of regulating the impact of the digital economy on the environment should include the following main areas:

- (1) legislative regulation of e-waste;
- (2) stimulating the energy efficiency of digital infrastructure;
- (3) development of technologies for the secondary use of resources;
- (4) implementation of educational programs to raise public and business awareness of the responsible use of digital technologies and equipment recycling;
- (5) deepening international cooperation by harmonizing policies and developing common standards for recycling and reducing the environmental impact of digital technologies.

The further evolution of digital business models and the implementation of innovative technologies, such as blockchain and AI, create the prerequisites for deeper integration of digital solutions into marketing management. However, the approach must be balanced to ensure the achievement of sustainable development goals.

Thus, the digital economy serves not only as a driver of innovation in marketing management but also as a tool for achieving sustainable development. While doing this, there is also a requirement to balance economic, social, and environmental objectives.

Businesses that succeed in managing innovation and sustainability in their marketing strategies are better positioned to achieve competitive advantage, foster customer loyalty, and grow globally.

In the digital economy, marketing management is no longer limited to promoting products or services—it is a strategic function that drives innovation, ensures adaptability, and supports sustainable development. Digital marketing and artificial intelligence tools allow us to study consumer behavior in the context of their sustainable preferences. Environmental marketing plays an important role in enhancing the competitiveness of an enterprise, attracting eco-conscious consumers and supporting environmental protection efforts.

Integrating sustainability principles into marketing management enhances the company’s image and is a prerequisite for creating long-term value. Given the influence of the UN Sustainable Development Goals on global politics and markets, companies that are the first to adapt their management systems and marketing strategies to these principles will gain a competitive advantage while preserving the planet’s resources for future generations.

A prospective area for further research is to identify the impact of digital content and social media on consumer habits with regard to sustainable development.

**Author Contributions:** Conceptualization, T.S. and I.M.; methodology, T.S. and I.M.; software, O.I. and I.C.; validation, O.I.; formal analysis, T.W. and J.S.-W.; investigation I.C. and O.I.; resources, T.S. and I.M.; data curation, O.I. and T.W.; writing—original draft preparation, T.S. and O.I.; writing—review and editing, T.S. and I.M.; visualization, O.I.; supervision, I.C. and J.S.-W. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data required for the study was collected using the Public Disclosure Platform Statista ([Statista.com](https://www.statista.com)), IEA ([iea.org](https://www.iea.org)), The Global E-Waste Monitor 2024 ([ewastemonitor.info](https://ewastemonitor.info)).

**Conflicts of Interest:** The authors declare no conflicts of interest.

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