

Article

Sustainable Development in the Digital Age: Harnessing Emerging Digital Technologies to Catalyze Global SDG Achievement

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Abstract: The digital revolution, characterized by rapid technological advancements, presents a unique opportunity to accelerate progress towards the United Nations' Sustainable Development Goals (SDGs). This research explores the transformative potential of cutting-edge digital technologies—including artificial intelligence, big data analytics, cloud computing, and the Internet of Things—in fostering sustainable development across economic, social, and environmental dimensions. Our study employs a rigorous empirical approach to quantify the impact of digital innovation on SDG achievement within the European Union. Utilizing the Digital Economy and Society Index (DESI) as a comprehensive measure of technological progress, we apply structural equation modeling to emphasize the complex interplay between digital advancement and sustainable development indicators. A key focus of our analysis is the mediating role of economic performance, measured by GDP per capita, in the relationship between digital technology adoption and SDG progress. This nuanced examination provides insights into how economic factors influence the effectiveness of digital solutions in addressing global challenges. Our findings underscore the need for adaptive policies that harness the power of digital technologies while addressing potential challenges and ensuring inclusive growth.

Keywords: emerging digital technologies; sustainable development goals; economic performance; European Union; structural equation modeling



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1. Introduction

The United Nations' Sustainable Development Goals (SDGs), introduced in 2015, offer a comprehensive framework with which to tackle global challenges such as poverty, inequality, climate change, and social injustice [1]. Achieving these ambitious targets by 2030 necessitates innovative approaches and cross-sector collaboration [2,3]. Digital technologies have emerged as pivotal in accelerating progress towards these goals [4].

The digital landscape has undergone a radical transformation in recent years, propelled by advancements in artificial intelligence (AI), Big Data (BD), cloud computing (CC), and the Internet of Things (IoT). These technologies reshape industries and profoundly impact societal and environmental outcomes [5]. AI and BD enable more informed decision making through complex data analysis, while IoT facilitates improved resource management via real-time monitoring and automation. These technologies' convergence creates unprecedented opportunities to address the multifaceted challenges encompassed by the SDGs [6].

However, the digital revolution is not without its challenges. While it offers vast potential for improving education, healthcare, and resource utilization, it also presents

risks such as workforce displacement, the need for large-scale reskilling, and the potential exacerbation of unsustainable consumption patterns [7]. Countries that effectively navigate these challenges through adaptive policies and education initiatives tend to make more remarkable strides in SDG achievement [8,9].

This research aims to explore the impact of digital technologies on SDG progress in EU countries, using the Digital Economy and Society Index (DESI) as a measure of technological advancement. We also investigate how economic performance, measured by GDP per capita, mediates this relationship. The study uses structural equation modeling to address two key questions. How do digital technologies, measured by DESI, influence SDG progress in EU countries? To what extent does GDP per capita mediate the relationship between digital technologies and SDG achievement? This paper aims to fill critical research gaps in understanding emerging technologies' collective impact on SDGs and economic performance's mediating role. The findings provide a more nuanced understanding of leveraging technological innovations to create a more sustainable and equitable future.

The paper is structured to provide a comprehensive exploration of this topic, beginning with an introduction to the SDGs and digital technologies, followed by a literature review and hypothesis development, methodology explanation, presentation of results, discussion of findings, and concluding remarks.

2. Literature Review and Hypothesis Development

2.1. *The Relationship Between Digitalization and the SDGs*

The SDGs formulated by the United Nations (UN) address essential issues such as poverty eradication, education, clean water and sanitation, inequality, and sustainable economic growth [10]. Each SDG is interconnected, reflecting a holistic approach to sustainable development, where the success of one SDG contributes to the achievement of others. Achieving these ambitious goals requires cooperation at all levels of society, from governments and international organizations to the private sector and civil society [11]. An essential aspect of the SDGs is the monitoring and evaluation of progress, conducted through periodic national and international reviews. This monitoring allows for the identification of areas where additional interventions are needed and for the adjustment of strategies to ensure target achievement [12].

Digitalization can facilitate the achievement of the SDGs through several essential mechanisms [13]. First, digitalization promotes connectivity and communication among people, facilitating cooperation and information exchange globally. Another fundamental aspect is the ability to monitor global activities and ecosystems. Digital technologies allow for real-time environmental monitoring, collecting valuable data on ecosystem health and the impacts of human activities. This information is essential for implementing effective conservation strategies and natural resource management [14].

The analysis of information and the organization of processes and resources represent significant benefits of digitalization. Advanced data analysis technologies enable the identification of patterns and trends, optimizing production and distribution processes [15]. Digitalization also enhances human capacities, providing access to information and educational resources that enable skill and knowledge development. Through online learning platforms and educational applications, people can access courses and training to improve their professional and personal skills, contributing to human capital development and reducing educational disparities. Digital technologies can support innovation and creativity, offering tools and platforms for developing new solutions and products [16,17].

Digital technologies enable organizations to better understand issues and provide more efficient and personalized solutions [18]. Thus, they facilitate public engagement in decision-making processes and promote transparency and accountability in governance [19]. The use of these technologies in innovation activities fosters collaboration among various stakeholders and supports the development of solutions that are better-adapted to community needs [20]. This fact leads to more inclusive innovation, integrating diverse perspectives and experiences from different societal groups. Therefore, these digital technologies optimize organizational processes and contribute towards building a more democratic and efficient society where innovation is accessible and beneficial to all its members [6]. Studies in this area have demonstrated that the adoption of digital technologies optimizes internal organizational processes and facilitates cross-border collaboration and the exchange of best practices [7]. The effects of digital technologies on the 17 SDGs vary depending on the specific targets pursued within each goal.

Goal 1: No Poverty (SDG 1). Digital technologies play a significant role in monitoring and evaluating the impact of poverty reduction programs, ensuring more efficient resource allocation and improved intervention strategies. AI-based BD identifies and replicates the most effective practices on a larger scale, amplifying the positive impact on vulnerable populations [21]. BD, IoT, and AI also support the development of more robust and responsive social protection systems that quickly address the needs of society's most vulnerable members. The integration of AI, BD, and CC into these systems enables governments and organizations to continuously and adaptively monitor the impact of poverty reduction policies and programs, optimizing them for the best possible outcomes [10]. Integrating technologies into sustainable development strategies can significantly reduce poverty and improve the quality of life for millions affected by this issue.

Goal 2: Zero Hunger (SDG 2). Digital technologies provide innovative and efficient solutions for achieving SDG 2, contributing to the eradication of hunger and promoting sustainable agriculture. These technologies enhance traditional farming methods by introducing precision agriculture practices [22], analyzing climate and soil data to predict weather conditions and plan crop cycles, thus reducing the risks associated with climate change. They also facilitate the development of personalized food programs tailored to the specific nutritional needs of vulnerable communities [23]. Digital technologies can be used in food supply chains to optimize resource distribution and minimize losses [24]. AI models can predict food demand and adjust production and distribution accordingly, ensuring that food reaches needy people.

Goal 3: Good Health and Wellbeing (SDG 3). CC and IoT-based technologies and BD-driven AI models monitor human health data. These technologies enable the provision of appropriate care and the prediction of disease risks. Mobile health applications (mHealth) play a significant role by facilitating access to medical information and the continuous health monitoring of individuals. These applications allow for the real-time measurement of vital parameters, enabling prompt intervention when anomalies are detected. For instance, mHealth applications can send automatic alerts to physicians or health centers when complications are detected, ensuring rapid and efficient interventions [25]. Data collected through sensors and mHealth applications within cloud environments are essential for creating predictive models that anticipate health problems and recommend preventive measures. These technologies improve resource management and the optimal distribution of health services, reducing inequalities in access to quality medical care [26].

Goal 4: Quality Education (SDG 4). The integration of digital technologies can ensure quality education globally. AI and BD-based technologies can monitor student progress in real time, providing continuous feedback to students and teachers [27]. These innovative technologies augment the learning process's efficiency and facilitate swift interventions when students encounter obstacles in their educational journey. Furthermore, these technological advancements can analyze learning trends and patterns on a macro scale, thereby contributing valuable insights toward enhancing curricula and formulating more effective educational policies [28].

Goal 5: Gender Equality (SDG 5). Digital technologies are essential in promoting gender equality and achieving SDG 5 objectives. By monitoring discrimination, eliminating biases, and empowering economically, these technologies help to build a more equitable and inclusive society where women can reach their full potential [29]. Implementing these technologies not only supports SDG 5 but also positively impacts interconnected areas such as education, health, and community development.

Goal 6: Clean Water and Sanitation (SDG 6). Monitoring progress towards SDG 6 is complex and costly; advanced technologies and global cooperation can play a decisive role in ensuring universal access to safe drinking water and adequate sanitation services, improving public health and the quality of life worldwide [30]. The integration of digital technologies can facilitate more efficient monitoring of these services, allowing for automatic data collection and the rapid analysis of relevant data [31].

Goal 7: Affordable and Clean Energy (SDG 7). Advanced digital technologies are essential for identifying and addressing global energy access issues and energy poverty [32]. Integrating geospatial, financial, and technological information and applying advanced analysis and modeling methods enables the identification of areas and communities most affected by the lack of access to energy, allowing for the development of effective strategies to enhance resilience to climate change [33], contributing to the achievement of SDG 7.

Goal 8: Decent Work and Economic Growth (SDG 8). AI-based technologies can simplify workers' lives, for instance, through intelligent systems that balance work time with private time [34]. Implementing appropriate policies and regulations to protect employee rights and welfare can help to mitigate the risks associated with using AI in the workplace and ensure a fairer and more sustainable approach to achieving SDG 8 [35].

Goal 9: Industry, Innovation, and Infrastructure (SDG 9). Investing in sustainable infrastructure, bolstered by cutting-edge digital technologies, is crucial for achieving SDG 9 and fostering a sustainable and equitable future for communities worldwide [36]. Digital technologies facilitate monitoring and evaluating progress towards SDG 9 and promote transparency and community participation [37]. Free access to information enables citizens to be better informed and participate in decision making.

Goal 10: Reduced Inequalities (SDG 10). Truby [35] argues that BD and AI-based technologies significantly impact inequality because developed countries can invest more in these technologies. Adequate digital infrastructures and high-speed Internet access are fundamental for adopting and efficiently using new technologies in emerging economies [38]. A concerted effort is required from governments, international organizations, and the private sector to ensure the responsible and equitable implementation of these technologies globally and that AI and BD technologies genuinely contribute to reducing inequalities and promoting sustainable development [39].

Goal 11: Sustainable Cities and Communities (SDG 11). Digital technologies can create more sustainable and efficient cities, supporting urban planning and infrastructure development to create safer and more accessible environments for all residents. AI can help to implement proactive measures to reduce emissions and improve air quality by predicting energy consumption and pollution [40]. Moreover, AI-driven simulations and forecasts provide valuable information for managing natural risks, such as floods, enabling authorities to prepare and respond more effectively to such events [10]. The design of green buildings enabled by AI reduces the carbon footprint of urban constructions and promotes a more sustainable built environment [41].

Goal 12: Responsible Consumption and Production (SDG 12). Digital technologies support the development of more sustainable production and consumption practices, creating a greener and more responsible future [42]. AI, combined with BD and IoT, optimizes manufacturing processes by reducing waste and improving material use efficiency [43]. Concerning specific production processes and cleaner production, AI can identify and implement methods with which to reduce emissions and minimize environmental impacts [44].

Goal 13: Climate Action (SDG 13). With its processing and data analysis power, digital technologies provide valuable tools for anticipating and preventing the impact of natural disasters caused by extreme weather events. Sophisticated monitoring and modeling systems can predict climatic hazards well in advance, allowing for proactive measures to protect communities and the environment [45]. The integration of climate data with information on social and economic vulnerabilities of different regions enables the development of personalized risk mitigation strategies. This approach ensures an equitable distribution of the benefits of digital technologies in combating climate change [46].

Goal 14: Life below Water (SDG 14). Digital technologies play a significant role in identifying and addressing challenges related to conserving and protecting marine ecosystems. They facilitate the constant monitoring of water quality and the health of aquatic ecosystems, contributing to reducing pollution and promoting sustainable marine resource use practices. The use of advanced digital tools, such as IoT sensors and environmental monitoring systems, enables scientists and conservationists to obtain precise and real-time data on the state of the aquatic environment, allowing for efficient preventive and corrective measures [5]. Moreover, digital technologies can educate and raise public awareness about the importance of conserving underwater life and marine ecosystems, encouraging active involvement in protecting these vital resources for our planet's health [10].

Goal 15: Life on Land (SDG 15). Digital technologies enable the monitoring and managing of terrestrial resources to support SDG 15. They can collect and analyze data on land use, biodiversity, and environmental changes, providing essential information for informed decision making on natural resource management [47]. The implementation of digital solutions, such as geographic information systems, sensor technologies, and data analysis, can improve the monitoring of the impacts of human activities on terrestrial ecosystems and identify effective strategies for biodiversity conservation and land degradation prevention [48].

Goal 16: Peace, Justice, and Strong Institutions (SDG 16). Digital technologies can facilitate access to relevant information, monitor the progress of reform implementations, and promote transparency within public institutions [2]. Advocating the use of digital technologies within the context of SDG 16 can strengthen the rule of law, improve anti-corruption mechanisms, and ensure better protection of citizens' fundamental rights, building robust institutions and promoting a more equitable and inclusive society [49].

Goal 17: Partnerships for the Goals (SDG 17). Digital technologies promote knowledge exchange, stimulate innovation, and support the efficient implementation of other sustainable development goals through strong partnerships and global cooperation [10]. Furthermore, digital technologies enable rapid information exchange, coordination of actions, and the monitoring of progress in implementing joint initiatives, thereby enhancing the impact and effectiveness of these partnerships [49]. Promoting the use of digital technologies in the context of SDG 17 can strengthen global collaboration and solidarity, identify innovative solutions to global challenges, and ensure an integrated and coherent approach to implementing the global sustainable development agenda.

The implementation of digital technologies across various fields can bring significant benefits by improving the efficiency, accuracy, and sustainability of processes. However, a responsible and ethical approach to digital technologies is decisive for the management of potential risks and negative impacts on society and the environment. Therefore, digital technologies substantially support efforts to achieve sustainable development goals, offering innovative tools and solutions to address global challenges and promoting sustainable development. Hypothesis H1 proposes testing the relationship between digitalization and sustainability.

Hypothesis H1. *Emerging digital technologies have a significant positive impact on the progress of SDGs in EU countries.*

2.2. The Mediating Effect of Economic Performance in the Relationship Between Digitalization and SDGs

Industry 4.0, powered by emerging digital technologies, marks a transition to interconnected and intelligent production systems. A distinctive aspect of Industry 4.0 is its ability to create deep connections and interdependencies between industrial sectors and fields of activity, facilitating information exchange and cooperation between organizations and economic growth [6]. Industry 4.0 redefines the relationships between people and technology, merging human skills with the power of intelligent machines in a synergy that optimizes efficiency and innovation [50–52]. This industrial revolution extends beyond transforming production processes, profoundly impacting society, including education, health, and the environment, contributing to enhanced economic performance. Thus, Industry 4.0 represents a holistic transformation in how we interact with the world and organize our economic and social activities [53].

An essential aspect of the SDGs is that they result from a global consultative and participatory process involving governments, civil society, the private sector, and other stakeholders rather than being top-down mandates. This process endows the SDGs with increased legitimacy and relevance within the international community. Furthermore, the SDGs act as catalysts for transforming policies and practices at national and local levels, directing investments and actions toward desired outcomes and ensuring that no country is left behind in development efforts, supporting inclusive economic growth for all countries [54]. Therefore, the SDGs are essential for economic growth and achieving a more equitable, sustainable, and prosperous world for all inhabitants of the planet.

The adoption of AI and other emerging technologies is necessary for advancing sustainable development, allowing for global challenges to be addressed through innovative and efficient solutions while ensuring a sustainable future for all nations [55]. Enhanced learning, communication, and reasoning capabilities enable digital technologies to significantly improve efficiency and productivity across various sectors, including health, education, transportation, energy, and agriculture [40,55]. Integrating these advanced technologies boosts countries' economic growth and supports the achievement of the SDGs,

profoundly transforming how we interact with the world. These technologies significantly improve operational efficiency, cost reduction, and sustainability promotion [55–57].

Jovanovic et al. [58] suggest that digitalization contributes to economic growth and improves social conditions by creating new business opportunities, increasing efficiency, and facilitating access to education and social services. Digital technologies can enhance productivity and competitiveness, thereby stimulating sustainable economic development. Investments in green technologies and sustainable digital infrastructure can drive sustainable economic growth, minimize environmental impacts, and balance digital development with environmental protection.

Digitalization has the potential to generate significant changes across various sectors, optimizing resource use, reducing negative environmental impacts, and ensuring sustainability [7,59–61]. Appropriate policies and regulations must be implemented to ensure the responsible and ethical use of digital technologies to ensure that digitalization effectively contributes to sustainability. Close collaboration between governments, international organizations, the private sector, and civil society is necessary to fully leverage digitalization's potential in achieving SDGs [4,62].

Digital technologies modernize economic and industrial processes and create a conducive framework for sustainable development, promoting a sustainable future [63]. The strategic and responsible implementation of these technologies can transform global challenges into growth and sustainable development opportunities. Hypothesis H2 examines the mediating effect of economic performance on the relationship between emerging digital technologies and the progress of SDGs.

Hypothesis H2. *Economic performance, measured by GDP per capita, positively mediates the relationship between emerging digital technologies and SDG progress.*

3. Materials and Methods

3.1. Research Design

The research process was complex and was structured into five distinct phases. The first phase involved defining the research theme and purpose. The second phase entailed a comprehensive analysis of the literature and the development of research hypotheses based on a deep understanding of how technologies, such as AI, IoT, BD, and CC, can contribute to achieving SDGs. The third phase was dedicated to collecting relevant data panels, using the DESI to measure the level of digital technology adoption in EU countries and the Sustainable Development Reports 2023 to illustrate the levels of SDG achievement for each EU country [3].

In the fourth phase, data panels were processed and interpreted using two statistical methods involving structural equation modeling (SEM). SEM enables the study of complex relationships between multiple variables, both observed, such as the components of DESI and GDP per capita, and latent, such as economic performance. Moreover, SEM is well-suited for handling multidimensional constructs, such as DESI, which comprises diverse components, including digital public services, human capital, and digital technology integration, thus ensuring a comprehensive evaluation of digitalization's impact. Furthermore, SEM facilitates hypothesis testing by assessing the fit of the theoretical model against empirical data, ensuring that the proposed relationships are statistically robust. In the context of this study, SEM allows for the rigorous testing of the research hypotheses, quantifies the mediated effects, and delivers reliable results that enhance the understanding of how digital technologies can accelerate progress toward sustainable development goals in the European Union.

The final phase involved formulating discussions and conclusions, highlighting the significant influences of emerging technologies on SDGs and the mediating effect of economic performance, measured by GDP per capita. Although the study has limitations, including a regional focus, its conclusions contribute to a deeper understanding of how technological innovations can be leveraged to accelerate progress toward a more sustainable future.

3.2. Selected Variables

The research variables include three components of DESI (digital public services, human capital, and digital technology integration), the overall SDG index (SDGi), and the indices for the 17 SDGs (SDG1–SDG17). Data from the Sustainable Development Reports 2023 and DESI reports were collected from 2017 to 2022.

The SDG indices are essential for monitoring global progress in achieving sustainable development goals [3]. The goals cover different aspects, each with specific indicators for assessment, allowing for a detailed analysis of areas where a country excels or needs improvement. Scores for each SDG are calculated through a detailed and rigorous process that includes multiple steps. In addition to providing a framework for progress evaluation, the SDG indices facilitate comparisons between countries and regions worldwide, promoting healthy competition and international collaboration [3,64].

To illustrate emerging digital technologies, we chose the DESI to measure the digital competitiveness of EU member states [65]. The DESI comprises the following four dimensions: connectivity; human capital; digital technology integration; and digital public services [66]. Connectivity refers to the infrastructure necessary for fast and reliable Internet access, an essential aspect of integrating and using digital technologies across all sectors of the economy. Human capital emphasizes the importance of education and digital skills for the workforce to use and develop emerging technologies. Internet usage reflects how individuals and companies access and leverage information and services online, influencing economic efficiency and productivity. Digital technology integration into businesses and administrative processes stimulates innovation and competitiveness, while digital public services improve citizens' access to government information and services, enhancing transparency and public administration efficiency.

Within the research, we selected only three components of the DESI, as follows: digital public services (DPS); human capital (HC); and digital technology integration (DTI). Connectivity was excluded because EU countries record consistently high and similar values for this component, which diminishes its explanatory power in differentiating sustainability levels. While connectivity undoubtedly plays a foundational role in enabling digitalization, its uniformity across EU member states does not significantly contribute to understanding variations in sustainable development outcomes within this regional context. Although excluded from this specific analysis due to methodological considerations, its underlying importance in promoting digitalization and sustainability remains indisputable.

The DESI methodology allows for a detailed and nuanced assessment. The DESI not only provides an overview of the current state of digitalization in the EU but also directs efforts toward areas that need improvement, contributing to the ambitious goals of the European Union for 2030. This approach enables countries to adapt their strategies and investments to specific needs, promoting equitable and sustainable digital development [65].

The DESI scores used in this study were obtained directly from the official DESI reports published annually by the European Commission. These reports offer standardized and detailed data on the digital competitiveness of EU member states, facilitating cross-country comparisons and trend analyses over time. The DESI is developed through a rigorous methodology that incorporates various indicators into four main dimensions: connectivity, human capital, Internet usage, and integration of digital technologies into

public and private sectors. The scores for these components were sourced from DESI reports spanning 2017 to 2022. The robustness and reliability of these official data sources ensure the credibility of the analysis and its alignment with the latest European Union digitalization strategies.

Integrating DESI dimensions into sustainable development analysis provides a comprehensive perspective on how digitalization can support the achievement of SDGs in EU countries [67]. The adaptation and implementation of digital technologies are essential to ensuring sustainable economic growth and improving the quality of life for all citizens.

Table 1 illustrates the selected variables, measures, and collection sources.

Table 1. Selected variables.

Variable	Data Sets	Measures	Sources
DPS	Digital public services	Score	[68]
HC	Human capital	Score	[68]
IDT	Integration of digital technology	Score	[68]
SDGi	SDG Index Score	Aggregate score (0 to 100)	[69]
SDG1–SDG17	Goal 1–Goal 17	Score (0 to 100)	[69]
GDPc	GDP per capita in PPS	Purchasing power parities (PPPs)	[70]

Source: developed by authors based on [68–70].

3.3. Research Methods

The study uses SEM to examine the impact of emerging digital technologies on SDG progress in European Union countries. SEM allows for the simultaneous evaluation of direct and indirect relationships between digital technologies, economic performance, and SDG progress. This method combines factor analysis and regression analysis [71], providing a detailed perspective on how components of DESI influence SDG progress.

Direct relationships represent the immediate effects of one variable on another without any intermediary influence. For instance, the direct relationship between the Digital Economy and Society Index (DESI) and SDG progress highlights how improvements in digital public services, human capital, and digital technology integration can directly contribute to sustainable development outcomes.

Indirect relationships, on the other hand, capture the mediated effects where one variable influences another through an intermediary variable. In this study, economic performance, measured as GDP per capita, acts as a mediator. The indirect relationship quantifies how digital technology adoption first impacts economic performance, subsequently affecting SDG progress. By incorporating both direct and indirect effects, the research provides a holistic understanding of the pathways through which digital technologies contribute towards achieving sustainability goals.

This dual perspective is essential to uncovering the complex interactions and dependencies within the digitalization and sustainability framework. SEM enables the testing of the two research hypotheses while quantifying these mediated effects, offering insights into both the immediate and long-term influences of digitalization on sustainable development.

Figure 1 illustrates the research model of digital influences on sustainability and the mediating role of economic performance.

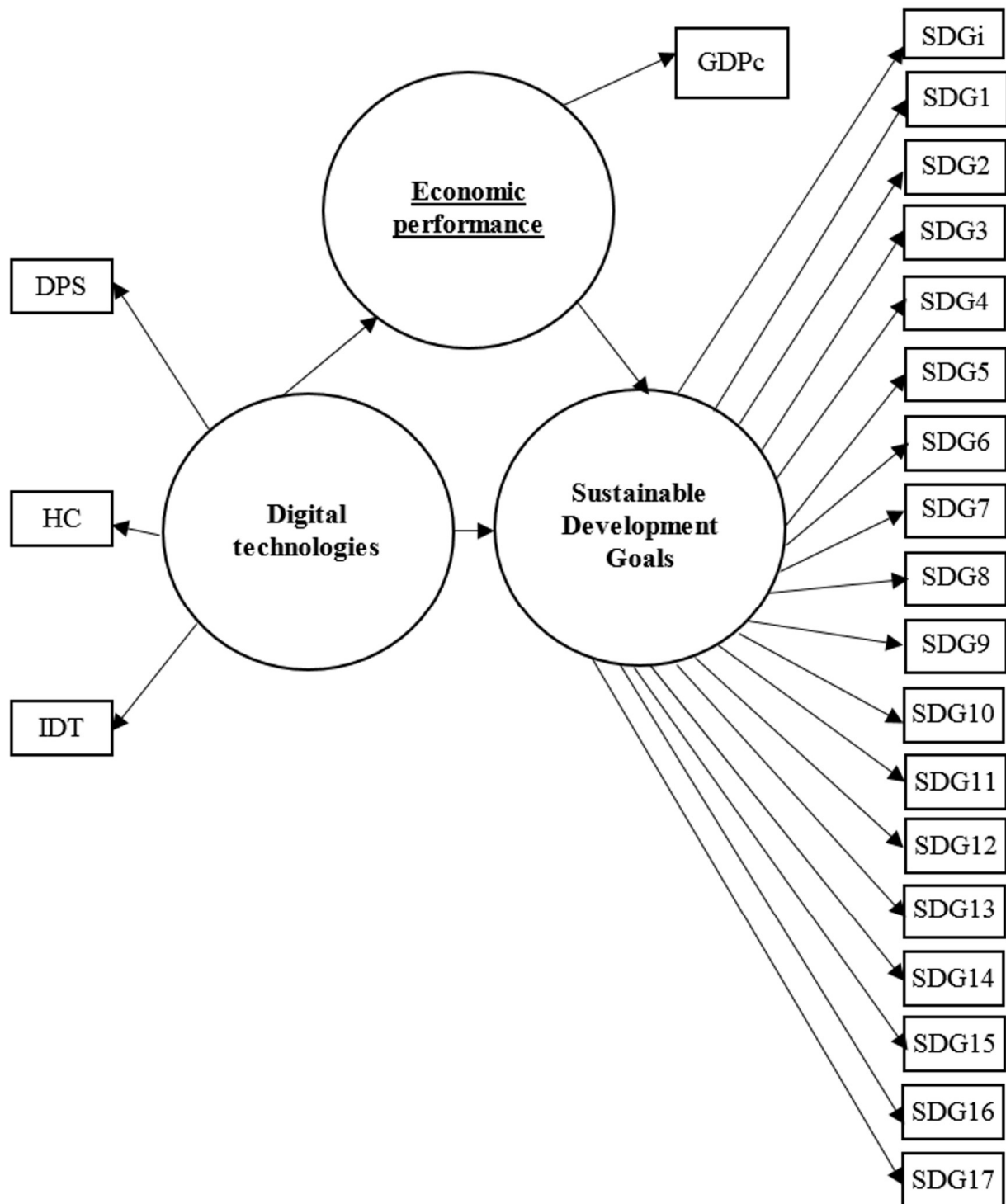


Figure 1. Research model of digitalization influences on sustainability. Source: author's design.

4. Results

The two hypotheses were tested using SEM with SmartPLS v3.0 software, known for its flexibility in analyzing complex data and handling models with multiple causal relationships [72]. Using this software, we assessed digitalization's direct and indirect impact on SDGs in EU countries. SEM also enabled us to identify the mediation effects of economic performance, represented by GDP per capita. Figure 2 shows the α model, illustrating the direct and indirect influences of selected DESI components on the SDG index (SDGi), along with models 1–5, showing the direct and indirect influences of the DESI

components on the first five indices associated with the first five goals (SDG1–SDG5). The DESI components are reflexive to the Digital Economy and Society Index latent variable [73]. Other latent variables, such as Economic Performance; Sustainable Development Goals Index; GOAL 1: No Poverty; GOAL 2: Zero Hunger; GOAL 3: Good Health and Well-being; GOAL 4: Quality Education; and GOAL 5: Gender Equality, each have an observable variable (GDP per capita, the aggregate SDG index, and the indices for the first five goals).

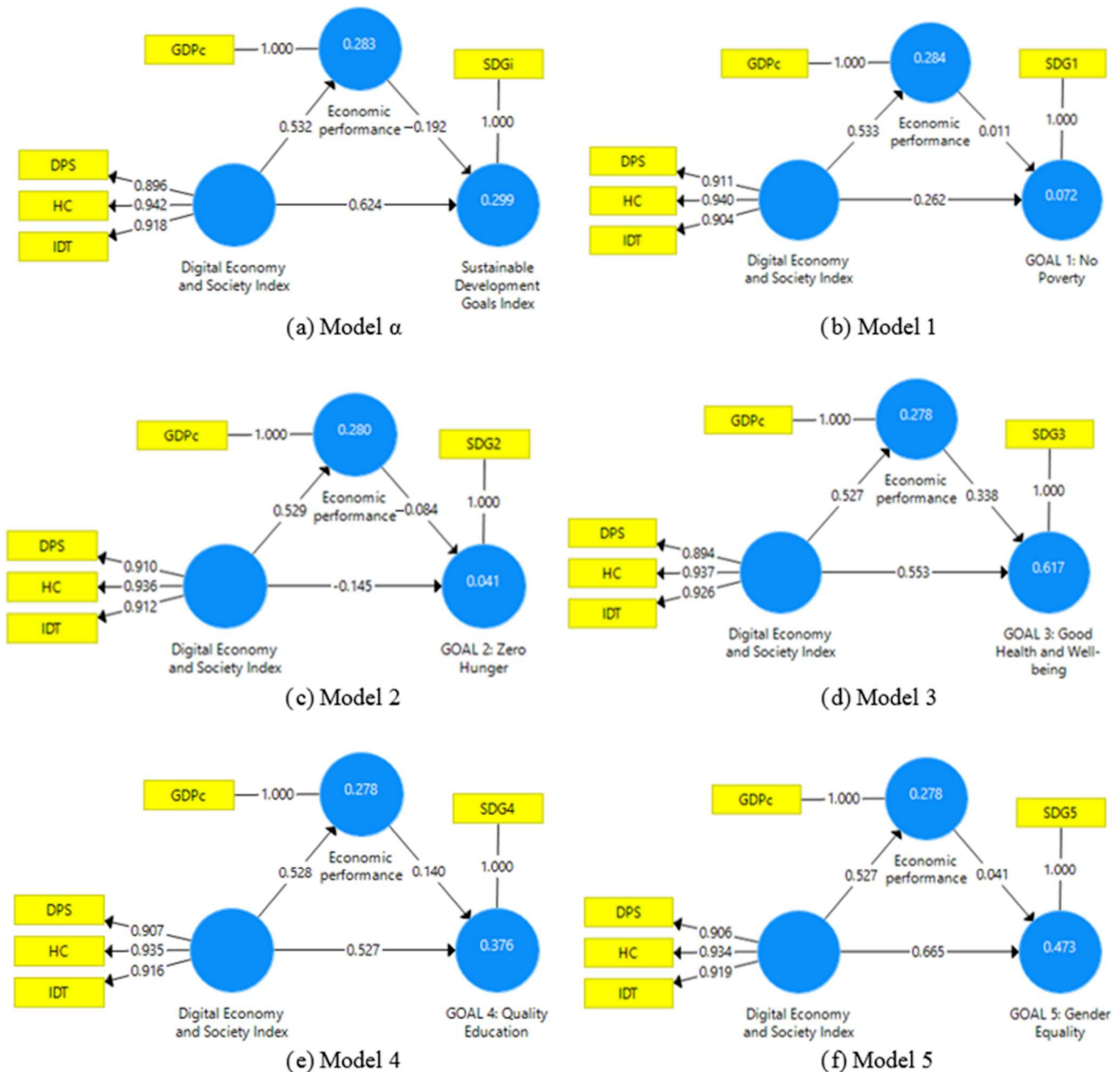


Figure 2. Models for the direct and indirect influence of DESI on SDGi, and SDG1–SDG5. Source: author's design using SmartPLS v3.0.

The outer loadings of exogenous variables (observables) in the six models are above 0.7, increasing the significance of the model [71]. To validate and ensure the reliability of the models, we used the Fornell–Larcker criterion. Table A1 (see Appendix A) presents the discriminant matrices for the six models and the standardized root mean squared residual (SRMR). These values are crucial for confirming the quality of the constructs used in the

models. In the discriminant matrix, the values on the main diagonal should be greater than any other value in the row and column (squared correlations) [73]. The SRMR provides a measure of the difference between observed and model-predicted values, highlighting the overall accuracy of the models [74]. Furthermore, Cronbach's alpha values (0.909), composite reliability (0.942), and average variance extracted (0.844) for the Digital Economy and Society Index latent variable are high for all six models.

Using bootstrapping with a significance level of 0.05 and performing two-tailed tests, we determined the direct and indirect from models α and 1–5 (Table A4 in Appendix B).

Table A4 shows that for models α and 1–5, hypotheses H1 and H2 are partially validated, although with some exceptions regarding the mediated effects studied by hypothesis H2. For H1, which posits that emerging technologies, measured through the DESI, significantly impact SDG progress in EU countries, the data confirm this hypothesis. All values for the relationship between the DESI, the SDG index, and the SDGs, as well as for most individual goals, are statistically significant and indicate a positive impact. High T-statistic values and p -values below 0.05 confirm this, suggesting that adopting digital technologies has a robust positive effect on progress toward SDGs. The only exception is perceived for GOAL 2: Zero Hunger, where the relationship between the DESI and GOAL 2: Zero Hunger is not statistically significant ($p > 0.05$), registering a negative value.

For H2, which states that economic performance positively mediates the relationship between emerging digital technologies and SDG progress, the data provide partial support. In model α , the indirect effect of the DESI on SDGs through economic performance is negative and significant (T statistic = 2.839, p Value = 0.005), indicating a negative mediation. This fact means that although the DESI has a direct positive effect on the SDGs, its indirect effect through GDP per capita is negative. In the case of specific goals, such as GOAL 1: No Poverty, GOAL 2: Zero Hunger, and GOAL 5: Gender Equality, the mediation is not statistically significant, suggesting that GDP per capita does not play a mediating role in these relationships.

Thus, while H1 is confirmed for models α and 1–5, H2 requires a more nuanced interpretation, considering the variations depending on the specific SDG goal and the direction of the economic mediation.

Figure 3 presents models 6–11 illustrating the DESI components' direct and indirect influences on the indices associated with SDG goals 6–11. DESI components have a reflexive relationship with the latent variable [73]. Other latent variables, such as Economic performance, GOAL 6: Clean Water and Sanitation, GOAL 7: Affordable and Clean Energy, GOAL 8: Decent Work and Economic Growth, GOAL 9: Industry, Innovation and Infrastructure, GOAL 10: Reduced Inequality, GOAL 11: Sustainable Cities and Communities, each have an observable variable (GDP per capita and indices for SDG goals 6–11).

The outer loadings of exogenous variables (observables) in the six models are above 0.7, further increasing the model's significance. Furthermore, Cronbach's alpha values (0.909), composite reliability (0.942), and average variance extracted (0.844) for the Digital Economy and Society Index latent variable are high for all six models. Table A2 (see Appendix A) presents the discriminant matrices for the six models and the SRMR.

Through bootstrapping with a significance level of 0.05 and conducting two-tailed tests, we determined the direct and indirect effects from models 6–11 (Table A5 in Appendix B).

Analyzing the data from the six models reveals a significant positive impact of emerging technologies measured through the DESI on SDG progress in European Union countries, which suggests that hypothesis H1 is supported. This issue is evident from the statistically significant coefficients between the DESI and various sustainable development goals (SDG6–SGG11), all with p -values below 0.05.

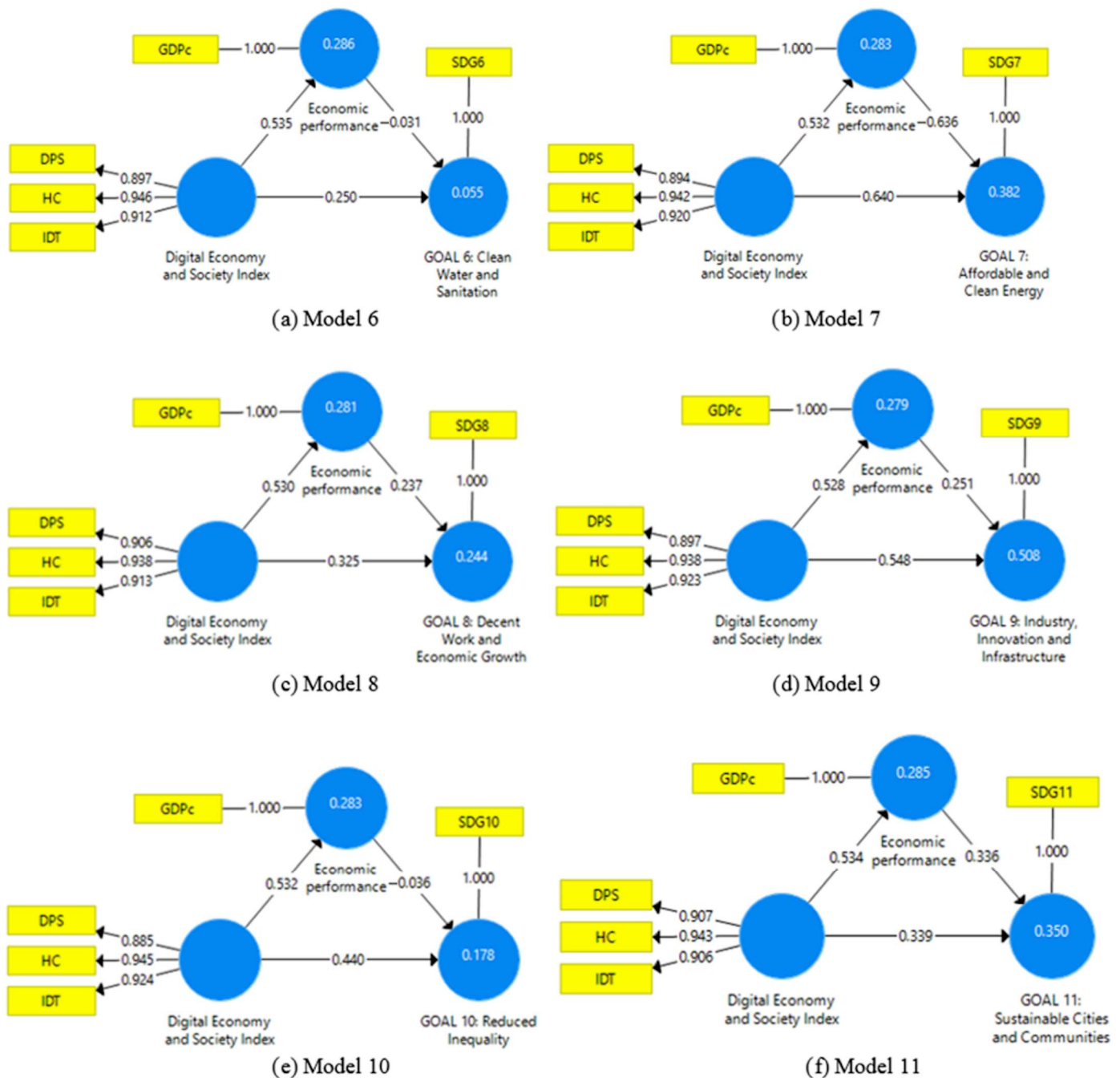


Figure 3. Models for the direct and indirect influence of the DESI on SDG6–SDG11. Source: authors' design using SmartPLS v3.0.

The results are mixed regarding hypothesis H2, which proposes that economic performance, measured by GDP per capita, positively mediates the relationship between emerging digital technologies and SDG progress. While there are statistically significant mediations for some goals (e.g., GOAL 8, GOAL 9, and GOAL 11), mediation is insignificant or negative in other cases. For example, in model 7, the indirect effect of DESI on GOAL 7 through economic performance is negative and significant (coefficient -0.338 , T value 6.469, p value 0), suggesting a potentially adverse mediating effect of GDP per capita in this context.

In conclusion, hypothesis H1 is supported across models 6–11, indicating that emerging digital technologies positively impact SDG progress. However, hypothesis H2 yields mixed results, indicating that the mediating role of economic performance varies depend-

ing on the specific sustainable development goal and may have both positive and negative effects. Unsustainable economic growth may negatively affect some SDGs.

Figure 4 describes models 12–17, illustrating the DESI components' direct and indirect influences on the indices associated with SDG12–SDG17. The DESI components exhibit a reflexive relationship with the latent variable. The other latent variables—Economic Performance, GOAL 12: Responsible Consumption and Production, GOAL 13: Climate Action, GOAL 14: Life Below Water, GOAL 15: Life on Land, GOAL 16: Peace and Justice Strong Institutions, GOAL 17: Partnerships to achieve the Goal—each have an observable variable (GDP per capita and the indices for the SDG12–SDG17 goals).

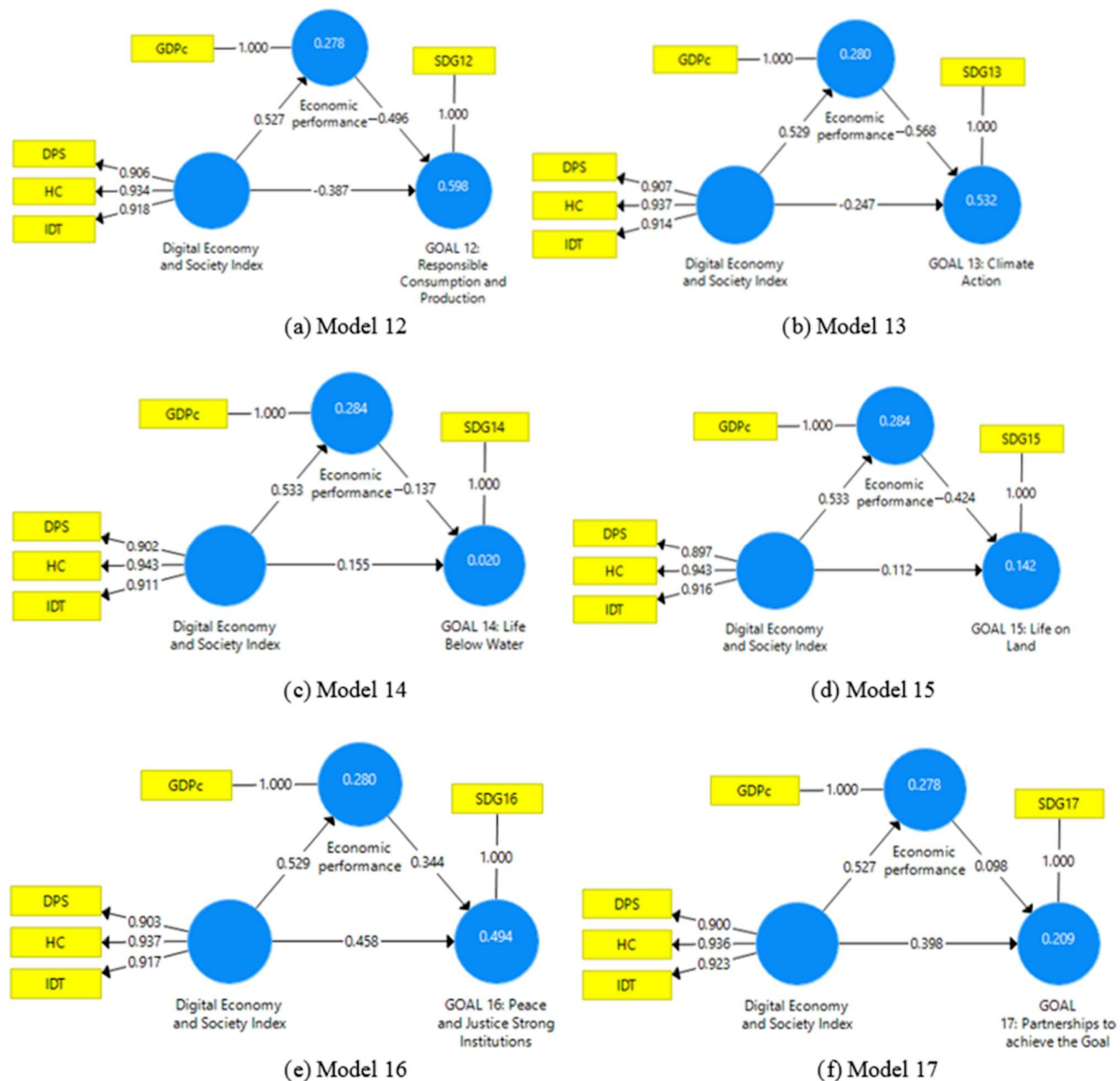


Figure 4. Models for the direct and indirect influence of DESI on SDG12–SDG17. Source: author's design using SmartPLS v3.0.

The outer loadings of the exogenous (observable) variables in the six models are above 0.7, enhancing the model's significance. Furthermore, Cronbach's alpha values (0.909), composite reliability (0.942), and average variance extracted (0.844) for the latent variable, Digital Economy and Society Index, are high across all six models. Table A3 (see Appendix A) presents the discriminant matrices for models 12–17 and the SRMR.

Through bootstrapping with a significance level of 0.05 and conducting two-tailed tests, we determined the direct and indirect effects from models 12–17 (Table A6 in Appendix B).

Analyzing the direct and indirect effects from Table A6 reveals several significant relationships between emerging technologies, economic performance, and progress toward SDGs in EU countries. Hypothesis H1, suggesting a significant positive impact of emerging technologies measured through the DESI on SDG progress in EU countries, is partially supported by the model results. Only models 16 and 17 indicate a significant positive influence of the DESI on GOAL 16: Peace and Justice Strong Institutions and GOAL 17: Partnerships. Models 14 and 15 show non-significant relationships, while models 12 and 13 indicate significant but negative relationships between the DESI and GOAL 12: Responsible Consumption and Production, and GOAL 13: Climate Action.

Table 2 summarizes the DESI components' direct influences on the indices associated with SDG1–SDG17 and the general SDG index.

Table 2. Direct effects of Digital Economy and Society Index on Sustainable Development Goals.

	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Sustainable Development Goals Index	0.624	0.62	0.069	8.983	0.000
Digital Economy and Society Index → GOAL 1: No Poverty	0.262	0.262	0.092	2.849	0.005
Digital Economy and Society Index → GOAL 2: Zero Hunger	−0.145	−0.154	0.087	1.662	0.097
Digital Economy and Society Index → GOAL 3: Good Health and Well-being	0.553	0.55	0.043	12.857	0.000
Digital Economy and Society Index → GOAL 4: Quality Education	0.527	0.526	0.056	9.341	0.000
Digital Economy and Society Index → GOAL 5: Gender Equality	0.665	0.664	0.063	10.605	0.000
Digital Economy and Society Index → GOAL 6: Clean Water and Sanitation	0.250	0.255	0.106	2.367	0.018
Digital Economy and Society Index → GOAL 7: Affordable and Clean Energy	0.640	0.638	0.067	9.511	0.000
Digital Economy and Society Index → GOAL 8: Decent Work and Economic Growth	0.325	0.318	0.059	5.541	0.000
Digital Economy and Society Index → GOAL 9: Industry, Innovation, and Infrastructure	0.548	0.543	0.06	9.106	0.000
Digital Economy and Society Index → GOAL 10: Reduced Inequality	0.440	0.437	0.055	8.008	0.000
Digital Economy and Society Index → GOAL 11: Sustainable Cities and Communities	0.339	0.336	0.053	6.438	0.000
Digital Economy and Society Index → GOAL 12: Responsible Consumption and Production	−0.387	−0.39	0.053	7.284	0.000
Digital Economy and Society Index → GOAL 13: Climate Action	−0.247	−0.246	0.06	4.083	0.000
Digital Economy and Society Index → GOAL 14: Life Below Water	0.155	0.153	0.111	1.397	0.163
Digital Economy and Society Index → GOAL 15: Life on Land	0.112	0.106	0.069	1.616	0.107
Digital Economy and Society Index → GOAL 16: Peace and Justice Strong Institutions	0.458	0.46	0.076	6.007	0.000
Economic performance → GOAL 16: Peace and Justice Strong Institutions	0.344	0.344	0.046	7.546	0.000
Digital Economy and Society Index → GOAL 17: Partnerships to achieve the Goal	0.398	0.4	0.069	5.762	0.000

Hypothesis H2, which posits that economic performance mediates the relationship between emerging digital technologies and SDG progress, is also partially supported by the model results. Economic performance, measured by GDP per capita, only exhibits a significant positive mediating effect between the DESI and SDG16. A statistically significant negative mediating relationship is perceived between the DESI and SDG12–SDG15. Economic performance does not have a statistically significant mediating role in the relationship between the DESI and GOAL 17: Partnerships to achieve the Goal. These results suggest that emerging technologies and sustainable economic performance are significant factors in EU countries' progress toward sustainable development goals.

5. Discussion

In an era of rapid technological advancement, the intersection of digital innovation and sustainable development presents unprecedented opportunities to address global challenges. In this study, we aim to analyze how digital technologies, evaluated through the DESI, influence the achievement of SDGs in EU countries by testing two hypotheses using SEM.

The results obtained from running the 18 SEM models partially confirm the validity of Hypothesis H1, namely, that emerging technologies, measured by the DESI, have a significant positive impact on SDG progress in European Union countries. Statistically significant path coefficients support the partial validation of this hypothesis, indicating that countries with higher DESI scores tend to make more significant progress in achieving SDGs. However, there are some exceptions. The DESI negatively influences goals, such as SDG 2, SDG 12, and SDG 13, while the impact of the DESI on SDG 14 and SDG 15 is insignificant.

For SDG 2, the rapid development of the digital economy may exacerbate inequalities in access to technology and resources between different regions and social groups. Farmers in rural and disadvantaged areas may face challenges in adopting new agricultural technologies and accessing digital markets, leading to inefficiencies in food production and increased food insecurity. Regarding SDG 12, the negative influence of the DESI stems from increased resource consumption and electronic waste generation. Responsible production and consumption require efficient resource management and a reduced ecological footprint; the rapid advancement of digital technologies may exacerbate overconsumption and inadequate waste management. SDG 13 experiences negative influences from the DESI, as the expansion of digital infrastructure and increased data usage require large amounts of energy, contributing to greenhouse gas emissions. The insignificant influence of the DESI on SDG 14 and SDG 15 is due to the digital aspects measured by the DESI having a less direct connection to marine and terrestrial biodiversity. Although digital technology can play a role in environmental monitoring and protection, the positive or negative effects on these goals are less evident than those related to food production, responsible consumption, and climate action.

These findings are consistent with the other findings, which underscores the importance of digitalization in achieving a sustainable future. Deloitte [13] argues that digitalization modernizes processes and interactions globally and creates a conducive framework for achieving SDGs by improving communication, monitoring, analysis, and human capacity development. Our study supports this perspective, highlighting the crucial role of digital technologies in building a sustainable future.

Another essential aspect noted by Akande et al. [75] is the increase in energy consumption and electronic waste generation, which can affect climate conditions and marine and terrestrial biodiversity. This issue underscores the need for a regulatory framework that promotes responsible and ethical practices, as suggested by Holzinger et al. [14]. Countries with strict policies on digital sustainability and e-waste management can better balance the benefits

of digitalization with its environmental impacts. Furthermore, digital transformation can stimulate innovation in sustainability. Moghrabi et al. [76] emphasize that companies can develop new products and services that address ecological and social challenges by adopting advanced technologies. Countries that integrate sustainability into their digital transformation strategies contribute towards achieving SDGs and strengthening their long-term success.

The partial confirmation of Hypothesis H1's validity underscores the importance of emerging digital technologies in achieving the SDGs. These technologies must be implemented strategically and responsibly to maximize the benefits and minimize the associated risks. This action requires collaboration between governments, the private sector, and civil society to create a conducive framework for sustainable digital transformation.

The results obtained from running the 18 SEM models also partially validate hypothesis H2, demonstrating that economic performance, measured by GDP per capita, can positively mediate the relationship between emerging digital technologies and progress towards some SDGs, if economic growth is sustainable. The analyses have shown that this mediation is significant only for certain SDGs, indicating a complex and diversified relationship between digitalization, economic performance, and sustainability. The literature supports the idea that a robust digital economy, fueled by sustainable economic growth, can accelerate progress toward sustainable development goals. Imran et al. [67] argue that digital technologies enable more efficient resource management, reduce negative environmental impacts, and facilitate the transition to a circular economy. The research results partially confirm these assertions, demonstrating that, for certain SDGs, increased economic performance due to digitalization contributes to sustainable progress.

Previous studies, such as those conducted by Banhidi et al. [66] and Imran et al. [67], emphasize that digitalization's economic component indirectly influences sustainable development through economic performance. According to this research, digitalization promotes sustainable economic growth, reduces social inequalities, and protects the environment. Our study highlights that although this mediating effect is present, it is not uniform for all SDGs. This fact suggests the need for a personalized approach to digitalization strategies to maximize benefits in different areas of sustainable development. Kasinathan et al. [77] and Ghobakhloo et al. [78] underscore the importance of applying emerging digital technologies for innovation and efficiency in various societal domains, accelerating progress toward a more sustainable and equitable world. This perspective is supported by our research findings, which show that countries with higher economic performance due to digitalization have made more significant strides in certain SDGs related to economy, health, education, and public and community governance (SDG 3, SDG 4, SDG 8, SDG 9, SDG 11, SDG 16).

However, the research results also indicate significant challenges. The research results show that the mediating effects of economic performance are not as strong in certain areas such as poverty, hunger, clean energy, social inequalities, and environmental protection. This fact suggests that while digitalization brings economic benefits, it needs to be integrated into broader sustainable development strategies to ensure a more uniform positive impact. Nagaraj [79] emphasizes that technological advancements require adaptation and a rethinking as to how we interact with the environment, the economy, and existing power structures.

Fox [80] and Hopster [81] argue that integrating emerging digital technologies into public policies can stimulate innovation, efficiency, and sustainability in various societal sectors. Our study confirms this need, highlighting the importance of a regulatory framework and a holistic strategy that includes investments in infrastructure, education, and innovation. It is only through such an approach that the economic benefits of digitalization can be transformed into significant progress in all areas of sustainable development [82,83].

The partial validation of hypothesis H2 underscores the complexity of the relationship between digital technologies, economic performance, and SDG progress. Although there is a positive mediating effect on economic performance, this effect varies between different SDGs.

5.1. Theoretical Implications

The sustainable adoption of digital technologies in organizational and societal transformation is a means to improve efficiency and competitiveness and a moral imperative to ensure that technological progress leaves no one behind.

Environmental conservation can significantly benefit from digital technologies through monitoring and managing natural resources, reducing pollution, and promoting sustainable practices. Organizations improve their operations by adopting sustainable digital transformation and contributing to a sustainable future. Thus, digital technologies become essential in achieving the SDGs' vision of creating a better world, where economic development, social equity, and environmental protection are harmonized.

5.2. Empirical Implications

The successful promotion of sustainable development through digitalization depends on a robust legislative and regulatory framework tailored to individual EU countries' specific needs and capacities. Recognizing the diversity in economic and digital development levels, EU governments must adopt differentiated policies that support innovation, ensure data protection, enhance cybersecurity, and foster sustainable economic practices. For countries with advanced digital infrastructure, these policies could focus on optimizing existing systems and fostering frontier innovations, while less developed regions may prioritize foundational investments in connectivity and digital literacy.

Collaboration between the public and private sectors, non-governmental organizations, and local communities is essential to address these disparities. Establishing partnerships can facilitate the transfer of knowledge and resources, enabling less digitally advanced regions to benefit from the experiences of their peers. Highly developed countries can share best practices in integrating digital technologies into public services, while economically weaker regions can leverage these insights to accelerate their digital transformation.

Companies close these gaps by integrating sustainability into their digital strategies and collaborating with governments to develop innovative solutions to address local, social, and environmental challenges. Tailored training and education programs are critical to ensuring that workforces in all regions are equipped for digital transformation. To maximize inclusivity and effectiveness, these programs must consider regional needs such as language barriers, technological access, and economic constraints. Investments in human capital will help to reduce inequalities between countries, ensuring that all EU nations can participate in, and benefit from, the digital revolution.

Green digital technologies, such as energy-efficient solutions and electronic waste management systems, should be prioritized to minimize environmental impacts. Less developed countries can adopt low-cost, sustainable technologies, while wealthier nations can lead in developing cutting-edge solutions. A circular economy model, supported by research and development investments in sustainable technologies, can serve as a unifying framework for all EU countries, promoting resource efficiency and environmental conservation.

By addressing these practical implications and emphasizing regional adaptation, European Union countries can ensure that digitalization accelerates progress toward the Sustainable Development Goals and promotes equitable and inclusive development across all member states. This differentiated approach enables countries at varying stages of development to harness the transformative power of digital technologies in alignment with their specific economic and digital contexts.

5.3. Limitations and Further Research

Despite the valuable insights our study provided on the transformative role of emerging digital technologies in achieving the SDGs, several limitations must be highlighted. These limitations not only contextualize the research findings but also suggest directions for future research.

First, the study's regional focus, limited to countries in the European Union, restricts the possibility of generalizing the research findings to other global contexts. The EU's economic, social, and infrastructural conditions may differ significantly from those in other regions, influencing the potential relationship between digital technologies and SDG progress. Future research should extend this analysis to include countries from different continents and with different economic levels to increase the universality of the conclusions.

Although the DESI is a comprehensive measure of digital technology adoption, it may not encompass all dimensions of digital transformation relevant to sustainable development. Emerging technologies such as blockchain, quantum computing, and advancements in renewable energy technologies were not explicitly included in the DESI-based analysis. Future research should consider a broader range of digital innovations and their specific contributions to different SDGs.

The analyses of digitalization's impact on sustainability highlight the mediating role of economic performance, measured by GDP per capita. However, GDP per capita may not fully capture the economic dynamics involved. Other economic indicators, such as income distribution, employment rates, and investment in research and development, could provide a more nuanced understanding of how economic factors mediate this relationship. Future studies should incorporate these additional economic variables to enrich the analysis.

6. Conclusions

The rapid advancement of digital technologies presents a transformative opportunity for achieving the Sustainable Development Goals (SDGs) within the European Union. This study demonstrates the significant role of emerging digital technologies, measured through the Digital Economy and Society Index (DESI), in fostering progress across economic, social, and environmental dimensions. Our research provides a nuanced understanding of how digital innovation drives sustainable development by analyzing the relationship between digitalization, economic performance, and SDG outcomes.

A key finding of this study is the mediating role of economic performance, as measured by GDP per capita, in the relationship between digital technology adoption and SDG progress. While digitalization positively impacts overall SDG performance, the effects vary across specific goals, underscoring the importance of integrating digitalization strategies with economic policies tailored to individual SDG targets. While economic growth amplifies the benefits of digitalization in some areas, it has limited influence in others, highlighting the need for targeted and adaptive approaches.

These findings emphasize that digital transformation is not merely a technological endeavor but a multidimensional process requiring alignment with broader societal and economic goals. To fully realize the potential of digital technologies, EU countries must invest in robust digital infrastructure, enhance technological education, and adopt policies that foster both sustainable and inclusive economic growth. Furthermore, nurturing collaboration among governments, private enterprises, and civil society is critical to ensuring that digital transformation benefits all sectors of society.

Leveraging digital technologies for sustainable development requires a comprehensive approach that bridges technological innovation, economic performance, and social equity. By adopting adaptive policies, fostering partnerships, and promoting digital education, the

European Union can harness the transformative power of digitalization to accelerate progress toward the SDGs while ensuring that no one is left behind.

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Conflicts of Interest: The author declares no conflicts of interest.

Appendix A

Table A1. Validity, reliability, and fit for models α and 1–5.

Model α				Model 1			
	Digital Economy and Society Index	Economic performance	Sustainable Development Goals Index	Digital Economy and Society Index	Economic performance	GOAL 1: No Poverty	
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.919		
Economic performance	0.532	1.000		Economic performance	0.533	1.000	
Sustainable Development Goals Index	0.522	0.14	1.000	GOAL 1: No Poverty	0.269	0.151	1.000
SRMR		0.054		SRMR		0.068	
Model 2				Model 3			
	Digital Economy and Society Index	Economic performance	GOAL 2: Zero Hunger	Digital Economy and Society Index	Economic performance	GOAL 3: Good Health and Well-being	
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.919		
Economic performance	0.529	1.000		Economic performance	0.527	1.000	
GOAL 2: Zero Hunger	−0.19	−0.161	1.000	GOAL 3: Good Health and Well-being	0.731	0.629	1.000
SRMR		0.06		SRMR		0.068	
Model 4				Model 5			
	Digital Economy and Society Index	Economic performance	GOAL 4: Quality Education	Digital Economy and Society Index	Economic performance	GOAL 5: Gender Equality	
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.92		
Economic performance	0.528	1.000		Economic performance	0.527	1.000	
GOAL 4: Quality Education	0.601	0.418	1.000	GOAL 5: Gender Equality	0.687	0.391	1.000
SRMR		0.056		SRMR		0.047	

Source: author's construction using SmartPLS v3.0.

Table A2. Validity, reliability, and fit for models 6–11.

Model 6				Model 7			
	Digital Economy and Society Index	Economic performance	GOAL 6: Clean Water and Sanitation		Digital Economy and Society Index	Economic performance	GOAL 7: Affordable and Clean Energy
Digital Economy and Society Index	0.918			Digital Economy and Society Index	0.919		
Economic performance	0.535	1.000		Economic performance	0.532	1.000	
GOAL 6: Clean Water and Sanitation	0.233	0.102	1.000	GOAL 7: Affordable and Clean Energy	0.302	−0.296	1.000
SRMR		0.057		SRMR		0.054	
Model 8				Model 9			
	Digital Economy and Society Index	Economic performance	GOAL 8: Decent Work and Economic Growth		Digital Economy and Society Index	Economic performance	GOAL 9: Industry, Innovation, and Infrastructure
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.919		
Economic performance	0.53	1.000		Economic performance	0.528	1.000	
GOAL 8: Decent Work and Economic Growth	0.451	0.41	1.000	GOAL 9: Industry, Innovation and Infrastructure	0.68	0.54	1.000
SRMR		0.049		SRMR		0.052	
Model 10				Model 11			
	Digital Economy and Society Index	Economic performance	GOAL 10: Reduced Inequality		Digital Economy and Society Index	Economic performance	GOAL 11: Sustainable Cities
Digital Economy and Society Index	0.918			Digital Economy and Society Index	0.919		
Economic performance	0.532	1.000		Economic performance	0.534	1.000	
GOAL 10: Reduced Inequality	0.421	0.198	1.000	GOAL 11: Sustainable Cities	0.519	0.517	1.000
SRMR		0.07		SRMR		0.064	

Source: author's construction using SmartPLS v3.0.

Table A3. Validity, reliability, and fit for models 12–17.

Model 12				Model 13			
	Digital Economy and Society Index	Economic performance	GOAL 12: Responsible Consumption and Production		Digital Economy and Society Index	Economic performance	GOAL 13: Climate Action
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.919		
Economic performance	0.527	1.000		Economic performance	0.529	1.000	
GOAL 12: Responsible Consumption and Production	−0.649	−0.700	1.000	GOAL 13: Climate Action	−0.547	−0.699	1.000
SRMR		0.057		SRMR		0.054	

Table A3. *Cont.*

Model 14				Model 15			
	Digital Economy and Society Index	Economic performance	GOAL 14: Life Below Water		Digital Economy and Society Index	Economic performance	GOAL 15: Life on Land
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.919		
Economic performance	0.533	1.000		Economic performance	0.533	1.000	
GOAL 14: Life Below Water	0.082	−0.054	1.000	GOAL 15: Life on Land	−0.114	−0.364	1.000
SRMR		0.049		SRMR		0.052	
Model 16				Model 17			
	Digital Economy and Society Index	Economic performance	GOAL 16: Peace and Justice Strong Institutions		Digital Economy and Society Index	Economic performance	GOAL 17: Partnerships to achieve the Goal
Digital Economy and Society Index	0.919			Digital Economy and Society Index	0.919		
Economic performance	0.529	1.000		Economic performance	0.527	1.000	
GOAL 16: Peace and Justice Strong Institutions	0.64	0.586	1.000	GOAL 17: Partnerships to achieve the Goal	0.449	0.307	1.000
SRMR		0.07		SRMR		0.064	

Source: author's construction using SmartPLS v3.0.

Appendix B

Table A4. Direct and indirect effects for models α and 1–5.

Model α					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.532	0.537	0.043	12.332	0.000
Digital Economy and Society Index → Sustainable Development Goals Index	0.624	0.62	0.069	8.983	0.000
Economic performance → Sustainable Development Goals Index	−0.192	−0.188	0.067	2.857	0.004
Digital Economy and Society Index → Economic performance → Sustainable Development Goals Index	−0.102	−0.1	0.036	2.839	0.005
Structural equation : $SDG_i = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.532, \beta_2 = 0.624, \beta_3 = -0.192, \varepsilon$ – error of the model					
Model 1					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.533	0.539	0.044	12.245	0.000
Digital Economy and Society Index → GOAL 1: No Poverty	0.262	0.262	0.092	2.849	0.005
Economic performance → GOAL 1: No Poverty	0.011	0.008	0.064	0.179	0.858
Digital Economy and Society Index → Economic performance → GOAL 1: No Poverty	0.006	0.004	0.035	0.173	0.863
Structural equation : $SDG1 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.533, \beta_2 = 0.262, \beta_3 = 0.011, \varepsilon$ – error of the model					

Table A4. *Cont.*

Model 2					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.529	0.536	0.042	12.504	0.000
Digital Economy and Society Index → GOAL 2: Zero Hunger	−0.145	−0.154	0.087	1.662	0.097
Economic performance → GOAL 2: Zero Hunger	−0.084	−0.073	0.107	0.789	0.430
Digital Economy and Society Index → Economic performance → GOAL 2: Zero Hunger	−0.045	−0.037	0.058	2.768	0.043
Structural equation : $SDG2 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.529, \beta_2 = -0.145, \beta_3 = -0.084, \varepsilon$ – error of the model					
Model 3					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.527	0.533	0.044	11.986	0.000
Digital Economy and Society Index → GOAL 3: Good Health and Well-being	0.553	0.55	0.043	12.857	0.000
Economic performance → GOAL 3: Good Health and Well-being	0.338	0.34	0.037	9.184	0.000
Digital Economy and Society Index → Economic performance → GOAL 3: Good Health and Well-being	0.027	0.033	0.044	0.986	0.000
Structural equation : $SDG3 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.527, \beta_2 = 0.553, \beta_3 = 0.338, \varepsilon$ – error of the model					
Model 4					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.528	0.536	0.043	12.230	0.000
Digital Economy and Society Index → GOAL 4: Quality Education	0.527	0.526	0.056	9.341	0.000
Economic performance → GOAL 4: Quality Education	0.14	0.14	0.04	3.546	0.000
Digital Economy and Society Index → Economic performance → GOAL 4: Quality Education	0.074	0.075	0.021	3.505	0
Structural equation : $SDG4 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.528, \beta_2 = 0.527, \beta_3 = 0.14, \varepsilon$ – error of the model					
Model 5					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.527	0.529	0.043	12.229	0.000
Digital Economy and Society Index → GOAL 5: Gender Equality	0.665	0.664	0.063	10.605	0.000
Economic performance → GOAL 5: Gender Equality	0.041	0.04	0.051	0.798	0.425
Digital Economy and Society Index → Economic performance → GOAL 5: Gender Equality	0.021	0.021	0.027	0.791	0.429
Structural equation : $SDG5 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.527, \beta_2 = 0.665, \beta_3 = 0.041, \varepsilon$ – error of the model					

Source: author's construction using SmartPLS v3.0.

Table A5. Direct and indirect effects for models 6–11.

Model 6					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.535	0.541	0.041	12.901	0.000
Digital Economy and Society Index → GOAL 6: Clean Water and Sanitation	0.25	0.255	0.106	2.367	0.018
Economic performance → GOAL 6: Clean Water and Sanitation	−0.031	−0.033	0.056	0.557	0.577
Digital Economy and Society Index → Economic performance → GOAL 6: Clean Water and Sanitation	−0.017	−0.018	0.031	0.542	0.588
Structural equation : $SDG6 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.535, \beta_2 = 0.25, \beta_3 = -0.031, \varepsilon$ – error of the model					
Model 7					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.532	0.539	0.043	12.476	0.000
Digital Economy and Society Index → GOAL 7: Affordable and Clean Energy	0.64	0.638	0.067	9.511	0.000
Economic performance → GOAL 7: Affordable and Clean Energy	−0.636	−0.621	0.097	6.548	0.000
Digital Economy and Society Index → Economic performance → GOAL 7: Affordable and Clean Energy	−0.338	−0.333	0.052	6.469	0.000
Structural equation : $SDG7 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.532, \beta_2 = 0.64, \beta_3 = -0.636, \varepsilon$ – error of the model					
Model 8					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.53	0.541	0.043	12.400	0.000
Digital Economy and Society Index → GOAL 8: Decent Work and Economic Growth	0.325	0.318	0.059	5.541	0.000
Economic performance → GOAL 8: Decent Work and Economic Growth	0.237	0.244	0.038	6.289	0.000
Digital Economy and Society Index → Economic performance → GOAL 8: Decent Work and Economic Growth	0.126	0.132	0.022	5.634	0.000
Structural equation : $SDG8 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.53, \beta_2 = 0.325, \beta_3 = 0.237, \varepsilon$ – error of the model					
Model 9					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.528	0.535	0.043	12.301	0.000
Digital Economy and Society Index → GOAL 9: Industry, Innovation, and Infrastructure	0.548	0.543	0.06	9.106	0.000
Economic performance → GOAL 9: Industry, Innovation, and Infrastructure	0.251	0.258	0.05	5.034	0.000
Digital Economy and Society Index → Economic performance → GOAL 9: Industry, Innovation, and Infrastructure	0.133	0.138	0.028	4.755	0.000
Structural equation : $SDG9 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.528, \beta_2 = 0.548, \beta_3 = 0.251, \varepsilon$ – error of the model					

Table A5. *Cont.*

Model 10					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.532	0.538	0.043	12.277	0.000
Digital Economy and Society Index → GOAL 10: Reduced Inequality	0.44	0.437	0.055	8.008	0.000
Economic performance → GOAL 10: Reduced Inequality	−0.036	−0.034	0.063	0.57	0.569
Digital Economy and Society Index → Economic performance → GOAL 10: Reduced Inequality	−0.019	−0.017	0.034	0.559	0.576
Structural equation : $SDG10 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.532, \beta_2 = 0.44, \beta_3 = -0.036, \varepsilon = \text{error of the model}$					
Model 11					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.534	0.539	0.041	12.990	0.000
Digital Economy and Society Index → GOAL 11: Sustainable Cities and Communities	0.339	0.336	0.053	6.438	0.000
Economic performance → GOAL 11: Sustainable Cities and Communities	0.336	0.339	0.07	4.801	0.000
Digital Economy and Society Index → Economic performance → GOAL 11: Sustainable Cities and Communities	0.179	0.182	0.035	5.151	0.000
Structural equation : $SDG11 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.534, \beta_2 = 0.339, \beta_3 = 0.336, \varepsilon = \text{error of the model}$					
Source: author's construction using SmartPLS v3.0.					

Table A6. Direct and indirect effects for models 12–17.

Model 12					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.527	0.532	0.044	12.091	0.000
Digital Economy and Society Index → GOAL 12: Responsible Consumption and Production	−0.387	−0.39	0.053	7.284	0.000
Economic performance → GOAL 12: Responsible Consumption and Production	−0.496	−0.493	0.042	11.714	0.000
Digital Economy and Society Index → Economic performance → GOAL 12: Responsible Consumption and Production	−0.261	−0.261	0.02	12.976	0.000
Structural equation : $SDG12 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.527, \beta_2 = -0.387, \beta_3 = -0.496, \varepsilon = \text{error of the model}$					
Model 13					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.529	0.54	0.043	12.421	0.000
Digital Economy and Society Index → GOAL 13: Climate Action	−0.247	−0.246	0.06	4.083	0.000
Economic performance → GOAL 13: Climate Action	−0.568	−0.566	0.049	11.536	0.000
Digital Economy and Society Index → Economic performance → GOAL 13: Climate Action	−0.301	−0.305	0.028	10.736	0.000
Structural equation : $SDG13 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.529, \beta_2 = -0.247, \beta_3 = -0.568, \varepsilon = \text{error of the model}$					

Table A6. *Cont.*

Model 14					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.533	0.539	0.04	13.284	0.000
Digital Economy and Society Index → GOAL 14: Life Below Water	0.155	0.153	0.111	1.397	0.163
Economic performance → GOAL 14: Life Below Water	−0.137	−0.137	0.061	2.240	0.026
Digital Economy and Society Index → Economic performance → GOAL 14: Life Below Water_	−0.073	−0.074	0.035	2.091	0.037
Structural equation : $SDG14 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.533, \beta_2 = 0.155, \beta_3 = -0.137, \varepsilon$ – error of the model					
Model 15					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.533	0.537	0.043	12.271	0.000
Digital Economy and Society Index → GOAL 15: Life on Land	0.112	0.106	0.069	1.616	0.107
Economic performance → GOAL 15: Life on Land	−0.424	−0.42	0.084	5.059	0.000
Digital Economy and Society Index → Economic performance → GOAL 15: Life on Land	−0.226	−0.224	0.041	5.466	0.000
Structural equation : $SDG15 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.533, \beta_2 = 0.112, \beta_3 = -0.424, \varepsilon$ – error of the model					
Model 16					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.529	0.536	0.041	12.860	0.000
Digital Economy and Society Index → GOAL 16: Peace and Justice Strong Institutions	0.458	0.46	0.076	6.007	0.000
Economic performance → GOAL 16: Peace and Justice Strong Institutions	0.344	0.344	0.046	7.546	0.000
Digital Economy and Society Index → Economic performance → GOAL 16: Peace and Justice Strong Institutions	0.182	0.184	0.025	7.134	0.000
Structural equation : $SDG16 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.529, \beta_2 = 0.458, \beta_3 = 0.344, \varepsilon$ – error of the model					
Model 17					
	Original Sample	Sample Mean	Standard Deviation	T Statistics	p Values
Digital Economy and Society Index → Economic performance	0.527	0.534	0.043	12.306	0.000
Digital Economy and Society Index → GOAL 17: Partnerships to achieve the Goal	0.398	0.4	0.069	5.762	0.000
Economic performance → GOAL 17: Partnerships to achieve the Goal	0.098	0.092	0.07	1.394	0.164
Digital Economy and Society Index → Economic performance → GOAL 17: Partnerships to achieve the Goal	0.052	0.048	0.037	1.389	0.165
Structural equation : $SDG17 = \beta_2 \times DESI + \beta_3(\beta_1 \times DESI) + \varepsilon$; $\beta_1 = 0.527, \beta_2 = 0.398, \beta_3 = 0.098, \varepsilon$ – error of the model					

Source: author's construction using SmartPLS v3.0.

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