DOES DIGITAL ECONOMY PROMOTE SUSTAINABLE DEVELOPMENT: CASE OF EU COUNTRIES?[1]

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Abstract

The digital economy and sustainable development are treated as the world's progress, and there is a vast number of papers investigating the indirect linkage between these two phenomena. However, there is a lack of studies analysing the direct influence. Hence, the purpose of the current paper is to find out if there is an impact of the digital economy, expressed by DESI sub-dimensions, on sustainable development, represented by SDGI. For that issue, statistical data covering 2017–2020 was gathered, and panel regression modelling was applied. The survey covers 28 EU countries (including the United Kingdom because the data was collected before Brexit). The findings revealed that DESI sub-dimensions influence SDGI; however, the impact was negative in most cases. Thus, the current paper showed that standard views on the influence of the digital economy are not always the right ones.

Keywords: digital economy, sustainable development, sustainable development goals

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1. Introduction

Sustainable development is one of the vital goals of the world announced by the United Nations (2015) and is expected to be achieved by 2030. Meanwhile, the Council of the European Union (2017) adopted Sustainable Development Goals (SDG) for the European Union, where the progress is measured by the sustainable development goals index (SDGI). So, sustainable development is one of the most vital priorities of the EU. Though, reaching SDG is not the only priority of the EU. One more objective is *A Europe fit for the digital age* (von der Leyen 2019). European Commission (2020a) established three activities for implementing this priority, one of which is *Shaping Europe's digital future*, which is being achieved through three pillars. One of such pillars is a *fair and competitive digital economy*. Hence, it could be stated that sustainable development and the digital economy are both the priorities of the EU. However, it is not clear if there are any relationships between those two phenomena.

As alluded to above, sustainable development is measured through SDGI; however, the assessment of the digital economy is unclear. There are several techniques for its measurement. One of which was proposed by the Organisation for Economic Co-operation and Development (OECD 2018). Another proposed index is the digital adoption index (DAI) which is constructed to evaluate the digitalisation of the countries. However, the statistical data for DAI is available for 2014-2016 only. Another shortcoming of this index – it has no dimensions. As the world is promptly transitioning to the digital economy, it could not be used for the analysis of the present situation because of the limited availability of up-to-date data. For monitoring the member states' digital economy progress, the European Commission uses the digital economy and society index (DESI), whose data is updated annually. Hence, the current paper uses the mentioned index as a technique to measure the digital economy.

The current study aims at identifying the possible influence of the DESI on SDGI. The hypothesis – the digital economy has an impact on sustainable development. The study systemises the scientific knowledge and develops econometric models to assess the effect of the digital economy on sustainable development and tests them empirically.

2. Theoretical Background

The digital economy and sustainable development are widely analysed topics in scientific literature. For instance, Savastano et al. (2022) examine it from the perspective of a company; Cook et al. (2022) focus on digital agriculture for a sustainable food system. It is worth mentioning that plenty of articles deal with digitalisation in a circular economy (Chauhan, Parida, and Dhir 2022; Denicolai, Zucchella, and Magnani 2021; Kusi-Sarpong et al. 2021; Moreno et al. 2019), and circular economy could be treated as a part of sustainable development. In other words, the digital economy has permeated almost all spheres of life as well as sustainable development issues. Because of that, the digital economy's relationship with sustainable development should be highlighted. According to UNESCO (n.d.), sustainable development is the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Scientists agree that the digital economy could be treated as an instrument to extend economic growth (Chinoracky and Corejova 2021; Laitsou, Kargas, and Varoutas 2020), which, in turn, is a part of the sustainable development concept. However, not all scientists focus on such a general phenomenon as economic growth but rather on more narrow fields of the economy.

There are scientists analysing the digital economy in terms of business and its readiness for sustainable development. For instance, Andreeva et al. (2018) state that the digital economy could be the basis of the financial stability of companies. Financial stability itself has a significant impact on economic growth, reduction of poverty and income inequality (Ratnawati 2020), which in turn represent the SDG1[2], SDG8[3], and SDG10[4]. Feng et al. (2017) agree that the stronger the financial stability is, the higher the level of sustainable development is. Moreover, financial stability could help overcome financial crises in businesses (Teplova and Shabalin 2017), which undoubtedly leads to constant sustainable development. In other words, it could be stated that the digital economy could be seen as a driver of sustainable development, which could be reached through the companies' financial stability.

[2] SDG1 – No poverty

[3] SDG8 – Decent work and economic growth

[4] SDG10 – Reduced inequalities

Other scientists concentrate on investigating the impact of different variables on economic growth, such as trade, taxation and e-commerce. All these could be treated as a part of the digital economy. For the purpose of managing those issues, digital technologies are used. For instance, Abendin and Duan (2021) claim that trade positively impacts economic growth. It is worth mentioning that trade is related to taxation issues, and low levels of taxation could stimulate economic growth (Hyams-Ssekasi and Song 2020). Alves (2021) studied individual taxes' revenues and real per capita growth and found out that there is a non-linear relationship between taxation levels and economic growth. Moreover, it is worth mentioning that e-commerce is going together with trade and taxation. Ortiz et al. (2020) claim that e-commerce is a source of economic growth. Jasińska-Biliczak (2022) state that e-commerce influences country's market position and its developmental. Hence, it could be claimed that the mentioned three phenomena indirectly influence sustainable development, as expressed by SDG8.

Another topic that deserves a broader analysis is the interface between information and communication technologies (ICT) diffusion and economic growth. ICT undoubtedly could be treated as a part of the digital economy and could be investigated as a variable having both direct and indirect impacts on sustainable development. However, there are only a few articles investigating that issue, most of them focus on ICT's impact on economic growth, and there are different points of view on the mentioned influence. According to Cheng et al. (2021), ICT could have a positive or no impact on economic growth, which depends on the level of a country's development, i.e. in high-impact countries, this effect is supported, which is not in middle and low-income countries. These findings are supported by Kurniawati (2020), who did research on OECD (i.e. high-income) countries and concluded that those countries had reached positive and significant economic development from high ICT penetration. In contrast, Pradhan et al. (2020) investigated middle-income countries, and the results revealed that ICT infrastructure development stimulates economic growth in the long run. However, there are different views on ICT impact. For instance, Alshubiri et al. (2019) assert that ICE has a negative impact on labour productivity, which is a part of economic growth. Thus, it could be stated that ICT could both positively and negatively influence economic growth and, in this way, contribute to sustainable development in different directions.

To sum it up, it could be claimed that the digital economy could be treated as a development trend and is a basis for sustainable economic growth (Silenko, Bezrodna, and Nikogosyan 2020), hence overall sustainable development.

Even though there are plenty of scientific studies on the indirect linkage between the digital economy and sustainable development, almost all of them state that the digital economy promotes sustainable development. For example, Lyaskovskaya and Khudyakova (2021) investigate the interface between sharing economy, which according to the authors, is a part of the digital economy and sustainable development. The authors found out that there was an insignificant impact of the sharing economy development on sustainable development goals. In other words, it could be stated that one of the parts of the digital economy does not affect sustainable development. Song, Zheng, and Wang (2022) showed that the digital economy advanced rapid economic growth, improved people's living standards, increased efficient utilisation of resources, and strengthened environmental protection, which, in turn, are parts of sustainable development. Li, Li, and Wen (2021) showed that the development of the digital economy reduces fine particulate matter ($PM_{2.5}$), which provides a piece of evidence that there is a relationship between the digital economy and the environmental pillar of the sustainability concept.

However, there is a limited number of research studies that measure the direct influence of the digital economy on sustainable development, and this could be treated as the research gap. Hence, the current study's main task is to fill this gap by putting forward a hypothesis:

H: The digital economy promotes the sustainable development of a country.

In order to test the hypothesis, the DESI and SDGI are treated as the digital economy and sustainable development measurement techniques. The impact of DESI on SDGI is calculated using panel regression modelling.

3. Methodology

The panel regression modelling has been selected to analyse the impact of DESI on SDGI. Panel regression is the method that is used for searching panel data, so-called cross-sectional data. The panel regression was conducted five times for each DESI dimension, and DESI sub-dimensions were chosen as variables (see Table 1).

Table 1: DESI dimensions and sub-dimensions

	DESI dimensions	**Code**	**DESI sub-dimensions**
DESI	Connectivity	1a1	Overall fixed BB take-up
		1a2	At least 100 Mbps fixed BB take-up
		1b1	Fast BB (NGA) coverage
		1b2	Fixed Very High-Capacity Network (VHCN) coverage
		1c1	4G Coverage
		1c2	Mobile BB take-up
		1c3	5G readiness
		1d1	Broadband price index
	Human capital	2a1	At least Basic Digital Skills
		2a2	Above basic digital skills
		2a3	At least basic software skills
		2b1	ICT Specialists
		2b2	Female ICT specialists
		2b3	ICT graduates
	Use of Internet Services	3a1	People who never used the Internet
		3a2	Internet Users
		3b1	News
		3b2	Music, Videos and Games
		3b3	Video on Demand
		3b4	Video Calls
		3b5	Social Networks
		3b6	Doing an online course
		3c1	Banking
		3c2	Shopping
		3c3	Selling online
	Integration of Digital Technology	4a1	Electronic Information Sharing
		4a2	Social media
		4a3	Big data
		4a4	Cloud
		4b1	SMEs selling online
		4b2	Commerce turnover
		4b3	Selling online cross-border
	Digital Public Services	5a1	e-Government Users
		5a2	Pre-filled Forms
		5a3	Online Service Completion
		5a4	Digital public services for businesses
		5a5	Open Data

Source: European Commission (2020b)

The regression model is used on four years' worth of panel data from 2017 to 2020 for a sample of 28 countries to find out if the DESI indicators influence the SDGI. The following empirical models have been developed (see Table 2).

Table 2: Theoretical research models

DESI dimension	Proposed model
Connectivity	Model 1: $SDGI_{it} = \beta_1 1a1_{it} + \beta_2 1a2_{it} + \beta_3 1b1_{it} + \beta_4 1b2_{it} + \beta_5 1c1_{it} + \beta_6 1c2_{it} + u_{it}$
Human capital	Model 2: $SDGI_{it} = \beta_1 2a1_{it} + \beta_2 2a2_{it} + \beta_3 2a3_{it} + \beta_4 2b1_{it} + \beta_5 2b2_{it} + \beta_6 2b3_{it} + u_{it}$
Use of Internet services	Model 3: $SDGI_{it} = \beta_1 3a1_{it} + \beta_2 3a2_{it} + \beta_3 3b1_{it} + \beta_4 3b2_{it} + \beta_5 3b3_{it} + \beta_6 3b4_{it} + \beta_7 3b5_{it} + \beta_8 3b6_{it} + \beta_9 3c\ 1_{it} + \beta_{10} 3c2_{it} + \beta_{11} 3c3_{it} + u_{it}$
Integration of Digital Technology	Model 4: $SDGI_{it} = \beta_1 4a1_{it} + \beta_2 4a2_{it} + \beta_3 4a3_{it} + \beta_4 4a4_{it} + \beta_5 4b1_{it} + \beta_6 4b2_{it} + \beta_7 4b3_{it} + u_{it}$
Digital Public Services	Model 5: $SDGI_{it} = \beta_1 5a1_{it} + \beta_2 5a2_{it} + \beta_3 5a3_{it} + \beta_4 5a4_{it} + u_{it}$

It is worth mentioning that for the Connectivity dimension, the 1c3 and 1d1 subdimensions have been removed from the research due to missing data. For the Human Capital dimension, 25 countries are investigated due to the missing data for the case of Croatia, Italy, and Luxembourg. For the Use of Internet Services, Luxembourg is omitted due to missing data. For the Integration of Digital Technology dimension, 24 countries are studied as Luxembourg, Finland, Slovenia and Germany were removed due to missing data. For the Digital Public Services, the 5a5 subdimension is removed due to missing values.

Fixed-effect vs random-effect

The Hausman test was employed to determine which regression model – fixed-effect or random-effect is most appropriate for the employed data. The null hypothesis is that the model is of random effect, and the alternative hypothesis is that the model is a fixed-effect. The Hausman test statistic under the null hypothesis is defined as (Imran 2021):

$$h = (\hat{\theta}_r - \hat{\theta}_e)[\widehat{Var}\left((\hat{\theta}_r - \hat{\theta}_e)\right]^{-1}(\hat{\theta}_r - \hat{\theta}_e) \sim \chi_K^2$$

Here it was assumed that there were two types of estimators for a certain factor θ of elements $K \times 1$. $\hat{\theta}_r$ is robust and reliable under both H_0 and H_a, while $\hat{\theta}_e$ is reliable only under H_0. The used Hausman test indicates that *h* has a limiting χ^2 distribution (Imran 2021).

According to the results, for all the models, the *p*-values were less than 0.0001, which means that the appropriateness of the fixed-effects model over the random-effects model was proved and, hence, it is used for the representations of the results.

Panel unit-root test

In order to avoid spurious regression and to check the stationarity of the variables, the unit-root test should be employed. There are plenty of unit-root tests presented in the literature. For example, Saglam and Ampountolas (2021) use Levin-Lin-Chu, Im-Pesaran-Shin, Fisher-type augmented Dickey-Fuller and Philips-Perron panel unit-root tests. Despite a wide variety of unit-root tests, the most commonly used is the Augmented Dickey-Fuller (ADF) test, which extends the Dickey-Fuller test and is used in the current study. The null hypothesis of the unit-root test is “unit root exists (in other words, the data is not stationary”. The ADF testing procedure to test the unit root hypothesis is the following (Naser 2015):

$$\Delta y_t = \theta_0 + \gamma_0 t + \gamma_1 y_{t-1} + \sum_{i=0}^{p} \theta_i \Delta y_{t-1} + \varepsilon_t$$

where:

y_t – the variable in period *t*
$\Delta y_{t-1} - y_{t-1} - y_{t-2}$
ε_t – i.i.d. disturbance with mean 0 and variance 1
t – the linear time trend
p – the lag order.

In the present research, all the p-values of ADF are less than 0.1 (our chosen significance level is 0.1); hence, the null hypothesis for all the cases is rejected. The time series is stationary, so, according to Zuo and Arbor (1997), if the variable is stationary, then the variable is I(0).

Cointegration test

In order to move on with the panel regression analysis, the cointegration of the panels should be taken into account. Two series are cointegrated when they have common trends, i.e. they are in some sense similar. The null hypothesis is that series are not cointegrated. In order to test series for cointegration, the Kao cointegration test was employed. The results are presented in the table below (see Table 3).

Table 3: Kao Cointegration Analysis

DESI Dimensions	**Test**	**Statistic**	**p-value**
Connectivity	Kao ADF	5.6878	0.0000
Human Capital	Kao ADF	4.6747	0.0000
Use of Internet	Kao ADF	6.5951	0.0000
Integration of Digital Technology	Kao ADF	7.1617	0.0000
Digital Public Services	Kao ADF	2.1247	0.0168

As it could be concluded based on the results provided in Table 3, all the panels are cointegrated and, hence, the research could be further conducted.

4. Results and Discussion

Before investigating the impact of DESI on SDGI, descriptive statistics are provided to give a good idea of the data that has been used in the research (see Appendix Tables A-E). After the descriptive statistics are calculated, the regression modelling is applied.

Fixed-model regression modelling has been chosen to investigate the influence of the digital economy on sustainable development through DESI impact on SDGI. All in all, five theoretical models based on DESI dimensions have been developed. The results are presented in the Tables below.

Table 4: Summary of Model 1

Indicators	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
1a1	0.097142	0.045863	2.1181	0.0365968*
1a2	0.148092	0.070047	2.1142	0.0369378*
1b1	–0.051340	0.038572	–1.3310	0.1861581
1b2	–0.018488	0.019355	–0.9562	0.3412343
1c1	0.168665	0.049061	3.4378	0.0008501***
1c2	0.051081	0.016385	3.1176	0.0023697**
Parameters				
R^2	0.287			
F-statistic	*p*-value < 0.0001			

Note: Signif. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

Table 4 shows that there are four statistically significant variables in Model 1. R^2 is equal to 0.287, and the F-statistic *p*-value is less than 0.0001. These tests show that the model could be used, although the R^2 is not high. Nevertheless, it is still higher than 0.2, which is enough to interpret the economic data. Hence, it could be stated that Overall fixed BB take-up (1a1), At least 100 Mbps fixed BB take-up (1a2), 4G coverage (1c1) and Mobile broadband take-up (1c2) are significant variables in the model.

The variable 1a1 stands for the percentage of households subscribing to fixed broadband. The higher the level of high-speed access to the public Internet is, the higher the probability that households will intend to make purchases online, use online services and so on, which in turn, could reduce the environmental pollution as going out is typically connected with the use of vehicles which negatively influences the environmental pillar of sustainability. The 1a2 indicator has a positive influence on sustainable development as well. Actually, the level of internet access positively affects the reduction of inequality in income (Cioacă et al. 2020).

Moreover, the results support the view of the scholars that 4G, which is considered new generation technology (NGN), could influence the country's sustainable development (Rafay and Khan 2016; Xia 2011). However, scientists are stating that using 4G and preparing to 5G has shockingly increased energy consumption; hence, it could be a challenge for sustainable development (Wu et al. 2014). Regarding the mobile broadband take-up, it positively influences SDGI. However, there are not many studies on that issue; because of that, the obtained result could contribute to the scientific literature on drivers of sustainable development. The mobile platform is a significant part of our lives; hence, many services might be accessed through this platform. In other words, the connection between people, businesses and other services is constant, which may help to manage daily life challenges faster and with less monetary expenses, which leads to sustainability.

Table 5: Summary of Model 2

Indicators	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
2a1	0.479550	0.326813	1.4674	0.14577
2a2	–0.081583	0.091821	–0.8885	0.37664
2a3	–0.243272	0.296471	–0.8233	0.41249
2b1	1.280280	0.706085	1.8132	0.07313 .
2b2	–0.096025	1.150739	–0.0834	0.93368
2b3	0.023885	0.211268	0.1113	0.91024
Parameters				
R^2	0.649			
F-statistic	*p*-value < 0.0001			

Note: Signif. codes: ‘***’ 0.001, ‘**’ 0.01, ‘*’ 0.05, ‘.’ 0.1.

Model 2 has one significant variable – ICT specialists (2b1) (see Table 5). The R^2 is 0.649, and the F-statistic *p*-value is less than 0.0001, which supports the model’s adequacy. According to the model, the mentioned variable has a positive influence on SDGI. It is not a surprising result, as the discussions about ICT’s negative and positive impact on sustainable development are widely discussed in the scientific literature. For instance, there are scholars claiming that ICT has a significant positive effect on sustainable development dimensions (Jayaprakash and Radhakrishna Pillai 2022; Nchofoung and Asongu 2022). However, there is a contradicting point of view as well. For instance, Ya’u (2004) states that ICT could be harmful to sustainable development as it is an antecedent of economic inequality. The ICT sector is one of the drivers of overproduction, which may cause unsustainable consumption. In other words, the higher the level of ICT specialists, the higher overproduction might be achieved, which, in turn, negatively affects SDG. However, while discussing that issue, it should be stated that SDG9 focuses on promoting sustainable industrialisation and fostering innovation (Nhamo, Nhemachena, and Nhamo 2020). In other words, ICT is a significant part of our lives; hence, it could not be removed. Still, the countries’ governments should consider the negative aspects of ICT while developing strategies for achieving sustainable development. The number of ICT specialists should be strictly stated by every country, as it would help to achieve the positive influence of ICT on SDGs.

Table 6: Summary of Model 3

Indicators	Estimate	Std. Error	t-value	Pr(>|t|)
3a1	–0.066719	0.339495	–0.1965	0.844768
3a2	–0.593087	0.315751	–1.8783	0.064500 .
3b1	0.219796	0.101459	2.1664	0.033691*
3b2	0.214517	0.184255	1.1642	0.248281
3b3	0.042007	0.070565	0.5953	0.553566
3b4	–0.028329	0.053529	–0.5262	0.598325
3b5	0.463211	0.167292	2.7689	0.007194**
3b6	–0.526523	0.197922	–2.6603	0.009674**
3c1	–0.436046	0.133895	–3.2566	0.001740**
3c2	–0.249253	0.169613	–1.4695	0.146166
3c3	0.069682	0.104992	0.6637	0.509070
Parameters				
R^2	0.639			
F-statistic	*p*-value < 0.0001			

Note: Signif. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

There are five significant indicators (variables) (see Table 6), two of which have a positive effect and three of which have a negative impact on SDGI. The R^2 is equal to 0.639, proving that the model could be used to analyse DESI indicators' influence on SDGI. Moreover, the F-statistic *p*-value is less than 0.0001, which proves that the developed model differs from the null model. The results show that News (3b1) and Social networks (3b5) have a positive impact on sustainable development. It could be due to the information which is provided through those channels. Nowadays, there is ample information related to sustainable development issues, which psychologically affect the users. In other words, it encourages people to sort waste, for example, which changes their way of thinking. On the other hand, Internet users (3a2), Doing an online course (3b6) and Banking (3c1) negatively influence sustainable development. Learning online has taken over a significant part of our lives, especially during the COVID-19 pandemic, limiting people's perception of the received information and reducing the intention to be sustainable. This is quite logical, as using online services increases the level of energy usage, which contradicts the sustainable development concept. The same situation is with banking, as almost all banking procedures are held online.

Table 7: Summary of Model 4

Indicators	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
4a1	0.00160991	0.17785492	0.0091	0.992806
4a2	–0.47750793	0.16620038	–2.8731	0.005485**
4a3	–0.09552064	0.43541498	–0.2194	0.827043
4a4	–0.00068073	0.18005236	–0.0038	0.996995
4b1	–0.60192428	0.36320589	–1.6573	0.102288
4b2	–0.24035146	0.32705232	–0.7349	0.465042
4b3	–0.42167070	0.49718657	–0.8481	0.399487
Parameters				
$\mathbf{R^2}$	0.390			
F-statistic	p-value < 0.0001			

Note: Signif. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

Model 4 could be developed using only one variable (see Table 7), as it is the only significant one. R^2 is 0.390, and the F-statistic *p*-value is less than 0.0001, which proves the model's adequacy. Model 4 states that social media (4a2) negatively influences the SDGI. There are plenty of scientific articles discussing this linkage. For instance, Bölükbaş et al. (2021) claim that social media influences the patterns of consumption. It could promote consuming more, which is not a concept of sustainable consumption. Grover et al. (2021) analysed political leaders' communication through Twitter. They found that politicians who promote sustainable development ignore the following goals: clean water and sanitation, life below water, zero hunger, no poverty and educational quality. Hence, such communication could harm SDGI as neither all the goals are being discussed nor paid attention to. This proved that in the current situation, social media does not contribute to SDGI but could do it after information provided in social media is reconsidered. Herranz de la Casa and García Caballero (2021) studied organisations' communication levels. They found out that the analysed organisations' presence in the principal social media networks (i.e. different social networks) is minimal and uneven. Moreover, social media is a platform for social commerce (s-commerce), which enables customers' participation in the sale of products and services (Shin, Park, and Kim 2021). So irresponsible traders could sell more goods than needed by using different marketing strategies, which would lead to unsustainable consumption. Responsibility is one of the core traits that sellers should have while using social media for their business. However, it is rather challenging to reach, as responsibility could lead to a lower income. Still, there is a contradicting approach in the scientific literature. For example, Ortega-

Gutiérrez et al. (2021) mention that social media is vital for business. It helps firms to acquire the necessary knowledge and capabilities, which, in turn, allow them to be more sustainability-oriented. To sum up, it could be stated that social media harms sustainable development, especially in terms of sustainable consumption. However, in case the values of social media users change, it could become one of the drivers of sustainable development in the future.

Table 8: Summary of Model 5

Indicators	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**
5a1	–0.100020	0.097020	–1.0309	0.30568
5a2	–0.065788	0.079773	–0.8247	0.41200
5a3	–0.337820	0.139828	–2.4160	0.01797*
5a4	–0.198352	0.114383	–1.7341	0.08675 .
		Parameters		
R^2	0.362			
F-statistic	p-value < 0.0001			

Note: Signif. codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

Table 8 shows the summary of Model 5. R^2 is equal to 0.362, and the F-statistics *p*-value is less than 0.0001; consequently, the model could be interpreted and used. It could be stated that both significant variables – Online service completion (5a3) and digital public services for businesses (5a4) harm SDGI. The obtained results are not in line with the discussion in the scientific literature, as most scholars claim that digital public services may have a positive impact on sustainable development (Fanea-Ivanovici et al. 2019; Fernández-Portillo et al. 2019). Still, the results show that the situation in the EU is vice-versa. It could be because the EU governments do not efficiently manage digital public services, which, in turn, leads to a high level of digital red tape, which is not sustainable from the very beginning.

Moreover, a wide range of the EU governments use a mixed model of public services, i.e. some of them are provided online and some – in offline mode, which primes to a mess in coordinating public services. Hence, sustainability is not achieved. Moreover, digital public services could support environmental sustainability, but not a social one. Usually, people need personal contact to solve their problems. Of course, nowadays, some services provide online help (e.g. online chat or video calls), but not all of them. So, to sum up, it could be stated that at present, sub-dimensions of integration of digital technology negatively influence SDGI. Still, suppose the EU governments prepare a consistent plan for a complete transition to the digital platform and reduce digital bureaucracy. The signs of the presented variables could change to positive ones. So, constant monitoring of the changes is needed.

5. Conclusions

The current research aims at investigating the impact of the digital economy on sustainable development by employing panel regression modelling. First of all, the conducted literature review shows that many scientific articles present the indirect influence of different digital economy indicators on sustainable development goals. It helps to identify the gap in the scientific knowledge as there is a limited number of articles analysing the direct impact. The systematisation of the available methodologies for measuring the digital economy confirms that the only factors that could be used as the digital economy factors are DESI sub-dimensions because only this index provides available and up-to-date data on the digital economy. For measuring the sustainable development level, SDGI was employed.

The research results revealed that, conversely to the scientific literature, the digital economy does not always positively influence sustainable development. Regarding the first dimension of DESI, connectivity, four sub-dimensions are assumed to be significant, and all of them have plus signs in terms of the effect on SDGI. They are as follows: Overall fixed BB take-up, At least 100 Mbps fixed BB take-up, 4G coverage and Mobile broadband take-up. The second dimension of DESI is Human capital. In its term, ICT specialists was a significant variable that positively influenced SDGI. The current result supports the standard view that ICT positively contributes to sustainable development. Although, there are studies claiming that there is a negative interface between ICT specialists and sustainable development. Hence, those results should be taken into account by the EU countries while preparing the sustainable development strategies, as the part of ICT in sustainable development is often overestimated. On the other hand, digitalisation in various fields (especially manufacturing, etc.) should be positive in the EU countries as it helps to solve the problem of ageing.

The third analysed DESI dimension was the use of Internet services. It has the most subdimensions, five of which were defined as significant. They are as follows: News, Social networks, Internet users, Doing an online course and Banking. The first two have a positive impact on SDGI, and the last three – have a negative one. This could be explained by the fact that news and social networks are a part of communication channels, positively affecting people's well-being. At the same time, online courses, internet users and banking do not promote socialisation, which is a part of mental health. The fourth dimension was Integrating digital technology with only one significant variable – social media, which was assumed to influence SDGI negatively. There is a contradicting point of view on that aspect in the scientific literature, but still, in the present, the negative features of social media overcome the positive ones. However, it should be mentioned that social media and social networks are closely related. Still, social networks are mostly devoted to communication, as was alluded to above, while social media is communication without feedback, which is necessary to humans, especially in the COVID-19 pandemic. So, the producers of the social media content should focus more on the audience's needs and, based on that, develop user-friendly content. In this case, the social media's sign of the effect could change, i.e. constant monitoring is needed.

The last investigated DESI dimension was the Digital public services. Its significant sub-dimensions were Online service completion and Digital public services for businesses; both coefficients were negative; hence the influences on SDGI were negative as well. As mentioned in the discussion of the results, it could be because not all of the EU countries appropriately manage the public services provided via the Internet. Still, both individuals and legal entities need personal contact as the transition to the digital economy is faster than the transition to online communication.

To sum up, it could be stated that the current study is unique because it investigates the direct impact of DESI on SDGI. Although it could be confirmed that the digital economy impacts sustainable development, however, not all the results positively answer the paper's question: "Does the digital economy promote sustainable development?". It could be stated that the digital economy partially contributes to SDGI.

The current results should be considered by policymakers while preparing the country's strategies for transmission to the digital economy. The policymakers should acknowledge that not all the dimensions of the digital economy measurement have a positive impact on sustainable development. For instance, in order to reach sustainable consumption, social media should provide appropriate information, especially for the younger generation, which is significantly dependent on social networks. In other words, the information provided on social media should be thoroughly revised in order to bring the right message to the users. It could be stated that the government ought to strengthen laws, policies and regulations connected to social media. Moreover, the country's services should be provided both in person and online, as delivering the services virtually does not lead to social sustainability.

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Table B. Human Capital descriptive statistics

Statistic	2a1	2a2	2a3	2b1	2b2	2b3	SDGI
Nbr. of observations	100	100	100	100	100	100	100
Minimum	26,245	8,595	28,314	1,20	0,381	1,100	55,800
Maximum	79,494	52,979	80,437	7,200	3,073	9,600	85,600
1st Quartile	49,367	25,124	52,082	2,675	0,914	2,975	72,700
Median	55,456	30,990	57,690	3,700	1,300	3,750	76,600
3rd Quartile	67,448	37,334	69,767	4,400	1,753	4,500	80,025
Mean	56,438	31,243	58,777	3,704	1,391	3,981	75,779
Variance (n-1)	164,276	109,638	155,488	1,817	0,400	2,730	34,970
Standard deviation (n-	12,817	10,471	12,469	1,348	0,632	1,652	5,914

Table C. Use of Internet Services descriptive statistics

Statistic	3a1	3a2	3b1	3b2	3b3	3b4	3b5	3b6	3c1	3c2	3c3	SDGI
Nbr. of observations	108	108	108	108	108	108	108	108	108	108	108	108
Minimum	1,67	56,33	49,41	63,08	3,87	31,25	46,55	2,85	7,41	17,97	2,79	55,80
Maximum	33,32	95,46	93,18	93,55	60,66	85,23	87,15	22,25	95,20	90,51	38,41	85,60
1st Quartile	7,93	74,02	71,87	74,64	11,04	45,20	65,39	5,08	51,13	48,81	11,13	72,70
Median	13,71	80,50	78,76	80,23	16,67	51,75	71,57	6,95	63,03	64,44	19,42	76,30
3rd Quartile	18,98	87,40	85,53	85,89	30,71	61,93	76,96	9,77	77,81	74,15	27,40	80,00
Mean	13,91	80,74	77,62	80,00	23,29	53,89	70,66	8,27	62,34	61,61	19,41	75,63
Variance (n-1)	61,37	85,20	106,23	63,43	244,45	162,30	88,30	18,09	494,99	281,44	102,56	33,94
Standard deviation (n-1)	7,83	9,23	10,31	7,96	15,63	12,74	9,40	4,25	22,25	16,78	10,13	5,83

Table D. Integration of Digital Technology descriptive statistics

Statistic	4a1	4a2	4a3	4a4	4b1	4b2	4b3	SDGI
Nbr. of observations	96	96	96	96	96	96	96	96
Minimum	14,333	8,368	2,620	4,719	5,189	1,697	1,844	55,800
Maximum	53,967	43,648	24,400	43,403	35,128	28,984	18,044	85,600
1st Quartile	25,567	14,312	7,843	10,866	11,407	6,611	6,153	71,775
Median	32,789	19,984	10,798	14,826	16,023	9,831	8,272	75,800
3rd Quartile	40,641	28,095	13,594	24,569	21,460	12,516	10,277	78,750
Mean	33,509	22,002	11,554	17,920	17,137	10,567	8,455	75,038
Variance (n-1)	100,471	99,939	23,947	111,736	50,526	27,980	12,874	33,895
Standard deviation (n-1)	10,024	9,997	4,894	10,571	7,108	5,290	3,588	5,822

Table E. Digital Public Services descriptive statistics

Statistic	5a1	5a2	5a3	5a4	SDGI
Nbr. of observations	112	112	112	112	112
Minimum	29,854	4,625	54,500	47,795	55,800
Maximum	96,114	100,000	100,000	100,000	85,600
1st Quartile	50,735	33,406	81,094	78,935	72,700
Median	64,597	58,063	88,438	87,153	76,100
3rd Quartile	80,980	74,406	94,688	93,056	79,925
Mean	64,727	54,920	86,136	83,836	75,520
Variance (n-1)	324,394	619,855	103,971	153,247	33,892
Standard deviation (n-1)	18,011	24,897	10,197	12,379	5,822