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The COVID-19 pandemic and the Digital Transformation: a comparative case study of the countries of the European Union

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Abstract: *COVID-19 pandemic wave has changed many aspects of human life. The effects of the pandemic are related to health, social, economic and environmental consequences. As people around the world apply social distances to prevent the spread of COVID-19, exclusion is putting pressure on the global economy. We are facing a severe recession, which has shifted the balance in many sectors of the economy and society, such as global supply chains, wages, unemployment rates, the workforce, transport, and climate change. To restore these balances, the development of the digital age and the transition to it, work, education, and socialization of citizens is considered imperative. As the pandemic lasts, new modes of operation will emerge, and digital space is already seeing a significant acceleration in the speed with which the digital transformation of our societies takes place.*

The goal of this study is to examine the degree of acceleration of digital transformation in all 27 countries of the European Union, which has taken place as a consequence of the spread of COVID-19 in the last five years, by examining and analyzing an indicator created by the European Commission to monitor the digital progress of its member states, the Digital Economy and Society Index (DESI). It is an evaluation system that publishes annual reports, since 2014, to compare and rank its member states in terms of their level of digital transformation. More specifically, based on the DESI Index we will compare the level of digital services of the member states of the EU and the rate at which they were accelerated in the context of the measures and policies adopted during the period of the Covid 19 pandemic.

Keyword: *Digital Transformation, COVID-19, Comparative Analysis; Benchmarking Index.*

1. INTRODUCTION

The coronavirus pandemic has radically changed the way a society functioned in all its aspects both in the health sector and in the social, economic and environmental sectors. As a consequence of the dramatic changes that took place there was a severe recession, which changed the balance in many sectors of the economy and society. In order to maintain the balance in the various sectors, the development of the digital age and the transition to it was considered imperative, both in the field of work and education and in the process of socialization of citizens who were applying deceleration measures. During the pandemic, new ways of working have emerged, and the digital space is already seeing a significant acceleration in the speed at which the Digital Transformation of societies is taking place. Digital transformation is a new concept developed in an evolving society based on emerging needs and achieved through the creation and adaptation of new applications and services provided by the new Industry 4.0. This new trend achieves new technological achievements, and also strengthens the economic and social relations of citizens with society. The transition to a new digital age will be the key strategy for overcoming the effects of the pandemic.

The goal of this study is to examine the degree of acceleration of digital transformation in all 27 countries of the European Union, which has taken place because of the spread of COVID-19. To achieve this, an indicator established by the European Commission to monitor the digital progress of its member states since 2014, the Digital Economy and Society Index (DESI) will be examined. The paper is organized as follows: Section 2 reviews the concept of Digital Transformation. Section 3 describes the Digital Economy and Society Index (DESI). The evolution of EU member states over time in terms of their digital transformation and their classification based on the DESI index is presented in section 4. Finally, conclusions are drawn in Section 5.

2. The Concept of Digital Transformation in the Context of the Coronavirus Pandemic

As people around the world practiced social distancing to prevent the spread of COVID-19, the lockdown put pressure on the global economy. The result of this pressure was a severe recession, which changed the balance in many areas of the economy and society, such as global supply chains, wages, unemployment rates, the workforce, transportation and climate change. To restore these balances, the development of the digital age and the transition to it, work, education and the socialization of citizens were considered imperative. During the pandemic, new ways of working are being observed and the digital space is already seeing a significant acceleration in the speed at which the digital transformation of our societies is taking place.

The biggest impact of the COVID-19 pandemic on digital transformation is on private sector organizations. The public sector appears mainly in the context of e-government and citizens' expectations of the services provided by their governments as well as the rapid jump of public servants to remote work.

Therefore, it is worth considering what, in fact, precipitated the COVID-19 pandemic? Has this pandemic really accelerated digital transformation or just the digitization of services?

Exactly this question in the age of the digital economy has become the strategic question for companies, as well as public authorities, especially in the private sector companies are driven to strategize based on the capabilities provided by DT in order to optimize their bottom line (Rogers, 2016 at (Rêgo, B.S., Jayantilal, S., Ferreira, J.J. et al., 2021)).

Digital transformation (DT) is a new concept that expands horizons regarding the growing forms of technological communications. Information and Communication Technologies provide innovative, more efficient and effective solutions to social and economic challenges. They enable a society to face unforeseen problems and support the development of digital solutions, as happened with the corona pandemic. To achieve the digital transformation, it is necessary for society to provide equal access to connectivity, to the necessary technology, but also to education for the acquisition of digital skills. According to the Council of the EU, with the corona pandemic it became imperative to take advantage of this unique opportunity to more actively shape the strategic direction of DT in the Member States. (Berlin Declaration on Digital Society and value-based Digital Governement, 2020).

The Fitzgerald et al. (2014) in (Rêgo, B.S., Jayantilal, S., Ferreira, J.J. etal., 2021)), consider the digital transformation in the business sector, as an exploitation of technology, and Industry 4.0 as well as social networks, for achieving the upgrade of the overall performance of its business model.

Herbert (2017) describes digital transformation as the process of adaptability and flexibility of a business or an organization as well as its reflexes, that will allow it to improve and develop functions that will respond to the existing, but also future needs of the business or organization (Herbert, 2017).

When we refer to the digital transformation of the public sector, then it can be described as transformational government (t-gov). It is essentially the evolution of e-government that has emerged in public administration to cover functions through ICT such as: connectivity, service delivery, efficiency and effectiveness, interactivity, decentralization, transparency and accountability (Yildiz, M., 2007).

T-gov enables digital transformation to respond to societal needs, as well as in an emergency situation that may arise, as was the case with the coronavirus pandemic, by intervening in structural changes to the structure and operation of government as opposed to a simple introduction of digitized services to citizens (Omar et al., 2020 in (Tangi, L., Janssen, M., Benedetti, M., & Noci, G., 2021).

In addition, T-gov can be seen as a transformation of government processes and structures so as to achieve public sector objectives such as efficiency, transparency, accountability and citizen-centricity (Weerakkody et al., 2011 in (Tangi, L., Janssen, M., Benedetti, M., & Noci, G., 2021).

3. Digital Economy And Society Index (DESI)

The European Commission monitors the digital progress of member states and publishes annual reports on the Digital Economy and Society Index (DESI) since 2014. It is an evaluation system used by the

European Commission to monitor on an annual basis the performance of the Member States in terms of the main predetermined progress parameters, but also to identify thematic areas that should be a priority. The Key Indicators are: i) Human Capital, ii) Connectivity, iii) Integration of Digital Technology and iv) Digital Public Services (European Commission-Shaping Europe's digital future, 2023).

The main pillars that make up the Digital Economy and Society Index are the following four:

1. The Human Capital
2. Connectivity
3. The Integration of Digital Technology
4. Digital Public Services

Table1. *The DESI framework*

Category	Sub-category	Indicators
1 - Connectivity	1a - Fixed Broadband take-up	1a1 - Overall fixed BB take-up
		1a2 - At least 100 Mbps fixed BB take-up
	1b - Fixed broadband coverag	1b1 - Fast BB (NGA) coverage
		1b2 - Fixed VH Capacity Network coverage
	1c - Mobile broadband	1c1 - 4G coverage
		1c2 - Mobile BB take-up
		1c3 - 5G readiness
	1d - Broadband price index	1d1 - Broadband price index
2 - Human capital	2a - Internet User Skills	2a1 - At least basic digital skills
		2a2 - Above basic digital skills
		2a3 - At least basic software skills
	2b - Advanced Skills and Development	2b1 - ICT specialists
		2b2 - Female ICT specialists
		2b3 - ICT graduates
3 - Use of internet services	3a - Internet use	3a1 - People who never used internet
		3a2 - Internet users
	3b - Activities online	3b1 - News
		3b2 - Music, video and games
		3b3 - Video on demand
		3b4 - Video calls
		3b5 - Social networks
		3b6 - Doing an online course
	3c – Transactions	3c1 - Banking
		3c2 - Shopping
		3c3 - Selling online
4 - Integration of digital technology	4a - Business digitalization	4a1 - Electronic information sharing

Category	Sub-category	Indicators
		4a2 - Social media
		4a3 - Big data
		4a4 - Cloud
	4b - e-Commerce	4b1 - SMEs selling online
		4b2 - e-commerce turnover
		4b3 - Selling online cross-border
5 - Digital public services	5a - e-Government	5a1 - e-government users
		5a2 - Pre-filled forms
		5a3 - Online service completion
		5a4 - Digital public services for business
		5a5 - Open data

Source: European Commission.

The four dimensions of the Digital Economy and Society Index are of equal importance, which is reflected in the weighting of each dimension in the calculation of the index.

The Total Index is calculated as the arithmetic mean of the normalized scores of the subcategory indicators as shown in Table 1 based on the following formula for each country C:

DESI(C) = Human Capital(C) * 0.25 + Connectivity(C) * 0.25 + The Integration of Digital Technology (C) * 0.25 + Digital Public Services (C) * 0.25

The DESI index is structured into three levels of indicators as depicted in the three columns in the table below:

The annual Digital Economy and Society Index measures the progress of EU member states. Towards a digital economy and society, based on both Eurostat data and specialized studies and collection methods. It helps the member states of the EU identify priority areas that require targeted investment and action. All EU member states have made progress in the field of digital transformation, yet the gap between the EU leaders and those with the lowest DESI scores remains large.

Despite these improvements, all Member States will need to make concerted efforts to achieve the 2030 targets as set out in the Digital Decade for Europe. For example, regarding Greece, the digital transformation of public services is high on the country's political agenda. In 2020, Greece acted quickly and decisively during the COVID-19 crisis to make public services available online during periods of restrictive measures and quarantine, so that the public and businesses can continue to enjoy public services remotely. Greece continues to improve its performance in almost all parameters of the DESI index, although in most cases its score is still below the EU average.

In 2021 the Commission adjusted the DESI to reflect the two major policy initiatives that will have an impact on digital transformation in the EU in the coming years: the Recovery and Resilience Facility and the Digital Compass for the Digital Decade.

4. A COMPARATIVE CASE STUDY OF THE COUNTRIES OF THE EUROPEAN UNION TO PROCEED WITH THE DIGITAL TRANSFORMATION BASED ON THE DESI INDEX.

The European Commission's proposal for the adoption of the Policy Program ’Path to the Digital Decade’ was approved in 2021 and aimed to facilitate and accelerate the process of digital transformation (DT) of the EU member states. This proposal included a guide entitled ‘2030 Digital Compass: The European Way for the Digital Decade’, setting out the EU's goals to be achieved by 2030. Additionally in 2022 the Commission supplemented this guide with a declaration on digital rights and principles aimed at guiding policy makers and private actors in shaping the Digital Decade in line

with European values and legal framework. According to this declaration, the digital transformation in the European Union should include security, trust, inclusion, equality, sustainability, resilience, improving the quality of life, respect for people's rights and should contribute to a fair distribution of the resources of the economy and society among the member states. To evaluate and rank EU member states in terms of digital transformation and to determine their preparedness in extraordinary situations such as the coronavirus pandemic, there is the Digital Economy and Society Index (DESI). in the following table we observe the evolution of the index values as a percentage over time for the 27 EU member states and their average.

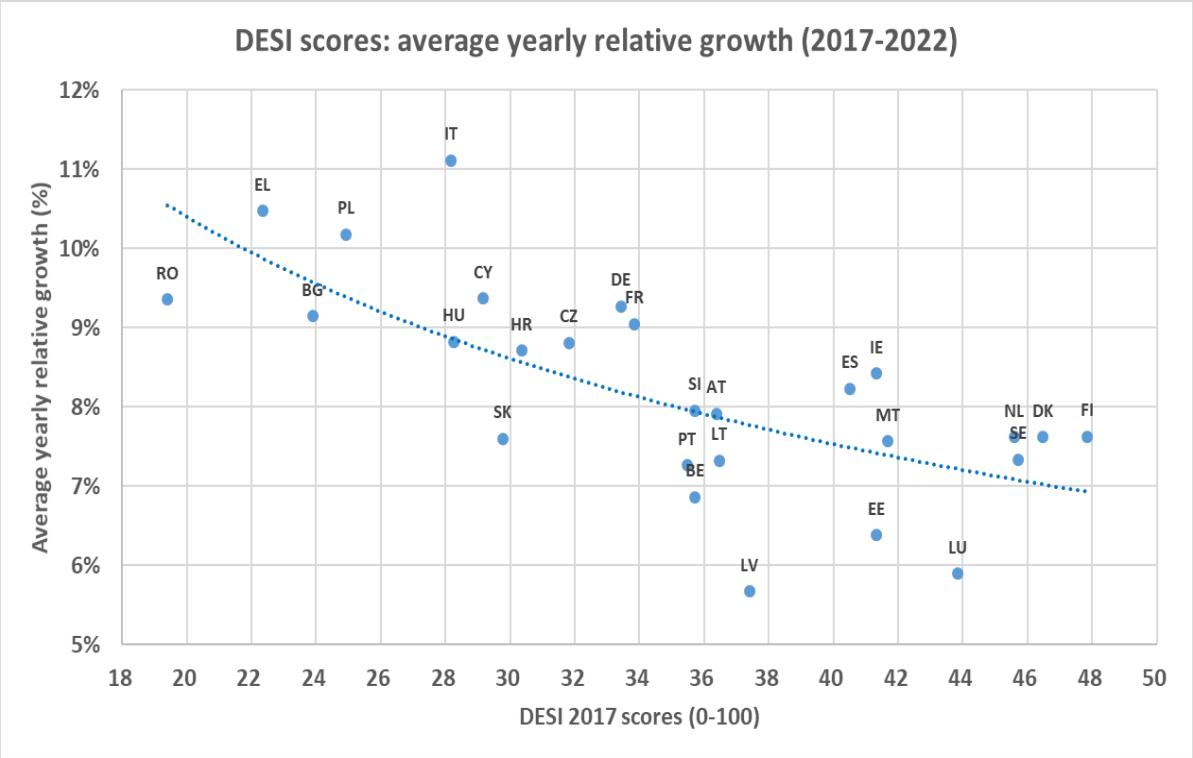
Table2. *The DESI overall index 2017-2022*

DESI overall INDEX 2017-2022						
EU Countries	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Belgium (BE)	35,73%	38,04%	40,00%	44,24%	46,71%	50,31%
France (FR)	33,84%	35,93%	39,46%	42,53%	45,92%	53,33%
Luxembourg (LU)	43,83%	45,82%	47,73%	51,20%	55,04%	58,85%
Greece* (EL)	22,36%	23,53%	25,53%	27,57%	32,51%	38,93%
Italy* (IT)	28,16%	30,56%	34,34%	36,72%	40,85%	49,25%
Spain* (ES)	40,52%	43,37%	47,04%	49,72%	54,81%	60,77%
Portugal* (PT)	35,48%	37,85%	40,31%	43,35%	45,86%	50,76%
Germany (DE)	33,44%	35,30%	38,35%	42,06%	47,07%	52,88%
Austria (AT)	36,37%	38,43%	41,22%	43,62%	50,52%	54,68%
Denmark (DK)	46,48%	48,69%	52,05%	55,97%	65,25%	69,33%
Finland (FI)	47,85%	50,37%	54,14%	58,43%	63,16%	69,60%
Netherlands	45,59%	48,06%	50,52%	54,68%	62,36%	67,37%
Sweden (SE)	45,71%	48,74%	51,96%	55,75%	60,49%	65,22%
Ireland (IE)	41,34%	44,10%	46,70%	50,81%	57,11%	62,74%
Malta (MT)	41,69%	43,85%	47,45%	51,52%	54,46%	60,88%
Cyprus (CY)	29,15%	30,40%	32,72%	35,34%	39,98%	48,35%
CzechRepublic (CZ)	31,83%	34,19%	37,19%	39,54%	43,37%	49,14%
Estonia (EE)	41,34%	43,98%	46,57%	49,05%	53,15%	56,51%
Hungary (HU)	28,26%	30,11%	32,18%	35,84%	38,72%	43,76%
Latvia (LV)	37,40%	39,40%	40,98%	44,06%	46,13%	49,71%
Lithuania (LT)	36,47%	39,58%	42,19%	44,67%	47,02%	52,71%
Poland (PL)	24,93%	27,12%	29,78%	33,20%	36,53%	40,55%
Slovakia (SK)	29,78%	31,68%	33,25%	36,19%	39,95%	43,45%
Bulgaria* (BG)	23,90%	25,79%	28,04%	29,82%	32,65%	37,68%
Croatia* (HR)	30,37%	32,15%	35,06%	37,01%	43,07%	47,55%
Romania* (RO)	19,40%	20,72%	22,37%	24,73%	27,43%	30,58%
Slovenia* (SL)	35,70%	37,86%	40,89%	42,92%	47,96%	53,37%
European Union (EU)	33,72%	35,92%	38,64%	41,67%	46,20%	52,28%

Source: European Commission

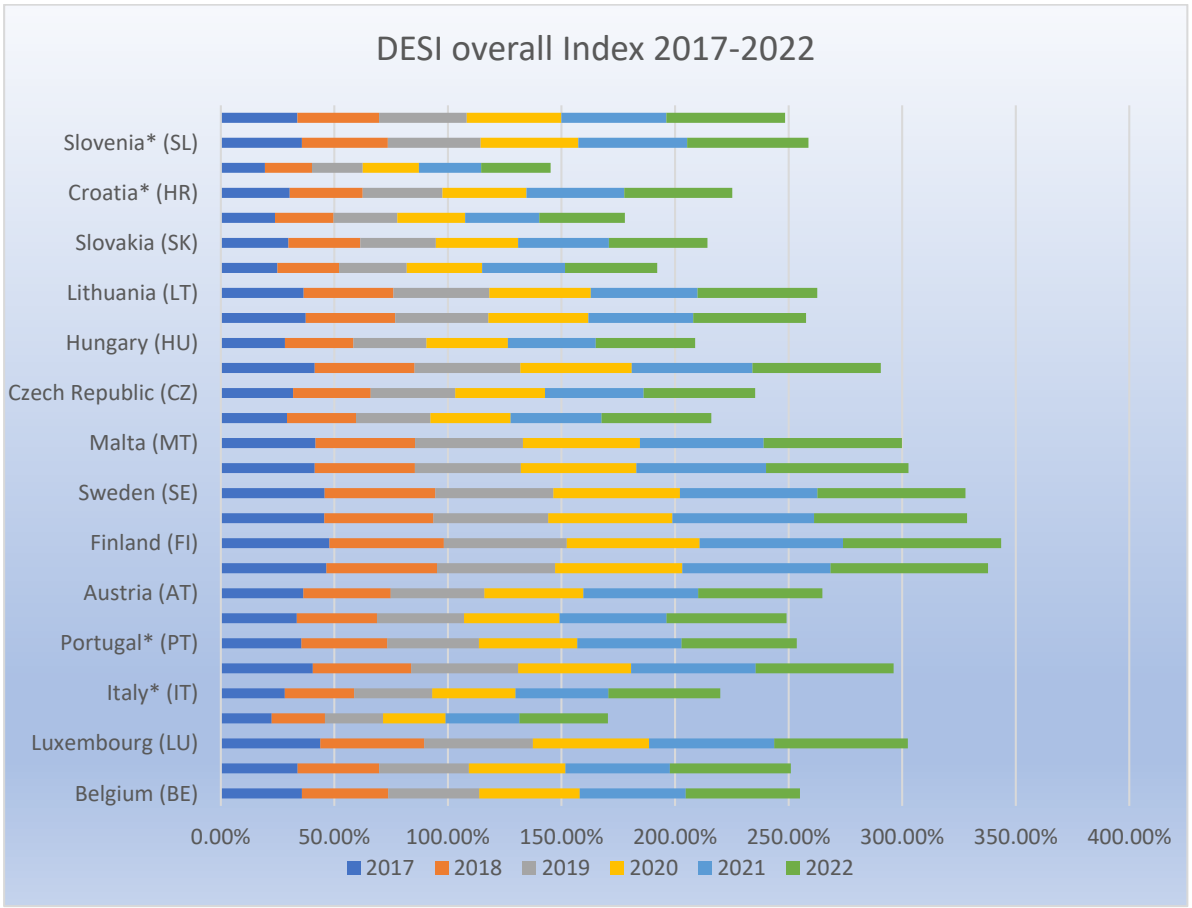
The first thing that one can notice by looking at the historical evolution of the index values is that all the Member States seek to improve their level of digital transformation. Even low-ranking countries such as Romania, Bulgaria and Greece show better values in 2022 compared to 2017 and have made progress focusing their policies on achieving Digital Transformation. These results are illustrated in the diagrams below, in which we see the average annual relative increase in terms of the DESI assessment during the period 2017-2022.

Graph1. *DESI scores: average yearly relative growth 2017-2022*



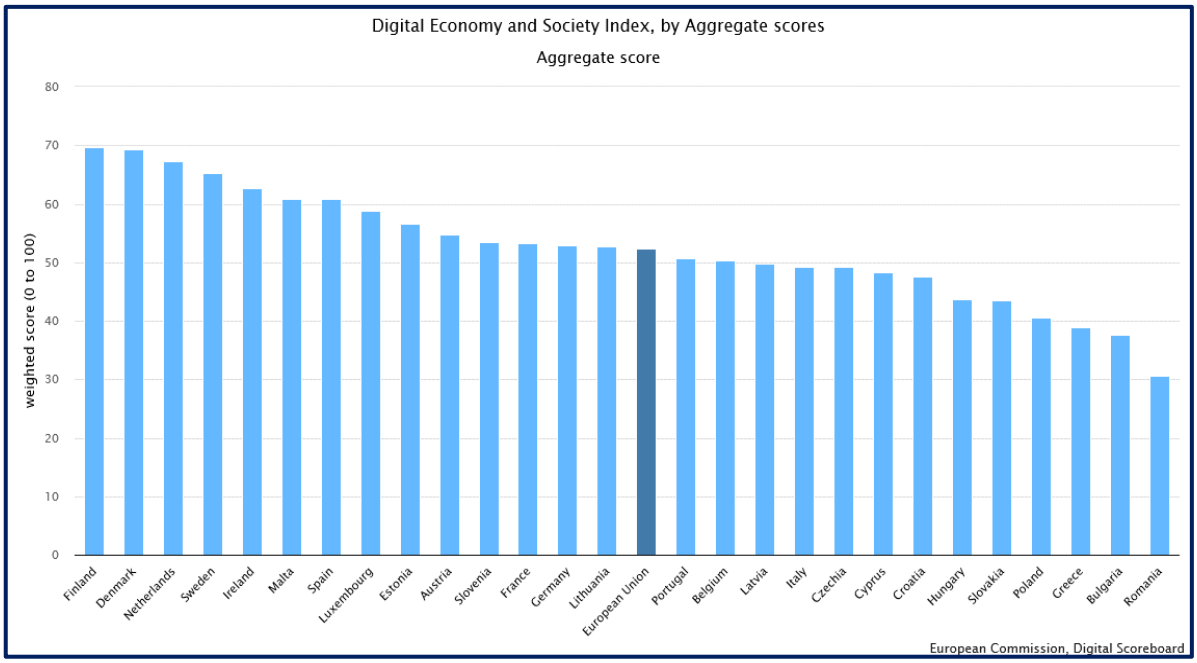
Source: European Commission: (DESI 2022, European Commission , 2022)

Graph2. *DESI overall Index 2017-2022*



Source: European Commission

Graph3. *DESI Aggregate score*



Source: European Commission

The Scandinavian countries have the highest score, for example Finland in 2022 had the DESI index in a percentage 69,60%. The other Nordic countries (Denmark, Sweden, the Netherlands, etc.) showed similar prices. The approximately 15% difference from the European average, show that the Nordic countries (Denmark 69,30%, Netherlands 67,40%, Sweden 65,20%) show a greater degree of readiness in the implementation of digital transformation both at the level of general performance and in the individual DESI indicators that concern not only the private but also the public sector.

From the countries of southern Europe Spain has the highest percentage (60.77%) and Greece has the lowest (38,9%) even though the growth rate is significantly high. Ireland and Malta collect percentage of 60%. Approximately 8% over the EU average aggregate DESI score. Germany and Austria follow and they present a aggregate DESI score is 53% which is not even 1% above the EU member states average.

The countries that were integrated in the last enlargement of the EU, the Eastern European countries, show DESI values ranging between 43-50%, which is the lowest among the EU countries and lower than the EU average. A percentage that indicates a low degree of readiness in terms of the implementation of DT in comparison with the rest of European countries. The only exception of this countries is the Estonia which in 2022 showed the DESI index at a percentage of 56%, which is 4% above the EU average.

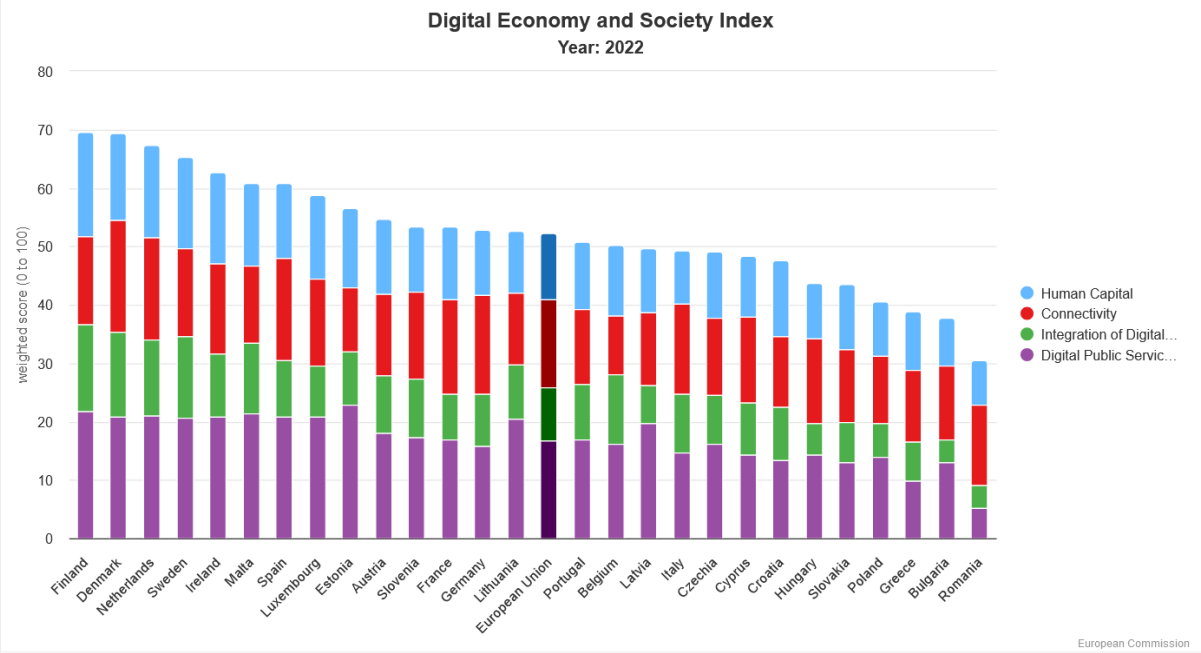
Additionally, in the diagram below we see the ranking of EU countries based on the four subcategories of the DESI index, for the last year under consideration in the present study (2022).

Table3. *The DESI dimension*

DESI Dimension	DESI sub-dimension
1 Human capital[16]	Internet user skills and advanced digital skills
2 Connectivity[17]	Fixed broadband take-up, fixed broadband coverage, mobile broadband and broadband prices
3 Integration of digital technology[18]	Business digitalisation and e-commerce
4 Digital public services[19]	e-Government

Source: European Commission

Graph4. *DESI Subcategories*



Source: European Commission

In 2021, the DESI index was restructured to align with the goals of the proposed path to the digital decade and this was reflected in the 2022 structure (DESI 2022, European Commission).

From 2022 the DESI includes eleven indicators to achieve the goals set in the Digital Decade to assess the progress of the Member States (DESI 2022, European Commission). These indicators are depicted in the table below:

Table4. *The DESI dimension 2022*

DESI Dimension	Indicators related to the Path to the Digital Decade proposal
1 Human capital	At least basic digital skills ICT specialists Female ICT specialists
2 Connectivity	Gigabit for everyone (Fixed very high capacity network coverage) 5G coverage
3 Integration of digital technology	SMEs with a basic level of digital intensity AI Cloud Big data
4 Digital public services	Digital public services for citizens Digital public services for businesses

Source: European Commission

In this study we will continue our analysis for the evaluation and ranking of the EU members states in terms of their digital transformation by considering one of the four parameters of the DESI indicator, which is the provision of digital public services and the sub-dimension of Electronic Government. This parameter gives us results regarding the provision of Digital Public Services for Citizens which was very critical during the pandemic period.

Table5. *The Digital Public Services Index 2017-2022*

Digital Public Services overall INDEX 2017-2022						
EU Countries	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Finland (FI)	64%	69%	73%	78%	83%	87%
Malta (MT)	63%	68%	71%	75%	80%	86%
Luxembourg (LU)	63%	67%	68%	72%	77%	83%
Denmark (DK)	60%	65%	69%	74%	78%	83%
Netherlands	60%	65%	69%	74%	79%	84%
Sweden (SE)	59%	64%	68%	72%	77%	82%
Spain* (ES)	59%	64%	68%	72%	78%	84%
Latvia (LV)	58%	62%	65%	69%	75%	79%
Lithuania (LT)	58%	63%	67%	72%	77%	82%
Ireland (IE)	57%	62%	65%	70%	75%	83%
Austria (AT)	50%	54%	58%	63%	68%	73%
Portugal* (PT)	50%	53%	56%	59%	64%	68%
Estonia (EE)	47%	72%	76%	81%	86%	91%
European Union (EU)	**47%**	**51%**	**54%**	**58%**	**63%**	**67%**
Slovenia* (SL)	46%	51%	55%	59%	65%	69%
Belgium (BE)	46%	49%	52%	56%	60%	65%
France (FR)	45%	50%	53%	58%	63%	67%
Germany (DE)	45%	48%	52%	56%	61%	63%
Czech Republic (CZ)	41%	47%	51%	54%	59%	64%
Italy* (IT)	38%	41%	45%	48%	52%	57%
Hungary (HU)	38%	42%	45%	48%	54%	58%
Cyprus (CY)	37%	41%	43%	48%	53%	58%
Slovakia (SK)	36%	39%	42%	46%	50%	52%
Croatia* (HR)	35%	38%	41%	44%	49%	54%
Poland (PL)	34%	38%	42%	47%	51%	56%
Bulgaria* (BG)	33%	37%	40%	44%	48%	51%
Greece* (EL)	24%	27%	29%	33%	36%	39%
Romania* (RO)	7%	10%	12%	15%	18%	21%

Source: European Commission

These results are illustrated in the diagram below, in which we see the ranking of EU member states based in the Digital Public Services Index in the period 2017-2022.

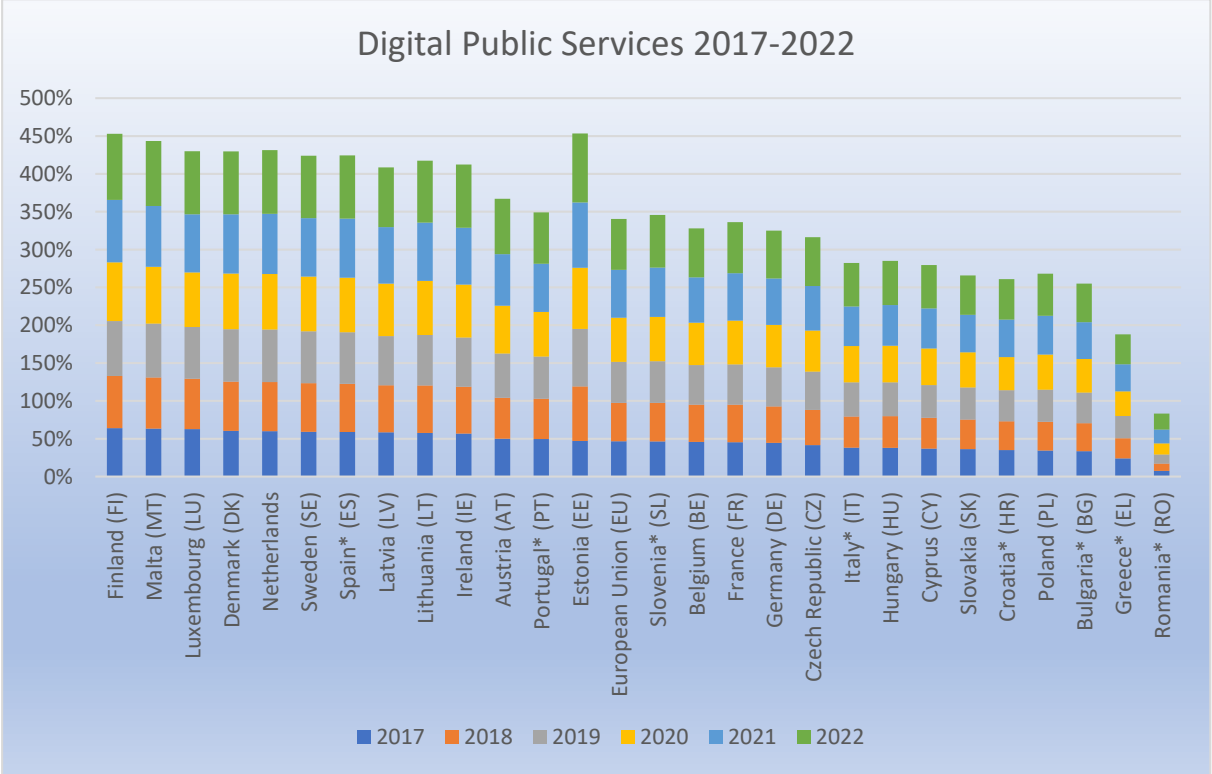
Analyzing the sub-index of digital public services, we observe a similar situation to the DESI index with the Nordic countries occupying the first positions, and having by far the best performance (Finland 87%, Netherlands 84%, Denmark 83%, Sweden 82%) and seem to be more prepared for the further DT of the system of providing digital public services to the citizens. Finland, as the country with the highest score (87%) out of 27, has a difference from the European average of 20%.

Of the southern countries of the EU, Spain continues to be in the highest position of the ranking and Greece in the lowest and far below the average limit of the EU, and it is worth noting that the overall progress made during the pandemic did not manage to be recorded in its entirety during the DESI 2022 reference period. The countries of central Europe (Germany, France, Belgium) move very close to the average European rate of the digital public services total score, but they are still below this average in contrast to the DESI index that was above the average.

Among these countries, the low percentage of Romania (21%) stands out, which brings it to the last place among the EU 27, as well as the high percentage of Estonia (91%) at the other end. Score reflecting the country's high degree of readiness to further digitally transform the system of providing public services to Estonian citizens.

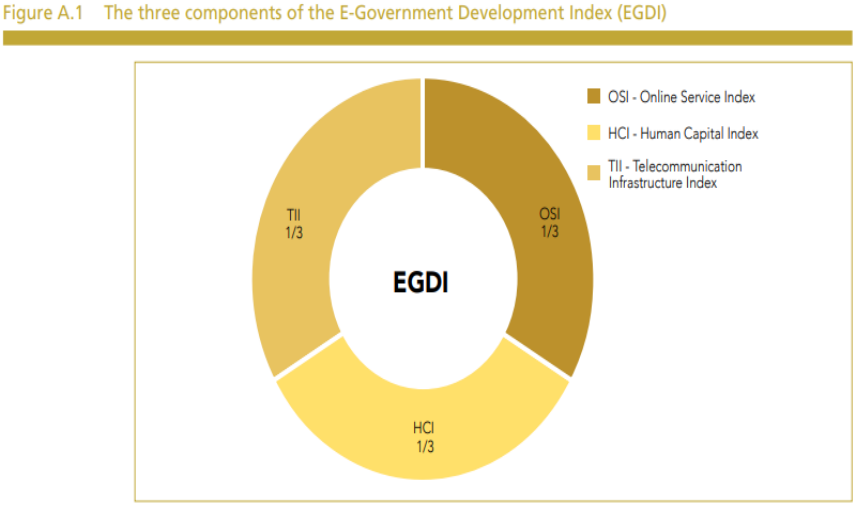
Another index that measures the performance, evaluation and ranking of the 27 EU member states is the United Nations E-Government Development Index (EGDI). In this study we examine the EGDI for the 2022 and the situation is similar. The E-Government Development Index contains characteristics such as infrastructure and education level and reflects how a country uses ICTS to promote access and inclusion of its citizens. The EGDI is a composite index of three important dimensions of e-government: online service delivery, telecommunication connectivity, and human resources.

Graph5. *Digital Public Services Index 2017-2022.*



Source: European Commission

Graph6. *The E-Government Development Index (EGDI) components.*

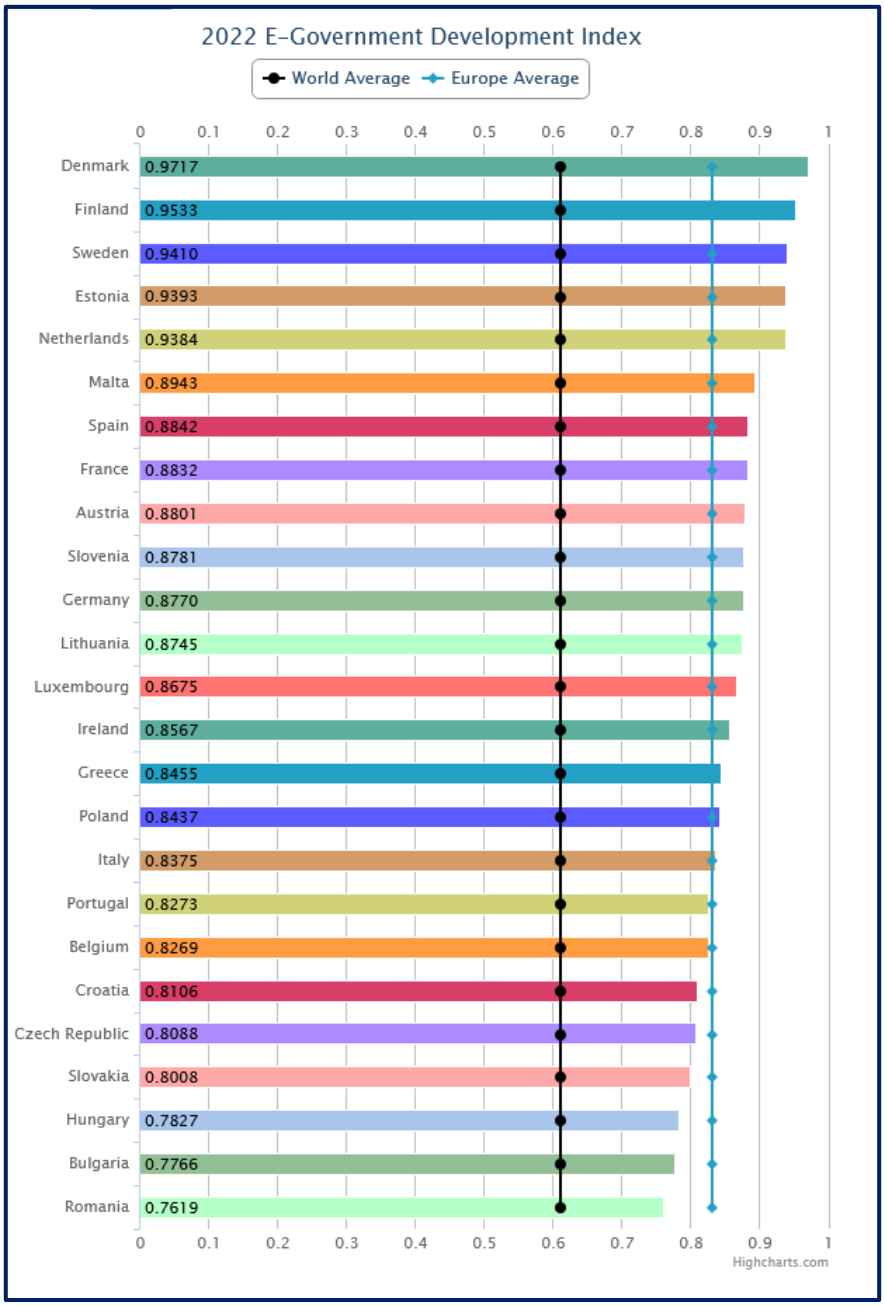


Source: (public administration.UN.org, 2023)

EGDI is not designed to capture the current state of e-government in the absolute sense. Instead, it aims to give a graded ranking of national governments in relation to each other (public administration.UN.org, 2023).

The following graph shows the overall performance of the Member States based on the 2022 EGDI.

Graph7. *E-Government Development Index (EGDI) 2022*



Source: (public administration.UN.org, 2023)

It is immediately noticeable that the image presented by the countries according to EGDI 2022 is quite like the canonization of DESI 2022. Therefore, according to the findings of this indicator we can conclude that the countries show the same degree of readiness in terms of consolidation and implementation on the DT in the three different indexes that we examined in this study.

5. Conclusion

The rapid development and evolution of information and communication technologies promoted the development process of a digital era. The corona pandemic accelerated this process to face a new reality and to satisfy the needs of citizens who faced social exclusion. The business world also followed this process, utilizing these technologies to make their businesses more competitive. The result of this approach was an effort to accelerate the Digital Transformation of the government and the local authorities that contribute to the improvement of the quality and efficiency of the services provided to the citizens.

In this study we analyzed the concept of digital transformation, and the degree of acceleration of digital transformation in all countries of the European Union, by examining and analyzing an indicator created by the European Commission to monitor the digital progress of its member states, the Digital Economy and Society Index (DESI). We carried out a longitudinal analysis of the last five years in order to find out if the corona pandemic affected and accelerated the process of digital transformation. In addition, we also compared the long-term evolution of the digital transformation of EU member states using different indicators beyond the DESI, such as the Digital Public Service Index and the EGDI 2022.

The first conclusion that emerges from the study of the DESI index (2017-2022) is that all countries showed an increase in the indicators depicting their levels of digital transformation. There is a higher increase from 2019 to 2022 compared to the previous period (2017-2019), which we can attribute to the acceleration given by the COVID-19 pandemic.

The first place in the digital transformation is occupied by the northern countries of Scandinavia, followed by the Anglo-Saxon countries, then central Europe countries and in the last place by the countries of Eastern Europe.

Overall, Finland, Denmark, Sweden and the Netherlands have the most advanced digital economies in the EU, followed by Luxembourg, Ireland, Malta and Estonia. Greece, Romania and Bulgaria have the lowest DESI values.

Greece ranks 25th among the 27 EU member states in the 2022 edition of the Digital Economy and Society Index (DESI). Greece continues to improve its performance in almost all parameters of the DESI index, although in most cases its score still below the EU average. Overall, the country has made little progress in terms of digital skills. However, Greece continues to improve its performance in almost all parameters of the DESI index, although in most cases its score is still below the EU average.

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