Analysis of e-government and digital society indicators over the years: A comparative study of the EU Member States

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Purpose – Benchmarking e-government and digital society developments using relevant indicators provides crucial insights into what aspects to consider while building a resilient digital society in which digital public services are delivered effectively and sustainably. The purpose of this paper is to analyse selected indices and indicators over the years and provide findings and recommendations on what indicators contribute most to the development.

Design/methodology/approach – A mixed research approach was used to conduct the research and collect, analyse, and interpret data. A qualitative analysis involving the search, decomposition, and comparison approaches to identify e-government and digital society reports, indices, rankings, and indicators was followed by a quantitative analysis comprising of regression and cluster analyses.

Findings – The findings revealed that changes in the mix of indicators used by e-government and digital society indices can be attributed to advances in ICT and channels through which people communicate and receive information. We found that digital and telecommunication infrastructures and the quality of their parameters such as broadband have the biggest influence on progress of the e-government and digital societies developments and contribute most to clustering of the EU Member States into groups.

Originality/value – The paper provides insights into how the structures of related indices changed over the years and how different indicators contribute to benchmarking of e-government and digital society developments by means of their weights. It provides governments with recommendations on which indicators to focus most.

Keywords Digital society, E-government, Indicators, Comparative study, Cluster analysis, European Union

Paper type Research paper

1 Introduction

Information and Communications Technologies (ICT) enabled delivery of digital public services to more people in an efficient and flexible way and removed the barrier that has been posed by distances in communication and interaction. This shift in communication has opened other channels which are fast, smart, convenient, and traceable for everyone to engage with (Bertot et al., 2016; Lnenicka and Saxena, 2021; Pedrosa et al., 2020; Sheoran and Vij, 2022). Digitalisation and technological advances have made the world accessible to everyone and helped people interact across all domains of life, in a fast and convenient way (Elmassah and Hassanein, 2022; Perriam and Carter, 2021). E-government cannot be disputed as one of the most advanced approaches to provision of digital public services to citizens and businesses as well as making the processes in public sector agencies and institutions more efficient and effective that have been improvised in the 21st century. Since the first global assessment of e-government efforts (United Nations, 2002), the success of e-government initiatives has allowed

for significant progress in delivery of digital public services to citizens and businesses (United Nations, 2022).

E-government and digital society indicators have been observed as diverse and within their diversity they have opened the window to an understanding and appreciation of digitalisation at various levels (Sheoran and Vij, 2022). According to Cenfetelli (2004), benchmarking progress in e-government and the digital society is one of the more complex aspects of digitalisation and ranking of ICT use. Over the years, various benchmarks and indices were introduced to compare groups of countries such as the E-government Development Index (EGDI), the ICT Development Index (IDI), the Network Readiness Index (NRI), the Waseda University World Digital Government Ranking, or the eGovernment Benchmark by the European Union (EU) (Heeks, 2008; Skargren, 2020). However, according to Beynon-Davies (2007), digitalisation does not occur over night. As such, evidence from Elmassah and Hassanein (2022) and Russo (2020) illustrated that indicators such as the Digital Economy and Society Index (DESI) by the EU was put in place to ensure that, digitalisation and the rate at which it is being accepted and received across Member States is noted and assessed for.

Therefore, because each of the above-mentioned indices consists of different indicators that focus on different aspects of digitalisation and ICT use by stakeholders, we need to know by which indicators are the indices composed before a complex analysis of countries can be performed. More precisely, the progress of the structure of these indices and weights of indicators over the years provides crucial insights into what aspects to consider while building a resilient digital society in which digital public services are delivered effectively and sustainably. Because the impacts of these changes are affected by the economic conditions and environment of the country, we need to select a representative sample that will enable us to draw relevant conclusions. In this regard, we developed the following research questions (RQs):

RQ1: How the structure of the e-government and digital society indices and weights of respective indicators changed over the years?

RQ2: What is the progress of selected sub-indices and dimensions of the EGDI and DESI in the EU Member States over the years?

RQ3: What are the similarities and clusters of the EU Member States for the EGDI and DESI over the years?

The structure of the paper is as follows. After this introduction, Section 2 gives the research background and significance, Section 3 includes the research methodology, Sections 4 and 5 present the overview of e-government and digital society reports, indices, and rankings, and identification and comparison of relevant indicators, Section 6 includes the analysis of indicators in the EU Member States, Section 7 provides contributions and discussion to the performed research, and the last section concludes the paper.

2 Theoretical background

This section provides an overview of the most relevant concepts that form the theoretical background of this paper: socio-technical theory, which provides us with a proper approach for our analysis and concepts related to the usage of ICTs by public administrations.

2.1 Socio-technical theory

The socio-technical system theory assumes that the utilisation of social and technical aspects of the engagements governs the design and performance of any organisation. In the context of our paper, this means that relationships between individuals, society, and the Internet should be considered together and treated as independent parts of a complex system. The theory utilises some aspects of Kramer's framework, influenced by the belief that true knowledge can only be achieved by falsification (Lu et al., 2011). According to Sony and Naik (2020), indices like IDI, EGDI, NRI, Waseda index, E-government Benchmark, and DESI are all part of a complex evaluation system that enables us to understand and acknowledge the role of people participation as indicated by these indicators. However, these indicators operate independently, and each resembles a significant dimension that is not closely related to the other but demonstrates similar evidence on digitalisation of society (Sony and Naik, 2020).

As the interactions between coherent systems of human relations, cybernetic processes, and technical objects are part of a larger and more complex structure (Lu et al., 2011), it is crucial to understand how these interactions sharpen the appreciation and adoption of digital technologies and how they are used within complex systems as proposed by Sony and Naik (2020). Fuenfschilling and Binz, (2018) reported that optimizing each aspect of the socio-technical systems theory increases the quality of unpredictable relationships and disbars those relationships that may be dangerous to the system. The theory brings forth the viewpoint that it is directed toward joint optimisation and the designing of social and technical systems that further accountability and transparency in the relationships and communications between citizens (C2C), citizens and public administration (C2G, G2C), within the administration (G2G), and further on (Cherp et al., 2018).

The theory further proposes different means of achieving joint optimisation. It states that organisational design centred on relationships between the socio and technical aspects forward productivity, well-being, and technological advancements. Therefore, this interaction may shape the general outcomes aligned with the introduction of new technologies, the level of acceptance, and the ability of the technology to meet the expectations of the designers and the users within which the technology is directed for use towards (Fuenfschilling and Binz, 2018; Venkatesh et al., 2003). Thus, according to e-government and the development of digitalised societies, when human elements and technical systems are combined, they create new opportunities and even pave the way for the technological developments and change orientation needed within this interaction (Cherp et al., 2018).

2.2 ICT in public administration

The 21st century has been described as a millennium of transformation and technovation on the digital front. Evidence states that most activities being done at individual, organisational, and societal levels are now heavily dependent on information technologies (Dwivedi et al., 2011; Falk et al., 2017; Sekgweleo et al., 2017). This transformation has brought forth digital democracy, thus expediting interaction between the government and the people it serves through modes observed as trustworthy, transparent, and responsive to citizens' and businesses' needs and demands (Chen et al., 2007; Sekgweleo et al., 2017). Recent years, mostly due to the global pandemic, popularised the work-at-

home concept (Dwivedi et al., 2011) and fast-tracked the adoption of digital channels within central and local governments, speeding up the development of e-government. Legislation governing the use and adoption of the Internet is still improving and being adjusted to suit this process (Venkatesh et al., 2003).

The role of ICT in public administration can be categorised into three aspects: internal administration, service delivery, and planning and decision-making. According to Sony and Naik (2020), in internal administration, ICT promotes centralised storage of files and data, which comes with reducing unnecessary effort and lessening security threats. Furthermore, cloud storage of important files implies that these can be accessed by authorized personnel from across the globe (Laxmikant, 2011). In the case of service delivery, ICT allows the provision of services through web portals, mobile applications, and other outlets without physically visiting the service providers. The information and services can be accessed from any place at any time (Laxmikant, 2011). Finally, Fadia and Fadia (2018) believe that ICT also plays a critical role in planning and decision-making. That is, the role of ICT is to gather as much information as possible and provide means for easy storage, management, and analysis of data. As such, ICT has also facilitated connectivity between and within government services (Laxmikant, 2011), allowing public institutions to share files in the digital space without major delays (Fadia and Fadia, 2018).

As the development of digital public services progressed, e-government as a concept has been widened to include open government, transparency, and participation dimensions (Lnenicka and Machova, 2016; Lnenicka and Saxena, 2021). As reported by European Commission (2022a), the open data approach that is not integrating the clients is failing, and as such, these solutions may not provide the expected benefits to society. At the same time, innovation and enhanced participation of citizens in government activities remain important aspects of e-government (European Commission, 2022b). European Commission (2022a) further elaborated that open data usage could refer to the activities people engage in to provide data to understand or change events within a particular system. Sheoran and Vij (2022) provided insights into different variables and dimensions that are used to evaluate a country's e-government at different phases.

The concept of participation has been strongly aligned with Sustainable Development Goals (SDGs) as proposed by the UN. This approach speaks towards ensuring that all individuals from all parts of the community (local governments) or the society (central governments) are involved (Falk et al., 2017; Harrison, and Sayogo, 2014). Furthermore, the level of engagement may also ensure that people everywhere have relevant information and awareness for sustainable development through the encouragement and promotion of effective public and private society partnerships. Thus, engaging citizens at all stages of policy and service delivery through close involvement in areas such as implementation and evaluation ensure that policies and services aimed at achieving all the SDGs are effective and meet the actual needs that are perceived as legitimate. In the case of benchmarking e-government, the concept of participation is present as e-participation - fostering civic engagement and open, participatory governance through ICT) (United Nations, 2022).

3 Research methodology

This research paper applied methodological steps introduced in Machova and Lnenicka (2016) with the difference that our paper considered a digital society dimension that enabled us to analyse the effects of related indicators in the context of e-government development. In addition, we performed a regression analysis to determine the contributions of respective indicators and dimensions over the years. First, we reviewed publications dealing with e-government and digital society development to identify the most important benchmarking and evaluation reports, indices, rankings, and indicators. We provided an overview of the latest editions of e-government and digital society indices. Then, we decomposed two indices, namely the EGDI and DESI, and analysed their structure and changes in the composition and weights of indicators over the years.

These two indices and respective indicators were applied to analyse and compare e-government and digital society developments in the EU Member States. The different indicators are essential as they give insights on the nature and form of digital integration that is assigned to the countries under study. The level of digitization is also draw through a cross examination of these factors. As such these factors lay the foundation from which composite indicators can be drawn and develop. They also lay the foundation for methodological computations as they open opportunities for cluster analysis to identify similarities between groups of countries (Nardo et al., 2008; Rencher and Christensen, 2012).

The data for the EGDI were gathered from the e-Government Knowledgebase available at https://publicadministration.un.org/egovkb/data-center. The data period covers 2003-2022. The data for the DESI were collected directly from the official website of the European Commission which can be accessed at https://digital-agenda-data.eu/datasets/desi/ and the respective reports then at https://digital-strategy.ec.europa.eu/en/library. The data period consisted of 2017-2022 years. The data were analysed using the Microsoft Excel and STATISTICA 12.0 analytics tool.

To answer the RQs, statistical analysis that is drawn towards understanding the level of progress and trends over the years for the composite indices against the sample countries is used. Thus, simple linear regression analysis is carried out. This assessment will allow for the identification of trends for the sample of the EU Member States as well as the progress of individual countries by observing the development. Furthermore, zooming in to pinpoint the sub-indices and dimensions where Member States performance could be improved based on the exploitation of similarities and differences between the countries, we apply the cluster analysis. Cluster analysis techniques can be hierarchical if the clusters are nested together. Thus, a cluster tree to the effect of adoption of the composite indicators, i.e., sub-indices and dimensions, paves way towards more intimate understanding of how digitalisation and e-government has been embraced within the sample countries over the years. Therefore, cluster analysis provides evidence through squared Euclidean distances and countries with similarities are noticed by the decrease in these distances. We used joining (tree clustering) and K-means clustering. Although cluster analysis will be computed, evidence also suggests that these clusters may prove useful or otherwise in classification of objects and this may depend upon the objectives of the analysis (Rencher and Christensen, 2012).

4 Development and benchmarking efforts over the years

This section summarizes the most important benchmarking and evaluation reports, indices, rankings, and indicators.

4.1 Overview of reports

The following Table 1 provides an overview of indices and rankings that appeared since 2000 and benchmarked countries in ICT use, e-government development, digital society, and other indicators. Five of them are still active, and reports are available. Based on the analysis of reports presented in Table 1, we can argue that each active index's methodology, i.e., the latest report was published in 2022, changed over the years. These changes can be attributed to advances in ICT and channels through which people communicate and receive information.

Table 1. Overview of e-government and digital society indices and rankings. Source: own processing.

Index	Publisher	First report	Last report	No. of reports
DESI	EU	2014	2022	8
EGDI	UN	2001	2022	12
eGov. Benchmark	EU	2001	2022	20
EIU index	The Economist	2000	2010	11
IDI	ITU	2009	2018	10
NRI	WEF, Portulans Institute	2002	2022	21
TBR index	Brown University	2001	2007	7
Waseda index	Waseda University	2005	2022	17

4.2 Indices and rankings

The **DESI** was first introduced in 2014, and this indicator has been monitored by the European Commission, with evaluations central to its Member State. The results and corresponding analyses, such as country profiles, have been published annually since 2014. Each indicator is aligned with strategies in the Commission proposal for a decision path to the digital goals, such as Digital Decade Targets. Several improvements have been made to the DESI over the years better to reflect the required digital competencies of citizens and businesses. Improvements have also been made by introducing the female ICT specialist indicators, where connectivity and the fibre to the coverage indicator have been added. This allows for a more comprehensive analysis of gigabyte connectivity (European Commission, 2022a).

The **EGDI** presents the state of e-government development of the UN's Member States. Since its second edition in 2003, it consists of three sub-indices. It is a composite measure of three important dimensions of e-government: provision of online services, telecommunication connectivity, and human capacity (United Nations, 2022). The EGDI is a composite index based on the weighted average of three normalized indices. The composite is divided into three, where one-third is derived from Telecommunications Infrastructure Index (TII), based on the data provided by the International Telecommunications Union (ITU). Another indicator is derived from the Human Capital Index (HCI), which is based on data acquired from United Nations Educational, Scientific and Cultural

Organisation (UNESCO), and the last third is derived from the On-line Service Index (OSI). These are independent online services. These datasets are collected from across 193 United Nations member states by completing a Member State Questionnaire.

eGovernment Benchmark by the EU has been published since 2001 with 20 reports that are based on comparisons of how governments across Europe deliver digital public services. Thus, the benchmarking evaluates provisions and delivery of the services in 35 countries, with 27 being EU Member States. The e-government benchmark uses life events to capture the landscape of public services. The eGovernment method paper was originally released in July 2012 and has been updated to remain relevant and internationally recognised. There has been a series of these benchmarks, starting from 2011, the 2015 edition, and the 2020 to 2023 edition. The eGovernment method connects its indicators with events. Thus, it uses two types of data collection to set its grounding. Thus, Mystery Shopping is the most prominent one and supported by the automated tools for selecting indicators. Thus, Mystery Methods further details itself through user centricity, transparency, cross-border mobility, and key enablers (European Commission, 2022b).

The **NRI** has been published since 2002, until the 2016 edition by World Economic Forum (WEF), Cornell University, and INSEAD, and since 2019 by Portulans Institute. Following its relocation to the Portulans Institute, the NRI has accorded significant emphasis to matters of direct relevance to the youth demographic. These areas include but are not limited to sustainability, inclusivity, governance, and trust. The list of indicators of this index was consistently updated through the years. The last update of the methodology was done in 2019. The NRI 2022 ranks 131 economies across the various components of digital readiness. The NRI is a multidimensional concept built from a composite index with four pillars: technology, people, governance, and impact. Each of these pillars also consists of dimensions which then consist of indicators (Dutta and Lanvin, 2022).

Digital Government Rankings by Waseda University have been on the record since 2005. It shows important trends in using new digital technologies in government activities. The digital governance analysis under this indicator is based on ranking a group of indicators to evaluate the overall digital government development. This range will include information on policy development and e-services implementation to manage optimisation and digital government promotion. Thus, in 2010 there was the introduction of the e-participation indicator, and later in 2014, open government and cyber-security were added to the ranking. In 2017, the usage of emerging ICT technologies to make it a total of 10 main indicators for evaluation was made. Lastly, digital transformation and innovation indicators were introduced in 2022 (the 17th edition of this index). Thus, the Waseda index is a composite index that is built from 10 indicators in 2022.

4.3 Indicators

Therefore, we can conclude that there are different indices and rankings, usually accompanied by analyses in the form of reports, that consist of sub-indices, dimensions, pillars, etc., which then consist of indicators. An indicator is a specific and measurable characteristic, and it is the lowest level that is considered by the index. In the context of e-government and digital society, cross-comparisons are made against a country's digitalisation and digital performance. Thus, according to Saltelli (2007), indicators are useful as they can be used to identify common trends across performance in digital

areas of a country. Thus, the quality and soundness of an indicator does not only depend on the methodology used but extends to the quality of the framework and the data used in its construction. Thus, an indicator based on a weak theoretical background or soft data containing large measurement errors can lead to disputable policy messages. As such, according to Nardo et al. (2008), it is important to have transparency and the guiding principle for the entire exercise to make and take shape.

Table 2 shows an overview of indices that could be used to compare selected countries. They are composed of several levels and respective indicators that can also be used as a measure to compare and analyse countries. All the latest editions in the table were published in 2022. It can also be seen from the table that each index covers a different number of countries.

Table 2. Overview of the latest editions of e-government and digital society indices. Source: own processing.

Index	Countries covered by the last report	No. of sub-indices / dimensions	No. of indicators in the last report
DESI	27	4 (10 sub-dimensions)	32
EGDI	193	3	13
eGov. Benchmark	35	4 (14)	48
NRI	131	4 (12 sub-pillars)	58
Waseda index	64	10	36

5 Identification and comparison of relevant indicators

This section deals with the identification and comparison of the indicators, as well as sub-indices, dimensions, pillars, etc., relevant to the e-government development and digital society context. We aim to provide an overview of existing indicators and how publishers of respective indices and reports include modern technologies in their frameworks. We decomposed the most representative indices and discussed changes in the sets of indicators used by these indices over the years.

5.1 Current lists of indicators and their comparison

We decomposed the latest editions of indices and reports discussed in the previous chapter to get a clear picture of indicators currently used to evaluate the state and development of e-government and digital society efforts in different countries. Because of the high number of indicators for the DESI, eGovernment Benchmark, and NRI, we listed only sub-levels for these indices in Table 3. We can conclude that there are some similarities in indicators across all indices. Each index includes indicators that measure human capital and how users, or concrete stakeholders such as citizens, businesses, and governments, consume and interact with online services. It is important to know users' competencies and capabilities to develop concrete online services that suit them most. Countries with low levels of these indicators cannot provide advanced online services because users could have problems using them.

This is closely related to ICT and digital infrastructure levels and the integration of digital technology among stakeholders in respective countries. This dimension is covered by indicators such as connectivity and broadband users, mobile subscriptions, etc. Some indices include only these general indicators, while the others, such as the NRI and Waseda index, also focus on future technologies,

such as cybersecurity, cloud, Internet of Things (IoT), and big data utilization. The last dimension common to all indices is dealing with the digital public services provided online. There are quite a few differences between indices in their lists of services because some of them focus only on services provided by websites, i.e., if the respective information can be found online and if a user can complete all the steps online or using a web or mobile application for this purpose. The other indicators also evaluate if these transactions are secure, usable, etc. Finally, the dimensions that are not covered by all indices and are affected by the purpose of the index are related to impacts, transparency, openness, sustainability, SDGs etc. Based on the lists of indicators included in each index, the number of countries covered, changes in the methodology, comparability of data over the years, and the availability of the input data, we decided that we will focus more closely on the EGDI and DESI and their indicators in the next sections.

Table 3. Decomposition of e-government and digital society indices and rankings from 2022. Source: own processing.

Index	**Indicators**	
	1st level	**2nd level**
DESI	Connectivity	Mobile broadband, broadband price index, fixed broadband take-up, fixed broadband coverage
	Human Capital	Internet user skills, advanced skills, and development
	Integration of Digital Technology	Digital technologies for businesses, e-commerce, digital intensity
	Digital Public Services	eGovernment
EGDI	On-line service index	Institutional framework, service provision, content provision, technology, e-participation
	Telecommunication infrastructure index	Internet users (% of the population), mobile-cellular subscriptions per 100 inhabitants, fixed broadband subscriptions per 100 inhabitants, active mobile-broadband subscriptions per 100 inhabitants
	Human capital index	Adult literacy rate, the combined gross enrolment ratio, expected years of schooling, mean years of schooling
eGov. Benchmark	User centricity	On-line availability, user support, mobile friendliness
	Transparency	Transparency of service delivery, transparency of service design, transparency of personal data
	Key enablers	eID, eDocuments, authentic sources, digital post, security
	Cross-border services	Cross-border online availability, cross-border user support, cross-border eID, cross-border eDocuments
NRI	Technology	Access, content, future technologies
	People	Individuals, businesses, governments
	Governance	Trust, regulation, inclusion
	Impact	Economy, quality of life, SDG contribution
Wased a	Network infrastructure preparedness	Internet subscribers, broadband users, digital mobile phone subscribers

Index	Indicators	
	1st level	**2nd level**
	Management optimization	Optimization progress, integrated enterprise architecture model, administrative budget system
	Online services	Electronic bidding system, electronic tax payment, electronic payment/customs clearance system, eHealth system, one-stop service
	National portal	Navigation function, two-way dialogue, interface, technical convenience
	Government Chief Information Officer (CIO)	Introduction of CIO, CIO authority, CIO organization, CIO human resources development plan
	Digital government promotion	Legal response, effective promotion business, support mechanism, evaluation mechanism
	E-participation	Information sharing mechanism, exchange/discussion, participation in decision making
	Open government data and digital transformation	Legal response, society, organization, activity
	Cybersecurity	Legal response, cybercrime measures, internet security organization
	The emerging technology in digital government	Cloud utilization, IoT utilization, big data utilization

5.2 E-government development index

The UN Public Administration Programme, led by the Department of Economic and Social Affairs, Division for Public Institutions and Digital Government, has published reports on e-government development assessments and benchmarking since 2002. The first report covered the year 2001. The latest report is from 2022. We analysed all the reports published, i.e., 12 reports, and listed all the used indicators over the years. Table 4 shows sub-indices and indicators' structure, coverage, and weights over the years. It should be noted that the OSI consists of a list of questions that changed over the years and their allocation to different sub-indices and indicators.

We can conclude that the structure of three sub-indices and their weights, i.e., OSI, TII, and HCI, did not change since 2002. However, the indicators from which these sub-indices are comprised evolved through the years. For the OSI, which was partially based on the e-government development stages between 2002 and 2020, the presence represents different levels of governments' ability to provide digital public services fully online. The emerging presence is characterised by the availability of information on websites only, including forms that can be downloaded. The central a-government portal usually represents the connected presence through which all digital public services are fully online. In 2022, the structure of the OSI was completely reworked, including the weights of indicators.

How have the significance and benefits of various technologies and infrastructures for citizens, businesses, and governments changed over the years do indicators of the TII represent the best. From the online population, PCs and TVs per 1000 persons, and fixed telephone lines, the most important indicators are now fixed and active mobile broadband subscriptions. It should also be noted that

Internet users and mobile telephones have been measured from 2002 till now. Finally, the HCI did not change much over the years; only indicators measuring expected years of schooling and mean years of schooling were added in 2014.

Table 4. Indicators of the EGDI over the years. Source: own processing.

Structure of sub-indices and indicators	**Coverage**	**Weight**
1. Web Measure/On-line Service Index (OSI)	2002–2022	33%
Emerging presence	2002–2020	20% (2002–2008), 25% (2010–2020)
Enhanced presence	2002–2020	20% (2002–2008), 25% (2010–2020)
Interactive presence	2002–2008	20%
Transactional presence	2002–2020	20% (2002–2008), 25% (2010–2020)
Networked presence	2002–2010	20% (2002–2008), 25% (2010)
Connected presence	2012–2020	25% (2012–2020)
Institutional framework	2022	10%
Service provision	2022	45%
Content provision	2022	5%
Technology	2022	5%
E-participation	2022	35%
2. Technological/Telecommunication Infrastructure Index (TII)	2002–2022	33%
PCs per 1000 persons/100 inhabitants	2002–2010	20%
Internet users per 1000 persons/100 inhabitants Internet users (% of population)	2002–2022	20% (2003–2018), 25% (2020–2022)
Fixed telephone lines (subscriptions) per 1000 persons/100 inhabitants	2002–2018	20%
Mobile telephones (cellular subscriptions) per 1,000 persons/100 inhabitants	2002–2022	10% (2002–2005), 20% (2008–2018), 25% (2020–2022)
On-line population per 1000 persons	2002–2005	20%
TVs per 1000 persons	2002–2005	10%
Fixed broadband subscriptions per 100 inhabitants	2008–2022	20% (2008–2018), 25% (2020–2022)
Fixed Internet subscriptions per 100 inhabitants	2012	20%
Wireless broadband subscriptions per 100 inhabitants	2014–2016	20%
Active mobile-broadband subscriptions per 100 inhabitants	2018–2022	20% (2018), 25% (2020–2022)
3. Human Capital Index (HCI)	2002–2022	33%
Adult literacy rate	2002–2022	66% (2002–2012), 33% (2014–2022)

Structure of sub-indices and indicators	Coverage	Weight
The combined gross enrolment ratio	2002–2022	33% (2002–2012), 22% (2/9) (2014–2022)
Expected years of schooling	2014–2022	22% (2/9)
Mean years of schooling	2014–2022	22% (2/9)

5.3 Digital economy and society index

The DESI 2022 provides four assessment dimensions that can be utilized in establishing how digital technologies have been adopted for use in the economy and society. To improve the methodology and consider the latest technological developments, several changes were made in 2019. Some bigger changes were also made in 2018 and 2020. Since 2021, the indicators are now structured around the four main areas in the Digital Compass, replacing the previous five-dimension structure. Table 5 below gives a general overview of the structure of this index over the years. The weights are available only for the first and second levels of the DESI structure.

Research by Stavytskyy et al. (2019) proves that there is a positive impact of the country's development level on the structural parts of DESI, i.e., the higher the level of economic development the greater the growth in digitization. Finally, they prove that the level of the country's digital development is determined primarily by its previous development, which makes it impossible to reach much growth in this context in a short period.

The DESI structure has gradually improved with aspects such as measuring 5G readiness, coverage, and spectrum added that did not exist in the previous ratings. The introduction of sub aspects of mearing fast broadband, fast broadband take-up, ultrafast broadband coverage, ultrafast take-up, broadband price index amongst other aspects in the connectivity dimension, has also advanced this. Furthermore, in terms of human capital, improvements were made by introducing aspects such as basic digital skills, basic software skills, basic digital content creation skills, female ICT specialists, and enterprises providing ICT training. These additional measurements were meant to initiate a close look into the aspects of the DESI that fostered development in that domain. In terms of internet use, additional dimensions such as online consultations and voting, purchase online products were added.

On the other hand, the DESI improvements for integration of digital technology involved changes in areas such as AI, ICT for environmental sustainability, digital intensity, and online presence. Lastly, the DESI structural changes also cascaded into digital public services where notifiable changes were in transactional services, connected services, digital public services for citizens, medical data exchange, and e-prescription. We can conclude that the structure of the DESI changed significantly over the years in terms of indicators' relevance to e-government and digital society trends valid in the given years.

Table 5. Indicators of the DESI over the years. Source: own processing.

Main dimensions and sub-dimensions	Coverage	Weight
1. Connectivity	2014-2022	25% (2014–2022)
Fixed Broadband	2014-2019	33% (2014–2017), 20% (2018)
Mobile Broadband	2014-2022	22% (2014–2017), 30% (2018–2019), 35% (2020), 40% (2021–2022)
Speed	2014-2017	33% (2014–2017)
Affordability	2014-2017	11% (2014–2017)
Fast Broadband	2018-2019	20% (2018–2019)
Ultrafast Broadband	2018-2019	20% (2018–2019)
Broadband Price Index / Prices	2018-2022	10% (2018–2019, 2021–2022), 15% (2020)
Fixed Broadband Take-up	2020-2022	25% (2020–2022)
Fixed Broadband Coverage	2020-2022	25% (2020–2022)
2. Human Capital / Digital Skills	2014-2022	25% (2014–2022)
Basic Skills and Usage / Internet User Skills	2014-2022	50% (2014–2022)
Advanced Skills and Development	2014-2022	50% (2014–2022)
3. Use of Internet (Services)	2014-2020	15% (2014–2020)
Content / Activities on-line	2014-2020	33% (2014–2018), 50% (2019–2020)
Communication	2014-2018	33% (2014–2018)
Transactions	2014-2020	33% (2014–2018), 25% (2019–2020)
Internet use	2019-2020	25% (2019–2020)
4. Integration of Digital Technology	2014-2022	20% (2014–2020), 25% (2021–2022)
Business digitization / Digital technologies for businesses	2014-2022	60% (2014–2020), 70% (2021–2022)
eCommerce	2014-2022	40% (2014–2020), 15% (2021–2022)
Digital intensity	2021-2022	15% (2021–2022)
5. Digital Public Services	2014-2022	15% (2014–2020), 25% (2021–2022)
eGovernment	2014-2022	100% (2014–2017, 2020–2022), 80% (2018–2019)
eHealth	2018-2019	20% (2018–2019)

6 Analysis of indicators in selected countries

6.1 Statistical analysis

As described in the previous sections, there are a lot of indicators that can be used to analyse the development of e-government and digital society. However, as we found in our comparisons of the structures and respective indicators included in these indices, they changed several times for each index over the years. Therefore, it can be difficult to get any relevant insights because of the comparability of these indices over the years. Based on these findings, we decided to analyse only

the main components, i.e., sub-indices and dimensions, which remained the same over the years. For this purpose, for our analysis we selected the EGDI and DESI. Finally, because of the availability of the input data, we selected the EU Member States as a sample of countries.

6.1.1 E-government development index

Figure 1 shows the progress of the EGDI in the EU Member States over the years. The countries are ranked according to the average value for the entire period covered and the main purpose of this chart is to compare the performance of individual countries, i.e., how the differences between countries have developed over the years and which countries have improved the most.

We can conclude that countries such as Cyprus, Croatia or Latvia improved the most, while countries such as Belgium and Germany show continuous improvements over the years. It should be also noted that some countries, and their levels oof e-government development, were affected by various internal and external pressures, which, however, would require a more detailed analysis of individual countries. Among the external pressures by which most of the countries were affected, we can mention the global financial crisis 2008/2009 which resulted in decline in values for the 2010 edition of the index. Also, the global Covid-19 pandemic slightly affected the results from 2022, depending on how much countries prioritised and invested in delivery of digital public services fully online, especially for the health domain.

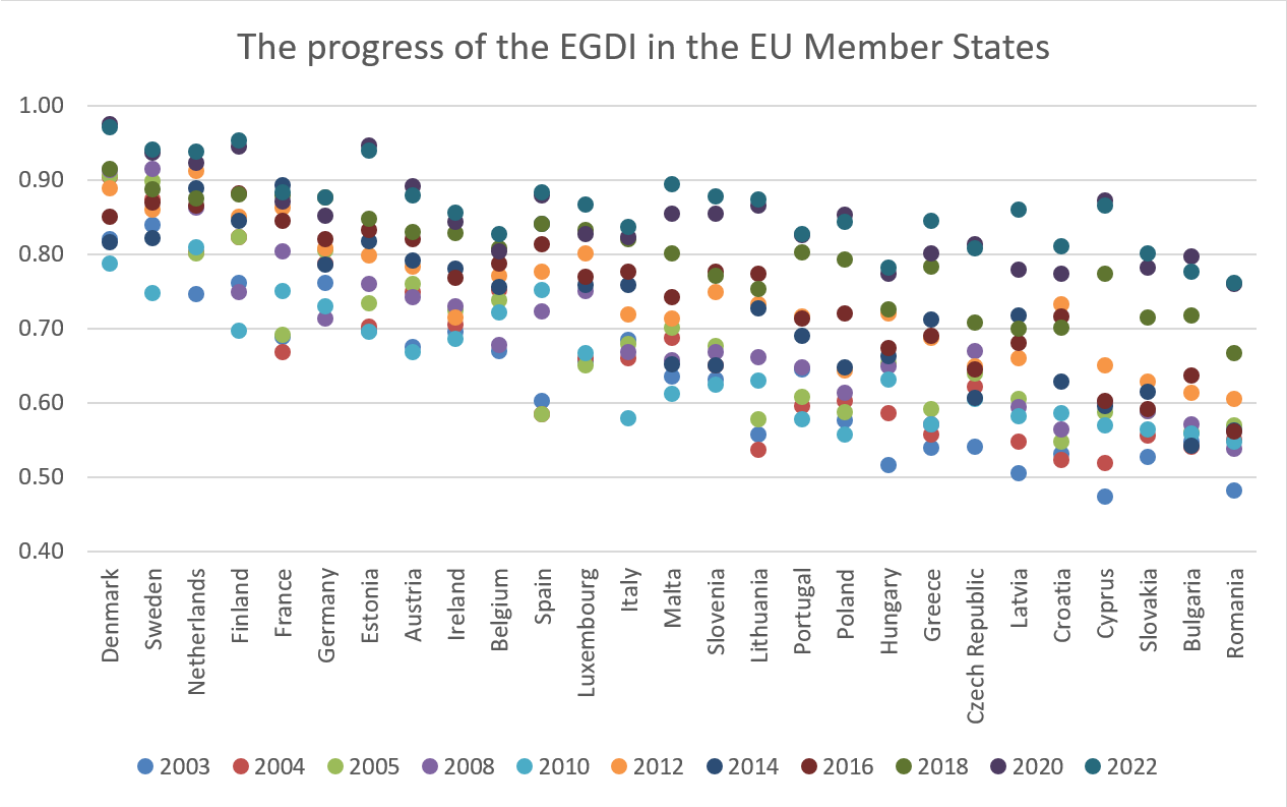

Figure 1. The progress of the EGDI in the EU Member States over the years. Source: own processing.

Figure 2 shows the trends of average values for the sub-indices of the EGDI, i.e., OSI, TII and HCI, between 2003 and 2022. All values are normalized to values between 0 (worst) and 1 (best). The findings demonstrate that in terms of HCU averages there is a slight decline over the years. Although this decline is not significant, and the average values increased in 2020 and 2022, we recommend

focusing on improving digital competencies and capabilities of citizens as well as businesses, because human capital is crucial for using digital public services. The results also show that the OSI and TII values improved significantly over the years. Especially the availability and quality of ICT infrastructures in terms of broadband and penetration of devices that can be used to deliver digital public services have seen a steady progress.

On the other hand, these improvements can be also affected in changes of the mix of indicators used for calculating the EGDI. It can be assumed that some countries already used modern ICT and e-government approaches, which were not yet part of the index. But when they were added into the index, the average value of the given sub-index increased. This situation could also occur the other way around, when some countries still used outdated technologies, which were still part of the index. In addition, the weights of individual indicators also affect the overall output.

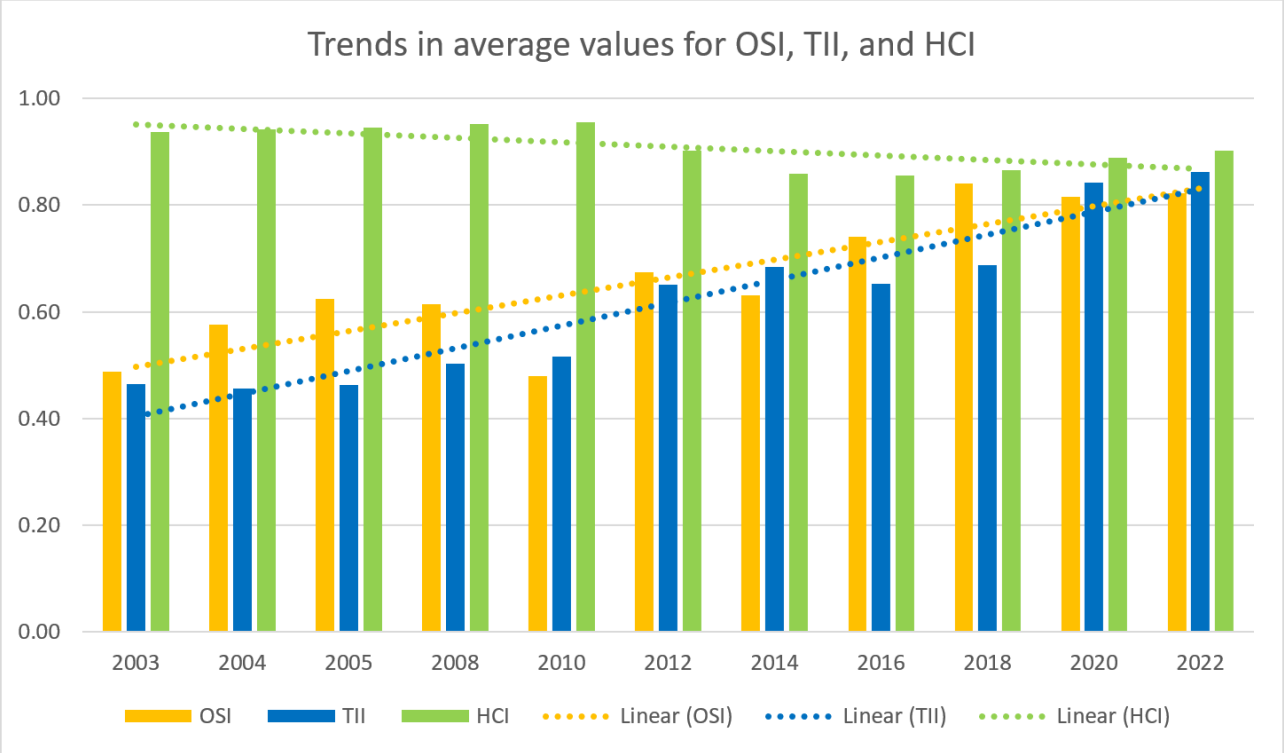

Figure 2. Trends in average values for OSI, TII, and HCI between 2003 and 2022. Source: own processing.

Figure 3 shows the trends of standard deviation and range values. The average differences between sample countries slightly increased in the case of the HCI, decreased in terms of the OSI, and significantly decreased for the TII. For the EU Member States, we can assume that this was enabled by the existence of the European single market and the free movement of goods, capital, services, and people. More precisely, the EU provides funding for increasing network coverage and broadband speeds across the Europe and supports cross-border delivery of digital public services.

All of these enable the unification of procedures and the quality and availability of services in individual countries, which results in citizens and businesses not having to limit their activities to the territory of one country. This contributes to increasing diversity and the exchange of information between different stakeholders from different EU countries. At the same time, it speeds up and makes decision-making processes more efficient and contributes to increasing competitiveness.

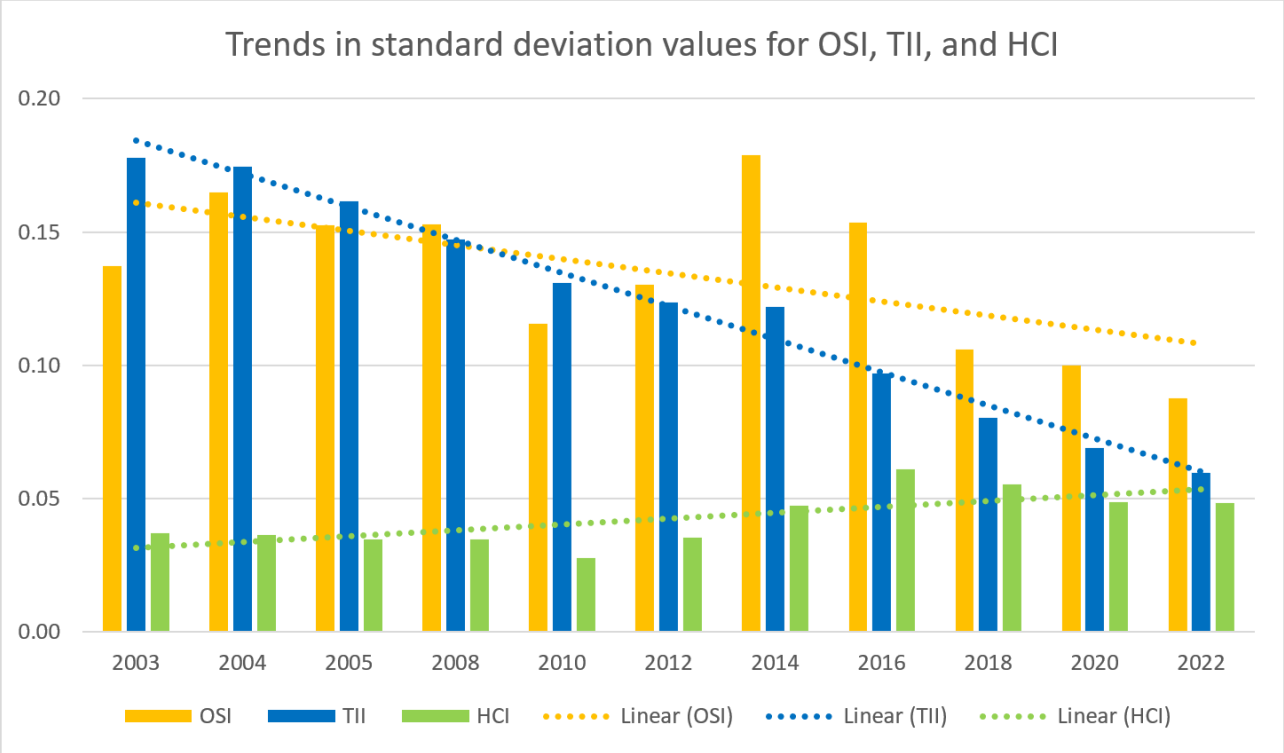

Figure 3. Trends in standard deviation values for OSI, TII, and HCI between 2003 and 2022. Source: own processing.

6.1.2 Digital economy and society index

Figure 4 shows the progress of the DESI in the EU Member States. The countries are ranked according to the average value for the entire period covered. The unit of measure of the DESI is weighted score (0 to 100). In contrast to Figure 1 and the progress of the EGDI, we can conclude that all countries continuously improve their performance in respective dimensions. However, the differences between individual countries tend to increase. The best performing countries improved their values between 2017 and 2022 more than countries such as Romania and Bulgaria. The results from the latest editions of this index, which were affected by the Covid-19 pandemic, show that some countries improved more than in previous years and we can argue that they took this opportunity for improvements.

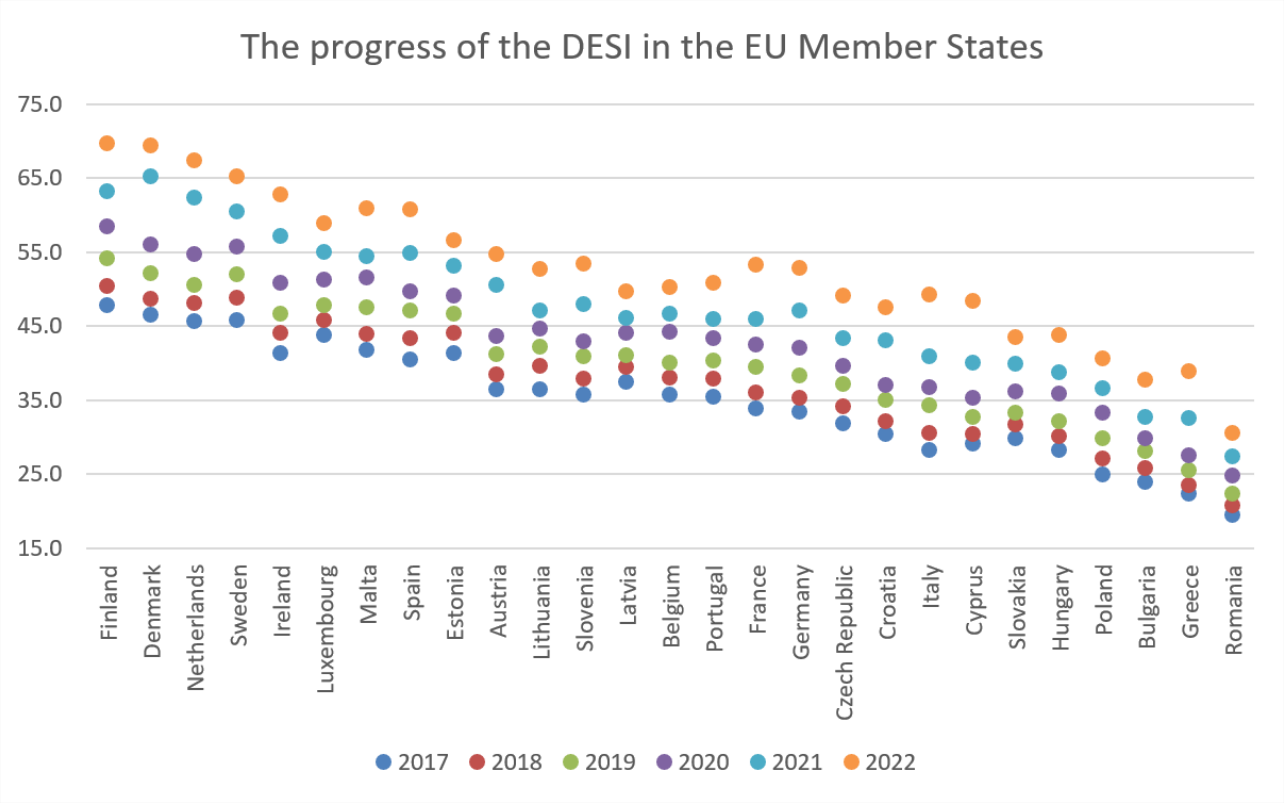

Figure 4. The progress of the DESI in the EU Member States over the years. Source: own processing.

Figure 5 shows the average values for dimensions of the DESI between 2017 and 2022. The findings illustrated that there was a steady growth in the averages from the period 2017 to 2022. Although the weights for dimensions were different through the years, see Table 5, the values in Figure 5 were recalculated so that each dimension has a weight of 25% and the results are comparable among different years. We can conclude that the dimensions that have improved most are connectivity and digital public services. Those are similar to findings for the EGDI.

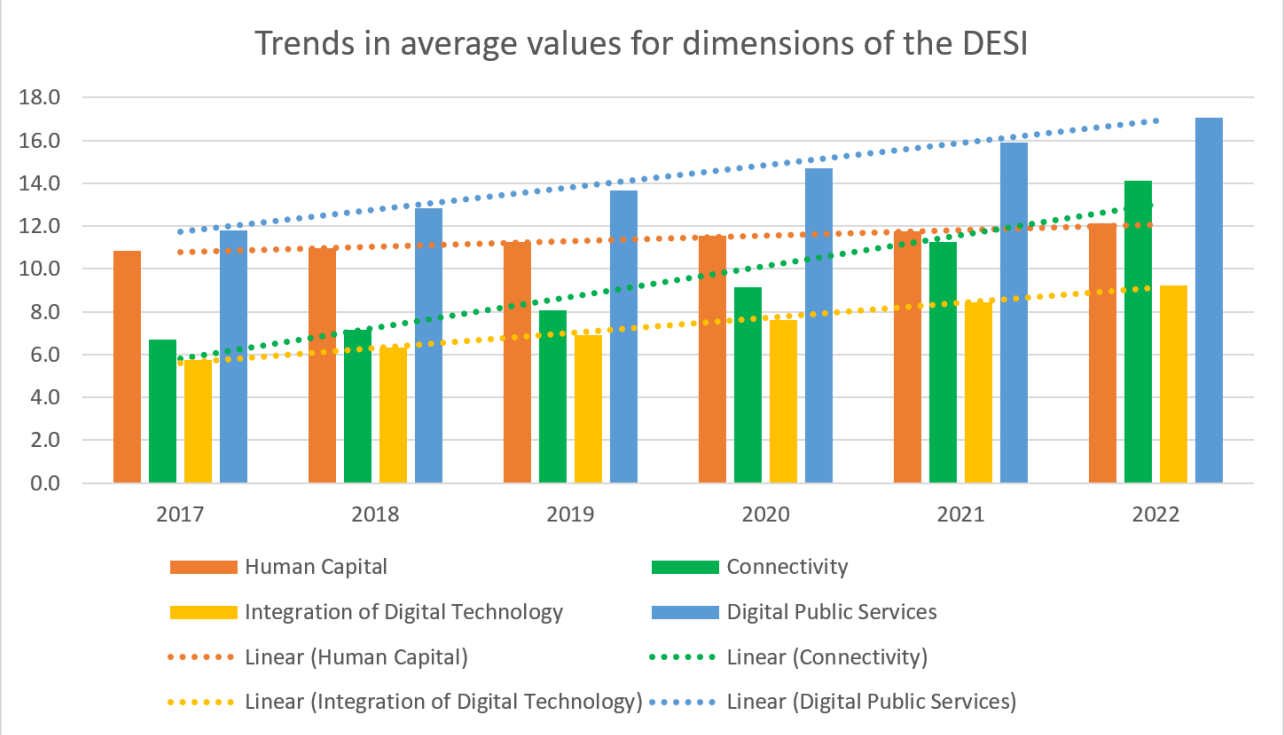

Figure 5. Trends in average values for dimensions of the DESI between 2017 and 2022. Source: own processing.

Figure 6 presents the trends of standard deviation and range values. The findings illustrate that there was a growth in standard deviations and range values from the period 2017 to 2022. This means that the differences between best and worst countries are slightly widening. Although the differences are not significant, the trend is obvious. Especially the integration of digital technology dimension could result in bigger disparities and digital divides among the EU countries. In this regard, countries should focus on developing projects that will improve the use of big data, AI, and ICT for environmental sustainability. These trends are crucial to reuse the existing data sources in the public as well as private sector and uncover hidden values from these data. In addition, AI and machine learning techniques are the key tools that could help in these efforts. It should be highlighted that this should be a priority for both governments and businesses, i.e., to improve digital intensity of their actions, to be able to provide more effective, faster, and quality digital services to citizens.

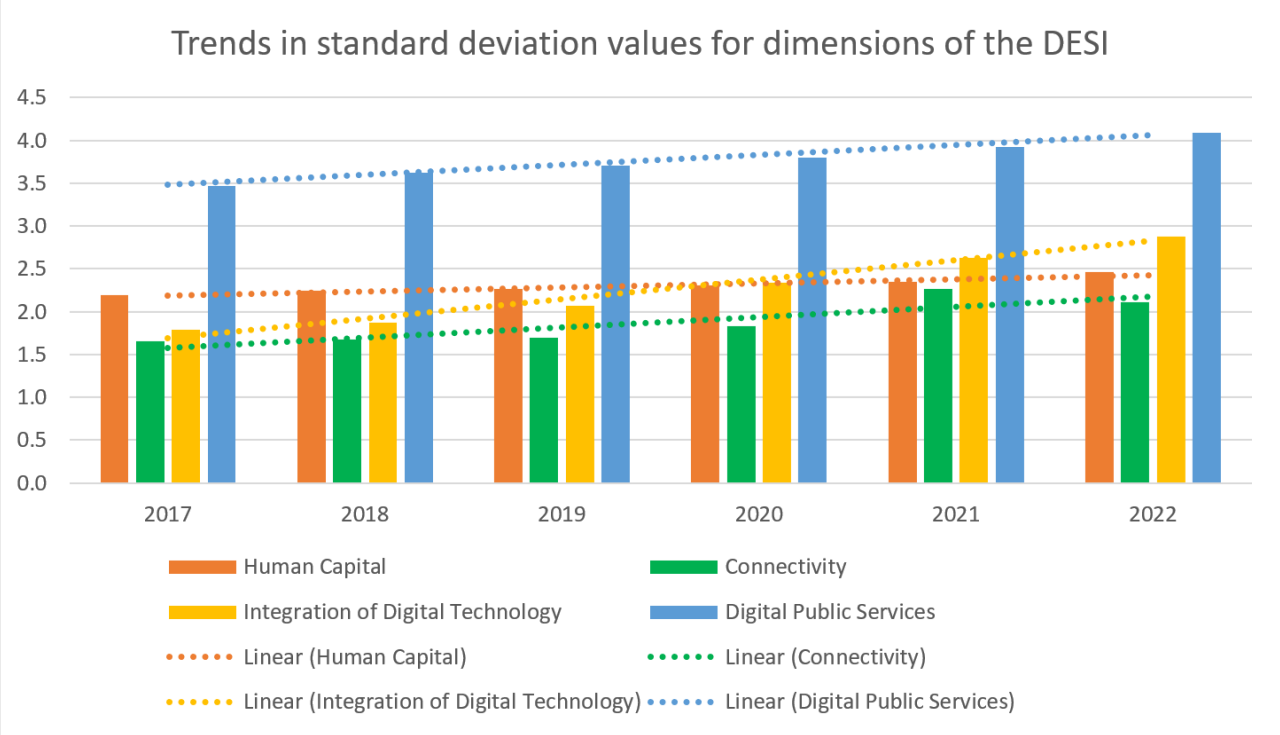

Figure 6. Trends in standard deviation values for dimensions of the DESI between 2017 and 2022. Source: own processing.

6.2 Cluster analysis

To identify similarities between countries in respect to sub-indices and dimensions, we applied the cluster analysis. With this, we aimed to understand whether it is possible to determine clusters based on indicators that would allow us to identify strengths and weaknesses that may be recognized as best practices to improve e-government and digital society development. Also, we are interested in whether the composition of the clusters has changed over the years. For the EGDI, we performed the cluster analysis for 2004, 2008, 2012, 2016, and 2020. For the DESI, we selected the years 2018, 2020, and 2022. The main reasons for this were clarity of results and to observe larger time spans over which some changes can be expected to occur.

We used the STATISTICA 12.0 analytics tool. First, we created data files for each index and respective years, i.e., we had two Excel workbooks with five and three sheets respectively. Then, the files (sheets) were imported into the tool – the options *Get variable names from first row* and *Get case names from the first column* were checked. The three sub-indices of the EGDI are already normalized scores and the Z-score standardization procedure was implemented for each component indicator, see the methodology section in United Nations (2022). However, the four dimensions of the DESI must be standardized before the cluster analysis takes place. This was done using *Transformations – Standardize* in the STATISTICA 12.0 analytics tool.

A joining (tree clustering) hierarchical algorithms and non-hierarchical K-means clustering method were applied then for each sheet. Initial tuning/setup of cluster centres was performed using a hierarchical single linkage algorithm and Ward's minimum variance method. By checking the dendrograms for both methods, we can get information about how the clusters are formed. In this regard, the non-hierarchical clustering was carried out using the K-means algorithm for 4, 5, and 6 clusters. Of the given numbers, 5 clusters provide the highest quality clustering (e.g., intra-cluster and inter-cluster distances, no empty cluster, no cluster with a single member etc.) for both the EGDI and DESI. This number has been selected for further processing.

The countries in each cluster for the EGDI in selected years are shown in Table 6, where the country with the largest distance from the centre is highlighted in bold. The findings from the analysis demonstrate that there are significant differences between the countries in terms of the periods 2004 to 2020. By analysing the *plot of means for each cluster* in all selected years, we can conclude that the most important variables (sub-indices) for the clustering are the OSI and TII. In 2004, countries with the highest average values for these sub-indices can be found in cluster 5, while countries with the lowest values are in cluster 4. In the next years, countries were clustered together based on increasing/decreasing values for the OSI and TII. Denmark, Finland, Netherlands, and Sweden are usually clustered together in the cluster with the highest values, while Bulgaria, Hungary, Romania, and Slovakia are usually clustered together in the cluster with the lowest values for all sub-indices. In 2020, countries with the lowest average value for the OSI are in cluster 3 but they have the second highest average value of the HCI and the third highest for the TII. This can be explained by the fact that some countries focus more on digital infrastructures and human capital when they expect these to be the key indicators for innovations.

If the cluster analysis would be performed without the OSI then the members of the clusters would remain more or less the same in all years because of how the TII values evolved over the years, i.e., proportionally for the given groups of countries. Therefore, it can be concluded that the similarities between groups in selected years are primarily based on how countries have implemented and improved the availability of their digital public services over the years. The progress of building digital and telecommunication infrastructures and the quality of their parameters such as broadband also have an influence on this. However, the existence of online services for citizens and businesses is key, because if they do not exist or are of poor quality, their uptake will be low.

Table 6. Clustering in selected years for the EGDI using K-means algorithm. Source: own processing.

2004	
Cluster 1	Czech Republic, France, Italy, **Luxembourg**, Slovenia
Cluster 2	Austria, **Belgium,** Estonia, **Germany**, Ireland, Malta
Cluster 3	Croatia, **Cyprus**, Greece, Latvia, Portugal, Spain
Cluster 4	Bulgaria, Hungary, Lithuania, Poland, **Romania**, Slovakia
Cluster 5	**Denmark**, Finland, Netherlands, Sweden
2008	
Cluster 1	Austria, Estonia, Finland, France, Ireland, **Luxembourg**
Cluster 2	Belgium, **Germany**, Italy, Slovenia
Cluster 3	Denmark, **Netherlands**, Sweden
Cluster 4	Czech Republic, Hungary, Lithuania, **Malta**, Portugal, Spain
Cluster 5	Bulgaria, Croatia, Cyprus, Greece, Latvia, **Poland**, Romania, Slovakia
2012	
Cluster 1	Austria, **Estonia**, Hungary, Lithuania, Portugal, Slovenia, Spain
Cluster 2	Denmark, **Finland**, France, Netherlands, Sweden
Cluster 3	Belgium, Croatia, **Ireland**, Italy, Malta
Cluster 4	Bulgaria, Cyprus, Czech Republic, Greece, Latvia, Poland, **Romania**, Slovakia
Cluster 5	Germany, Luxembourg
2016	
Cluster 1	Croatia, Italy, Lithuania, **Malta**, Portugal, Slovenia
Cluster 2	Belgium, Ireland, **Poland**
Cluster 3	Bulgaria, Cyprus, Czech Republic, Greece, Hungary, Latvia, **Romania**, Slovakia
Cluster 4	Austria, Estonia, Finland, France, Germany, Netherlands, **Spain**, Sweden
Cluster 5	Denmark, Luxembourg
2020	
Cluster 1	**Denmark**, Estonia, Finland, Netherlands, Sweden
Cluster 2	**Austria**, France, Italy, Lithuania, Poland, Portugal, Slovenia, Spain
Cluster 3	Belgium, Czech Republic, Germany, Greece, Ireland, **Latvia**
Cluster 4	**Cyprus**, **Luxembourg**, Malta
Cluster 5	Bulgaria, Croatia, Hungary, Romania, **Slovakia**

The countries in each cluster for the DESI in selected years are shown in Table 7, where the country with the largest distance from the centre is highlighted in bold. Based on the *plot of means for each cluster* in 2018, countries with the highest average values for all dimensions, expect of the connectivity, can be found in cluster 5, while countries with the lowest average values for all dimensions, expect of the connectivity, are in cluster 1. It seems that indicators related to connectivity are the ones that have influenced the clustering of countries in this year the most. However, it should

be noted that this dimension has changed the most over the years, respectively its indicators, so it is difficult to identify any relevant indicators that can be recognized as best practices.

In 2020, the results are similar to 2018, i.e., cluster 5 includes the countries with the highest average values and cluster 4 covers the countries with the lowest average values. Connectivity and integration of digital technology are the dimensions that affected the clustering in this year. The post-covid year 2022 is characterized by significant progress in the connectivity dimension for most countries. This resulted in a rearrangement of cluster members compared to 2020. Countries with the best values are in cluster 4 and countries with the lowest values can be found in cluster 5. The countries in cluster 5 significantly lag behind the others in the dimensions of integration of digital technology and digital public services.

Table 7. Clustering in selected years for the DESI using K-means algorithm. Source: own processing.

2018	
Cluster 1	Bulgaria, Hungary, Poland, **Romania**
Cluster 2	Austria, Belgium, Czech Republic, France, Germany, **Lithuania**, Portugal, Slovakia, Slovenia
Cluster 3	Estonia, **Latvia**, Luxembourg, Spain
Cluster 4	Croatia, Cyprus, **Greece**, Italy
Cluster 5	Denmark, Finland, **Ireland**, Malta, Netherlands, Sweden
2020	
Cluster 1	Germany, **Hungary**, Latvia, Portugal
Cluster 2	Austria, Belgium, Croatia, Cyprus, Czech Republic, France, Italy, **Lithuania**, Slovakia, Slovenia
Cluster 3	**Estonia**, Luxembourg, Malta, Spain
Cluster 4	Bulgaria, Greece, Poland, **Romania**
Cluster 5	Denmark, Finland, **Ireland**, Netherlands, Sweden
2022	
Cluster 1	**Finland**, Ireland, Luxembourg, Malta, Sweden
Cluster 2	Cyprus, France, Germany, **Italy**, Slovenia
Cluster 3	Austria, **Belgium**, Croatia, Czech Republic, Estonia, Latvia, Lithuania, Portugal
Cluster 4	Denmark, Netherlands, **Spain**
Cluster 5	Bulgaria, Greece, Hungary, Poland, **Romania**, Slovakia

7 Discussion and contributions

7.1 Discussion

In our study, we found that several indices, rankings, and reports that focus on the e-government and digital society development have emerged over the years. We also found that their structure and importance of respective indicators in terms of their weights and assignment to sub-indices, dimensions, and pillars have changed as well in time. Most of these changes were shaped by technological advances and how stakeholders work with digital information. Considering the findings

by Sony and Naik (2020) who argue that similarities between indicators and their inclusion into respective categories are affected by the digitalization of society, we can conclude that our findings support this claim. Our study fits into the broader literature about socio-technical theory by showing how indicators should be treated and connected to respective sub-indices, dimensions, and pillars regarding technological advances and stakeholders' digital readiness to profit from them.

The findings from the data indicated that there were significant differences between these composite indicators. However, comparisons could only be done in terms of countries with challenges associated with the use of these indicators were noted, that is updating the changes that were encountered as the indicator was modified or utilised would imply changes to the entire index's structure. Thus, these small and minor differences can make the whole analysis interpretation difficult to cross compare and establish validity and reliability of the findings.

One of the most profound indicators of digital social was observed as performance expectancy, which was noted as the ability or the degree to which individuals believes that the systems that they are using is enabling and helping them to achieve their intended goals and aspirations (OECD, 2019; Venkatesh et al., 2003). In this regard, performance expectance and its related indicators are a strong predictor of behavioural intention. As such, when there is an intention and a very strong one, it becomes easy to note that the involvement of persons into digital technologies is influenced and inspired by the core existence with other that share the same point of view or rather perspectives (Falk et al., 2017; Venkatesh et al., 2003). Furthermore, Hunnius and Krieger (2014) argued that interfaces that are not user friendly within the Internet have a strong deterring effect on how the Internet and digital technologies are adopted and utilized by the masses.

Another indicator which is effort expectancy was also bright forwards where the belief is around individual potential users hang the belief that the govern application is useful and at the same time believing that the system might be useful. According to Ding et al. (2012), various factors may influence effort expectancy for technologies. They suggested to link available open data to increase transparency of actions. For this purpose, a transparency-by-design approach developed by Lnenicka and Nikiforova (2021) to design features of open data portals can be used. Petychakis et al (2014) argued that due to the large amount of available data, it can then be hard to find the exact open datasets that individuals would be intending to use as they do their work and deliver services.

These are registered as aspects of the digital technologies that enable the experience of use of technology to be friendly and accepting of the diversity. The approach allows for an understanding of adaptation of reasonable accommodation on the part of all involved within the scope of the technological inventions. This is understood as the degree of which the individual believes that an organization and technical infrastructure exists to support the use of the system. On the contrary others such as Dwivedi et al. (2017), facilitating condition maybe the best predictors for behavioural intentions and these can and may be best for e-government services. Also, as reported by Stavytskyy et al. (2019), digital innovation activities are crucial for ensuring a sustainable development at the level of the state. In this regard, relevant digital and e-government initiatives and strategies must be benchmarked to ensure their sustainability towards targeted improvements (Heeks, 2008; Lnenicka et al., 2024; Skargren, 2020).

Finally, the question dealing with what users, i.e., citizens and businesses, want and expect to get from the supply side, i.e., the governments, remains unanswered, especially regarding the effectiveness of the public sector agencies and institutions in delivery of digital public services. Indicators that would reflect these views among stakeholders are however difficult to get agreement on them and then obtain the relevant data.

7.2 Theoretical implications

This study provides a model for analysing and tracking changes in e-government and digital society indices over time. The mixed methods approach can inform future benchmarking studies. From a methodological point of view, the integration of socio-technical theory provides a theoretical approach for researchers to assess complex interactions between humans, technology, and organizations in this domain and to understand the structure of the indices that can be used as an e-government and digital society framework in the EU context. More precisely, the socio-technical theory can enhance the understanding of respective indicators in terms of 1) contextualization of the indicators within broader societal and organizational contexts, e.g., understanding the connectivity dimension involves not only technical infrastructure but also social factors like digital inclusion and accessibility; 2) organizational change, e.g., indicators related to adoption of digital innovations consider not only technological aspects but also organizational culture, employee behaviour, and power relations; 3) user-centric design, e.g., indicators related to the use of the internet are affected by user experiences, usability, and user-centred approaches; and 4) collaboration and participation, e.g., indicators differentiate between stakeholders and how they are involved participatory design and co-creation of digital services and policies.

The main theoretical implications to the e-government and digital society literature are represented by the overview of the most important indices, rankings, and reports that focus on the e-government and digital society development and analysis of their structure of sub-indices, dimensions, pillars, and individual indicators that are used to evaluate these developments. We found that the most important ones are the EGDI, which is published since 2001, and the DESI, which is published since 2014. Both are still active, i.e., the current editions available are from 2022, so we analysed how the indicators changed over the years. While the EGDI's structure and composition of indicators were slightly changed and some outdated technologies were replaced by more current ones, the DESI's dimensions, indicators, and their weights towards the overall score of the index has changed significantly.

ICT, technological infrastructures, services to access and use digital platforms, knowledge and skills, and other activities performed by citizens, businesses, and governments to interact with each other, and exchange information had dramatically evolved over the years. So, it is obvious that all indices must respond to these with corresponding indicators. Because the EGDI covers all the UN's Member States, its structure cannot be changed so much because there developed as well as developing countries. On the other hand, the DESI covers only the EU's Member States which are developed countries that rely on modern technologies and have financial and human resources to transform their use into innovations and economic growth.

7.3 Practical implications

The findings of this study highlight specific indicators like broadband infrastructure as top priorities for countries to focus investments and policies toward. This can help guide strategic e-government planning. The main implications for practice result from the comparative analysis performed in the section dealing with the analysis of indicators in selected countries. We chose the EU Member States and performed the statistical and cluster analyses using the data for the EGDI and DESI. The results showed that the OSI and TII values improved significantly over the years. For the DESI, the dimensions that have improved most are connectivity and digital public services. We also found that the Nordic countries are usually among the best performers, so we can recommend learning from their experiences. On the other hand, some countries such as Bulgaria, Romania, Hungary, Poland, or Slovakia are still lagging in some areas compared to other Member States.

To sum up, the use of indicators to identify the significant differences existing between and within countries' adoption of the DESI and the EGDI allowed for the easy assessment and establishing of the degree of integration. More so the data analysis allowed us to make cross comparisons per country per use without too many explanations tied to the observations. With evidence gathered specifically to the identified indicators only used to understand the country performance specific to the sub-indicator. These significant differences played a critical role in differentiations of country adaptation to digitalisation and the extent to which the digital integration was made. Further evidence demonstrates that digital rankings and placing of countries based on the weighted and average digital performance into ranks is difficult to establish. There are major flows in the approach especially given changes in digital trends and digital integration at each level of integration. For public policy, results pointing to digital divides across EU countries suggest more equalization of technology infrastructure and skills is needed. Policymakers can apply these insights.

8 Conclusions

All the RQs established in this research paper were successfully answered. The relevant literature was first examined, and the basic terms related to the researched area were described. We found that the digitization of the society is key for communication and the exchange of data and information between stakeholders, and at the same time the development of digital societies determines what services will be delivered using ICT. We provided an overview of indices, rankings, and reports that appeared since 2000 and benchmarked countries in ICT use, e-government development, digital society, and other indicators. We found that changes in the mix of indicators used by these indices can be attributed to advances in ICT and channels through which people communicate and receive information. We suggest that each index should include indicators that contribute to increase of efficiency of decision-making processes, support the growth of human capital, development of digital infrastructures, and delivery of new digital services.

We focused on the identification and comparison of the indicators, as well as sub-indices, dimensions, pillars etc., relevant for the e-government development and digital society context. We provided an overview of existing indicators and how publishers of respective indices and reports include modern technologies in their frameworks. Based on the lists of indicators included in each index, the number of countries covered, changes in the methodology, comparability of data over years, and the

availability of the input data, we chose the EGDI and DESI and their indicators for the analyses. We decomposed them and discussed changes in the sets of indicators that were used by these indices over the years.

Then, we explored and analysed e-government and digital society indicators in the EU Member States using the indicators of the EGDI and DESI. We used statistical and cluster analyses. The findings revealed that digital and telecommunication infrastructures and the quality of their parameters such as broadband have the biggest influence on progress of the e-government and digital societies developments and contribute most to clustering of the EU Member States into groups. However, the existence of online services for citizens and businesses is also crucial, because if they do not exist or are of poor quality, their uptake will be low. In this regard, future research should be focused on the provision of digital public services to citizens and businesses and what are the expectations of these stakeholders towards their availability, quality, usability etc.

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