

## INDEX OF DIGITAL ECONOMY AND SOCIETY

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**Abstract:** *At present, technological progress affects both work and personal life. It is technological trends to determine the direction of development of all industries. With the help of digital transformation, all data can be brought into digital form. Subsequently, it is possible to draw from them anywhere in the world. The digital decade presupposes the involvement of all citizens in basic digital skills. The openness and active participation of citizens is also needed in the acquisition of new specialized digital skills as a skilled workforce. In the private sector, digital technologies enable companies to gain a competitive advantage. They also give you the opportunity to improve your services and products. Then it is possible to expand their sales markets. The digital transformation of businesses opens up new opportunities and supports the development of new and credible technologies. The aim of this paper is to review the DESI index in individual dimensions in comparison with previous periods in EU countries. Within the DESI index with a focus on Slovakia, the secondary goal is to identify its strengths and weaknesses.*

**Keywords:** Digital transformation; DESI; technological trends.

### 1 INTRODUCTION

Member States' progress in digital technologies is measured by the Digital Economy and Society Index (DESI). Each year, the DESI reports include country profiles that can guide Member States and identify priority areas for action, as well as the thematic chapters of the EU-level analyses provided in key areas of digital policy. In 2021, the Commission adapted DESI to reflect the two main policy initiatives that will have an impact on the EU's digital transformation in the coming years. They are the recovery and durability of the device and the compass of the digital decade.

DESI harmonization has taken place in four main areas and objectives under the digital compass. The methodology has also been improved, taking into account the latest technological and political developments.

The Commission has introduced several changes in the DESI edition of 2021. In the latest version, the indicators in the Digital Compass are structured into four key areas, replacing the previous five-dimensional structure. Just 11 DESI 2021 indicators measure progress towards the targets set in the digital compass. The outlook for the DESI index is that the initiatives lead to greater alignment with the digital compass. This trend is to ensure that all objectives are discussed in the reports.

In addition to the above, DESI currently implies an indicator measuring the level of support, which includes ICT technologies that will enable companies to take greener measures (ICT for environmental sustainability). The use of gigabit services is also encouraged. In addition, Eurostat statistics show that the percentage of companies offering ICT training and the use of e-invoicing is increasing.

DESI was established according to OECD guidelines and recommendations as a "Handbook for the creation of composite indicators: methodology and user guide". The data included in the index were

largely collected from the competent authorities of the Member States with the assistance of the European Commission (Directorate-General for Communication Networks, Content and Technology, Eurostat) as well as ad hoc studies launched by the European Commission.

In terms of DESI updates and fixes, they are part of the life cycle and nature of statistics. It can be observed over the years that the values for one indicator are subject to small changes and only completely stabilize months or even years after the original calculation of the indicator. This is the case with a significant number of indicators used in DESI construction. Each publication also examines historical data to accommodate such changes. The current report takes into account the changes notified to the European Commission by 31 August 2021. Any adjustments made after this date will be included in the next report, which is expected in 2022.

### 2 STRUCTURE OF THE DIGITAL ECONOMIC AND SOCIAL INDEX

It represents a set of relevant indicators of the current mix of digital policies in Europe. The Digital Economy and Society Index (DESI) has been available since 2014. The Digital Economy and Society Indices (DESI) from previous years have been recalculated for all countries to reflect changes in the choice of indicators. Subsequently, corrections to the basic data were made. DESI provides four main types of analysis:

- General performance evaluation: obtaining a general performance characteristic of each Member State by monitoring their overall index score and the main dimensions of the index.

- Approximation: serves to identify areas where Member States' performance could be improved, includes analyses of index sub-dimensions and individual indicators.
- Follow-up: defines the assessment of whether progress has been made over time.
- Comparative analysis: groups member countries according to their index scores, also compares countries at similar stages of digital development in order to highlight the need for improvement in the relevant policy areas.

When examining the DESI structure, it is possible to define a three-layer structure as shown in Figure 1. It consists of 4 main dimensions, each of which is divided into a set of subdimensions. Individual subdimensions are divided into individual indicators.

At the dimensional level, DESI is currently addressing the four main policy areas of the 2030 Digital Compass digital strategy. In the case of these areas, it might seem that they are all built separately. However, this is not the case, they are not isolated areas. However, it should be noted that they independently contribute to digital development in interconnected areas. If we look at developments in the digital economy and society as a whole, it is not possible to make improvements in terms of isolated improvements in specific areas. Joint improvements are needed in all areas. In the following parts of the paper, the individual DESI 2021 indicators will be characterized.

*Table 1 Structure of the DESI. Source: DESI 2021, European Commission*

Dimension	Sub-dimension	Indicator
1 Human capital	1a Internet user skills	1a1 At least basic digital skills
		1a2 Above basic digital skills
		1a3 At least basic software skills
	1b Advanced skills and development	1b1 ICT specialists
		1b2 Female ICT specialists
		1b3 Enterprises providing ICT training
		1b4 ICT graduates
2 Connectivity	2a Fixed broadband take-up	2a1 Overall fixed broadband take-up
		2a2 At least 100 Mbps fixed broadband take-up
		2a3 At least 1 Gbps take-up
	2b Fixed broadband coverage	2b1 Fast broadband (NGA) coverage
		2b2 Fixed Very High Capacity Network (VHCN) coverage
	2c Mobile broadband	2c1 4G coverage
		2c2 5G readiness
		2c3 5G coverage
		2c4 Mobile broadband take-up
	2d Broadband prices	2d1 Broadband price index
3 Integration of digital technology	3a Digital intensity	3a1 SMEs with at least a basic level of digital intensity
	3b Digital technologies for businesses	3b1 Electronic information sharing
		3b2 Social media
		3b3 Big data
		3b4 Cloud
		3b5 AI
		3b6 ICT for environmental sustainability
		3b7 e-Invoices
	3c e-Commerce	3c1 SMEs selling online
		3c2 e-Commerce turnover
		3c3 Selling online cross-border
4 Digital public services	4a e-Government	4a1 e-Government users
		4a2 Pre-filled forms
		4a3 Digital public services for citizens
		4a4 Digital public services for businesses
		4a5 Open data

## 2.1 Human capital dimension

The first category in DESI 2021 is the human capital dimension, which has two sub-dimensions, including "internet user skills" and "advanced skills and development". The first term comes from the European Commission's Digital Skills Indicator, which is calculated on the basis of the number and complexity of activities involving the use of digital devices and the Internet. It contains indicators on ICT specialists, ICT graduates and companies providing specialized training in the field of ICT.

The sub-dimension of advanced skills and development targets the workforce and its potential to work and develop the digital economy. This fact is taken into account by the percentage of people in the workforce with the skills of ICT specialists, divided into ICT experts. It also includes the proportion of ICT graduates.

From the point of view of Digital Decade communication, Europe has a fundamental goal in the form of basic digital skills (80% of people), which is set out in the Digital Education Action Plan and the European Pillar of Social Rights. Also, by 2030, there are plans to reach 20 million employed ICT specialists in the EU with a balanced number of ICT specialists between women and men.

In the case of a survey of the number of citizens who regularly used the Internet. It can be stated that already in 2019, 84% of citizens used the Internet regularly. However, it is worth noting that only 56% of these citizens have at least basic digital skills. At the same time, only about one third of Europeans have above basic digital skills (31%). And only 58% of citizens have at least basic software skills. Skills indicators in particular are strongly influenced by socio-demographic aspects. It follows that it is not enough to have an internet connection and use the internet. Everything must be connected. The Internet and adequate digital skills allow you to reap the benefits of a digital society. The introduction of digital skills extends to the basic user skills of individuals up to the involvement of the digital society. It implies digital goods and services, advanced skills that allow you to acquire new specialized digital skills, develop new digital technologies.

Digital equipment and capable citizens are the guarantee of a digitally qualified workforce and consequently well-applicable digital professionals in practice. In order to achieve this goal, successful human resources management is needed, while finding clear answers in terms of demographic trends and bridging existing skills gaps in the context of the digital and environmental transformation of society as a whole.

## 2.2 Connectivity dimension

DESI in the field of connectivity focuses on both the demand and supply of fixed and mobile broadband. A necessary condition for taking advantage

of the digital society is the complete connection of all individuals to the Internet.

By 2030, the digital decade is expected to meet the two broadband targets. They are gigabit coverage for all households and 5G in all populated areas.

The DESI connectivity dimension focuses on both sides of the demand and supply of fixed and mobile broadband. In the area of fixed broadband, the overall utilization, at least 100 Mbps and at least 1 Gbps of broadband, also observes the availability of fast broadband (next generation access of at least 30 Mbps) and finally very high-capacity fixed networks (VHCN).

When researching mobile broadband, it focuses on covering the population with 4G and 5G networks. The mentioned 5G coverage was introduced in DESI in 2021. Next, the allocation of radio spectrum for 5G (5G readiness) as well as the takeover of the mobile broadband network are assessed. Which is an indicator of mobile broadband usage. It was revised during the creation of DESI 2021. Further information and details can be found in the DESI methodological note.

In addition to the above, the report captures the retail prices of fixed and mobile offers, as well as the prices of converged packages. Such packages consist of fixed and mobile service components.

The DESI connection dimension is calculated as a weighted average of the following sub-dimensions. Fixed broadband: implies a weighted average of two normalized metrics. These are Fixed BB Coverage (standard fixed broadband coverage) and Fixed BB Take-up (households that have a fixed broadband connection):

- Mobile broadband: calculated as a weighted average of these normalized indicators. These are the deployment of mobile broadband (use of mobile broadband) and spectrum (percentage of allocated spectrum outside the target to be harmonized at EU level).
- Speed: includes the weighted average of normalized indicators. It contains two indicators, namely NGA coverage (households covered by NGA broadband) and Fast BB subscriptions (share of fixed broadband subscribers  $\geq 30$  Mbps).
- Affordability: consists of the weighted average of the standardized Fixed BB Price (monthly costs of the cheapest fixed broadband subscriptions with a speed of 12-30 Mbps).

## 2.3 Integration of digital technology

Digital technologies in the private sector give businesses the opportunity to gain a competitive advantage. Subsequently, they can focus on improving their services and products as well as expanding their markets. When introducing a new product, they have a better basis for the preparation and use of new technologies. It is the digital transformation of businesses that opens up new opportunities and supports the development of new and credible

technologies. The EU's digital space will in future depend on storage capacity, data extraction and processing. It is also necessary to think about meeting the requirements of citizens' trust, security and fundamental rights. This dimension measures the digitization of businesses and the size of e-commerce.

When we look at the best countries in terms of digital integration, we can include Finland, Denmark and Sweden. By contrast, Bulgaria, Hungary and Romania have the weakest performance.

The fundamental goal of Digital Compass is that more than 75% of companies in the EU should adopt Big Data technology by 2030. In order to achieve this goal, companies across the EU are constantly adapting to new technologies for data collection, storage and analysis. In the previous year 2020, Big Data analysis was performed on 14% of companies. This analysis has helped to generate results in a short time or in real time from data that comes in different types of formats. From the point of view of large companies, it can be stated that they have a majority share in the processing of large data (34% of them already use Big Data technology). In the case of SMEs, there is still room for improvement so that they can reap the full benefits of Big Data (only 14% use Big Data).

When examining the take-up of artificial intelligence technologies in the European Union, companies can be divided into three groups: "adoptors" (42%) who currently use at least one artificial intelligence technology, nor do they intend to use any of the artificial intelligence technologies in the near future (next two years). The last group are companies that plan to adopt AI in the next two years, but currently do not use AI solutions (18%).

## 2.4 Dimension of digital public services

Citizens expect a shift in the public sector that is possible through digital technologies. As in the private sector, new requirements and expectations are increasingly being placed on the public sector. It is effective e-government that can provide a wide range of benefits for citizens, businesses and cooperation with other public institutions. This promotes greater efficiency and savings for both governments and businesses. From the point of view of fundamental challenges for the government sector, the main point is to use the full potential of these technologies. It is also possible to increase transparency and openness. This dimension measures both the demand and supply side of digital public services, such as data openness. This analysis can be complemented by fact sheets on digital governance and interoperability of the National Interoperability Framework Observatory.

The goal of the digital decade by 2030 is to make all key public services for businesses and citizens fully online. From the point of view of the indicator's digital public services for citizens and digital public services for businesses, they imply progress in meeting the set goals. When monitoring these indicators, it can be deduced that Estonia, Denmark and Finland are the best in this area. In contrast, there are countries that are

the weakest in this area. These are Romania, Greece and Hungary the lowest scores. These indicators include all Internet users, of which the percentage of individuals who have used the Internet in the last 12 months to interact with public authorities. This indicator has been revised to better cover the volume of online interaction between citizens and public authorities. Another indicator deals with online forms and their completion by citizens, while the previous indicator dealt with only a percentage of citizens. Examining these indicators, Denmark, Finland and the Netherlands have performed very well in this area, with more than 90% of Internet users (aged 16-74) interacting with public administrations who have chosen government portals. Romania, Bulgaria and Italy can be included in countries where the percentage of citizens interacting with the public administration was below 40%.

*Table 2 Weights attributed to the DESI dimensions. Source: DESI 2021, European Commission*

Dimension	Weight
1 Human capital	25%
2 Connectivity	25%
3 Integration of digital technology	25%
4 Digital public services	25%

### 3 DESI SUB-DIMENSION

Digital Compass has four dimensions. All parts are equally important, so they are assigned the same percentage. The scales also monitor sub-dimensional levels and individual indicators. If we look at the comparison with the previous edition of the DESI report, mobile broadband has a higher weight than the 5G coverage now included in the index. A new sub-dimension has been included for the digital integration dimension, where a report on the digital intensity target has been added. In addition, the weight of the Digital Technologies for Business sub-dimension has increased, as this sub-dimension contains 3 indicators measuring the targets of the Digital Decade Compass.

*Table 3 Weights attributed to the DESI sub-dimensions. Source: DESI 2021, European Commission*

Sub-dimension	Weight
1 Human capital	
1a Internet user skills	50%
1b Advanced skills and development	50%
2 Connectivity	
2a Fixed broadband take-up	25%
2b Fixed broadband coverage	25%
2c Mobile broadband	40%
2d Broadband prices	10%
3 Integration of digital technology	
3a Digital intensity	15%
3b Digital technologies for businesses	70%
3c e-Commerce	15%
4 Digital public services	
4a e-Government	100%

When examining the individual indicators, it can be deduced that most of the indicators within each sub-dimension are considered to be equally important and therefore had the same weight within the relevant sub-dimension. In terms of targets for 2030, Digital Compass indicators are considered to be of higher importance. For this reason, they have a double weight within their subdimension. These indicators are listed in the table below.

*Table 4 DESI indicators with double weights. Source: DESI 2021, European Commission*

1 Human capital	At least basic digital skills ICT specialists Female ICT specialists
2 Connectivity	Gigabit for everyone (Fixed very high-capacity networks 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

The individual items in DESI are sorted according to the following procedure. The aggregation of indicators into sub-dimensions, of sub-dimensions into dimensions, and of dimensions into the overall index was performed from the bottom up using simple weighted arithmetic averages following the structure of the index.

As an example, the top-level DESI score for country C was calculated using the following formula:  

$$DESI(C) = \text{Human\_capital}(C) * 0.25 + \text{Connectivity}(C) * 0.25 + \text{Integration\_of\_Digital\_Technology}(C) * 0.25 + \text{Digital\_Public\_Services}(C) * 0.25$$

(1) Where *Connectivity(C)* is the score obtained by country C in the Connectivity dimension.

### 4 DIGITAL ECONOMY AND SOCIETY INDEX FOR SLOVAKIA

Slovakia's performance in DESI is increasing, although some areas have still not achieved the scores of developed countries of the European Union.

Within DESI 2021, Slovakia ranks 22nd among the 27 EU Member States. Compared to the previous DESI 2020 assessment, the country remained in the same position. If the position is compared with the EU average, Slovakia is placed just below the EU average. Figure 1 shows the individual EU countries within the DESI according to individual performances in specific dimensions.

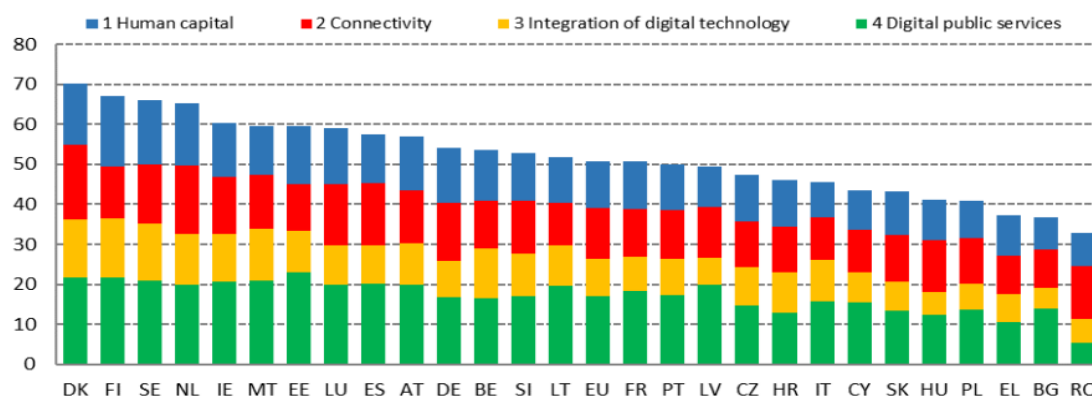


Figure 1 Digital Economy and Society Index 2021. Source: DESI 2021, European Commission

Within the human capital field, it oscillates around the EU average. The DESI report, which also includes a digital skills survey, shows that 54% of Slovaks have at least basic digital skills and 27% have above-average digital skills compared to the EU average of 56% and 31%. If we look at the number of companies providing ICT training in 2020, it was 16%, which is 4 percentage points less than the EU average of 20%. The share of ICT specialists in total employment has also grown and has almost reached the EU average. In the case of the total use of fixed broadband in Slovakia, it steadily increased from 72% in 2019 to 78% in 2020.

One of the suitable solutions in this area for Slovakia is considered to be the introduction of super-fast internet, and the coverage of a network with a very high capacity has also increased. Also in 2021, 5G was introduced in Slovakia. If we look at SMEs, they show

52% in the baseline level of digital intensity, which is below the EU average of 60%. In particular, 15% of businesses used at least two artificial intelligence (AI) technologies in 2020, compared to 25% in the EU. Taking into account another area, we can see that the number of companies using electronic invoices is 16%, which is well below the EU average of 32%.

A very weak area within DESI is the area of digital public services for Slovakia. They are below the EU average, with the exception of 68% of eGovernment users in 2020, compared to 64% in the EU. However, this increase is only 4 percentage points. Overall, it can be stated that Slovakia's progress in the monitored areas is very low and limited. When examining public funds, it is clear that the funds spent to stimulate the digital transformation have not achieved the desired effect.

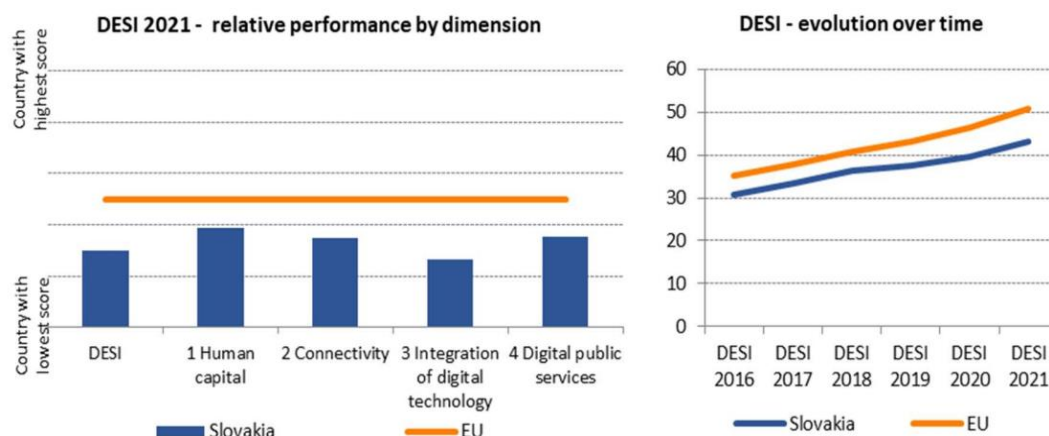


Figure 2 Relative performance by dimension and DESI evolution over time 2021. Source: DESI 2021, European Commission

From the positive results, it is possible to select an area of digital technology integration where some progress has been made. For example, the percentage of companies using cloud computing services is constantly growing. However, it should be noted that there is still a need for businesses to exploit the potential of Big Data, artificial intelligence and electronic information sharing systems. Within the indicators, which remained almost unchanged compared to previous periods, we can mention the

average use of e-commerce. This area is a missed opportunity for Slovakia.

When examining another area such as the digitization of education, it can be seen that it is far from reaching its potential. We can see gaps in tools in school facilities, skills of teachers and consequent lack of skills of students. We see an area of potential improvement in improving the coverage of fast broadband and very high-capacity networks. This is an obstacle to the wider use of digital technologies and

services by households and businesses. It is this deployment of networks that in many cases slows down administrative barriers. Consequently, it can be stated that Slovakia has still not transposed the provisions of the European Code of Electronic Communications. Although it has introduced new digital public services, work is still needed to improve them. Above all, it is appropriate to raise the area of quality and interoperability. In terms of benefits for citizens and businesses, the benefits can be seen in the increased availability, efficiency and user-friendliness of digital public services. One of the main pillars of Slovakia's Recovery and Resilience Plan is digital transformation. The main emphasis is on public services, skills and business digitization.

Looking to the future, it can be stated that Slovakia has good links with major European initiatives in the digital field and the Plan for Recovery and Resilience plans to continue to support several projects involving several EU countries.

As part of future developments, the Ministry of Investment, Regional Development and Informatization has set out a detailed strategy and action plan with specific measures to address the shortcomings identified by the DESI index indicators. The main areas of the DESI index are covered in this document. Its goal is to achieve significant improvements by 2025. This initiative is based on the strategy for the digital transformation of Slovakia until 2030 and the related action plan.

## 5 CONCLUSION

The great potential and importance of digital technologies has become apparent in the recent period of COVID-19. Fixed and mobile broadband plays a key role within DESI. Citizens' active and open participation is also needed to increase their digital skills. The goal of the digital decade by 2030 is to make all key public services for businesses and citizens fully online. Digital business transformation offers new opportunities and also supports the development of new and credible technologies.

The current pandemic of COVID-19 has further highlighted the existing shortcomings in the digital economy of Slovakia and in Slovak society. In particular, areas such as connectivity, the acquisition of digital skills and the digitization of schools, households, businesses and public services have come to the fore. Within the public sector, there was the greatest pressure on information systems in hospitals, schools and public institutions. These institutions were not prepared in terms of material or personnel for the sudden transition to online and remote operation. Subsequently, Slovakia undertook to improve its score and position in the DESI index.

The area of digital transformation of the economy and society is dealt with in the Recovery and Resilience Plan of Slovakia. It is digital reforms and investments that help this plan in modernizing Slovakia and supporting areas that require a large amount of investment. In the future, Slovakia plans to spend 1.33

billion on the digital transformation. EUR, i.e. 21% of the total allocation of 6.33 billion EUR.

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