



DIGITALISATION AND SMART DEVELOPMENT OF THE SLOVAK REPUBLIC IN THE CONTEXT OF THE DIGITAL DECADE OF THE EUROPEAN UNION

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Abstract: Digitalisation and smart development are critical for economic growth, societal progress, and improving quality of life in the 21st century. Slovakia, as a member of the European Union, strives to align with the goals of the European Union Digital Decade 2030 through national strategies. This article analyses Slovakia's progress in digital skills, infrastructure, enterprise digitalisation, and public services. While advancements are noted in basic digital skills and high-capacity network coverage, significant gaps remain in advanced skills, 5G adoption, and digital public services. Recommendations highlight the importance of infrastructure investment, education reform, and public-private collaboration to enhance Slovakia's digital competitiveness.

Keywords: Digitalisation, smart development, digital skills, digital infrastructure, Slovakia.

Introduction

Digitalisation and smart development have become key priorities of economic and societal strategies at national and international level in recent years. Slovakia, as part of the European Union, is facing challenges related to the transformation to a digital environment, while it needs to use its specific prerequisites and resources to ensure competitiveness and sustainable development. This process requires not only the introduction of innovative technologies such as artificial intelligence, the Internet of Things or fifth-generation networks, but also systemic change in education, infrastructure and legislation [1, 2, 3, 4].

Through the Digital Decade, the European Union has set clear targets such as achieving 80% basic digital skills in the population, full coverage of fifth-generation networks and at least 75% of businesses using advanced digital technologies by 2030. These ambitions require intensive efforts by Member States, including Slovakia, which ranked 23rd in the 2022 Digital Economy and Society Index. This result underlines the need for improvement in the areas of digital skills, infrastructure, digitalisation of businesses and public services [5, 6, 7, 8].

The Slovak Republic has adopted a number of strategic documents to support digitalization, such as the Digital Transformation Strategy of Slovakia 2030, the National Concept of Informatization of Public Administration for 2021-2026, and the Action Plan for Digital Transformation of Slovakia for 2023-2026. These documents reflect the need not only for technical infrastructure, but also for societal changes, including increasing digital

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inclusion, improving cybersecurity, and promoting education focused on digital skills [9, 10, 11, 12].

However, Slovakia faces several challenges. In the area of digital skills, it scores slightly above average in basic skills, but advanced digital skills and digital literacy of the population lag behind. In the area of infrastructure, Slovakia is making progress, in particular in the roll-out of fibre and high-capacity networks, but the adoption of gigabit connections and coverage of fifth-generation networks are still below the European Union average. Digitalisation of businesses and public services remains another key challenge [13, 14, 15].

The aim of this paper is to analyse the state of digitalisation and smart development in Slovakia in the context of the European environment, with a particular focus on comparing key indicators in the Digital Economy and Society Index for 2022 and 2023. This approach allows to identify the main trends, challenges and opportunities that can support Slovakia on its path towards a digital future.

Methodology

The aim of this thesis is to analyse the state of digitalisation and smart development of the Slovak Republic and its comparison with other European Union Member States. In particular, we focus on the assessment of key indicators of the Digital Economy and Society Index for 2022 and 2023. This analysis is intended to reveal the main trends, challenges and opportunities in the digital transformation of the Slovak Republic, with a particular focus on the country's ability to adapt to European and global digitalisation goals.

In order to achieve this objective, secondary research has been chosen, which includes the analysis and synthesis of information from relevant documents. This approach allows the use of already available data and knowledge to provide an informed answer to the research questions. Secondary research is an effective method that provides an overview of current data and allows for comparison of trends at both national and international levels.

The following research questions were formulated in order to systematically address the issue:

1. What are the main trends and challenges in the field of digitalisation of the Slovak Republic in comparison with other Member States of the European Union?
2. To what extent is Slovakia succeeding in achieving the objectives of the Digital Decade of the European Union in the field of digital transformation?
3. What measures are needed to accelerate Slovakia's digital transformation and to eliminate the identified gaps?

The methodology draws on key secondary sources to provide comprehensive and up-to-date data. The Digital Transformation Strategy of Slovakia 2030 outlines strategic priorities for national digitalisation [1], while the Digital Economy and Society Index 2022 - Slovakia offers a detailed assessment of the country's digital performance within the European Union context [2]. Sector-specific analyses, such as Implementation of Smart Solutions by Local Governments [4] and The Use of the Internet of Things in Smart Local Government [5], provide insights into smart city initiatives and technological strategies. Additionally, the Digital Decade Country Report 2023 - Slovakia and the Action Plan for Digital Transformation of Slovakia 2023–2026 present actionable measures and quantitative data to support digitalisation efforts [11].

These documents were selected based on their relevance to the topic and contain both quantitative and qualitative data necessary to answer the research questions. The documents focus on the main strategic, methodological and practical aspects of digitalisation in the Slovak Republic, providing concrete data and context for comparison with other European Union Member States. The addition of these research questions has ensured that the analysis and interpretation of the results is systematic, enabling the identification of not only current

challenges but also concrete opportunities for improvement in Slovakia's digital transformation.

The secondary research used in this paper has certain limitations that are important to take into account when evaluating the results. The analysis is dependent on existing data that is contained in available documents, thus limiting the ability to supplement the information if gaps or incompleteness are present. In addition, the context of the data may be influenced by the perspective of the authors, which may lead to some biased interpretation or misrepresentation, and therefore the results require a thorough assessment in terms of their objectivity and representativeness. Timeliness is another factor, as some of the data contained in the analysed documents may not reflect recent developments in the field of digitalisation, which may affect their relevance to current debates. In addition, the documents analysed often contain detailed data on the Slovak Republic, while detailed comparative data on other European Union Member States may be missing, limiting the possibility of direct and in-depth comparisons.

It should also be stressed that data for 2024 could not be included in the analysis as this year is not yet closed and the available data is therefore incomplete or only preliminary. These limitations suggest the need for a critical approach in synthesizing the results and an emphasis on contextualizing the conclusions.

Results

Digitalisation and smart development are key drivers of economic and social transformation. Technologies like AI, IoT, big data, and 5G have reshaped business and global economic dynamics. Organizations such as the UN and OECD stress the inclusive and sustainable use of digital technologies, addressing social, environmental, and economic impacts [1, 5].

The European Union is responding to these challenges with a comprehensive approach, framed by the Digital Decade vision. Specific initiatives have been created to support these objectives, such as the Digital Europe programme, which funds projects in the fields of artificial intelligence, cyber security and advanced infrastructure, and the Connecting Europe Facility, aimed at developing high-capacity networks and data centres. The European Union's strategic frameworks, such as the Digital Single Market Strategy, underline the need to align Member States' national policies with European priorities. These policies emphasize openness, interoperability and consumer data protection, thus promoting the harmonization of the digital environment across the European Union [1, 5].

These initiatives provide the basis for effective digitalisation across Europe, but also highlight the differences in preparedness between Member States. While digitalisation leaders such as Finland, Sweden and Denmark regularly score highly in the Digital Economy and Society Index, many countries in Central and Eastern Europe, including the Slovak Republic, lag behind. This disparity highlights the need for targeted support from the European Union, which should reflect the diversity of national needs and capacities of Member States [2, 3].

The Slovak Republic has considerable room for improvement in digital transformation and can thus make a significant contribution to the common effort to achieve the objectives of the Digital Decade of the European Union. Priority areas include the development of digital skills and the digitalisation of public services, where progress is visible. On the other hand, efforts need to be significantly stepped up in the digitalisation of businesses and in the expansion of fifth-generation network infrastructure, which are key to increasing connectivity and the efficient use of modern technologies [1].

In December 2022, the Slovak government adopted the Action Plan for Digital Transformation of Slovakia for 2023-2026 and the National Digital Skills Strategy along with an action plan for the same period. These documents are closely aligned with the European Union's Digital Decade Policy Programme, which sets out the strategic priorities for digital

transformation for all Member States. Together with the National Concept for the Computerisation of Public Administration 2021-2026, these documents form the basis for a coordinated approach to digital transformation in the public sector. The strategic priorities include increasing the accessibility of digital public services, promoting education and improving cybersecurity [1].

The Slovak Republic places emphasis on monitoring the security and resilience of electronic communication networks and cyber security. In cooperation with the European Union Agency for Cyber Security (ENISA), it adopted an amendment to the Cyber Security Act in 2021, which includes European Union tools to protect fifth-generation networks. In addition, Slovakia is planning further legislative updates to ensure compliance with the European Electronic Communications Code and the NIS2 Directive, which are key to modernising and protecting digital infrastructure. These measures aim to increase Slovakia's resilience to cyber threats while supporting the development of secure communication systems [1].

The Slovak Recovery and Resilience Plan includes ambitious digital targets, with 21% of the total allocation (€1.3 billion) dedicated to digitalisation. Of this, €1.2 billion is to contribute to the Digital Decade objectives. The plan includes projects to digitise public administrations, increase cyber security and develop digital skills. Specific initiatives include, for example, the pilot phase of the 'tablet for seniors' project, which has provided equipment and digital training to thousands of elderly people, increasing their digital literacy and ability to use e-services [1].

In April 2023, Slovakia submitted a modified Recovery and Resilience Plan to take into account the reduction of the financial allocation by €321 million and to include a REPowerEU chapter aimed at reducing dependence on fossil fuels from Russia and supporting the green transformation. This updated plan, adopted in July 2023, confirms the Slovak Republic's commitment to achieving the digital and environmental targets set by the European Union. The projects also include measures to increase energy efficiency in digital infrastructure, reflecting the link between digital and green transformation [1].

Despite the progress made, the Slovak Republic faces a number of challenges that include a lack of digital integration in businesses and a relatively low level of advanced digital skills among the population. In order to achieve further milestones and improve its position in the Digital Economy and Society Index, it is essential to continue the implementation of action plans and national strategies, while at the same time stepping up investment in key areas such as fifth generation network infrastructure and digital public services.

Table 1 Internet Usage and Digital Skills in Slovakia and the EU

Indicator	Slovakia DESI 2021	Slovakia DESI 2022	Slovakia DESI 2023	EU DESI 2023
Internet use (% individuals)	88	87	88	89
At least basic digital skills (% individuals)	-	55	55	54
Above basic digital skills (% individuals)	-	21	21	26
At least basic digital content creation skills (% individuals)	-	72	72	66
Enterprises providing ICT training (% enterprises)	16	16	15	22
ICT specialists (% individuals in employment aged 15-74)	4.2	4.3	4.3	4.6
ICT graduates (% graduates)	3.9	4.4	4.4	4.2

Source: Author according to [1]

Table 1 highlights key digital indicators comparing Slovakia and the EU. It examines internet usage, basic and advanced digital skills, digital content creation, ICT training in enterprises, and the representation of ICT specialists and graduates.

- **Internet usage.** Internet penetration in Slovakia remains stable at 88%, slightly below the EU average of 89%. Expanding access, particularly in rural areas, remains a critical challenge to achieving parity with the EU [1].
- **Basic digital skills.** In Slovakia, 55% of individuals aged 16–74 possess at least basic digital skills, slightly surpassing the EU average of 54%. However, this figure is still far from the EU Digital Decade target of 80% by 2030, emphasizing the need for further educational investments [1].
- **Advanced digital skills.** Only 21% of Slovaks demonstrate advanced digital skills, compared to the EU average of 26%. This gap underscores the need to enhance education and retraining programs focused on digital technologies [1].
- **Digital skills for content creation.** Slovakia outperforms the EU in basic digital content creation skills, with 72% of the population competent in this area versus the EU average of 66%. This strong performance highlights potential growth in the creative and technology sectors [1].
- **ICT training for businesses.** Only 15% of Slovak enterprises provide ICT training, significantly lagging behind the EU average of 22%. This indicates the need for targeted initiatives to promote digital skill development within businesses [1].
- **ICT professionals and graduates.** While Slovakia's ICT specialists account for 4.3% of the workforce—slightly below the EU average of 4.6%—the country surpasses the EU in ICT graduates, with 4.4% compared to the EU's 4.2%. This presents a solid foundation for workforce development in the ICT sector [1].

Table 2 Broadband Coverage and 5G Network Adoption

Indicator	Slovakia DESI 2021	Slovakia DESI 2022	Slovakia DESI 2023	EU DESI 2023
At least 100 Mbps broadband take-up (% households)	28	29	33	55
At least 1 Gbps broadband take-up (% households)	0.4	1.1	0.9	13.8
Fixed Very High Capacity Network (VHCN) coverage (% households)	50	67	71	73
Fibre to the Premises (FTTP) coverage (% households)	49	62	67	56
Mobile broadband take-up (% individuals)	75	86	86	87
Overall 5G coverage (% populated areas)	0	14	55	81
5G spectrum (assigned spectrum as a % of total harmonised 5G spectrum)	67	67	67	68

Source: Author according to [1]

Table 2 summarizes digital infrastructure indicators for Slovakia compared to the EU, focusing on fixed broadband, 5G coverage, and national strategies for digital connectivity.

- **Fixed broadband.** Slovakia has made gradual progress in fixed broadband adoption, with households using at least 100 Mbps connections rising from 28% in 2020 to 33% in 2022. However, this remains far below the EU average of 55%. For 1 Gbps connections, Slovakia lags significantly, achieving only 0.9% compared to the EU

average of 13.8%. Meanwhile, fixed Very High-Capacity Network (VHCN) coverage improved from 67% in 2021 to 71% in 2022, nearing the EU average of 73%. Notably, fibre-to-the-premises (FTTP) coverage reached 67%, surpassing the EU's 56% [1].

- **Mobile networks and 5G coverage.** Mobile broadband adoption stands at 86%, close to the EU average of 87%. 5G network coverage saw rapid expansion from 14% in 2021 to 55% in 2022, though it remains below the EU average of 81%. In the crucial 3.4–3.8 GHz spectrum, Slovakia's 39% coverage aligns closely with the EU's 41% [1].
- **National strategies and plans.** The Slovak National Broadband Plan, adopted in 2021, aims to provide all households with 100 Mbps connections upgradeable to gigabit speeds. A feasibility study in 2022 supported this plan, resulting in €112 million allocated under the Slovakia Programme, co-financed by the European Regional Development Fund. However, the Recovery and Resilience Plan excludes connectivity investments, potentially slowing progress [1].
- **5G spectrum.** Approximately 67% of the harmonised 5G spectrum has been allocated, which corresponds to the level of previous years. The 3.6 gigahertz frequency band has been allocated to mobile operators who can use it to provide 5G services. New licences for the use of this band have been allocated with validity until 2045, with operators obliged to build a minimum of 300 5G access points nationwide by the end of 2027 [1].
- **Challenges and other aspects.** Covering Slovakia with 5G infrastructure remains a challenge, with the plan to cover rural areas heavily dependent on public investment and cooperation with operators. To support mobility and automation on railway corridors, a study funded through the Connecting Europe Facility programme is underway and due to be completed by the end of 2023. This study represents a key step towards modernising transport networks and improving digital infrastructure in Slovakia [1].

Table 3 Digitalisation of Enterprises: Technology Adoption and Usage

Indicator	Slovakia DESI 2021	Slovakia DESI 2022	Slovakia DESI 2023	EU DESI 2023
SMEs with at least a basic level of digital intensity (% SMEs)	-	-	60	69
Electronic information sharing (% enterprises)	31	31	31	38
Social media (% enterprises)	18	21	21	29
Big data (% enterprises)	6	6	6	14
Cloud (% enterprises)	-	31	31	34
AI (% enterprises)	-	5	5	8
e-Invoices (% enterprises)	17	17	17	32
SMEs selling online (% SMEs)	17	13	14	19
e-Commerce turnover (% SME turnover)	11	8	9	11
Selling online cross-border (% SMEs)	7	7	7	9

Source: Author according to [1]

Table 3 presents the results of an analysis of the digital intensity of Small and Medium Enterprises (SMEs) in Slovakia, including their use of electronic systems, social media, advanced technologies, e-invoices and engagement in e-commerce. These indicators provide

the basis for the more detailed analysis that follows and highlight the main challenges and gaps in the digitalisation of the business sector compared to the European Union average.

- **Digital intensity of SMEs.** Around 60% of Slovak SMEs meet at least a basic level of digital intensity, below the EU average of 69%. This indicates a need for stronger support and training in digital technologies to achieve the Digital Decade's 90% target by 2030 [1].
- **Electronic information sharing.** Only 31% of Slovak enterprises use enterprise resource planning software, significantly below the EU average of 38%, highlighting the need for modernized business processes and integrated information systems [1].
- **Social media.** Just 21% of Slovak businesses utilize social media, compared to the EU average of 29%, limiting their reach and communication with customers [1].
- **Advanced technologies: Big Data, cloud computing and artificial intelligence.** Adoption of big data analysis (6%), cloud computing (31%), and artificial intelligence (5%) in Slovak businesses remains below EU averages (14%, 34%, and 8%, respectively). Greater use of advanced technologies is essential to enhance competitiveness in the digital market [1].
- **Electronic invoices.** Only 17% of Slovak businesses use e-invoices, far below the EU average of 32%. This low adoption hampers financial process automation and business efficiency [1].
- **E-commerce.** The share of SMEs selling their products online was only 14% in 2022, below the European Union average of 19%. In terms of turnover from e-commerce, Slovak businesses had a share of 9%, while the European Union average was 11%. Only 7% of Slovak SMEs were selling products online to other EU Member States, compared to an average of 9%. These figures indicate the need for investment in digital infrastructure, strengthening digital marketing and education of entrepreneurs [1].

Table 4 E-Government and Digital Public Services in Slovakia and the EU

Indicator	Slovakia DESI 2021	Slovakia DESI 2022	Slovakia DESI 2023	EU DESI 2023
e-Government users (% internet users)	-	-	82	74
Digital public services for citizens (score 0 to 100)	-	65	67	77
Digital public services for businesses (score 0 to 100)	-	75	78	84
Pre-filled forms (score 0 to 100)	-	45	56	68
Transparency of service delivery, design and personal data (score 0 to 100)	-	44	46	65
User support (score 0 to 100)	-	74	80	84
Mobile friendliness (score 0 to 100)	-	83	88	93
Access to e-health records (score 0 to 100)	-	-	45	72

Source: Author according to [1]

Table 4 presents the results of the analysis of the digitalisation of public services in Slovakia, including the use of e-government, assessment of digital services for citizens and businesses, prepared forms, transparency, and access to electronic health records. The table also includes data on mobile identity and electronic identification, providing a comprehensive

view of the state of digitalisation of the public sector and its comparison with the European Union average. These data form the basis for a more detailed analysis and identification of challenges and opportunities in the digitalisation of public services.

- **Use of e-government services.** In 2022, 82% of Slovak internet users accessed e-government services, exceeding the EU average of 74%. This highlights Slovakia's potential to further enhance the accessibility and efficiency of digital public administration [1].
- **Digital public services for citizens and businesses.** Slovakia's index for digital services for citizens improved slightly, from 65 to 67 points, but remains below the EU average of 77. Similarly, services for businesses increased from 75 to 78 points, trailing the EU average of 84. More efforts are needed to improve usability and accessibility [1].
- **Ready-made forms and transparency of services.** In 2022, Slovakia scored 56 points in the Ready Forms Index and 46 points for transparency in service provision, significantly below EU averages of 68 and 65, respectively. These gaps indicate ongoing issues in user-friendliness and public trust [1].
- **Access to electronic health records.** Slovakia scored 45 points for electronic health records in 2022, far below the EU average of 72. Only 20% of the population has technical access to these records, which are not updated in real time. A lack of a mobile app further limits usability [1].
- **Mobile identity and digitalisation of processes.** The introduction of the "Slovakia on Mobile" app in June 2022 improved e-government access by eliminating the need for card readers. Plans are underway to expand mobile services for greater accessibility [1].
- **Electronic identification.** In 2022, 72% of the Slovak population had access to eID, aligning with the eIDAS regulation. Slovakia's participation in the European Digital Identity pilot projects underscores its progress toward integrating secure digital solutions [1].

The analysis showed mixed results for Slovakia in the area of digitalisation. In digital skills, the country scores slightly above average in basic digital skills and digital content creation skills, but lags behind in advanced digital skills and business engagement in employee training.

In digital infrastructure, significant progress has been made in fibre and high-capacity network coverage, but high-speed broadband adoption and 5G network coverage still lag behind the European Union average.

The digitalisation of businesses shows persistent shortcomings, with low adoption of advanced technologies such as big data, cloud computing and artificial intelligence. Businesses also show poor performance in e-commerce and e-invoicing. In digital public services, Slovakia has made progress in e-government services for citizens and businesses, but lags behind in transparency, user-friendliness and access to electronic health records. These challenges point to the need to improve the availability and quality of digital services.

Discussion and conclusion

The results of the analysis suggest that while Slovakia has made some progress in digitalisation, it is still lagging behind in a number of key areas. The digital skills of the population are a mixed bag. While 55% of the population has at least basic digital skills, slightly above the European Union average (54%), only 21% of the population has advanced digital skills, well below the average of 26%. This gap highlights the need for investment in education and skills development, with a strong emphasis on advanced digital skills, which are key to the modern labour market. This area illustrates that the main challenges for Slovakia in the digital transformation lie in the underdevelopment of advanced digital skills,

which directly answers the first research question on challenges compared to other EU Member States [1,2,6].

In the area of digital infrastructure, Slovakia has improved its coverage of high-capacity fixed networks (71% vs. 67% in 2021), bringing it closer to the European Union average (73%). Nevertheless, the adoption of gigabit connections is only 0.9%, compared to the European Union average of 13.8%. Similarly, 5G network coverage is 55%, well below the average of 81%. These disparities point to the need for greater investment in infrastructure and faster expansion of network capacity. The current situation also reveals Slovakia's limits in achieving the objectives of the European Union's Digital Decade, which answers the second research question on the extent to which the European digital transformation objectives are being met [3,7,8].

Business digitalisation remains a weakness, with the adoption of advanced technologies such as big data, cloud computing and artificial intelligence well below European Union averages. Only 6% of Slovak enterprises analyse big data, 31% use cloud computing and 5% use artificial intelligence, which is far from the Digital Decade targets (75%). E-commerce is another challenge, as only 14% of SMEs sell online, which is below the European Union average (19%). These results show that to effectively engage businesses in the digital transformation, the business sector needs to be more involved in employee training and to support the implementation of modern technologies. The answer to the third research question suggests that Slovakia urgently needs to increase the availability of support for businesses and strengthen their innovative potential [4,9,10].

Slovakia has made some progress in the area of digital public services. The e-government services index for citizens has risen to 67 points, but still lags behind the European Union average (77 points). Similarly, the index for businesses is at 78 points compared to the European Union average of 84 points. Particularly critical is the low level of access to electronic health records, where Slovakia scores only 45 points compared to the European Union average of 72. This reflects the need for comprehensive reforms in public services and healthcare, including increased transparency and accessibility of services. These challenges and proposals to address them confirm the importance of linking national strategies to the Digital Decade goals and strengthening collaboration between key actors [5,11,12].

These results point to the need for better integration of national strategies with the objectives of the Digital Decade of the European Union, deeper cooperation between the public and private sectors, support for research and development, and coordination between national and European strategies. The answers to the research questions underline the importance of investing in education, infrastructure and digitalisation of public services, which is essential for Slovakia's further progress in the digital transformation [6,7,13].

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