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A 1.3

Transnational SMEs digitalization gap-analysis and identification of key technologies and solutions that SMEs should embrace regarding digital transformation in production and logistics in the region

D.1.3.1

Gap analysis and technology solutions inventory

Document Control Sheet

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Contents

List of abbreviations

PP(s)	- Project Partner(s)
SMEs	- Small and Medium Enterprises
SO	- Specific Objective
EC	- European Commission
DR	- Danube Region
GDP	- Gross Domestic Product
ICT	- Information and Communication Technology
UNIDO	- United Nations Industrial Development Organization
EQuIP	- Enhancing the Quality of Industrial Policy
AI	- Artificial Intelligence
CC	- Cloud Computing
IoT	- Internet of Things
IIoT	- Industrial Internet of Things
BC	- Blockchain
IT	- Information Technology

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Summary

This deliverable supports the project's SO1, entitled "*Establishment of the Danube DNA Network and Platform*" by providing a detailed SMEs gap analysis, identifying key technologies for digital transformation in production and logistics, and creating a technology portfolio for priority sectors. Deliverable D1.3.1 is linked to Activity 1.3, with the main objective of providing a detailed digital readiness gap analysis at the national level in order to identify key groups of technologies and solutions that SMEs in the participating PP countries should adopt.

1. Introduction

1.1. Document background

In many countries, including the Danube Region, SMEs face multiple disruptions, such as supply chain issues, rising costs, reduced energy supply, and tighter credit conditions. Some of these challenges may be short-term, but others are becoming long-term vulnerabilities, especially for SMEs with non-digital business models. Digital tools can help mitigate immediate cost pressures and enhance long-term resilience, but their integration must be carefully evaluated due to potential drawbacks, such as rising cloud computing costs and supply chain fragility. Despite recent progress, digital transformation remains hindered by persistent barriers, including skills shortages and the need for continuous upskilling. Effective data management and digital security are increasingly critical, yet many SMEs lack the necessary awareness and expertise [1].

Public authorities, national and local governments, businesses of all sizes, industry associations, chambers of commerce, academia, and civil society can collaborate through various ways and initiatives to support SMEs in their digital transition and bridge the digital gap between small and large enterprises. One such initiative is the establishment of “one-stop shop” digital transformation centers for SMEs (called “molecules”) within the project Danube DNA. These digital transformation centers will provide SMEs in the Danube Region with support services to help them address digital challenges and enhance their competitiveness. According to European Commission (EC) and its Communication “2030 Digital Compass: the European way for the Digital Decade” [2], the following objectives for SME digitalization have been set:

- enabling access to digital technologies as-a-service by providing and improving local access to cloud-based industrial services platforms and marketplaces to increase the visibility of their production/manufacturing capacities,
- ensuring that at least 90% of SMEs reach a basic level of digital intensity,
- achieving at least 75% adoption of cloud computing services, big data, and artificial intelligence (AI).

The Danube DNA initiative will contribute to achieving these targets for the countries in the Danube Region. In this context, it is important to understand the needs of SMEs, national strategies regarding digitalization priorities, and the best approaches and technological solutions for their digital transformation. Additionally, ensuring a balanced digitalization effort across borders and industries is imperative.

This deliverable is part of **SO1**, entitled: *“Establishment of the Danube DNA Network and Danube DNA Platform”*, which, among other objectives, focuses on the development and

implementation of transnationally aligned smart specialization guidelines for the synchronized digital transformation of SMEs across the Danube Region. More specifically, the present report is part of *Activity 1.3*, which initially focuses on conducting a detailed SMEs gap analysis and identifying key technologies and solutions that SMEs in the participating project partners' (PPs) countries should adopt for digital transformation in production and logistics. Following this, *Activity 1.3* entails the development of a *portfolio or inventory* of key technologies and potential technology solutions suitable for different priority sectors identified earlier in the project.

1.2. Objectives of the Activity 1.3 and Deliverable 1.3.1

Activity 1.3 has a three-fold aim, and this deliverable D1.3.1 addresses the first two objectives. *The first objective* is to conduct a detailed gap analysis at the national level, building upon the findings presented in deliverables D1.2.1 and D1.2.2. This analysis focuses on identifying key technologies and solutions that SMEs in the participating PPs countries should adopt to drive digital transformation, mainly in production and logistics, on a national level.

The second objective, based on the results of the gap analysis, is to develop a structured inventory of suitable technological solutions tailored to different sectors. These sectors were prioritized by each PP country in Activity 1.2. The resulting portfolio of technologies will serve as a comprehensive repository of potential solutions, forming the basis for the development of joint solutions, as the main output of the Activity 3.1. These joint solutions will be adapted to specific country-industry context in the Danube Region, ensuring that digital transformation efforts align with sector-specific needs and national priorities.

2. Methodology

In general, gap analysis is a method used to evaluate an entity's current state and compare it to a desired or expected level of performance. The difference between these two states is referred to as a gap. This approach also helps assess whether previously allocated resources are being utilized efficiently and whether objectives are being met. By identifying these gaps, planners and key stakeholders can determine if their current strategies are effective and, if necessary, develop an action plan to bridge the gaps and achieve their goals.

This chapter describes the methodology used in the preparation of this report regarding gap analysis and technology solutions inventory. The starting point for conducting the gap analysis was the report provided on D1.2.1, which summarizes key insights on Smart Specialization Strategies (S3) at national, regional, and sectoral levels for each PP country. This report offered only a high-level overview of the S3 focus areas. Therefore, ***the first step was to analyze it in more detail to identify similarities and differences at the national level regarding sectoral and industry priorities***. The goal was to determine the critical sector or industry that should be the focus of the subsequent gap analysis. Particular attention will be given to the sectors/industries that are least represented when considering all PPs collectively.

Secondly, based on the report and materials provided on D.1.2.2, a comprehensive evaluation of digital readiness across DR countries will be provided. The analysis will assess the current digital maturity of each PP's country based on various foundational capabilities represented by UNIDO's EQuIP tool 8. Based on this assessment, tailored recommendations for each DR country will be specified, along with suggested collaboration and networking opportunities among PPs. ***In the third step***, ***the previously identified country specific recommendations will be cross-analyzed by cutting digital transformation themes and industry context to identify areas for potential improvement***, which will also serve as a basis for further development of Transnational guidelines for the smart specialization of the Danube Region, joint solutions development and pilot projects.

The fourth stage involves creating an appropriate pool of technology solutions that could be serve as a foundation for developing tailor-made solutions based on country-specific requirements.

3. S3 sectoral and industry priorities: a national level analysis

3.1. The S3: basic insights

Building on the key findings from *Deliverable D1.2.1*, it is important to recall that *Smart Specialization Strategy (S3)* aims to enhance regional productivity, competitiveness, and convergence by focusing resources and efforts on priority areas for innovation. This approach not only fosters regional specialization but also encourages the formation of industrial clusters capable of excelling in transnational value chains and exploiting cross-regional synergies.

By concentrating resources and efforts on priority areas for innovation, the S3 aims to enhance regional productivity, competitiveness, and convergence. This approach not only fosters regional specialization but also encourages the formation of industrial clusters capable of excelling in transnational value chains and exploiting cross-regional synergies. Central to the S3 strategy is the concept of "playing to strengths" which emphasizes the identification of a region's unique competitive advantages, whether they be specific industries, research expertise, or natural resources.

A variety of policy instruments are employed in S3 implementation, ranging from support for research, development, and innovation projects to education and training programs. These instruments aim to advance industrial modernization, collaboration, entrepreneurial discovery, and strategic priority setting. By aligning with EU funding priorities, S3 strategies ensure access to crucial financial resources necessary for effective implementation. ***The Danube DNA project supports S3 implementation by developing open source solutions that will enable SMEs accross the DR to digitally transform and enhance their ability to new business conditions***. In a market where industrial modernization and strategic priority setting are urgent and essential, the project provides SMEs with the necessary tools to remain competitive.

3.2. Sectoral priorities

Each country in the DR has identified sectoral priorities within their S3. However, there are differences in focus areas as it has shown in Table 3.1.

Regarding ***Automotive and Mobility*** sector, Austria, Bosnia and Herzegovina, Czech Republic, Germany, Hungary, Slovakia and Slovenia place a general emphasis on this industry. Austria explicitly specifies *production optimization, competitivity enhancement* and *innovative mobility* as key priorities, while Germany and Slovenia also highlighted *innovative*

mobility. For ***Mechanical Engineering and Mechatronics***, Austria, the Czech Republic, and Serbia clearly emphasize *advanced machinery development*, whereas Austria, Croatia, Bulgaria, Germany and Serbia target *production and manufacturing process improvement*. Slovakia and Slovenia take a broader approach, generally targeting the field of Mechanical Engineering and Mechatronics.

In the ***Healthcare***, the Czech Republic and Slovenia prioritize this area overall. Austria and Hungary specifically emphasize *AI diagnostics and smart care*, while Bulgaria stands out with focus on *biotechnology*. Montenegro uniquely prioritizes *health tourism*. The ***Tourism and Leisure Industry*** is in focus in Romania and Slovakia. Austria, Croatia, and the Czech Republic explicitly highlight *digital marketing* as an important aspect of this sector. Additionally, Croatia, the Czech Republic, Hungary and Serbia recognize the *creative industry* as a significant area of interest. Slovenia also specifies also *sustainable tourism* as a priority.

The ***ICT*** sector is included in the S3 of all PP countries, though with varying emphasis. The *Internet of Things (IoT)* and *Artificial Intelligence (AI)* are key focus areas in Austria, Germany, Serbia, Slovakia, and Slovenia. *Cybersecurity and digital infrastructure* are identified as critical in Bosnia and Herzegovina, Bulgaria, Croatia, Germany, Hungary, and Slovenia. *Big data and supercomputing* are explicitly mentioned in Austria, Hungary, Serbia, and Slovakia. In contrast, the ICT sector is included in general terms within the S3 strategies of the Czech Republic, Montenegro, and Romania. The ***Energy*** sector is prioritized in Bosnia and Herzegovina and Montenegro. Within this sector, *renewable energy* is emphasized in Croatia, while *energy efficiency* is uniquely prioritized in Hungary.

The ***Agriculture*** industry is identified as a priority in six PP countries. *Biotechnology* is highlighted in Bulgaria, Romania, and Slovakia, while *sustainable agriculture* is a key focus in Croatia, the Czech Republic, Montenegro, Serbia, and Slovenia. **The** *food industry and fisheries* are primary areas of interest in Hungary, Romania, and Serbia. In Bosnia and Herzegovina, the ***Agriculture*** sector is generally included in its S3 strategy. ***Life Sciences and Materials*** is the least specified sector in S3 strategies. *Life Sciences* is explicitly mentioned only in Germany, while *materials research* is highlighted in Slovenia.

Regarding ***Smart Cities***, Slovenia focuses on *smart communities*, and *smart buildings and homes*, while the Czech Republic and Slovakia include ***Smart Cities*** in their S3 strategies from a general perspective. The ***Economy*** sector is included in the S3 strategies of six PP countries. *Digital business and market solutions* are emphasized in Croatia, the Czech Republic, and Hungary, whereas Slovenia and Bulgaria highlight *sustainable and circular economy* approaches. Finally, *the shipping and clothing industries* are recognized as priorities in Romania.

Table 3.1: Comparison of the S3 priority areas in DR countries (national level)

S3 National Goals		AUT	BiH	BUL	CRO	CZE	GER	HUN	MNE	ROM	SER	SVK	SLO
Sectoral priorities/ Industry	**Technology/ digitalization focus**												
Automotive and mobility	Production optimization	X	X			X	X	X				X	X
	Innovative mobility	X											
	Competitivity enhancement	X											
Mechanical Eengineering / Mechatronics	Advanced machinery development	X				X					X	X	X
	Production / manufact. process improvement	X		X	X		X				X		
Healthcare	Telemedicine	X				X							X
	AI diagnostics and smart care	X						X					
	Biotechnology			X									
	Healt toursim								X				
	Personalized healtcare	X											
Tourism and leisure industry	Digital marketing	X			X	X				X		X	
	Customer engagement	X											
	Creative industry			X		X		X			X		
	Sustainable tourism												X
	Data analytics	X											
ICT	IoT	X				X	X		X	X	X	X	X

	AI	X					X				X	X	X
	Cyber security and digital infrast.		X	X	X		X	X					X
	Geolocation												X
	Time services												X
	Big data and supercomputing	X						X			X	X	
Energy	Renewable energy		X		X				X				
	Energy efficiency							X					
Agricultural	Biotechnology		X	X						X		X	
	Data analytics							X			X		
	Food industry / Fisheries							X		X	X		
	Sustainable agriculture				X	X			X		X		X
Smart Cities	Smart communities					X						X	X
	Smart buildings and home												X
Life Science and Materials	Life Science						X						
	Materials												X
Economy	Digital Business&Market Solution				X	X		X					
	Shipping industry									X			
	Sustainable and Circular economy			X									X
	Clothing industry									X			

As shown in Figure 3.1, the analysis of S3 strategies defined for the PPs countries has identified several common priority areas, including ***ICT***, ***Agriculture***, ***Tourism***, and ***Mechanical Engineering & Mechatronics***. These sectors exhibit a strong presence across multiple regions, indicating their strategic importance for economic and technological development. On the other hand, certain sectors are represented to a lesser extent within the analyzed S3 strategies. Notably, ***Energy, Smart City*** initiatives***,*** and ***Life Sciences*** appear with a lower percentage of representation. This suggests that, despite their potential for innovation and development, these areas may require additional support, targeted policies, and investment to enhance their role in regional and national economies.

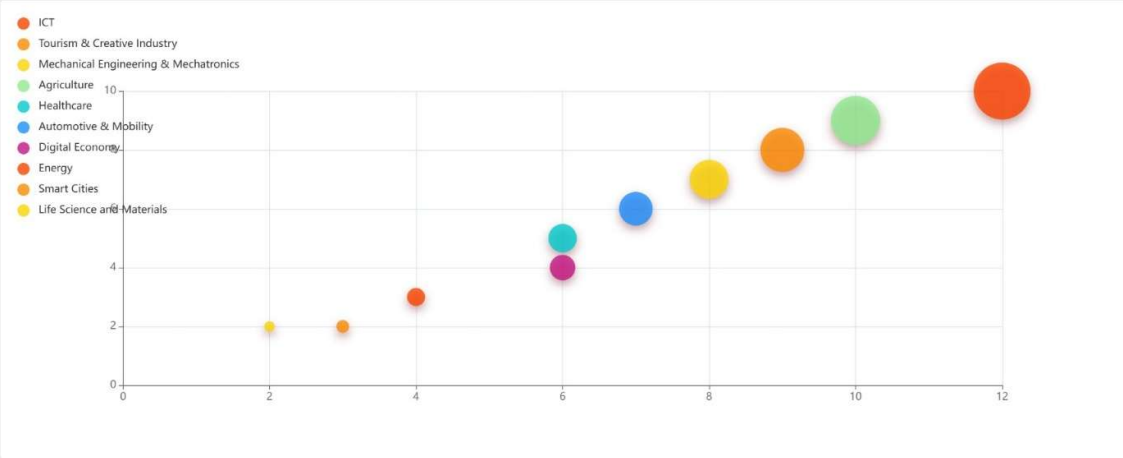


Figure 3.1: Distribution of S3 priority areas in the DR countries

When considering SMEs, it can be stated that they are present across all dominant priority areas. However, in less dominant areas within the analysed S3 strategies, ***the Energy sector*** stands out as requiring additional attention, particularly from the perspective of SMEs in the manufacturing and logistics sectors, which are relevant to the Danube DNA project. Regarding the digitalization of SMEs, key challenges include resistance to adopting digital technologies and innovations, often due to the strong presence of traditional industries. Additionally, high costs associated with implementation can hinder SMEs from fully participating in the digital transition. The Energy sector, particularly energy efficiency and the use of renewable energy sources, presents an opportunity for SMEs in their digital transformation. Improving energy efficiency can enhance their market competitiveness, and this can often be achieved through relatively accessible software and hardware solutions. Therefore, there is a need to foster expertise and innovation in this sector, focusing on affordable digital solutions. Furthermore, awareness-raising campaigns are essential to drive a cultural shift in business mindsets toward embracing energy-efficient and digitally-enabled practices.

3.3. Industry focus stated by national experts

After the first stage of the S3 analysis at the national level, the second stage involved discussions among all PPs and accompanying national experts before and during the realization of national training workshops. They reached a consensus on the strategic industries that should be the focus, primarily from the perspective of SMEs (Figure 3.2).

Industry - specific focus	PP1 - Faculty of Technical Sciences, University of Novi Sad	PP2- IT&C Cluster "Lower Danube"	PP3 - Foundation Cluster Information and Communication Technologies	PP4 - TERA TEHNOPOLIS Ltd.	PP5 - Institute of Technology and Business in České Budějovice	PP6 - South Trasndanubian Regional Innovation Agency	PP7 - Pomurje Technology Park	PP8 - SOVA Digital Inc.	PP9 - TUM International GmbH	PP10 - CAMPUS 02 University of Applied Sciences	PP11 - Sarajevo Economic Region Development Agency	PP12 - CHAMBER OF ECONOMY OF MONTENEGRO
SECTOR 1 (most preferable for selection of SMEs for participation at the training session)	manufacturing	creative industri	manufacturing	helathcare	manufacturing	creative industri	manufacturing	manufacturing	manufacturin	manufacturing	manufacturing	tourism
SECTOR 2 (most preferable for selection of SMEs for participation at the training session)	textile industry	textile industry	agriculture and food	agriculture ar	machinery	agriculture and f	agriculture and foo	machinery	energy and c	energy and clima	ICT	agriculture and foo
SECTOR 3 (most preferable for selection of SMEs for participation at the training session)	plastic industry	ICT	ICT	ICT	ICT						machinery	ICT
Training topics (Note: Each PP is expected to mark at least 4 items)												
Introdution: Digital transformation potentials for SMEs	x	x	x	X			X	X	X		X	X
Strategic Foresight for Digital Transformation of SMEs	x		x	X				X	X		X	
Reverse engineering / Additive manufacturing	x				x		X					
Artificial intelligence	x	x	x			x			X		X	
Guidelines for AI compliance			x						X		X	
Automation and robotics			x		x		X	X		X		
Energy efficiency			x	X	x					X	X	
Cyber security	x	x	x	X		x						X
Blockchain technologies	x	x		X	x							
Big data and analytics	x				x	x					X	X
Digital marketing				X		x					X	X
IoT			x		x							
Bio-informatics							X					
Additive manufacturing	x				x							
Smart actuators for technological processes					x			X				
Simulation modeling (towards products, processes and systems digital twins)	x		x					X				
Energy monitoring										x		

Legend for topics selection	
	Existing capabilities at PP - only theoretical concepts
	Existing capabilities at PP - only practical concepts
	Existing capabilities at PP - theoretical and practical concepts
	Considered as highly relevant, but no capabilities at PP

Figure 3.2. Overview of preferred industry and digital technologies stated by national experts

As shown in Figure 3.2, *Manufacturing* is identified as the primary strategic industry for PPs from Serbia, Bulgaria, the Czech Republic, Slovenia, Slovakia, Germany, Austria, and Bosnia and Herzegovina. In contrast, the *Creative Industry* is the main strategic choice for Romania and Hungary. *Healthcare* is highlighted as the key strategic focus for Croatia, while the PP from Montenegro has selected *Tourism* as its main strategic industry. Furthermore, the overview presented in Figure 3.2 consolidates all relevant information to support the identification of specific industries and cross-cutting digital technology pairs with the highest potential for implementation at the PP level.

4. Gap analysis of the digital readiness by country in the Danube Region

This section provides a comprehensive evaluation of digital readiness across individual Danube Region (DR) countries. The analysis assesses the current digital maturity of each PPs country based on various foundational capabilities represented by UNIDO's EQuIP tool 8. Based on this assessment, country-specific disparities and common challenges are identified.

4.1. Austria

The country-level dashboard, presented in Table 4.1, shows ***that Austria performs exceptionally well in most of the considered indicators. However, it lags in a few areas, such as Fixed broadband subscriptions, ISO 9001 certificates, Total patents produced, Imports and Exports of digital products, and Exports of computer and information services***. ***Overall, Austria ranks above the DR average and performs particularly well in infrastructure and innovation capabilities***.

Enabling Infrastructure - Austria exceeds the DR average in two out of three indicators, with outstanding performance in one: *Access of digital connectivity measured by fixed broadband subscriptions per 100 people*. Notably, Austria has received "green lights" in all three indicators, meaning its values exceed of 75% of EU countries, signaling strong readiness for digital transformation.

Production Capabilities – Regarding indicators for Production Capabilities, Austria is more or less in line with averages indicators values for the DR, with two out of four indicators above the average and other two are below it. However, it lags slightly more in the area of ISO 9001 certification. Additionally, Austria has received a "green light" only for the Productive Investment indicator, while for the others, it has received "red lights", meaning their values are at or below 25% of EU countries, signalling low readiness for digital transformation in this category.

Innovation Capabilities – The results in Table 4.1 show that Austria ranks above the DR average and performs well in Innovation Capabilities. Furthermore, Austria exceeds 75% of EU countries in four out of six indicators, with outstanding performance in the *Gross enrolment ratio in tertiary education (% of total enrollment)* and *Total patents in force per 100 billion USD GDP*. On the other hand, it has received "red lights" in the areas of *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP*.

Digital Capabilities - Austria exceeds the DR average only in one of four indicators: *Imports of computer and information services as a share of GDP*. In the case of EU level, Austria is in "green" for two and in "red" for other two indicators from this category.

Table 4.1: Austria Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Austria	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	8.25	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	29	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	45.56	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	25.30%	22.73%
	Productive skills	Mean years of schooling	2021	12.26	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.43	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.39%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	30.60%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	93.90%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	3.30%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	1536	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	24832	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.357%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.003%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.002%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	2.052%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	2.139%	2.437%

4.2. Bosnia and Herzegovina

The country-level dashboard, presented in Table 4.2, shows ***that Bosnia and Herzegovina performs ineffectively in most of the considered indicators***. However, ***in***

one area ***Gross expenditure in R&D (GDP) (%), it ranks above the DR average***. Additionally, the results from Table 4.2 show that ***Bosnia and Herzegovina's values in several areas,*** *such as Electricity consumption per capita, Fixed broadband subscriptions per 100 people, Mean download speed (Mbps), Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people,* and *Total patents in force per 100 billion USD GDP* ***exceed those of 75% of EU countries***.

Table 4.2: BiH Digital Readiness Dashboard

Layer	Indicator	Measure	Year	BiH	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	3.81	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	27	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	8.16	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	21.40%	22.73%
	Productive skills	Mean years of schooling	2021	10.54	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.29	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.06%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	23.96%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	43.60%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	2.00%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	281	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	123	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.027%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.002%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.000%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022		1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022		2.437%

Enabling Infrastructure – Bosnia and Herzegovina does not score near the DR average in any of the three indicators. However, it has received "green lights" in all three indicators, meaning its values exceed 75% of EU countries, signaling strong readiness for digital transformation regarding this category.

Production Capabilities – Similar to the previous category, Bosnia and Herzegovina falls short of the DR average in all four indicators. When comparing indicator values with the EU level, unlike in the previous category, Bosnia and Herzegovina has received "green lights" only in the area of *Share of Gross Fixed Capital Formation (GFCF) % Gross Domestic Product (GDP)*.

Innovation Capabilities – The results in Table 4.2 show that Bosnia and Herzegovina ranks above the DR average and performs well only in the area of *Gross expenditure in R&D (GDP) (%)*. When comparing indicator values with the EU level, apart to previously mentioned indicator, Bosnia and Herzegovina has received "green lights" in two additional areas: *Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP*.

Digital Capabilities - Bosnia and Herzegovina falls below the average in both indicators at both the DR and EU levels. Additionally, it is worth mentioning that no appropriate data was provided by the PPs for the other two indicators: *Deployment and adaptation of computer and information services* and *Industrial competitiveness in computer and information services.*

4.3. Bulgaria

The country-level dashboard, presented in Table 4.3, shows ***that Bulgaria underperforms in most of the considered indicators***. However, ***in three areas: Fixed broadband subscriptions per 100 people, Gross enrolment ratio in tertiary education (% of total enrollment)***, and ***Exports of computer and information services as a share of GDP, it ranks above the DR average***. Additionally, the results from Table 4.3 show that ***Bulgaria's values in several areas exceed those of 75% of EU countries***, ***performing well in Infrastructure and Innovation capabilities***.

Enabling Infrastructure – Bulgaria ranks above the DR average in only one of the three indicators. However, it has received "green lights" across all three, indicating that its value surpass those of 75% of EU countries, demonstrating strong readiness for digital transformation in this category.

Production Capabilities – As in the previous category, Bulgaria lags behind the DR average in three of the four indicators. When compared to the EU level, Bulgaria has received "green lights" solely for the *Share of Gross Fixed Capital Formation (GFCF) % Gross Domestic*

Product (GDP), unlike in the previous category where Bulgaria has received "green lights" across all three given indicators.

Table 4.3: Bulgaria Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Bulgaria	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	5.26	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	35	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	24.77	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	17.06%	22.73%
	Productive skills	Mean years of schooling	2021	11.41	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.98	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.29%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	19.50%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	74.00%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	0.80%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	594	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	2384	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.323%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.003%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.002%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	0.757%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	3.346%	2.437%

Innovation Capabilities – The results in Table 4.3 show that Bulgaria ranks above the DR average and performs well only in the area of *Gross enrolment ratio in tertiary education (% of total enrollment)*. Considering this indicator at the EU level, it falls between the 25th and 75th percentiles indicating performance that is within the median range ("yellow light"). Apart from this indicator, Bulgaria has received "green lights" in three additional areas: *Gross*

expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people, and *Total patents in force per 100 billion USD GDP.*

Digital Capabilities - Bulgaria outperforms the DR average in just one of the four indicators: *Exports of computer and information services as a share of GDP.* Compared to the EU level, Bulgaria is rated "green" for one indicator, "yellow" for another, and "red" for the remaining two indicators from this category.

4.4. Croatia

The country-level dashboard, presented in Table 4.4 shows ***that Croatia underperforms in most of the considered indicators***. However, ***in six areas:*** *Mean years of schooling, ISO 9001 certificates*, *IPR payments (royalties) per GDP, Percentage of graduates from STEM programmes in tertiary education (%), Gross enrolment ratio in tertiary education (% of total enrollment),* and *Scientific and technical journal articles per million people,* ***it ranks above the DR average***. Additionally, the results from Table 4.4 show that ***Croatia's values in several areas exceed those of 75% of EU countries***, ***performing well in Infrastructure and Innovation capabilities***.

Enabling Infrastructure – Similar to Bosnia and Herzegovina, Croatia does not perform near the DR average in any of the three indicators. Nevertheless, it has received "green lights" in all three indicators, meaning its values exceed 75% of EU countries, highlighting strong readiness for digital transformation regarding this category.

Production Capabilities – In contrast to the previous category, Croatia falls behind the DR average in just one of the four indicators. At the EU level, Croatia, like Bulgaria, Bosna and Herzegovina, and Austria, has received a "green light" solely for the *Share of Gross Fixed Capital Formation (GFCF) % Gross Domestic Product (GDP)*.

Innovation Capabilities – The results in Table 4.4 show that Croatia ranks above the DR average and performs well in three areas: *Percentage of graduates from STEM programmes in tertiary education (%), Gross enrolment ratio in tertiary education (% of total enrollment),* and *Scientific and technical journal articles per million people*. At the EU level, the *Gross enrolment ratio in tertiary education (% of total enrollment)* falls between the 25th and 75th percentiles indicating performance that is within the median range ("yellow light"). Apart this, Croatia has received "green lights" in three additional areas: *Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP.* However, for two indicators: *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP*, Croatia's values are ranked as "red", indicating weaker performance in these areas.

Digital Capabilities - Croatia falls below the DR average in all four indicators. Compared to the EU level, it receives a "green light" for one indicator, a "yellow light" for another, and "red lights" for the remaining two indicators from this category, mirroring Bulgaria's case in this category of Digital Capabilities.

Table 4.4: Croatia Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Croatia	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	4.48	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	27	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	20.74	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	19.63%	22.73%
	Productive skills	Mean years of schooling	2021	12.19	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.74	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.54%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	28.50%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	72.30%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	1.20%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	1186	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	1043	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.175%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.002%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.001%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	0.943%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	2.138%	2.437%

4.5. Czech Republic

The country-level dashboard, presented in Table 4.5, shows ***that Czech Republic performs exceptionally well in most of the considered indicators. However, it lags in four areas:*** *Mean download speed (Mbps), Percentage of graduates from STEM programmes in tertiary education (%), Total patents in force per 100 billion USD GDP,* and *Exports of computer and information services*. ***Overall, Czech Republic ranks above the DR average and performs particularly well in Production Capabilities***.

Table 4.5: Czech Republic Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Czech Rep.	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	6.35	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	38	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	39.15	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	26.80%	22.73%
	Productive skills	Mean years of schooling	2021	12.87	12.18
	Operational efficiency	ISO 9001 certificates	2021	1.13	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.56%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	25.90%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	69.10%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	2.00%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	1402	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	4321	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.285%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.014%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.014%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	1.327%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	2.372%	2.437%

Enabling Infrastructure – Czech Republic exceeds the DR average in two out of three indicators. Notably, Czech Republic has received "green lights" across all three indicators, meaning its values exceed of 75% of EU countries. This strong performance highlights the country's well-developed infrastructure, which serves as a solid foundation for digital transformation.

Production Capabilities – Regarding indicators for Production Capabilities, the Czech Republic performs exceptionally well, as expected from a country at a high stage of development. However, Czech Republic lags behind the EU level in three indicators, receiving the "red sign" for them. In contrast, its performance in *Productive Investment* represented by *Share of GFCF % GDP* exceeds that of 75% of EU countries, earning a "green light".

Innovation Capabilities – The Czech Republic also demonstrates strong innovation capabilities across most indicators relative to the DR average, except for *STEM graduates*, *Total patents in force per 100 billion USD GDP*, and *IPR receipts as % GDP*. At the EU level, the Czech Republic exceeds 75% of EU countries in three out of six indicators, with outstanding performance in *Scientific and technical journal articles per million people* and *Total patents in force per 100 billion USD GDP*. On the other hand, it has received "red lights" for *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP*, as well as "yellow light" for the *Gross enrolment ratio in tertiary education (% of total enrollment).*

Digital Capabilities – The results indicate that Czech Republic performs well in the last layer of digitalization capabilities due to its high share of production and digital technologies imports as a share of GDP. The country exceeds the DR average in three out of four indicators. In the case of EU level, Czech Republic is in "green" for two and in "red" for other two indicators from this category.

4.6. Germany

The country-level dashboard, presented in Table 4.6, shows ***that Germany performs exceptionally well in most of the considered indicators. However, it slightly lags in three areas:*** *Share of GFCF % GDP, ISO 9001 certificates,* and *Imports of digital products as a share of GDP.* Additionally, it ***significantly lags in additional two other areas***: *Imports of computer and information services as a share of GDP,* and *Exports of computer and information services*. ***Overall, Germany ranks above the DR average and performs particularly well in Infrastructure and Innovation Capabilities***.

Enabling Infrastructure – In this set of indicators, that measures a country's effort to build up the preconditions, e.g. the necessary infrastructure to digitalize the productive structure, Germany performs above DR average in all three indicators, with an exceptional performance in one indicator, namely the *Quality of connectivity* measured by the *mean*

download speed. Consequently, Germany has received "green lights" across these three indicators, meaning its values exceed of 75% of EU countries.

Table 4.6: Germany Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Germany	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	6.40	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	45	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	72.95	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	22.09%	22.73%
	Productive skills	Mean years of schooling	2021	14.09	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.57	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.49%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	35.80%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	75.70%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	3.10%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	1315	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	30552	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	1.306%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.003%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.003%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	0.315%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	0.372%	2.437%

Production Capabilities – In contrast to the previous category, Germany slightly falls behind the DR average in two out of four indicators: *Share of Gross Fixed Capital Formation (GFCF) % Gross Domestic Product (GDP)* and *ISO 9001 certificates*. At the EU level, Germany, like all DR countries, has received a "green light" only for the *Share of Gross Fixed*

Capital Formation (GFCF) % Gross Domestic Product (GDP), indicating strong performance in this specific area while lagging in others.

Innovation Capabilities – The Germany also demonstrates strong innovation capabilities across all indicators relative to the DR average. At the EU level, the Germany exceeds 75% of EU countries in three out of six indicators, with outstanding performance in *Scientific and technical journal articles per million people* and *Total patents in force per 100 billion USD GDP*. It has received "red lights" only for *Percentage of graduates from STEM programmes in tertiary education (%)*, as well as "yellow light" for two areas *Gross enrolment ratio in tertiary education (% of total enrollment),* and *Intellectual property rights receipts (royalties) as % GDP*.

Digital Capabilities – The results from the Table 4.6 indicate that Germany performs poorly in the final layer of digitalization capabilities, primarily due to its lower share of production and digital technologies import as a share of GDP. Germany does not exceed the DR average in any indicators. At the EU level, Germany has received a "green light" for one indicator, a "yellow light" for another, and a "red light" for the remaining two indicators.

4.7. Hungary

The country-level dashboard, presented in Table 4.7, shows ***that Hungary performs well in half of the considered indicators. It lags in nine areas:*** *Electricity consumption per capita, Mean download speed (Mbps),* in all areas regarding *Innovation Capabilities* except *Intellectual property rights receipts (royalties) as % GDP,* and *Exports of computer and information services*. Additionally, the results from Table 4.7 show that ***Hungary's values in several areas exceed those of 75% of EU countries***, ***performing particularly well in Production Capabilities.***

Enabling Infrastructure – Hungary exceeds the DR average only in one out of three indicators (*Fixed broadband subscriptions per 100 people*). Notably, Hungary has received "green lights" across all three indicators, meaning its values exceed of 75% of EU countries. This strong performance highlights the country's well-developed infrastructure, which serves as a solid foundation for digital transformation.

Production Capabilities – Regarding indicators for *Production Capabilities*, Hungary performs exceptionally well at the DR level. However, it lags behind the EU level in three indicators, receiving the "red sign" for them. In contrast, its performance in *Productive Investment* represented by *Share of GFCF % GDP* exceeds that of 75% of EU countries, earning a "green light".

Innovation Capabilities – The results in Table 4.7 show that Hungary ranks above the DR average and performs well only in one area: *Intellectual property rights receipts*

(royalties) as % GDP. At the EU level, the *Gross enrolment ratio in tertiary education (% of total enrollment)* falls between the 25th and 75th percentiles indicating performance that is within the median range ("yellow light"). Apart this, Hungary has received "green lights" in three additional areas: *Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP.* However, for two indicators: *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP* (even the result is highly above DR average), the values are ranked as "red", indicating weaker performance in these areas.

Table 4.7: Hungary Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Hungary	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	4.65	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	35	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	42.99	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	28.18%	22.73%
	Productive skills	Mean years of schooling	2021	12.25	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.67	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.77%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	15.50%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	56.50%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	1.60%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	767	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	4263	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.903%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.009%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.007%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	1.329%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	1.758%	2.437%

Digital Capabilities – The results indicate that Hungary performs well in the last layer of digitalization capabilities due to its high share of production and digital technologies imports as a share of GDP. The country exceeds the DR average in three out of four indicators. In the case of EU level, Hungary is in "green" for two and in "red" for other two indicators from this category.

4.8. Montenegro

The country-level dashboard, presented in Table 4.8, shows ***that Montenegro performs ineffectively in almost all the considered indicators***. That is, ***only in two areas*** *Imports of computer and information services as a share of GDP* and *Exports of computer and information services as a share of GDP****, it ranks above the DR average***. Additionally, the results from Table 4.8 show that ***Montenegro's values in several areas,*** *such as Electricity consumption per capita, Fixed broadband subscriptions per 100 people, Mean download speed (Mbps), Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people****,*** *Total patents in force per 100 billion USD GDP, Imports of computer and information services as a share of GDP,* and *Exports of computer and information services as a share of GDP* ***exceed those of 75% of EU countries***.

Enabling Infrastructure – Montenegro, very similarly to Bosnia and Herzegovina, does not score near the DR average in any of the three indicators. However, it has received "green lights" in all three indicators, meaning its values exceed 75% of EU countries, signaling strong readiness for digital transformation regarding this category.

Production Capabilities – Similar to the previous category, Montenegro falls short of the DR average in three out of four indicators. However, in the *Mean years of schooling* category, it aligns with the DR average. When comparing indicator values with the EU level, unlike in the previous category, Montenegro has received "green lights" only in the area of *Share of Gross Fixed Capital Formation (GFCF) % Gross Domestic Product (GDP)*.

Innovation Capabilities – The results in Table 4.8 show that Montenegro ranks below the DR average regarding entire set of indicators. When comparing indicator values with the EU level, Montenegro has received "green lights" in two areas: *Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP*. Additionally, it is worth mentioning that no appropriate data was provided by the PPs for two indicators: *Percentage of graduates from STEM programmes in tertiary education (%)*, and *Gross expenditure in R&D (GDP) (%)*.

Digital Capabilities - Montenegro falls below the average in two indicators at both the DR and EU levels (*Imports of digital products as a share of GDP*, and *Exports of digital products as a share of GDP*). For two other indicators regarding *Imports* and *Exports of*

computer and information services as a share of GDP, Montenegro is well performed at the both the DR and EU level.

Table 4.8: Montenegro Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Montenegro	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	5.01	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	31	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	38.65	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	21.51%	22.73%
	Productive skills	Mean years of schooling	2021	12.18	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.26	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.11%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021		26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	56.80%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022		1.68%
	Research output	Scientific and technical journal articles per million people	2020	498	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	498	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.015%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.002%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.000%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	1.485%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	3.055%	2.437%

4.9. Romania

The country-level dashboard, presented in Table 4.9 shows ***that Romania underperforms in most of the considered indicators***. However, ***in five areas:*** *Mean download speed (Mbps), Share of GFCF % GDP, Percentage of graduates from STEM*

programmes in tertiary education (%), Imports of computer and information services as a share of GDP and *Exports of computer and information services as a share of GDP, **it ranks above the DR average***. Additionally, the results from Table 4.9 show that ***Romania's values in several areas exceed those of 75% of EU countries***, ***performing well in Infrastructure and Innovation capabilities***.

Table 4.9: Romania Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Romania	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	2.90	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	32	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	112.39	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	24.94%	22.73%
	Productive skills	Mean years of schooling	2021	11.28	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.56	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.32%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	29.10%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	55.30%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	0.50%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	504	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	1105	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.032%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.003%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.001%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	1.315%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	3.266%	2.437%

Enabling Infrastructure – Romania does not perform near the DR average in two out of three categories. However, in terms of *Mean download speed (Mbps)*, it performs

extraordinary. Nevertheless, it has received “green lights” in all three indicators, meaning its values exceed 75% of EU countries, highlighting strong readiness for digital transformation regarding this category.

Production Capabilities – Similarly to the previous category, Romania performs above the DR average in just one of the four indicators. At the EU level, Romania, like most of the DR countries, has received a “green light” solely for the *Share of Gross Fixed Capital Formation (GFCF) % Gross Domestic Product (GDP)*.

Innovation Capabilities – The results in Table 4.9 show that Romania ranks above the DR average and performs well only in area of *Percentage of graduates from STEM programmes in tertiary education (%)*. At the EU level, the *Gross enrolment ratio in tertiary education (% of total enrollment)* falls between the 25th and 75th percentiles indicating performance that is within the median range (“yellow light”). Apart this, Romania has received “green lights” in three areas: *Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP.* However, for two indicators: *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP*, Romania’s values are ranked as “red”, indicating weaker performance in these areas.

Digital Capabilities - Romania falls below the DR average in two out of four indicators. In the case of EU level, Romania receives a “green” rating for two indicators, a “red” rating for one indicator, and a “yellow” rating for another.

4.10. Serbia

The country-level dashboard, presented in Table 4.10 shows ***that Serbia underperforms in most of the considered indicators***. However, ***in seven areas:*** *Mean download speed (Mbps), Share of GFCF % GDP, IPR payments (royalties) per GDP, Percentage of graduates from STEM programmes in tertiary education (%), Gross enrolment ratio in tertiary education (% of total enrollment),* and *Exports of computer and information services as a share of GDP,* ***it ranks above the DR average***. Additionally, the results from Table 4.10 show that ***Serbia’s values in several areas exceed those of 75% of EU countries***, ***performing well in Infrastructure and Innovation capabilities***.

Enabling Infrastructure – Serbia falls below the DR average in two out of three categories. However, in terms of *Mean download speed (Mbps)*, it performs well. Nevertheless, it has received “green lights” in all three indicators, meaning its values exceed 75% of EU countries, highlighting strong readiness for digital transformation regarding this category.

Table 4.10: Serbia Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Serbia	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	5.03	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	26	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	51.84	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	24.16%	22.73%
	Productive skills	Mean years of schooling	2021	11.37	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.52	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	1.01%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	30.50%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	68.70%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	1.00%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	687	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	1213	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.331%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.003%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.001%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	0.987%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	4.236%	2.437%

Production Capabilities – Regarding indicators for *Production Capabilities*, Serbia performs relatively well at the DR level, with two indicators above and two indicators below the DR average. However, it lags behind the EU level in three indicators, receiving the "red sign" for them. In contrast, its performance in *Productive Investment* represented by *Share of GFCF % GDP* exceeds that of 75% of EU countries, earning a "green light".

Innovation Capabilities – The results in Table 4.10 show that Serbia ranks above the DR average and performs well in two areas: *Percentage of graduates from STEM programmes*

in tertiary education (%), and *Gross enrolment ratio in tertiary education (% of total enrollment)*. At the EU level, the *Gross enrolment ratio in tertiary education (% of total enrollment)* falls between the 25th and 75th percentiles indicating performance that is within the median range ("yellow light"). Apart this, Serbia has received "green lights" in three additional areas: *Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP.* However, for two indicators: *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP*, Serbia's values are ranked as "red", indicating weaker performance in these areas.

Digital Capabilities - Serbia falls below the DR average in three out of four indicators. Compared to the EU level, it receives a "green light" for one indicator, a "yellow light" for another, and "red lights" for the remaining two indicators from this category, indicating generally weak performance in the last layer of digitalization capabilities.

4.11. Slovakia

The country-level dashboard, presented in Table 4.11, shows ***that Slovakia, much like Hungary, performs well in half of the considered indicators. It lags in nine areas:*** *Fixed broadband subscriptions per 100 people, Mean download speed (Mbps), Share of GFCF % GDP, in almost all areas* regarding *Innovation Capabilities* except for *Intellectual property rights receipts (royalties) as % GDP,* and *Scientific and technical journal articles per million people.* It also lags in *Imports* and *Exports of computer and information services*. Additionally, the results from Table 4.11 show that ***Slovakia's values in several areas exceed those of 75% of EU countries***, ***performing particularly well in Production Capabilities.***

Enabling Infrastructure – Slovakia exceeds the DR average only in one out of three indicators (*Fixed broadband subscriptions per 100 people*). Notably, Slovakia has received "green lights" across all three indicators, meaning its values exceed of 75% of EU countries.

Production Capabilities – Regarding indicators for *Production Capabilities*, Slovakia performs exceptionally well at the DR level, except *Share of GFCF % GDP*. However, like all other countries in the DR it lags behind the EU level in three indicators, receiving the "red sign" for them. In contrast, its performance in *Productive Investment* represented by *Share of GFCF % GDP* exceeds that of 75% of EU countries, earning a "green light".

Innovation Capabilities – The results in Table 4.11 show that Slovakia ranks above the DR average and performs well only in two areas: *Scientific and technical journal articles per million people* and *Intellectual property rights receipts (royalties) as % GDP*. At the EU level, Slovakia has received "green lights" in three areas: *Gross expenditure in R&D (GDP) (%), Scientific and technical journal articles per million people*, and *Total patents in force per 100 billion USD GDP.* However, for the other three indicators: *Percentage of graduates from*

STEM programmes in tertiary education (%), Gross enrolment ratio in tertiary education (% of total enrollment) and *Intellectual property rights receipts (royalties) as % GDP* the values are ranked as "red", indicating weaker performance in these areas.

Table 4.11: Slovakia Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Slovakia	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	4.66	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	33	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	21.19	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	20.08%	22.73%
	Productive skills	Mean years of schooling	2021	12.91	12.18
	Operational efficiency	ISO 9001 certificates	2021	0.71	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.64%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	22.20%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	50.70%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	0.90%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	993	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	2,016	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.045%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.010%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.006%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022	1.063%	1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022	1.685%	2.437%

Digital Capabilities - Slovakia falls below the DR average in two out of four indicators. Compared to the EU level, it receives a "green light" for one indicator, a "yellow light" for another, and "red lights" for the remaining two indicators from this category, indicating generally weak performance in the last layer of digitalization capabilities.

4.12. Slovenia

The country-level dashboard, presented in Table 4.12, shows ***that Slovenia, much like Hungary and Slovakia, performs well in half of the considered indicators.***

Table 4.12: Slovenia Digital Readiness Dashboard

Layer	Indicator	Measure	Year	Slovenia	DR average
Enabling Infrastructure	Energy availability	Electricity consumption per capita	2022	6.75	5.30
	Access to digital connectivity	Fixed broadband subscriptions per 100 people	2022	32	32.68
	Quality of connectivity	Mean download speed (Mbps)	2022	38.15	43.05
Production Capabilities	Productive investments	Share of GFCF % GDP	2022	21.62%	22.73%
	Productive skills	Mean years of schooling	2021	12.8	12.18
	Operational efficiency	ISO 9001 certificates	2021	1.03	0.66
	Technology absorption	IPR payments (royalties) per GDP	2022	0.47%	0.47%
Innovation Capabilities	Specialized skills	Percentage of graduates from STEM programmes in tertiary education (%)	2021	28.60%	26.38%
	Advanced skills	Gross enrolment ratio in tertiary education (% of total enrollment)	2022	82.20%	66.57%
	Research effort	Gross expenditure in R&D (GDP) (%)	2022	2.10%	1.68%
	Research output	Scientific and technical journal articles per million people	2020	1821	965
	Innovation output (patents)	Total patents in force per 100 billion USD GDP	2022	6177	6543
	Innovation output (royalties)	Intellectual property rights receipts (royalties) as % GDP	2022	0.260%	0.338%
Digital Capabilities	Deployment and adaptation of digital production technologies	Imports of digital products as a share of GDP	2022	0.004%	0.005%
	Industrial competitiveness in digital technologies	Exports of digital products as a share of GDP	2022	0.002%	0.003%
	Deployment and adaptation of computer and information services	Imports of computer and information services as a share of GDP	2022		1.157%
	Industrial competitiveness in computer and information services	Exports of computer and information services as a share of GDP	2022		2.437%

Slovenia lags in seven areas: *Fixed broadband subscriptions per 100 people, Mean download speed (Mbps), Share of GFCF % GDP, Total patents in force per 100 billion USD*

GDP, Intellectual property rights receipts (royalties) as % GDP, Imports and *Exports of digital products as a share of GDP*. Additionally, the results from Table 4.12 show that ***Slovenia's values in several areas exceed those of 75% of EU countries***, ***performing particularly well in Innovation Capabilities.***

Enabling Infrastructure – Slovenia exceeds the DR average only in one out of three indicators (*Electricity consumption per capita*). However, it is important to note that its value for the other two indicators are just below the DR average. Notably, Slovenia has received "green lights" across all three indicators, meaning its values exceed of 75% of EU countries.

Production Capabilities – Regarding indicators for *Production Capabilities*, Slovenia, very much similar to Slovakia, performs exceptionally well at the DR level, except *Share of GFCF % GDP*. However, like all other countries in the DR it lags behind the EU level in three indicators, receiving the "red sign" for them. In contrast, its performance in *Productive Investment* represented by *Share of GFCF % GDP* exceeds that of 75% of EU countries, earning a "green light".

Innovation Capabilities – Like Germany, Slovenia also demonstrates strong innovation capabilities across all indicators relative to the DR average. Only for two indicators *Total patents in force per 100 billion USD GDP* and *Intellectual property rights receipts (royalties) as % GDP* its value are just below the DR average. At the EU level, Slovenia exceeds 75% of EU countries in four out of six indicators, with outstanding performance in *Gross enrolment ratio in tertiary education (% of total enrollment)*. It has received "red lights" only for *Percentage of graduates from STEM programmes in tertiary education (%)* and *Intellectual property rights receipts (royalties) as % GDP*.

Digital Capabilities - Slovenia falls below the DR average in two out of four indicators. For these same two indicators, Slovenia receives a "red light" when compared to the EU level. For the remaining two indicators from this category (*Imports* and *Exports of computer and information services as a share of GDP*), no relevant data was provided by the PP.

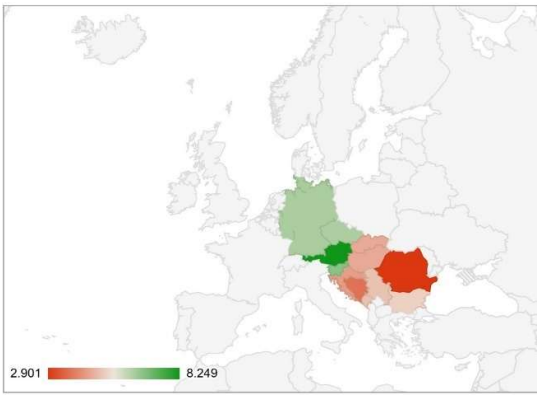
4.13. Summary of findings from individual country assessments

In this section of the report, a summary of findings from individual country assessments is presented in the form of a comparative analysis of digital readiness across the DR countries is provided. The analysis is conducted in two ways. First, the digital readiness level of DR countries is evaluated in comparison to the EU level. Then, the distribution of countries across key indicators is visualized using geomaps.

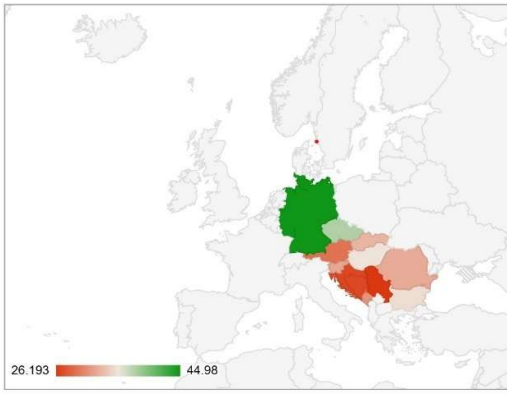
By analysing these key indicators, it is possible to identify potential areas for improvement in each country and the DR as a whole. These findings will help in understanding

the current state of digitalization and in defining joint solutions to enhance digital transformation of SMEs.

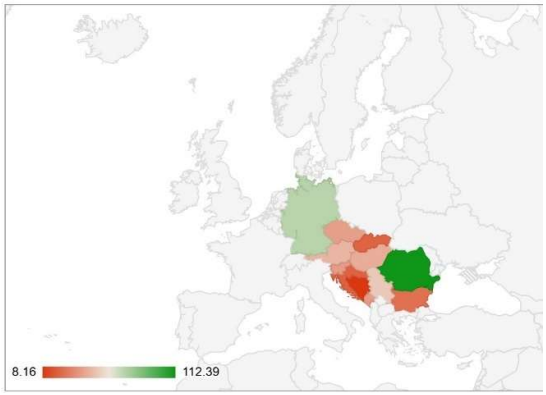
When it comes to ***Enabling infrastructure***, as an essential precondition for adopting digital technologies, the entire DR is in the "green light", meaning that each country's values exceed of 75% of EU countries. However, insights from the geomaps reveal some variation in distribution of values across partner countries for the three key indicators. Overall, Germany stands out as the country with almost the highest values for all three parameters, while Romania stands out in terms of Quality of connectivity (Figure 4.1).



Energy availability
(*Electricity consumption per capita*)



Access to digital connectivity
(*Fixed broadband subscriptions per 100 people*)



Quality of connectivity
(*Mean download speed (Mbps)*)

Figure 4.1: Geomap representation on Enabling Infrastructure

In contrast to Enabling infrastructure, where all DR countries are in the "green light", the situation for ***Production capabilities*** is quite the opposite. Except the indicator Productive investments, all other indicators show that DR countries perform below the lower quartile benchmark compared to EU countries. Czech Republic, Slovakia and Hungary exhibit the particular critical strengths in this layer of digitalization (Figure 4.2). On the other hand, Bosnia and Herzegovina and Montenegro demonstrates low performance, particularly in the areas of Operational efficiency and Technology absorption.

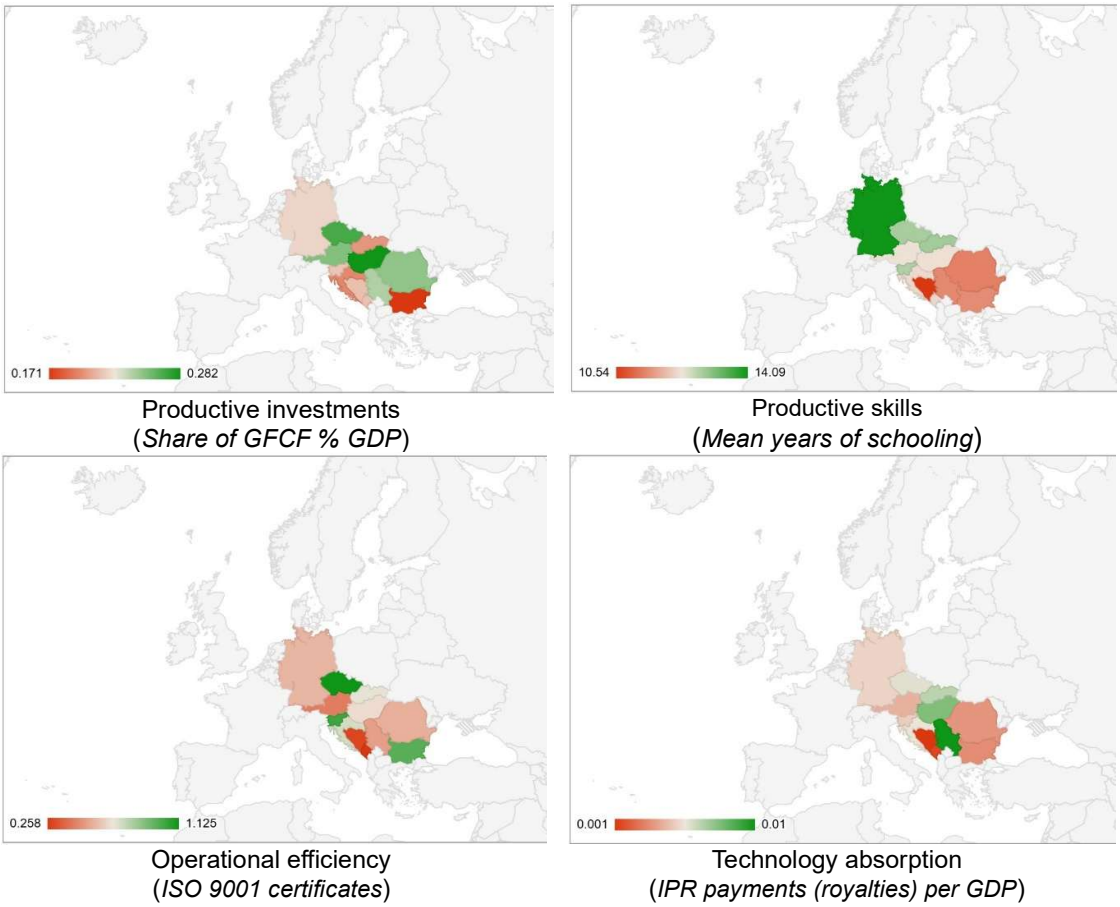
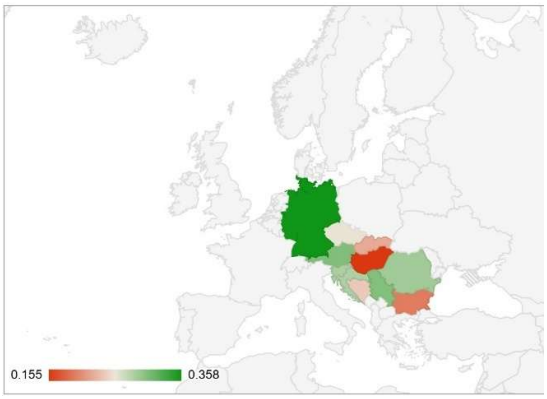


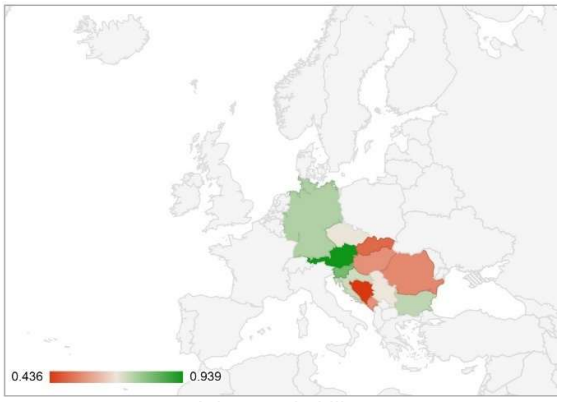
Figure 4.2: Geomap representation on Production Capabilities

The third layer considers the role ***Innovation capabilities*** in the adoption and engagement with digital technologies. Regarding this set of indicators, the entire DR performs well in comparison to the EU level. Within the intra DR ladders, Germany and Austria are the best performing countries. Notably, in terms of Innovation outputs, measured by intellectual property rights receipts and total patents, all countries significantly underperform compared to Germany, Austria and Hungary, highlighting their lower level of capability in terms of absorbing and developing digital technologies. One way to enhance this capability is by establishing digital innovation hubs, facilitating cross-border cooperation, and promoting the adoption of digital technologies through appropriate support initiatives.

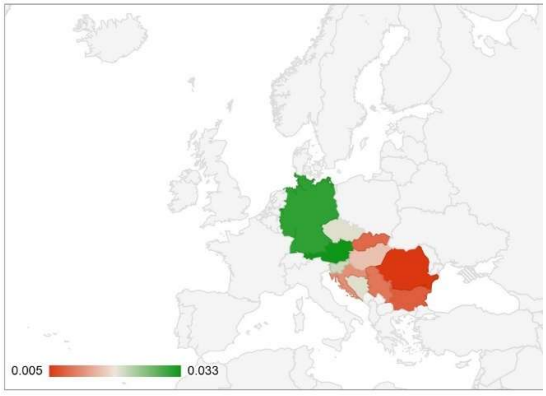
The fourth layer, ***Digital capabilities,*** captures both the exposure to and deployment of digital technologies, as well as technologies imports. The values for this set of indicators, when compared to EU countries, indicate that the DR must increase investment in digital capabilities.



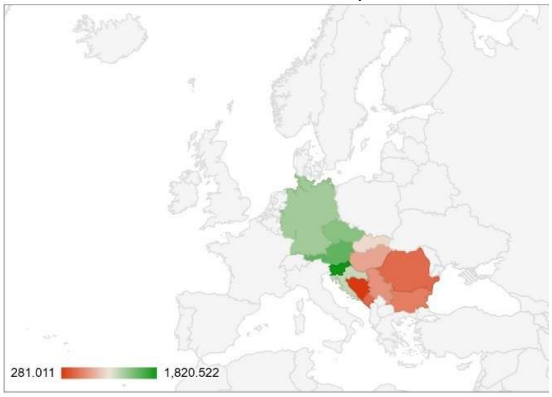
Specialised skills
(*Percentage of graduates from STEM programmes in tertiary education (%)*)



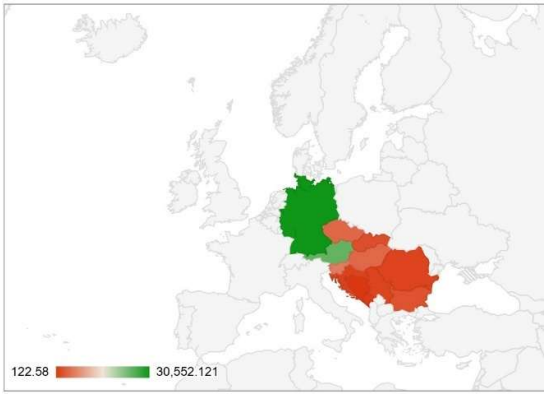
Advanced skills
(*Gross enrolment ratio in tertiary education (% of total enrollment)*)



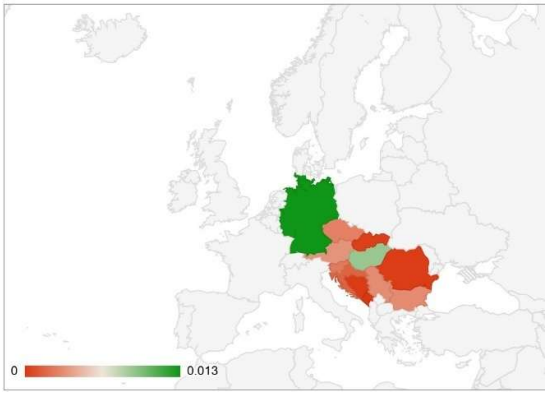
Research effort
(*Gross expenditure in R&D (GDP) (%)*)



Research output
(*Scien. and techn. journal articles per million peop.*)



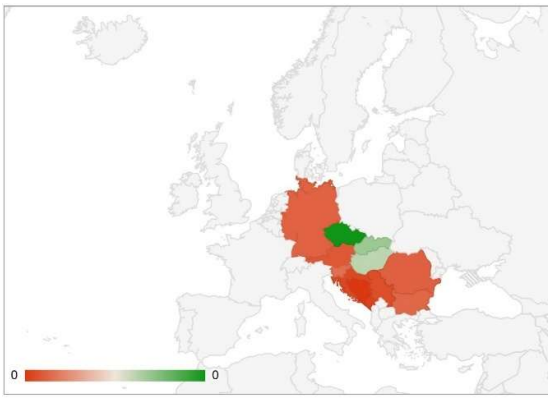
Innovation outputs (patents)
(*Total patents in force per 100 billion USD GDP*)



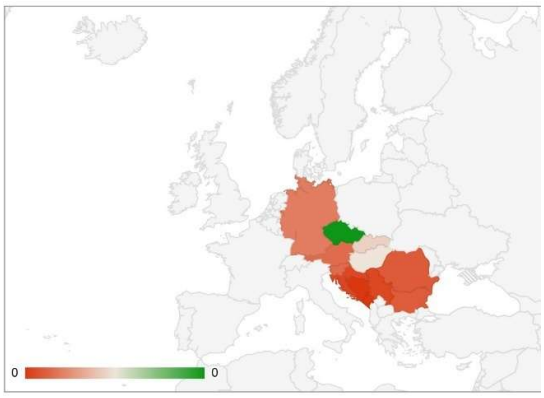
Innovation output (royalties)
(*Intellectual property rights receipts (royalties) as % GDP*)

Figure 4.3: Geomap representation on Innovation Capabilities

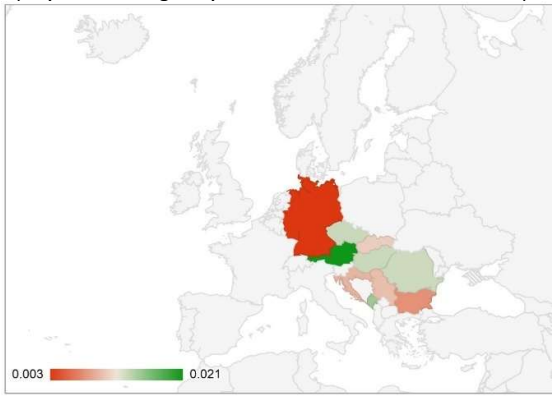
According to the distribution of indicator performance across DR countries, there is a notably low level of imports and exports of digital products as a share of GDP. This indicate that DR countries needs to import digital technologies and adapt them for deployment in their production systems. Conversely, the low export of digital products reflects the low country's competitiveness in digital technologies. Therefore, cross-border cooperation, as well as the development and deployment of new digital solutions should be a priority.



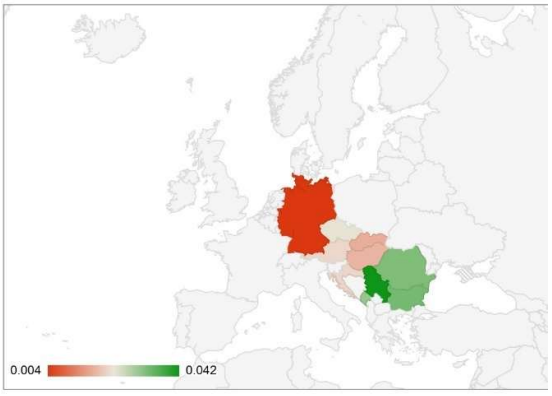
Deployment and adaptation of digital production technologies
(*Imports of digital products as a share of GDP*)



Industrial competitiveness in digital technologies
(*Exports of digital products as a share of GDP*)



Deployment and adaptation of computer and information services
(*Imports of computer and information services as a share of GDP*)



Industrial competitiveness in computer and information services
(*Exports of computer and information services as a share of GDP*)

Figure 4.4: Geomap representation on Digital Capabilities

5. Identification of priorities and key technologies for digital transformation

5.1. Identification of common challenges and priorities across PPs countries

After analyzing common S3 areas at the national level, as well as the strategic industries prioritized by PP countries, the following areas have been identified as priorities for the DR from the perspective of SMEs in production and logistics: ***ICT***, ***Manufacturing***, and ***Energy***. The ICT sector is considered a priority due to its crucial role in supporting the digital transformation of production and manufacturing. This transformation has led to the development of entirely new manufacturing processes and technologies, represented by the ICT subsector—ICT manufacturing. Manufacturing has been directly identified as the primary strategic industry for the majority of PP countries. Additionally, it is the core industry sector concerning the SOs of the Danube DNA project. The Energy sector has been recognized as requiring additional attention, particularly from the perspective of SMEs in manufacturing and logistics. Its significance lies in its impact on overall business competitiveness, especially in the context of a highly volatile and unpredictable energy market.

On the other hand, findings from digital readiness assessments indicate that ***Digital Capabilities*** are a key area for improvement at both the Danube Region (DR) and individual country levels. The results show that DR countries have a low level of digital technology deployment and development, as well as low industrial competitiveness in digital technologies. Therefore, the broad development and implementation of new digital solutions should be considered a priority.

According to abovementioned results of the project activities, the following three cross-cutting digital transformation themes (or enablers) for developing joint solutions in the context of SMEs are proposed:

1. ***Business Digital Transformation Enablers***,
2. ***Energy Efficiency Enablers***,
3. ***Production Optimization Enabler***.

The objective of Business Digital Transformation Enablers is to facilitate and accelerate the adoption of digital technologies, enhancing SMEs' competitiveness, efficiency, and resilience in an increasingly volatile economy. Specifically, their objectives include enhancing digital capabilities, improving business productivity and efficiency, enhancing decision making, and enabling market expansion and funding access.

Concretely, ***Business Digital Transformation Enablers*** will consist of a cluster of three solutions designed to help SMEs define an appropriate pathway toward digital transformation, identify suitable business solutions, and secure funding for their implementation. The proposed solutions are:

- ***Digital Maturity Assessment***,
- ***Digital Business Solutions Generator***,
- ***Digital Project Proposal Generator***.

The objective of Energy Efficiency Enablers is to enhance energy efficiency, reduce operational costs, and improve sustainability of SMEs through the adoption of smart energy management technologies. These enablers help SMEs optimize energy consumption, comply with environmental regulations, and increase competitiveness in an increasingly energy-conscious market. Therefore, in this project, the ***Energy Efficiency Enablers*** should focus on developing two solutions:

- ***Energy Optimization***,
- ***Energy Measurement***.

The objective of Production Optimization Enablers is to enhance production efficiency, reduce waste, and improve overall performance through data-driven and smart manufacturing technologies. These enablers support SMEs in adopting high-tech solutions to optimize production processes, improve resource utilization, and increase competitiveness. In this project, within the context of Production Optimization Enablers, the aim is to develop the following solution, leveraging one of the most promising and emerging technologies for enhancing production efficiency:

- ***Production Optimization Solution based on AI***.

The abovementioned priorities regarding digital transformation themes will be the focus of the upcoming project activities, specifically the development of joint solutions that will be tested through twelve pilot actions

These digital transformation themes are identified due to their broad applicability, regardless of the industry type or business function. Experience and practice show that some technologies are more relevant to digitalization in certain sectors and more closely related to value creation within those sectors, which highlights cross-industry differences in technology diffusion. Therefore, these three themes are suitable for the digital transformation of SMEs, which are heterogeneous and operate within diverse business ecosystems, regardless of the general digital transformation approach, whether mainstream or tailor-made digital tools and instruments.

5.2. Specification of key digital technologies

5.2.1. Emerging technologies with highest potential for SMEs

Recently, digital tools have transformed how companies operate, regardless of their size, from small businesses to large corporations. These tools encompass a wide range of technologies, with no universally agreed-upon list. Researchers and practitioners tend to focus on the tools they consider most significant. However, emerging technologies such as ***Artificial Intelligence (AI)***, ***Cloud Computing (CC)***, ***Blockchain (BC)***, and the ***Internet of Things (IoT)*** are among the most promising for SMEs, without necessarily claiming they are the most important.

Artificial Intelligence

AI, often described as machine-generated intelligence, enables machines to perform tasks and solve complex problems that traditionally surpassed human cognitive abilities [3]. The foundation of generative AI lies in the so-called AI Triad, which consists of three core components: *data*, *algorithms*, and *computing power (compute)*. These elements are further interconnected by *specialized expertise*, including model training, evaluation, optimization, and research into new capabilities. Cutting-edge generative AI systems now demand extensive resources and expertise across all four components, making them accessible primarily to major industry players with substantial financial and technical capacity. Generative AI can be embedded into a wide array of digital products and services, with its impact likely extending across most sectors of the economy [4].

The widespread adoption, distribution, and integration of AI face several significant barriers [4]: (i) *data dependency*: AI systems require vast amounts of high-quality data; (ii) *proprietary research*: cutting-edge AI research is increasingly controlled by private entities; (iii) *restrictive licensing*: open-source AI components, including algorithms, are frequently replaced by restrictive, non-permissive licenses by some market players; (iv) *computing infrastructure*: developing, training, deploying, and distributing AI systems rely heavily on cloud computing or in-house data centers; and (v) *talent shortages*: the lack of AI expertise, particularly in Europe, remains a major obstacle to AI expansion.

Considering SMEs, several factors influence how SMEs adopt this emerging technologies, including compatibility, organizational readiness, efficiency gains, and time savings. These elements play a direct and indirect role in AI adoption, particularly through automated accounting and business processes. AI presents significant opportunities for SMEs by enhancing various aspects of business operations [3]: (i) *improved customer experience*: Intelligent communication systems lead to higher customer satisfaction, fostering loyalty and opening new market opportunities through advanced customer data insights; (ii) *enhanced decision-making*: AI supports complex data analysis, enabling SMEs to offer personalized

services and products; (iii) *operational efficiency*: AI-driven automation streamlines processes, reducing costs and improving overall productivity.

Cloud Computing

Cloud adoption is widely recognized as a fundamental enabler of digital transformation for SMEs, as it allows them to scale their operations without requiring significant upfront investment in hardware and IT infrastructure. Cloud Computing (CC) refers to the delivery of computing services, including storage, processing power, and software applications, over the internet, commonly known as "the cloud" [5]. The key components of CC include *cloud storage*, *cloud servers*, *cloud software*, and *cloud networking*. CC services are typically categorized into three main models: (i) Infrastructure-as-a-Service (IaaS); (ii) Platform-as-a-Service (PaaS), and (iii) Software-as-a-Service (SaaS).

One of the primary advantages of cloud adoption is its ability to enhance flexibility and operational efficiency. SMEs can access business applications from any location, enabling remote work, collaboration, and real-time decision-making. Additionally, cloud-based solutions provide cost savings by eliminating the need for expensive hardware maintenance and reducing IT management complexities [5]. The adoption of cloud solutions among SMEs is driven by several factors that align with the needs and challenges, including cost efficiency, scalability, and flexibility.

One of the most transformative aspects of CC is its ability to provide SMEs with access to advanced technologies that were previously unattainable due to the high implementation cost. Cloud service providers offer cutting-edge solutions, such as AI, big data analytics, and automation, as part of their service packages. Despite its benefits, cloud adoption presents several challenges that SMEs must address to ensure successful implementation and long-term success: (i) *cybersecurity risks*: migrating sensitive data and critical applications to the cloud increases vulnerability to data breaches, cyberattacks, and security threats; (ii) *integration complexity*: many SMEs rely on a mix of software applications and databases that may not be fully compatible with cloud platforms; (iii) *regulatory and compliance issues*: SMEs operating in highly regulated industries must ensure that their cloud adoption strategy complies with industry standards and data protection laws; (iv) *skills gap*: cloud migration often requires significant changes to IT infrastructure, business processes, and employee workflows, creating a high demand for staff with expertise in cloud technologies, security protocols, and system administration.

Blockchain

By blockchain (BC) is a distributed database in which records are verified through consensus and shared among participants. Once added, a record becomes permanent and cannot be deleted. In cases where records pertain to transactions, participants do not need to rely on a central authority to validate them, once a transaction is recorded in the BC ledger, its occurrence is indisputable [6]. Originally developed to facilitate cryptocurrency transactions,

BC has since evolved into one of the fastest-growing and most widely discussed technologies worldwide. Its potential to transform the economy and society is often compared to the impact of the internet.

The literature identifies several defining characteristics of BC, stemming from its unique ledger structure, network architecture, consensus protocol, and cryptographic mechanisms. These core features include [7]: (i) *decentralization*: the absence of a central authority enhances the reliability of data and transactions, as verification occurs through consensus algorithms; (ii) *immutability*: once recorded, information on the BC is considered tamper-proof due to the distributed consensus mechanism; (iii) *transparency*: BC enables all users to read and verify transactions, fostering a high level of openness and accountability; and (iv) *data integrity*: BC ensures data security and accuracy by storing information in a distributed ledger, securing interactions through public-key cryptography, and enabling verification based on predefined rules.

For SMEs, BC offers significant advantages that can reshape their operations [8]: (i) *enhancing trust through transparency:* the immutable nature of BC fosters trust among customers, as SMEs can leverage a secure and verifiable transaction ledger to reduce fraud risk; (ii) *reducing costs and enabling global expansion*: by eliminating intermediaries, BC significantly lowers transaction costs, making cross-border transactions more efficient and enabling SMEs to expand into global markets.; (iii) *transforming supply chain management*: BC's provide real-time tracking of goods, optimizing inventory management and mitigating delays; and (iv) *facilitating capital raising and secure data storage*: BC provides SMEs with innovative financing models, such as tokenization and decentralized funding, while also ensuring cost-effective and secure data management.

Internet of Things

The IoT refers to a network of physical devices connected to the internet, enabling data collection and exchange. This connectivity allows individuals and businesses to interact more effectively with their environment and make informed, intelligent decisions. A subset of IoT, the Industrial IoT (IIoT), specifically involves industrial devices such as sensors, actuators, automated machinery, and robots. As a core technology for smart manufacturing, IIoT enhances production capabilities by providing real-time insights, improving operational efficiency, and optimizing resource management. It enables manufacturers to monitor and trace raw materials and products throughout the production process while simultaneously performing quality control and planning tasks [10].

For SMEs, IoT presents a significant competitive advantage by facilitating process automation and reducing time-intensive tasks. SMEs across various industries have already begun integrating IoT solutions, ranging from simple sensors to complex actuators. A step-by-step implementation approach allows business to start with basic IoT applications and expand as they grow, making the technology more accessible while mitigating financial and

operational risks. Additionally, cloud-based IoT platforms provide SMEs with access to advanced analytics and machine learning tools, enabling them to process large volumes of data efficiently [11].

Despite its benefits, IoT adoption by SMEs faces challenges, including *data security concerns*, *privacy risks*, and the need for *specialized technical skills*. Addressing these obstacles requires collaboration among technology providers, regulatory authorities, and SMEs to develop tailored IoT frameworks and protocols that reduce implementation complexity and costs. Furthermore, as recommended by the European Commission (2022), enhancing digital skills and competencies among SME employees is essential to fully leverage IoT's potential. By overcoming these barriers, SMEs can unlock IoT's full benefits, driving innovation and fostering sustainable business growth in an increasingly digital economy [11].

5.2.2. Tools and technologies for SMEs

Digital transformation is achievable for SMEs with the right tools and technologies. By choosing cost-effective, scalable and simple solutions, operations, customer engagement and decision-making can be significantly improved. Below is a list of tools, developed on the basis of the previously described emerging technologies, which can find or have already found their application in SMEs:

- Cloud-based solutions
  - *Microsoft Dynamic 365*: combines ERP and CRM capabilities to manage finances, operations, and customer relationships.
  - *Google Workspace*: a suite of productivity tools for collaboration, including Gmail, Drive, Docs, and Sheets.
  - *Zoho One*: offers over 40 business applications for everything from sales to human resources.
  - *TalentSoft*: a cloud-based HR software that enables human resource managers to have better interactions with other managers across the organization as well as employees.
- Customer Relationship Management (CRM)
  - *HubSpot CRM*: a free tool with features for managing leads, email marketing, and tracking sales pipelines.
  - *Salesforce Essentials*: scaled for SMEs, it helps businesses manage customer relationships and automate sales processes.
  - *Freshdesk*: help desk for customer support.
  - *eBanqo*: a conversational AI solution that helps businesses automate customer engagement and deliver services instantly on messaging apps like Facebook Messenger, Instagram DM, Google My Business and WhatsApp, meeting customers right where they already engage.

- *Amplitude*: is a platform that helps businesses understand how customers use their products. It gives insights into user behavior and helps companies make informed decisions to improve their products.

- Project Management and Collaboration
  - *Trello*: a visual project management tool with customizable boards for task tracking.
  - *Asana*: enables teams to plan, organize, and track project progress efficiently.
  - *Slack*: a communication platform that integrates with other tools for seamless collaboration.
  - *LucidChart*: a mind mapping app for help in visualizing how the elements you're working with connect, what you want to accomplish in the future, what the most important categories in your website are, etc.
  - *ClickUp*: s an all-in-one small business software designed to simplify task management, project tracking, and team collaboration for businesses of all sizes.
  - *LivePlan*: is a tool for sales professionals and entrepreneurs, particularly those starting new business ventures. Its primary focus is helping users create detailed business plans with revenue projections and financial forecasts.
  - *Cascade.app*: is a cutting-edge digital transformation tool designed to streamline project management and strategy execution.
  - *Monday.com*: is a highly customizable work management platform for help in project management.
  - *Notion*: is versatile tool that can assist in project, task, and document management.
- Marketing and Analytics
  - *Mailchimp*: automates email marketing campaigns and provides analytics for customer engagement.
  - *Google Analytics*: tracks website traffic and customer behavior for data-driven marketing strategies.
  - *Canva*: an easy-to-use design tool for creating marketing materials like social media posts and ads.
  - *Flipsnack*: a cloud-based digital tool for creating a variety of digital documents: magazines, catalogs, brochures, etc. to show off their products or services.
  - *Buffer*: is the social media management tool.
- Finance and Accounting
  - *QuickBooks*: simplifies accounting and financial management for SMEs.
  - *Wave*: a free accounting software for invoicing, expense tracking, and payroll.

- *FeelSafe*: providing instructions on preventing electronic fraud based on three axes: electronic entrepreneurship and entrepreneurs, electronic entrepreneurship and employees, and electronic commerce.
- *Sage Cloud Accounting*: a transformative digital tool for any business that has adopted it. The software comes fully fitted with advanced inventory, stocks management, invoicing, debtor management, and can be used across different kinds of industries.
- *PayFit*: a payroll management tool that completely takes away the hassle of manually preparing and processing payment of employees' salaries and entitlements from HR managers.
- *Xero*: a cloud-based accounting software platform connects people with the right numbers anytime, anywhere, on any device.

- Cybersecurity
  - *Norton Small Business*: protects devices and data from malware and cyber threats.
  - *LastPass*: a password management tool that enhances security and simplifies logins.
  - *Cloudflare*: offers solutions for website performance and protection against cyberattacks.
- Data Analytics and Business Intelligence
  - *Microsoft Power BI*: provides advanced analytics and visualization to turn raw data into actionable insights.
  - *Tableau*: helps SMEs create interactive dashboards and gain deeper insights into business performance.
  - *Delve.ai*: is an innovative tool that leverages AI to revolutionize data analytics and decision-making processes.
- E-Commerce Platforms and Digital Market
  - *Shopify*: a comprehensive platform for creating and managing online stores.
  - *WooCommerce*: a WordPress plugin that transforms websites into fully functional e-commerce stores.
  - *Choose my craftsman*: application developed by Assembly of French Chambers of Crafts that brings together entrepreneurs and apprentices.
  - *BigCommerce*: a flexible B2B or B2C solution.
- Process Optimization and Workflow Automation
  - *Evocon*: a visual, user-friendly OEE software that helps SMEs improve productivity, reduce waste, and cut costs.
  - *MRPeasy*: is a seriously powerful yet easy-to-use manufacturing software for managing manufacturing and distribution.
  - *Zapier*: automation tools help streamline repetitive tasks by connecting different apps and automating workflows.

- *Integromat*: apps for connecting a number of applications in a unique and visual way in order to save time, reduce errors and improve efficiency by automating routine processes.

Generally, SMEs lag behind in digital adoption across all technology areas. However, they tend to prioritize the digitalization of specific business functions, such as general administration and marketing operations. The digital gap between SMEs and large firms is narrower in areas like business-to-government interactions, electronic invoicing, social media usage, and online sales. However, this gap widens as technologies adoption become more advanced or when economies of scale are crucial for implementation [12].

Existing research on SMEs digital transformation ***emphasizes the importance of conducting preliminary digital capability and maturity assessments***. As a result, various assessment tools have been developed to evaluate these aspects. In line with this, the primary ***recommendation of this deliverable is to develop a suitable digital diagnostic tool tailored to the business environment of the DR***, ensuring its format and recommendations align with the specific needs of SMEs in this context.

6. Conclusions

Digital transformation is no longer optional for SMEs, it is essential for long-term growth, competitiveness, and sustainability. By adopting the right tools, strategies, and approaches, SMEs can optimize operations, improve customer experiences, and unlock new opportunities. Although the transition may seem challenging, breaking it down into manageable steps and seeking expert guidance can significantly ease the process.

The Danube DNA initiative aims to facilitate a smooth digital transformation for SMEs across the entire Danube Region by providing well-founded recommendations on best approaches and technological solutions. Additionally, the project promotes a balanced digitalization effort across borders and industries, ensuring alignment with SMEs' specific needs, national digitalization strategies, and existing digital gaps.

In line with this objective, this deliverable presents a detailed gap analysis of digital readiness levels across Danube Region countries. Through comprehensive data collection, analysis, and evaluation, it identifies key areas where digital adoption lags and highlights potential barriers to transformation. Furthermore, the deliverables support the identification of priorities, common challenges and key technologies for digital transformation, as well as the development of a structured inventory of technological solutions applicable to the identified industry sectors of interest. According to the deliverable's findings, Digital Capabilities emerge as the key area for improvement at both the Danube Region and individual countries. Additionally, three cross-cutting digital transformation themes (or so-called enablers) for developing joint solutions are specified, considering factors such as cost-effectiveness, scalability, and sector-specific applications. The outputs of this deliverable will serve as the primary inputs for the subsequent one, which focuses on developing transnational guidelines for the smart specialization of the Danube Region.

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