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DIGITAL TECHNOLOGY INTEGRATION AMONG EASTERN EUROPEAN COMPANIES, BASED ON DIGITAL ECONOMY AND SOCIETY INDEX

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ABSTRACT

The European Commission has given special attention to the digital evolution of the European economy and society since the early 2000s. Starting with 2014, the Digital Economy and Society Index has become a key monitoring and assessment instrument. In 2021, the main indicators of the Digital Economy and Society Index were matched with the Digital Agenda 2030 targets, which encompass four dimensions: human capital, connectivity, digital technology integration, and digital public services. The article aims to verify the convergence amongst Member States in integrating digital technologies, which is the third dimension of the Digital Economy and Society Index yearly database. The σ-convergence analysis assessed decreased disparities in digital technology integration between Member States over time. The β-convergence analysis was used to evaluate the pace of catch-up from the initial development level. The σ- and β-convergence were not confirmed. The specific digital technology integration indicators (11) are studied to identify crucial areas that must be addressed in the future to guarantee that digital inclusion is as widespread as feasible. The present research is concentrated on the member countries that joined the EU during the Eastern enlargements. All individual indicator performance is typically behind the EU average, and as the β-convergence study indicates, the average catch-up rate is not encouraging.

KEYWORDS

convergences, digital transformation, SMEs, EU enlargements

CLASSIFICATION

JEL: M15, O14

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INTRODUCTION

For the European Union, the knowledge-based economy serves as the foundation for the development of human resources, and ongoing research and development (R&D) in information and communication technologies is directly related to the EU's competitiveness [1]. In order to accelerate their development and make them strong, resilient, efficient, and independent contributors to the national economy, micro, small, and medium-sized enterprises (MSMEs) need to be encouraged and strengthened [2, 3].

All of these were intentionally developed at the EU level beginning in 2000 with the Lisbon Strategy, followed in 2010 by the EU 2020 Strategy, which, for the first time, outlined the crucial role of ICT in accomplishing European goals. The Digital Agenda was enhanced further in 2015 by the European Digital Single Market Strategy, which also laid out specific guidelines based on three pillars to establish a just, open, and secure digital environment:

- improving access to digital goods and services for consumers and businesses across Europe,
- increasing the growth potential of the digital economy.

Three primary digital goals were the focus of the second five-year Digital Agenda, "Shaping Europe's Digital Future" in 2020:

- technology for people,
- fair and competitive economy,
- an open, democratic and sustainable society.

The Digital Agenda for Europe serves as the vehicle for these strategies to advance digital technology in Europe. The European Commission (EC) developed the Digital Economy and Society Index (DESI), which has been released annually since 2014 [4, 5] to gauge and track progress. The DESI last underwent a substantial reorganisation and methodological revision in 2021. The European Commission presented the Path to the Digital Decade, a program to aid in the digital transformation of the European economy and society, the same year the European Parliament adopted the Digital Agenda 2030: A European Method to accomplish the Digital Decade [6].

Currently, the DESI index ranks the EU Member States and tracks their development using 33 distinct and four main indicators. The four key areas are as follows:

- desi_1 Digital skills and competencies of human capital,
- desi_2 Internet coverage and quality of access,
- desi_3 Digital technologies in the enterprise,
- desi_4 The penetration of digital public services.

A recent study investigated whether member-state convergence could be identified using the annual databases of the DESI [7]. We discovered statistical evidence of convergence between the EU27 Member States for the DESI overall index using the σ- and β-convergence tests. One can wonder, though, if the convergence for the core indicators (desi_1, desi_2, desi_3, desi_4) can be shown independently [8-10].

The third dimension of the DESI index, which gauges the level of digital technology adoption in EU Member States, is the topic of this study. As shown in Table 1, the core indicator desi_3 consists of 11 individual indicators and three sub-dimensions:

The weighted value of the desi_3 subdimensions 15-70-15 % determines the degree of digital technology integration ranking:

$$\text{desi\_3a} \times 0{,}15 + \text{desi\_3b} \times 0{,}75 + \text{desi\_3c} \times 0{,}15.$$

Table 1. The desi_3 core indicator's structure.

desi_3 subdimensions	Individual indicators
Digital intensity (desi_3a)	SMEs with at least a basic level of digital intensity
Digital technologies for businesses (desi_3b)	Electronic information sharing
	Social media
	Big data
	Cloud
	AI
	ICT for environmental sustainability
	e-Invoices
e-Commerce (desi_3c)	SMEs selling online
	e-Commerce turnover
	Selling online crossborder

The article aims to verify the convergence amongst Member States in integrating digital technologies, which is the third dimension of the DESI yearly database. Convergence calculations are used to track the level of cohesiveness in various sectors. The convergence of the development of the Member States that joined the European Union (EU) during the 2004-2007-2013 enlargements (Eastern European enlargements) and the old EU Member States is a priority. The article emphasises two different types of convergence. The average relative deviation of the DESI index values from the mean, presented as a percentage, is the first, also known as the relative standard deviation or σ-convergence. There is a convergence when the development levels' dispersion decreases with time. β-convergence is another well-known convergence indicator [11, 12]. The neoclassical growth theories of Ramsey [13], Solow [14] and Koopmans [15] are the foundation for this growth indicator. The Solow-based and endogenous growth theories asserted that national economic policies and nation-specific features are significant predictors of a country's catching-up performance from the 1980s onward. Foreign capital inflows speed up growth, which eventually causes the gap between developed and developing countries to close.

Another focus area is the digital development of businesses, as this is a crucial factor in determining R&D and regional economic growth [16, 17]. Schumpeter asserted that technological advancement would be the deciding factor as early as 1934. Businesses would be driven out of the market and the competition if they could not adapt to these technological advancements [18]. Porter contends that a company's competitive edge stems from how it organises and conducts its numerous operations. However, to achieve a competitive edge, it must offer a service comparable to its rivals but more effectively or with a value distinction that sets its goods or services apart [19, 20]. The differential implies that effective adoption and use of digital technology at the corporate level can lead to more productive operations and, thus, higher levels of competitiveness.

In order to prepare human resources for changes in the labour market, industrial revitalisation 4.0 must be implemented. A serious challenge, especially in the manufacturing sector, is the reduction of the workforce's low-skilled and average workers. More jobs will likely be created than destroyed in the future due to the demand for new skills and job types. In order to meet the demands of technical competence, professional/methodological competence, social competence, and personal competence needed in the future, higher education must be able to adapt learning approaches and topics [21].

In order to determine whether existing convergence in the use of digital technology by businesses across the Member States, we examined the desi_3 index of the EU Member States between 2016 and 2021. There are no published predictions or data, and no other authors have addressed this issue.

The following null hypothesis was formulated for the desi_3 core indicator:

> **H_0:** We assumed no convergence between the Member States based on the desi_3 core indicator change between 2016 and 2021.

Following the introduction in the part of the literature review, a bibliometric analysis was conducted for the DESI index topic in the Web of Science Core Collection - Clarivate Analytics database between 2014 and 2022 using VOSviewer. The methodology part presents all the statistical instruments used for DESI index analysis, followed by the results and discussion part, which presents the main findings of the present research. During the conclusion, the contribution of research and practice are stated as research limitations and possible further research directions.

This article is a revised, expanded version of the presentation published in the 2022 Enterprise Research Innovation (ENTRENOVA) conference proceedings.

LITERATURE REVIEW

Web of Science Core Collection – Clarivate Analytics, the database we used. A bibliometric analysis was conducted to investigate the literature by analysing or discussing the DESI index. In order to accomplish this, we looked at keywords of articles that addressed the DESI index theme. We investigated the correlations among them using the free bibliometric program VOSviewer 1.6.17 [22], as Vida, Kovács, Nagy, Madai and Bittner [23] also used similar analyses to investigate a topic in her research. Another work of consistent terminology is presented in Gašpar, Seljan and Kučiš [24], where the Herfindahl-Hirshman Index is used to evaluate terminology diversity. Scholarly journal articles and conference proceedings were analysed between 2014 to 2022 that had the terms *integration of digital technology* and *business digitalisation*. These terms were examined in the title, abstract, author-provided keywords, and keyword plus. The database analysis produced 143 direct results and 49 related documents relevant to the search terms and might aid in a more thorough understanding of the area.

Colours are used by the VOSviewer program to identify the clusters detected throughout the investigation. The software discovered 1082 keywords in the research study, some of which were similar; therefore, we chose to combine them using a thesaurus file. After integrating the thesaurus results in 1070 terms, 33 matched the criteria with a minimum recurrence rate of 7 times the given criterion. Figure 1 depicts the network of relationships between the relevant keywords, which can be interpreted as follows: the size of the nodes represents the frequency of occurrence; the thickness of the edges connecting the nodes represents the frequency of co-occurrence of each keyword; and the distance between each node represents the strength of the relationship between the keywords.

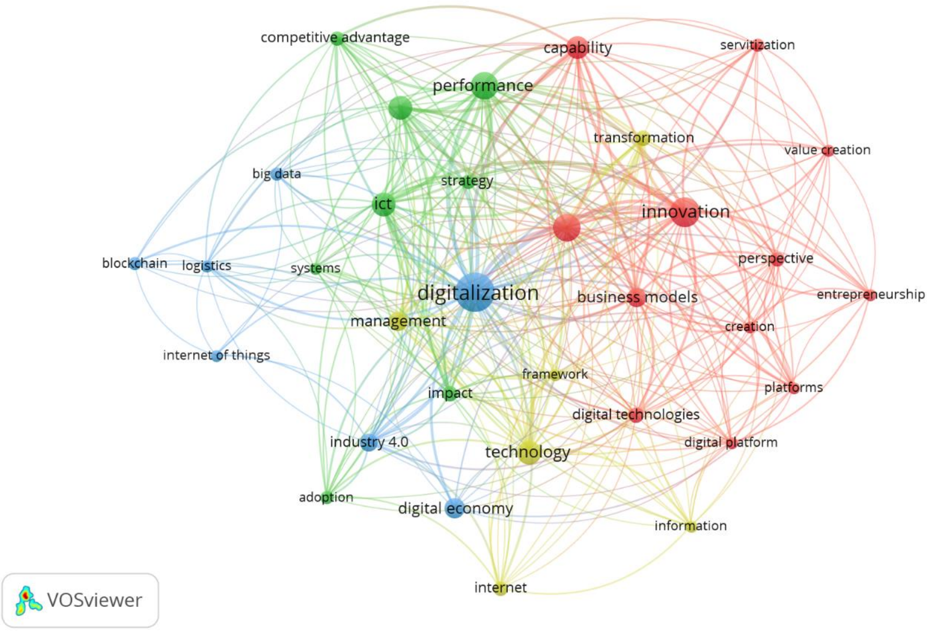

Figure 1. The frequency of keywords in the selected publication database passing the threshold of 7.

The minimal occurrence in the chosen database for analysing keyword associations had to be seven. Four clusters were detected using the software's default resolution level for producing clusters. The clusters are colour-coded and are represented by

Figure **1** and Table 2. In each cluster, the most frequent terms are *innovation* (40 occurrences), *performance* (33 occurrences), *digitalisation* (69 occurrences) and *technology* (27 occurrences).

Table 2. Keyword clusters.

1st cluster (red)	2nd cluster (green)	3rd cluster (blue)	4th cluster (yellow)
business models	adoption	big data	framework
capability	competitive advantage	blockchain	information
creation	ICT	digital economy	Internet
digital platform	impact	digitalisation	management
digital technologies	integration	industry 4.0	technology
digital transformation	performance	Internet of things	transformation
entrepreneurship	strategy	logistics	
innovation	systems		
perspective			
platforms			
servitisation			
value creation			

The main keyword of the first cluster, highlighted in red, is *innovation*, which is frequently mentioned alongside the keywords *digital transformation*, *capability*, and *business models*, implying that a company's ability to transform digitally and the degree of integration of digital technology in the business model are essential determinants of its innovation activity [25-27]. The significance and possibility of integrating digital technology vary across company structures and sectors [23, 28-33]. Small businesses have a reduced intensity of digital technology integration, but large businesses are further reinforced by their digitalisation capabilities, as their vast corporate structure increases their chances of success [34-36]. However, a favourable association exists between digital technology adoption, industrial processes' digitalisation, and environmental sustainability [37]. Digital transformation can only be effective according to a well-defined plan [38-41].

The second cluster, denoted in green, has the most often occurring term, *performance*, which is connected to the keywords *ICT* and *integration*, implying that firm performance is directly linked to ICT technology integration. It influences business strategy creation and achieving competitive advantage [42, 43]. Given the importance of digitalisation, integrating the IT department is critical to digital transformation [44-47]. Mandl, Schwab, Heuwing, and Womser-Hacker [48] concluded from focus group discussions with business decision-makers that the failure of digitisation is frequently human, mainly management. Nábrádi, Madai and Lapis [49] emphasised the special importance of digital technology in agriculture by using precision technologies as a tool for effectiveness and managing risk [50]. The complexity of integrating information systems and the lack of structure in information management were both mentioned as impediments.

Considering the resource needs of digitisation before implementing its potential [51-53]. The most significant keyword in the third blue cluster is *digitalisation*, which has enabled the establishment of the *digital economy*, allowing industry transformation, currently known as Industry 4.0. Massive data volumes, blockchain technology, and smart devices that connect are all part of the digital transformation (IoT). Along the digitalisation road, many ecosystem-based business models have arisen, emphasising the necessity of cooperation [54-57]. Unfortunately, even in more developed countries, the degree of digitalisation of businesses is only moderate, so Volkova, Kuzmuk, Oliinyk, Klymenko and Dankanych [22] investigated the application and diffusion trends of various digital technologies such as blockchain technology, 3D printing, IoT, 5G networks, cloud computing, automation and robotisation, and artificial intelligence and data analytics. Ahmad and van Looy state that the fastest-increasing trends are Industry 4.0, blockchain technology, and IoT [58]. Automation, digitalisation of the whole value chain, and simultaneous consideration of Industry 4.0 success criteria will considerably boost the company's success and performance [59]. Following a thorough literature review, Fonseca [60] identified the dimensions that Industry 4.0 entails: the digitisation and integration of industrial manufacturing and logistics processes, the use of the Internet and IoT, and the fusion of physical and virtual reality combined with the application of ICT technology. Simultaneously, Industry 4.0 business models have arisen, with potential benefits such as shorter operating cycles, shorter delivery times, faster time to market for new goods or services, enhanced quality, product or service customisation, and more loyal consumers [60-62].

Finally, the fourth cluster, highlighted in yellow, contains the most relevant keyword, *technology*, which has presented substantial difficulties to management, frequently necessitating organisational transformation. Management's attention determines the effectiveness of digital transformation and its capacity to acquire information from inside and outside the organisation [26]. The state's involvement in advancing digitalisation initiatives cannot be overlooked since it must provide the necessary framework for use in the commercial domain with adequate efficiency [63]. As a helpful structuring tool, a framework for digital advancement should be established at the state level and by all firms, saving resources [64].

The bibliometric analysis suggests that the digitalisation of companies is based on the following pillars: leadership, size, innovation, performance and technology used. Considering this, we analyse desi_3 data over the 2016-2021 period.

METHODOLOGY

The term σ-convergence refers to closing the gap between Member States over time, whereas the term β-convergence focuses on identifying a prospective catching-up process.

The σ-convergence (relative standard deviation or coefficient of variation) allows comparing manifolds or samples with various averages and attributes to be compared. The coefficient of variation is the proportion of the average relative departure of the parameter values from the mean. σ-convergence occurs when the dispersion of development levels diminishes with time. In our scenario, we are dealing with a manifold comprising the desi_3 index values from 2016 to 2021.

The calculation of relative dispersion is given in formula (1):

$$V_{(\%)} = \frac{\sigma_t}{\bar{x}}(100)\ \%, \tag{1}$$

where: σ_t = the variance of the desi_3 indices at time t and ($\bar{x}$) = the average of the desi_3 indices.

The standard deviation is calculated according to formula (2):

$$\sigma_t = \sqrt{\frac{\sum_{i=1}^{n}(x_{it}-\bar{x})^2}{n}}, \tag{2}$$

x_{it} = the desi_3 index of an ith Member State at time t; ($\bar{x}$) = the average of the desi_3 index, and n denotes the number of Member States.

Based on the hypothesis of absolute β-convergence, formula (3) expresses the empirical relationship between growth per Member State and the initial level of development:

$$\frac{1}{T-t_0-1}\ln\left(\frac{X_{iT}}{X_{it_0}}\right) = \alpha + \beta*\log(x_{it_0}) + \varepsilon_i, \tag{3}$$

where $\frac{1}{T-t_0-1}\ln\left(\frac{X_{iT}}{X_{it_0}}\right)$ is the average annual growth rate of the values of the desi_3 index for the ith Member State; t_0 is starting year; *T* ending year; $x_{(it_0)}$ the initial level of development of the desi_3 index; ε_i the error, which is assumed to be independent and identically distributed; while α and β denote the parameters to be estimated.

In this expression, the initial development level alone explains the catching-up rate. The sign and value of the β coefficient indicate the strength of the effect. Univariate linear regression (OLS) was used to estimate the α and β coefficients. However, the estimation would be error-free only in the case of a perfect relationship (r = 1 or r = -1), and therefore εi is the error of the estimate. The least-squares procedure was used to minimise the squared error to estimate the coefficients α and β. The β-coefficient was considered significant only if the empirical significance level (p-value) was less than 5 %. However, conditional convergence suggests too much information hidden in α and εi to be extracted on a case-by-case basis, but in this case, we only tested absolute convergence.

RESULTS

In 2016, the desi_3 core indicator values varied from 10 % to 40 % (with most Member States falling between 21 % and 30 % (15 states). Finland received the highest score (37,39 %), somewhat behind but still in the same ballpark as Sweden and Denmark (31 % – 40 %). Bulgaria, Latvia, Romania, Poland, and Hungary rank last (10 % to 20 %).

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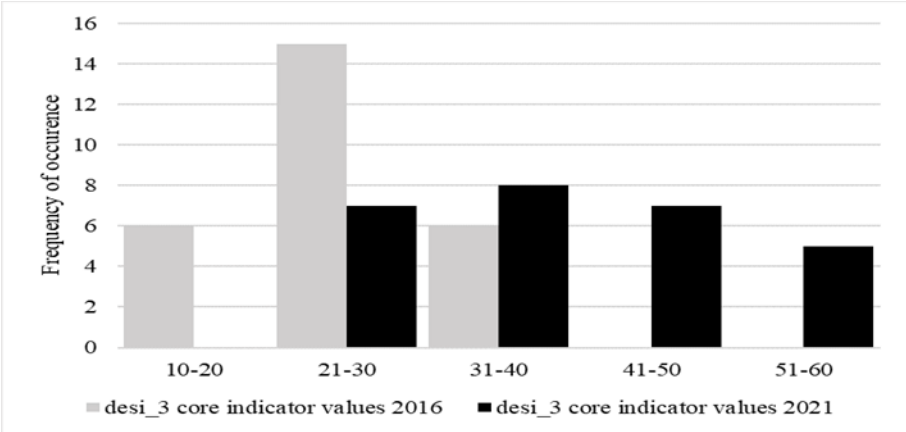

Figure 2. Distribution of desi_3 core indicator values in 2016 and 2021.

The dispersion of the core indicator values has expanded from three to four ranges by 2021, from 21 % to 60 %. Most Member States fall between 31 % and 40 % (8 countries). There has been no notable change at the top, while Malta and the Netherlands have joined Finland, Sweden, and Denmark in the top quadrant. Looking at the absolute values of the desi_3 core indicator, Bulgaria, Poland, Hungary, and Romania did not significantly improve their position; therefore, they remain at the bottom of the ranking. They have not made considerable progress in digital inclusion during the last six years. Croatia, Luxembourg, the Czech Republic, and Spain matched the EU average between 2016 and 2021. Finland will have the most significant level of digital technology integration in 2021, followed by Denmark and Sweden (Figure 3). Bulgaria, Hungary, Romania, and Poland are on the other side. The ranking of nations for the desi_3 core indicator has not changed much during the reviewed time. Latvia has the highest average growth rate (14.3 %) and one of the lowest rates in 2016; thus, its strong growth rate is predictable, but it still has a long way to go. Estonia, Malta, and Croatia are next in line in terms of catching-up rates, followed by nations that have been and are already at the forefront of digital technology integration, with an average rate of progress of between 9 % and 10 %.

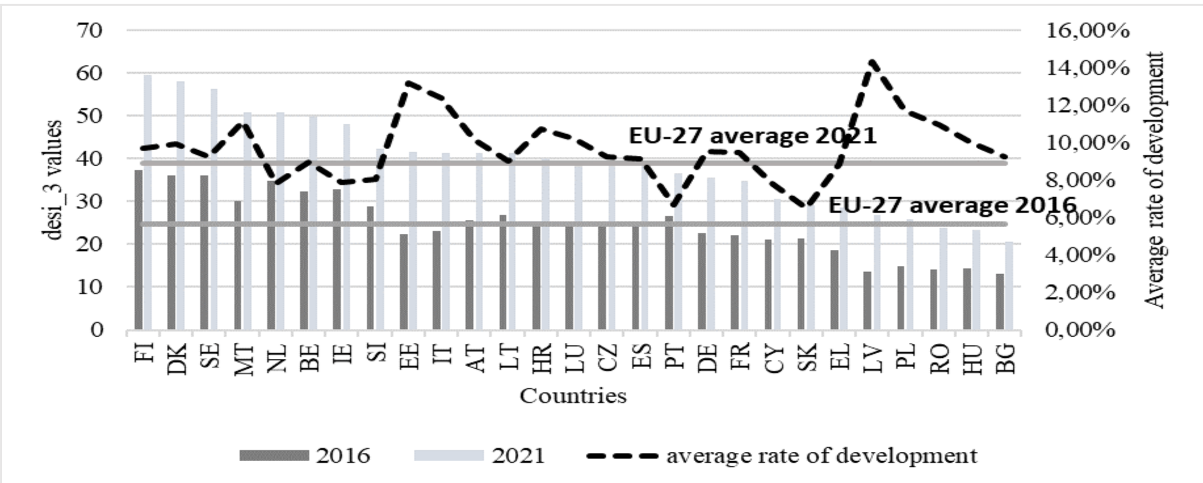

Figure 3. Country rankings based on the desi_3 core indicator. Additional information from 2016-2021 and the average rate of development.

The underlying premise of β-convergence is that increases in the desi_3 core indicator are more significant in nations with a lower value. This assumption, however, is not supported in our scenario. Although there is a negative connection (–0,0197) between the starting level of development and the average growth rate of the desi_3 core indicator from 2016 to 2021, the regression coefficient is not significant since the p-value (0,0556) is higher than α (0,05), Table 3.

Table 3. Linear regression values for the desi_3 core indicator.

No. Observations	R-squared	Intercept Coeff.	β	θ	t-value	p-value
27	0,1388	0,1548	–0,0197	–	–2,0075	0,0556

Because the dispersion of the desi_3 core indicator displays a declining tendency over time, the EU-27 Member States converge, but this is not the case here. The relative dispersion amongst the EU-27 Member States is not diminishing; therefore, the desi_3 indicator displays a slight divergence, Figure 4. The disparities shrank between 2016 and 2018. Following that, the tendency reversed, and the dispersion of development levels began to expand again.

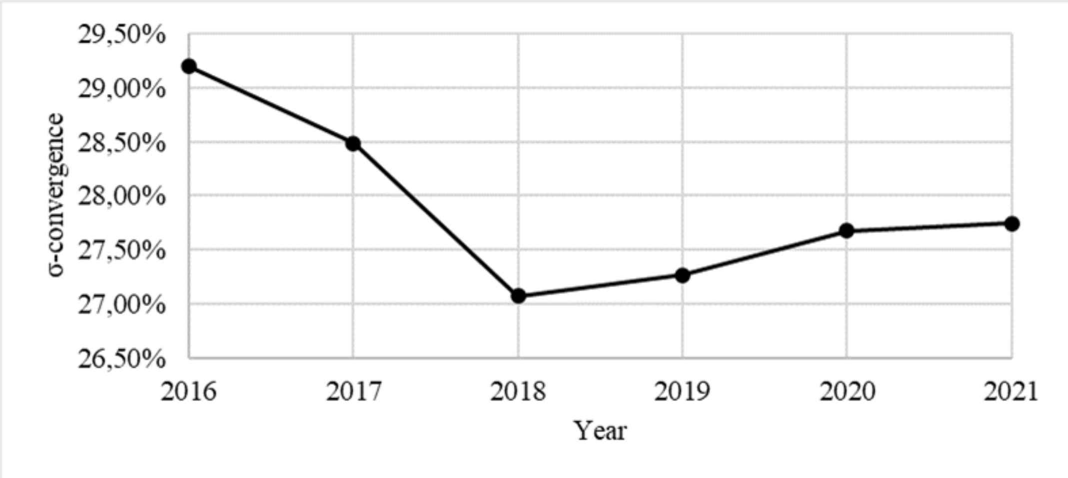

Figure 4. σ-convergence for the desi_3 core indicator between 2016-2021.

The β-convergence serves the σ-convergence since it is required for the compression and densification of cross-sectional data from worse-performing nations. However, Ligeti [65] has mathematically demonstrated that β-convergence is only required but insufficient for σ-convergence.

As a subdimension, digital intensity (desi_3a) assesses utilising various digital technologies at the corporate level, Figure 5. The digital intensity of a corporation is determined by how many of the following 12 technologies it employs: 1) website; 2) the fastest fixed internet connection has a maximum contracted download speed of at least 30 Mb/s; 3) the website has at least one of the following: description of goods or services, price lists; possibility for visitors to customise or design goods or services online; tracking or status of orders placed; personalised content on the website for regular/returning visitors; 4) businesses where more than 50 % of employees used a computer with internet access for business purposes; 5) providing more than 20 % of employees with a portable device that allows internet access via a mobile phone network for business purposes; 6) sending e-invoices for automated processing; 7) cloud computing; 8) hiring ICT professionals; 9) companies with at least 1 % of turnover from e-commerce; 10) analysing data sets from any source (external or internal); 11) using industrial or service robots; 12) using 3D printers.

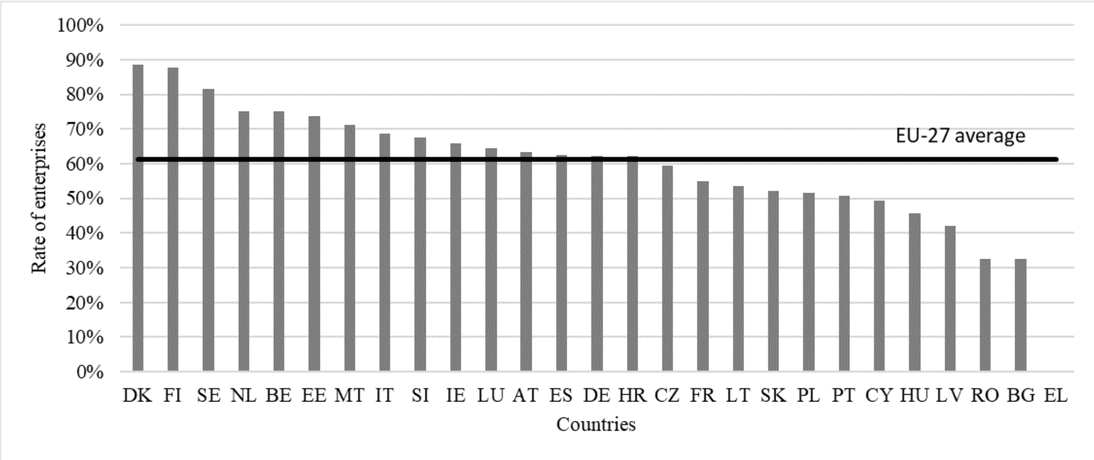

Figure 5. Country rankings based on the digital intensity of SMEs (2021).

The percentage of firms using digital technologies varies between 55 % and 65 % across Member States, and the intensity of use ranges from 4 to 6 technologies [66]. Companies in Denmark and Finland have very high digital penetration, with at least 4 to 9 of the 12 digital technologies listed above being used. The percentage in Eastern European enlargement nations is significantly lower, with Bulgaria and Romania at the bottom of the scale (30 %). In Latvia and Hungary, the situation is slightly better but far from ideal because the proportion of SMEs that integrate digital technologies is low (between 40 % and 45 %), but the digital intensity, which would imply merging them, is at most 3.

The EU Member States of Finland, the Netherlands, Belgium, and Denmark are at the forefront of enterprise use of digital technology (desi_3b), Figure 6. Digital technology application in the company includes:

- enterprise resource planning (ERP) and customer relationship management (CRM) systems,
- use and adoption of social media tools – companies that use at least two of the following: social networking sites, corporate blogs and microblogs, multimedia content-sharing websites, wiki-based knowledge-sharing tools,
- big data analytics - companies that analyse data sets from any source,
- cloud computing services – companies that purchase at least one of the following cloud computing services: Enterprise database hosting, accounting software, online case management systems (CRM), operational performance,
- artificial intelligence – businesses that use at least two: written language for analysis; machine learning; automation of various work processes or decision making; conversion of spoken language into machine-readable format; identification of objects or people based on images; generation of written or spoken language and AI technologies that allow machines to physically move based on autonomous decisions based on observation of the environment,
- ICT for environmental sustainability – number of environmentally friendly measures adopted by the company,
- e-invoices – use of e-invoices that allow automated processing.

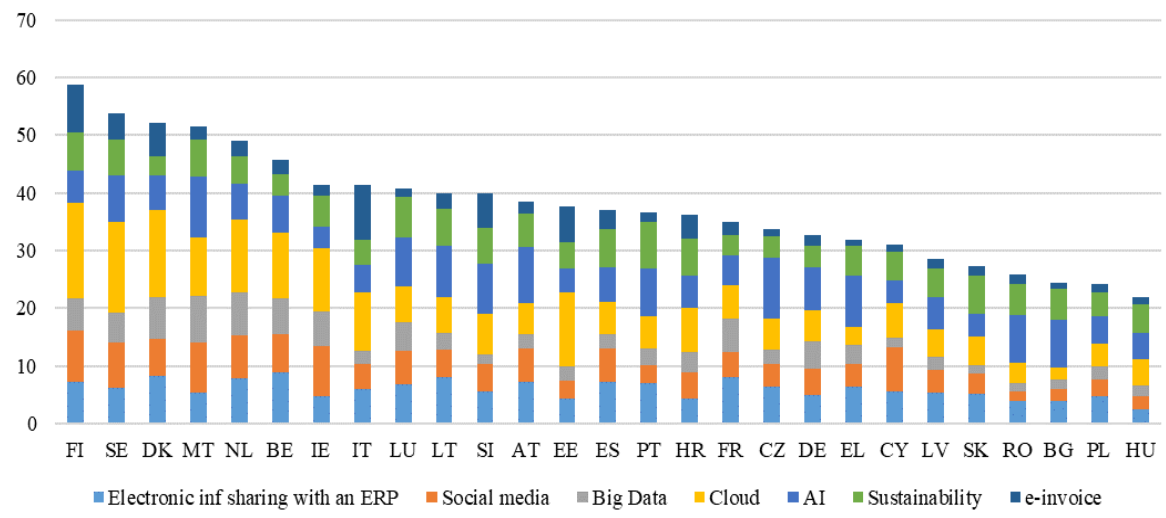

Figure 6. Ranking of Countries Based on the Degree of Integration of Digital Technologies in Enterprises (desi_3b) (2021).

Finland is the leader in social media adoption and cloud service use, Belgium is the leader in electronic information exchange, and Maltese firms are leaders in big data analytics and artificial intelligence. More than 85 % of businesses in Portugal indicate that their use of ICT has resulted in substantial green initiatives, putting them top. Nearly 95 % of Italian businesses send electronic invoices (32 % in the EU-27). Less than a fifth of firms in Hungary, Poland, Bulgaria, Romania, Slovakia, and Latvia use any digital technologies listed here.

Furthermore, Ireland, the Czech Republic, Denmark, Belgium, and Sweden have the highest aggregate performance in e-commerce (desi_3c). Individual indicators for e-commerce as a sub-dimension include SMEs selling online (at least 1 % of total revenue), total e-commerce turnover, and the percentage of SMEs selling online across borders (Figure 7).

Ireland is the undisputed leader in all three of these categories. SMEs in Bulgaria, Greece, Luxembourg, and Latvia have yet to recognise the numerous opportunities e-commerce presents.

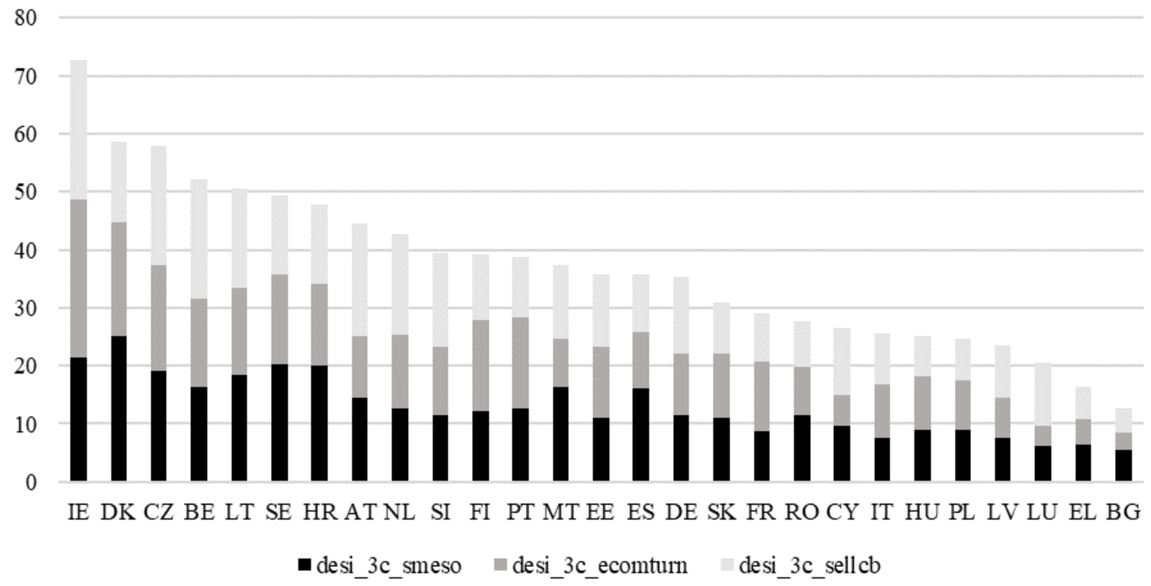

Figure 7. Ranking countries by e-commerce (desi_3c) (2021).

DISCUSSION

Because they constitute the preponderance of EU enterprises and are a major source of innovation, SMEs play a critical role in this transformation. Digitalisation may give SMEs several chances to increase their manufacturing processes' efficiency and produce more creative goods and business models. There are many ways to measure efficiency: partial, complex, social, corporate, regional and macro-economical [67]. Blockchain, artificial intelligence, cloud computing, and high-performance computers may significantly boost competitiveness. The European Commission's 2030 goal is to have more than 200 European Digital Innovation Centres and industrial clusters in the EU to support the digital transformation of both innovative and non-digital SMEs, ensuring that they have straightforward and fair access to digital technologies or data under appropriate regulatory conditions and receive appropriate digitisation support. The goal is to achieve high digital intensity to ensure no one falls behind. To achieve the 2030 targets, the Commission will reform its industrial strategy to expedite the digital transformation of industrial ecosystems. The "Digital Agenda 2030: A European Way to Achieve the Digital Decade," adopted by the European Parliament in March 2021, is overseen by the "Digital Agenda for the Decade" policy, which establishes the following end goals for digital business transformation to achieve the EU-wide digital goals by 2030:

- 75 % of EU businesses use cloud services, big data and artificial intelligence,
- more than 90 % of EU SMEs achieve at least a basic level of digital intensity,
- the EU will increase the opportunities for its growing innovative businesses and improve their access to finance, leading to a doubling of unicorns [68].

According to classical and neoclassical economics, technical development and innovation are the primary drivers of growth [14, 69-72]. Economic growth can only be accomplished by investing in human capital and increasing the integration of digital technologies. The incorporation and use of digital technologies are inextricably related to human capital development [73]. As a result, the emphasis should be on increasing learning opportunities and research, exploration, and development efforts at both the government and industry levels. A framework for digital advancement should be built at the state level and by all firms as a resource-saving structuring tool [64]. The state's responsibility in fostering companies' digitalisation efforts cannot be avoided since it should provide the necessary framework to guarantee that it can be used in the business sector efficiently [26]. Management's attention to digitalisation and its capacity to acquire information from within and outside the organisation influence the effectiveness of digital transformation.

The desi_3 core Indicator is divided into digital intensity, digital technology integration, and e-commerce. Digital intensity and technological integration are essentially the product of the firm owners' decisions and their ability to recognise digitalisation's opportunities. To make the digital shift a reality, they require the proper skills and financial backing [51-53]. The degree of digitalisation also varies among economic activities, with high degrees of digitisation in sectors such as computing, telecommunications, publishing, cinema and music, television, travel and tour operators, and so on. [36]. We confirm that the shift in the desi_3 indices does not imply any convergence amongst the Member States, according to hypothesis $\mathbf{H_0}$. The main premise of β-convergence is that increases in the desi_3 core indicator are more significant in nations with a lower value. However, this assumption is not statistically supported, although the starting level of development is negatively related to the average growth rate of the desi_3 core indicator from 2016 to 2021.

Company Size And Digitalisation – A Case In Hungary

Development policy divides companies into four categories according to their size: micro, small, medium and large. Depending on the enterprise size, the nature of the digitalisation solutions used, their embeddedness in day-to-day operations, and their impact on competitiveness vary widely. From a digitalisation perspective, the number of employees/users is a key characteristic of an effective work organisation.

Table 4 shows the business results by company size for SMEs operating in Hungary in 2021 [74]. It is clear from the revenue per employee data that the smaller the enterprise, the less productive it is, and the larger the size of the enterprise, the more productive it is. From our point of view, this is interesting because efficiency is closely related to digitalisation, and experience shows that the smaller the enterprise, the less it uses the opportunities offered by digitalisation. In many cases, this is due to the difficulty of generating the costs of the digital switchover and the "brain drain" effect of large international companies offering more competitive salaries, which makes it very difficult for domestic SMEs to attract workers with high digital skills.

Table 4. Business performance indicators by category of small and medium-sized enterprises in Hungary (2021).

SME's enterprise category	Number of enterprises	Number of employees	Turnover per employee, Eur	Distribution of number of employees, %	Net turnover from sales, million Eur	Distribution of net turnover of sales, %	Value added (at factor cost), million Eur	Distribution of value added (factor cost), %	Turnover from export sales, million Eur
Microenterprise with 0 employees	41 732	-	-	-	880	0,2	199	0,2	60
Microenterprise with 1 employee	604 145	604 145	23 897	19,0	14 438	3,8	4 780	5,7	562
Microenterprise with 2-9 employees	196 878	656 385	50 916	20,6	33 421	8,8	9 534	11,4	1064
Small enterprises	36 119	560 430	95 263	17,6	53 389	14,1	13 247	15,9	4 864
Medium enterprises	5 602	365 226	145 732	11,5	53 225	14,0	11 329	13,6	12 123
Non-SME's organisations	7 630	1001 496	224 051	31,4	224 387	59,1	44 417	53,2	106 270
Total	892 106	3187 682	119 127	100	379 739	100	83 503	100	124 942

Over several years, let us look at the KSH's relevant statistics (Hungarian Central Statistical Office). We can report an improvement: the value added and productivity ratio of the SME sector has improved greatly compared to large enterprises, but further strengthening is needed to exploit the economy's growth potential [74].

CONCLUSIONS

Integrating and properly implementing digital technology at the company level is a crucial differentiator that leads to a competitive advantage. We may infer that, at the moment, neither β- nor σ-convergence is seen between the Member States by reviewing and evaluating the values of the European Commission's DESI index on digital technology integration. Although the coefficient is negative, the gap between developed and undeveloped Member States is narrowing, which is not statistically significant (p-value > α). The insignificance indicates that the growth rate of digital technology integration in less developed Member States is not greater than that of developed Member States. The presence of σ-convergence would suggest a decrease in the disparities between Member States over time, i.e. a decrease in the relative dispersion between levels of development over time. Because β-convergence is a required but not sufficient condition for σ-convergence, the lack of β-convergence anticipated the absence of σ-convergence.

Members of the European Union who joined after 2004 were often rated in the bottom half of the rankings. Regarding digital technology integration, the key aggregate indicator, Hungary was just one rank ahead of Bulgaria in 2021 and one place below Romania in 2016. Romania's average annual growth rate was one percentage point greater during this period.

Looking at specific metrics, Hungary has a long way to go. The proportion of SMEs having at least basic digital intensity is 46 %, which is lower than the EU-27 average of 60 % but higher than Bulgaria, Romania, and Latvia. At the EU level, the 90 % aim is still far from being met, with Hungary accounting for half of the target and Bulgaria and Romania accounting for barely a third. The Commission stresses using big data analytics, cloud services, and artificial intelligence as examples of digital technologies for business use. Hungary is likewise in the bottom third, coming in 22nd and 23rd place. It only qualifies for last place when seen as a whole (as seven distinct indicators combined). 14 % of enterprises in Hungary (27th) utilise some ERP system, while the same proportion uses social media (25th). E-invoices for automated processing are used by 13 % of Hungarian enterprises, which is still less than one-third of the EU average. In e-commerce, Hungary's difference from the EU average is not clear, with a more considerable disparity in cross-border online sales. Given the low degree of digital penetration among firms, ranking 22nd in e-commerce is not a bad outcome. Overall, we confirm the digital divide among enterprises in the European countries [75].

To summarise, increasing the usage of digital technologies in businesses requires educating the business community on the various applications of digital technology. Many breakthrough technologies are viewed as threats rather than opportunities. As we will explore in the literature review, the combination of leadership, size, innovation, performance and technology is necessary for digitalisation efforts to be realised within a company. The absence or underdevelopment of these factors can affect overall success. At the same time, it is critical to recognise that digital technology-based advancements come at a high financial cost, which must be offset by human resource development. In order to calculate the return on investment, the expenses of human resource deployment, training, and retraining must be included. The government should encourage digital growth through different procurement methods, which is also inadequate. Developing the ICT sector as an integrated component with the firm in question would also be necessary, surrendering independence to implement projects efficiently.

We believe that, particularly in the case of SMEs, entrepreneurs are more likely to engage in different digitalisation-related activities instinctively rather than deliberately, considering the possible benefits/disadvantages.

Complementing the descriptive statistics currently used in analysing the desi_3 core indicator with the methods presented in this study could help connect macroeconomics to solutions. The evolution of the DESI index and its main constituent indicators, and their monitoring, will provide evidence of whether the Member States currently lagging in the digitalisation process are catching up and the effectiveness of the improvements.

LIMITATIONS

To perform the σ- and β convergence calculations, we used the values of the DESI overall index, which are presented as a transformed percentage. This database was used as the basis for our analysis and was not compared with other databases monitoring the digital development of human capital.

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