Annals of "Dunarea de Jos" University of Galati
Fascicle I. Economics and Applied Informatics
Years XXX – nº1/2024
ISSN-L 1584-0409 ISSN-Online 2344-441X
www.eia.feaa.ugal.ro

DOI https://doi.org/10.35219/eai15840409397

The Implications of Digitization for Sustainable Competitiveness

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ARTICLE INFO

Article history:
Accepted March 2024
Available online April 2024
JEL Classification
M15, M21, E62

Keywords:
sustainable competitiveness, digital competitiveness, DESI dimensions, Eastern European countries

ABSTRACT

The results of previous studies conducted at the European level highlight the low level of Eastern European countries, which are predominantly in the second half of the Digital Competitiveness (DC) ranking, and the situation is similar for Sustainable Competitiveness (SC). On these premises, the purpose of this research was set to analyze the influence of the four dimensions of the Digital Economy and Society Index (DESI) of Eastern European countries from 2014-2022 on the SC index selected on the basis of the same criteria. The achievement of this aim is supported by setting the following objectives: objective 1: identification of the interdependence relationship between the digital economy and the sustainable economy; objective 2: bibliometric analysis of the literature indexed on the Web of Science platform of the most relevant studies dealing with the four dimensions of the DESI: "connectivity", "human capital", "digital technology integration" and "digital public services"; objective 3: determination of the influence of the DESI dimensions on CS through econometric analysis. The results of the research are materialised in the confirmation of the link between digitisation and sustainability based on bibliometric and econometric analysis. The usefulness of the results lies in the fact that this study represents a contribution to the literature in terms of investigating the relationship between DESI dimensions and CS index in Eastern European countries.

1. Introduction

People's needs are the mainstay of new advances in technological development and consumption. The needs are constantly increasing in direct proportion to the numerical growth of the population. As a consequence of satisfying them, different processes appear that over time diminish the Earth's natural resources, which later give rise to new needs and requirements. This endless string of production processes has direct effects on sustainability, which with the passage of time will become a new need (Karki, B.R et al, 2021).

In full expansion of the fourth industrial revolution, the effects of technological changes are increasingly visible and felt at the level of the economy and society. The current economic environment, characterized by transparency and competitiveness, positions superior digital infrastructure at the base of the main activity sectors of developed countries (Ivanović, V., et al, 2023). In specialized literature, the perspectives on which contemporary socio-economic development depends are defined by the terms "digital competitiveness" (CS) and "sustainable competitiveness" (CD) (Stankovic, J. J., et al, 2021).

Digitization can play a crucial role in increasing the sustainable competitiveness of an organization, enabling the optimization of operations, innovation and better responding to market and environmental demands.

Digitization enables the optimization of processes and the use of advanced technologies to improve operational efficiency. This can reduce costs and improve performance while minimizing environmental impact while opening up new opportunities for innovation, enabling companies to develop innovative products and services that meet customer needs more efficiently and sustainably.

We can also talk about the fact that digitization can facilitate access to global markets, allowing companies to reach a wider audience without the need for an extensive physical presence in other countries. Digital technologies also enable greater transparency in supply chains and production processes, facilitating more effective monitoring and management of environmental and resource impacts (Cristache, N. et al, 2021).

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Companies that are well digitized are often more resilient to environmental changes and market disruptions. The ability to adapt quickly and innovate continuously can strengthen the competitive position in the long term.

The results of previous studies carried out at the European level highlight the low level of Eastern European countries, which mainly occupy the places in the second half of the CD ranking, the situation being similar in the case of CS. On these premises, the purpose of this research was established, to analyze the influence of the four dimensions of the DESI index of the Eastern European countries from 2014-2022 on the CS index selected based on the same criteria. The fulfillment of this goal is supported by establishing the following objectives: objective 1: identifying the interdependence relationship between the digital economy and the sustainable economy; objective 2: bibliometric analysis of the specialized literature indexed on the Web of Science platform of the most relevant studies dealing with the four dimensions of the DESI index: "connectivity", "human capital", "integration of digital technology" and "digital public services"; objective 3: determining the influences exerted by the dimensions of the DESI index on CS by means of econometric analysis. The research results materialize in the confirmation of the link between digitalization and sustainability based on bibliometric and econometric analyses. The usefulness of the results lies in the fact that this study represents a contribution to the specialized literature in terms of researching the relationship between the dimensions of the DESI index and the CS index at the level of Eastern European countries.

2. Literature review

Globalization and new digital technologies are important factors due to which changes are taking place in the 21st century with repercussions observed at the global level in terms of the development of the digital and sustainable society. The problems of today's society will find their solution through the integration of digital technologies (Grigorescu, A. et al, 2021), the new sustainable technologies being those that offer not only a competitive advantage, but also effective solutions (Bohnsack, R. et al, 2022). According to Nasifoglu Elidemir et al. (2020), sustainability and digitization are two elements that have the power to influence the economy and society (Gruia, L. A. et al, 2020). Being unexploited to their maximum potential, their contingency gives rise to opportunities and challenges of transition to sustainable development (Castro, G. D. R. et al, 2021).

In this respect the functional congruency refers to the match between stakeholders' expectations regarding the implementation of a social responsibility code and their perceptions on how an organization or system is assessed form the social perspective (Cristache et al, 2019).

Adaptation to the demands of the digital economy is connected to the economic situation of the countries because the implementation of the digital infrastructure depends on it. Europe is a social and political space, which is why the fragmentation of digital technology adoption depends on social and political factors. The development of the digital economy of the countries located in the eastern part of the EU is interdependent with socio-cultural factors, namely the quality of the educational system, investments in research and development and support from the political leadership (Tőkés, G. E., 2022). The European Commission (EC) annually monitors and analyzes the CD of the member states through the Digital Economy and Society Index (DESI) since 2014. The DESI indicator and its dimensions facilitate the assessment of the current level of CD and compare the position of the economy of each member state with the EU average. Time-series research helps to determine the dynamics and directions of change, thereby being able to assess fluctuations in the development of the digital society of the members and the EU as a whole (Borowiecki, R. et al, 2021). As of 2021, the composition of DESI consisted of four dimensions: "connectivity", "human capital", "integration of digital technology" and "digital public services" (Kovács, T. Z., 2022). Thus, currently the four dimensions are structured in four main areas:

Table 1. Dimensions of the DESI index

Connectivity (CNT)	Adoption of fixed broadband, mobile telephony and their prices
Human capital (CU)	Internet skills and advanced digital skills
Integration of digital technology (ITD)	Business digitization and e-commerce
Digital public services (SPD)	eGovernment

Source: Digital Economy and Society Index (DESI)

CS has in its composition several interrelated elements of the concept of sustainable development, which intersect with the elements of economic competitiveness to which is attributed the role of engine of long-term prosperity and growth, without ignoring social and environmental concerns. Future competitiveness cannot be sustained by accelerated use of environmental resources (Doyle, E. and Perez-Alaniz, M, 2017). The interdependence relationship between digitization and sustainability has become a topic addressed in the specialized literature based on which Ordieres-Meré et al. (2020) state that sustainability is one of the main benefits of digital expansion, along with increased productivity and knowledge acquisition. Considering the specialized literature analyzed, objective 1 was established together with the research hypothesis:

H1: An interdependent relationship is formed between digital competitiveness and sustainable competitiveness

The CS index measures competitiveness through several indicators derived from official databases such as the World Bank, IMF, UN agencies, later grouped to form the following sub-indices: Natural capital, Resource efficiency and intensity, social capital, Intellectual capital, Economic sustainability, and Governance Efficiency. These components are interconnected and must be encompassed simultaneously to provide sustainable development. This index can facilitate the assessment of economic performance in this regard and generate important information needed for political and business decision-making (SolAbility, 2022).

In order to more thoroughly explore the specialized literature that studies the four dimensions of the DESI index, we performed a bibliometric analysis in the VOSviewer program, using a database formed by studies published on the theme of the respective dimensions. Initially, we formed the database through the Web of Science platform, where the search was of the form: "Connectivity" OR "Human capital" OR "Integration of digital technology" OR "Digital public services". Following this search, we obtained a total number of 255,657 works on which we applied inclusion and exclusion criteria. Thus, the inclusion criteria consist of selecting research fields relevant to our study, namely economics, management and business, and selecting certain types of documents, namely articles, books and book chapters. Moreover, we selected papers that were published between 2014 and 2023, DESI being introduced starting in 2014. Exclusion criteria consisted of excluding all research areas not relevant to this study and types of documents were not previously mentioned. Finally, by applying the inclusion and exclusion criteria, we obtained a number of 8,691 works, which constitute the database that will be processed later in the VOSviewer program.

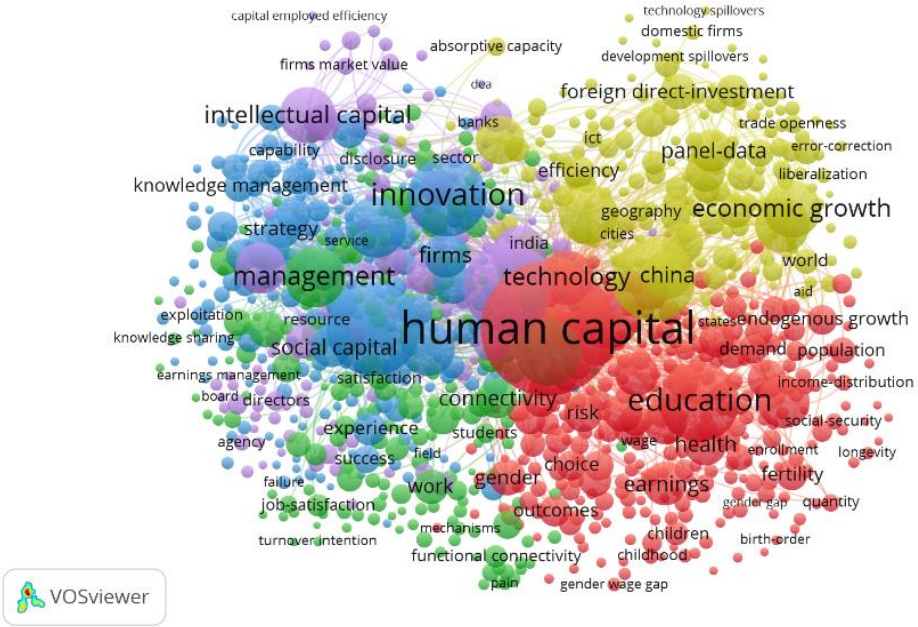

Figure 1. Network of key terms related to the topic„Connectivity", „Human capital", „Integration of digital technology", „Digital public services"

Source: Own processing in the VOSviewer program

Figure 1 shows the network of key terms obtained after processing the database in the VOSviewer software. Therefore, the key terms grouped according to their frequency and relevance, form a total number of five different color clusters. The first cluster, shown in the image in red, contains 288 key terms that revolve around the concept of CU, which is one of the components of the DESI index. CU is considered the key to the development of an innovative economy based on knowledge and digitization. Basic digital skills are for everyday activities that are limited to the use of Internet and communication resources, while the digital society requires advanced skills that are adaptable to the pace of changes in the labor market (Olczyk, M., and Kuc-Czarnecka, M, 2022).

The second cluster in the network of key terms is illustrated in green and totals a total of 212 terms that form the concept of CNT, another dimension of the digital economy and society index. Therefore, CNT is the index by means of which it is evaluated to what extent a country is connected to the Internet. If the increase in the CNT value indicates the increase in the number of inhabitants of a country who have access to the Internet, the decrease in the accessibility value is caused by technical factors specific to the infrastructure or the much too high cost required to expand the network (Başol, O. and Yalçın, E. C., 2021). Also, within this cluster we find the term "sustainability" which reveals the fact that in order to increase CS, European countries

will need both a more developed digital sector and a channel towards digital transformation (Dabbous, A. et al., 2023).

Cluster number three is represented by the color blue in the keyword grid and comprises 190 terms that refer to the next two dimensions of the DESI index, namely ITD and SPD. ITD expresses the level of integration in business and e-commerce, of new digital technologies (Imran, M. et al, 2022). The last dimension of the DESI index is represented by the SPD, which measures the degree of digitization at the level of public institutions, focusing mainly on e-Government. This dimension stands out for its importance regarding the fact that the SPD makes both the activity of public administration and the activity of citizens more efficient (Laitsou, E. et al, 2022).

The last two clusters add up to a total of 310 key terms, illustrated in the network by the colors yellow and purple, respectively, these terms referring mainly to concepts such as "firm performance", "innovation", competitive advantages", "productivity" and "growth economic". All these terms reflect the fact that the DESI index, through its four dimensions, significantly influences economic growth and firm performance.

Although we did not include the term "sustainability" in the bibliometric analysis carried out on the four dimensions of the DESI index, the concepts of "sustainability", "sustainable development", "sustainable competitiveness" are often found in the clusters of the network of key terms obtained. This aspect supports the idea that the four dimensions of the DESI index maintain the competitiveness of European countries and increase the sustainability of those countries that present a high score of this index. According to the results obtained from the bibliometric analysis, hypothesis H1 is confirmed. Following the realization and interpretation of the above analysis, objective 2 was established and the following hypothesis was formulated:
H2: The dimensions of the DESI index are influencing factors on sustainable competitiveness

3. Research methodology

This section of the paper is intended to describe the research method to obtain the results of the econometric analyses, which are to be discussed. The following table presents the main information regarding the structure of the database and the applied criteria:

Table 2. Research strategy

Database: *CS index and DESI dimension scores for Eastern European EU countries*	
Type of research: quantitative, time series econometric analysis method	
Structure of the database: 11 sections, each with 9 records according to the analyzed period	
The analyzed period	interval 2014-2023
Inclusion criteria;	Eastern European countries, members of the EU
Exclusion criteria	countries which do not belong to the Eastern European area and the EU
Dependent variable	CS
independent variables	CNT, CU, ITD și SPD
Date of data processing	03.02.2024
Data processing	SPSS25 application

Source: Own processing

After completing the data collection and processing process, they will be analyzed and discussed in the next section.

4. Results and discussions

The purpose of this section is to create an econometric model for each Eastern European country that is also a member of the EU. Afterwards, the results will be analyzed to highlight the level of influence exerted by the independent variables: CNT, CU, ITD and SPD on the dependent variable CS.

Following the elaboration of the econometric models, the best results were obtained within the multiple linear regression models, represented by the following equation for CS:

$$CS = \alpha + \beta 1 * CNT + \beta 2 * CU + \beta 3 * ITD + \beta 4 * SPD + \varepsilon \quad (1)$$

According to the Model Summary table, it is found that between the dependent variable CS and the independent variables CNT, CU, ITD and SPD there are strong correlations between 0.933 and 0.968. Based on the analysis of the determination reports, it is noted that the variation of the independent variables influences the variation of the dependent variable CS in proportions between 89.3% and 93.7%, depending on the analyzed country.

Table 3. Model summary[b]

Model	R	R adjust	Adjusted square	The estimated standard error	Durbin-Watson
Romania	0,965	0,932	0,863	1,1448	2,954
Hungary	0,851	0,724	0,448	1,8122	2,109
Bulgaria	0,968	0,937	0,874	1,0044	2,558
Poland	0,928	0,862	0,724	1,1004	1,814
Czech Republic	0,913	0,833	0,666	1,4540	2,651
Slovakia	0,945	0,893	0,785	1,1149	0,930
Slovenia	0,933	0,870	0,739	1,1671	2,495
Croatia	0,850	0,723	0,445	2,5154	1,259
Lithuania	0,868	0,753	0,505	1,5488	3,391
Latvia	0,965	0,931	0,863	1,3058	2,622
Estonia	0,946	0,895	0,789	1,4003	3,388
Dependent variable: CS					
Predictors: (Constant), SPD, CNT, ITD, CU					

Source: Own processing based on data obtained in SPSS

Also, according to the ANOVA table, the econometric models made for the countries Romania, Bulgaria, Slovakia, Slovenia, Latvia and Estonia are validated with the probability of 95%, the value of Sig. being less than the significance threshold of 0.05.

The four independent variables exert positive influences on the dependent variable CS registered at the level of Romania. Analyzing the unstandardized coefficients, the greatest influence on CS is CU, whose increase by one unit, in the context in which the other variables remain constant, will generate an increase of 0.770 units. CU represents an essential source of competitive advantage in the process of sustainable development, not only in Romania. Despite being at the bottom of the ranking, Romania registers a constant annual increase in the number of ICT specialists, in 2021 being 2.6%, but below the EU average of 4.5%. This influence can be capitalized through the CNT, a dimension that has a score of 55.2, which places us in 15th place, a score close to the EU average of 55.9. ITD has a contribution of 0.196 units on CS, respecting the same mentioned conditions. At the national level, investment projects aimed at digitizing the SME sector are underway with the aim of innovating the current business environment. Regarding the reduced influence of the SPD, the main category of factors that make it difficult to align this dimension with the EU average are demographic factors. The large differences between the rural and urban areas, the aging population, as well as the relatively low level of public sector investment are important factors that maintain a low influence of the SPD on the SC. In order to improve the level of development of SPD in Romania, there is a need for an approach that involves a significant increase in investments in IT infrastructure, the modernization of administrative and bureaucratic processes and the increase of ICT skills among the population.

Considering the low level of ITD, Bulgaria has made efforts in recent years to improve the situation, which is why this dimension exerts the greatest influence on CS. Starting from 2021, it supports micro-enterprises and SMEs in the process of increasing ICT capacity and has several national IT security strategy projects underway. Thus, it is found that an increase of one unit in ITD, if other variables remain constant, will generate an average increase of 0.240 units. A close influence of 0.219 units is brought about by a one-unit change in SPD, but by 0.071 units as a result of an increase in CU, if specific conditions are met. The modest influence of the three variables is a consequence of the negative influence exerted by the CNT variable, namely the decrease by 0.06 units of the CS index. Even if, according to the data, Bulgaria has surpassed fast broadband coverage and high-capacity networks, it is experiencing problems of adaptation and use, which does not favor a sustainable use that would encourage competitiveness and increase social and economic well-being in the long term. Another factor affecting CD is the low level of digital literacy of the population, but also of businesses. In addition to these factors, corruption can intervene, but also the economic and social situation of the country. Carrying out the same analysis on Slovakian data, a positive influence of CNT on the SC index is noted. In recent years, a significant increase in the percentage of households with high-capacity fixed network coverage has been observed on the territory of Slovakia, although a difference between rural and urban environments is maintained. From this point of view, the country is close to the EU average level possible due to the low prices applied. Despite this level of connectivity, one unit increase in TNC influences the increase in CS by 0.219 units due to faster access to information, research and innovation tools, and effective communication. Although Slovakia is beginning to have the necessary infrastructure that benefits the two types of competitiveness, based on the econometric analysis, a negative influence of the other three variables on sustainability is found. A multitude of national strategic documents discuss the need to increase the level of digital skills among the population and to attract specialists in this field. The use of artificial intelligence, cloud services, big data analysis, the practice of e-commerce are elements that improve operational efficiency, increase innovation and

new product development and reduce the impact on the environment, but unfortunately ITD is not carried out in large proportions in Slovakia, thus not contributing to increasing CS. As for the SPD, they were at the objective stage, the steps starting in 2021 with the "National Concept for the computerization of public administration for the years 2021-2026". The main barrier to SPD in Slovakia has been the reluctance of large-scale adoption by both citizens and businesses, blocking the process of sustainable development. Adopting policies that encourage the development of the digital economy in a sustainable way, as well as adopting policies that promote the development of other sectors of the economy are some proposals to reduce the negative influences of CU, ITD and SPD.

In the case of Slovenia, the greatest influence on SC is given by the size of the CNT, which reaches the EU average of 59.9 in 2021. Slovenia has focused on increasing 5G coverage, which has developed considerably globally in recent years, registering a significant increase from 0% in 2020 to 98% in 2021. The SPD dimension has an average influence on sustainable competitiveness at the level of Slovenia, managing to exceed the EU average in 2021. Slovenia has the high share of e-Government users, 77% of internet users accessing the e-Government platform, while the EU average is 65% of internet users. In 2021, Slovenia achieved its goal of creating online medical records on its own zVEM platform, with a percentage of approximately 20% of all registered users. In the case of the ITD dimension, it shows a negative influence on CS. This is because Slovenia scores below the EU average on the CU dimension, and this is reflected in the ITD. Although the implementation of new technologies is advanced within Slovenian companies, CU does not have enough basic digital skills to use these technologies to the desired level. Therefore, a one-unit increase in digital technology integration, other variables remaining constant, will lead to a decrease in CS by 0.067 units.

Analyzing the data related to Latvia, we can see a high influence of ITD size on the dependent variable CS. This is confirmed by the fact that although Latvia's score on this dimension is below the EU average of 36.1, it shows significant year-on-year increases. In 2021, 39% of businesses in Latvia distribute information electronically, one percentage point above the EU average. In this situation, a one-unit increase in digital technology integration, other variables remaining constant, will increase the dependent variable CS by 0.700 units. A high influence on CS is exerted by the size of CU, an aspect explained by the continuous increase of ICT graduates in the country. The share of ICT graduates in Latvia is 4.6%, almost one percentage point higher than the EU average. This is a significant influence on CS because young graduates represent the future of the country, they are an important factor in the economic development of Latvia. Also, CNT size shows an important influence on CS. Although Latvia is slightly below the EU average of 59.9, it excels in many components of this dimension. For example, in the year 2021,

Latvia stands out with 91% high-capacity fixed network coverage, 21 percentage points above the EU average. Moreover, Latvia is 7 percentage points above the EU average in terms of 5G spectrum. A significant share is also found in fiber-to-the-premises coverage, where 89% of Latvian households have it, while the EU average is only 50% of households. A small influence on CS is given by the size of the SPD, although it has a score above the EU average, a fact that may be caused by the existence of other factors that exert a greater influence on CS such as the efficiency and intensity of resources or the efficiency of governance.

Estonia is considered one of the most digitized nations in the world, being awarded the name eEstonia. In the case of this country, a high influence on CS is exerted by the size of the SPD. Since 2014, Estonia has distinguished itself in this dimension with a score of 80, ranking 2nd in the EU, and from 2017 to 2021 it will maintain its first position, with an upward score between 85 and 91 ,2. Citizens of Estonia have a wide range of SPDs, such as: eID, the electronic identity card held by about 90% of citizens, electronic voting, which can be done at local, national and European level, and services of electronic health. Holding other variables constant, a one-unit increase in SPD will generate a 0.387-unit increase in CS. Estonia shows a significant influence of CU on CS. In this chapter, Estonia is slightly above the EU average in terms of the share of individuals with basic digital skills and those with above basic digital skills. CNT has a medium influence on CS, on this dimension Estonia scores below the EU average, due to the lack of 5G spectrum allocation and coverage, but the Estonian government proposes to address this issue by progressively allocating the relevant spectrum bands. A lower influence on CS is given by the ITD dimension, this aspect being explained by low indicators of the CNT dimension. Thus, although Estonian businesses have the necessary technologies, the poor internet connection resulting from the above factors makes these technologies difficult to use. Therefore, other variables remaining constant, a one-unit increase in ITD size will lead to an increase in CS of only 0.095 units.

Following the data obtained based on the econometric analysis for the countries whose models have been validated, hypothesis H2 is confirmed, according to which the dimensions of the DESI index are factors that influence CS.

Analyzing the standardized coefficients in the case of the six countries, it is found that the order of influence is relatively similar as in the case of the unstandardized coefficients, which confirms the results of the analysis performed. According to the ANOVA table, the econometric models for the countries Hungary, Poland, Czech Republic, Croatia and Lithuania, were not validated due to the fact that the value of Sig. is greater than the 0.05 significance threshold. There are several factors that can determine the non-validation of the econometric models used to analyze the relationship between CS and CD, such as the variables not included that can have a greater influence on sustainable competitiveness, among which can be found: "natural

resources", "business environments favorable", "innovation capacity". Also, the lack of a correlation may indicate the interest directed towards the fulfillment of other objectives in the agenda of the mentioned countries.

5. Conclusions

According to the study of specialized literature, bibliometric analysis and econometric analyses, the dimensions of the DESI index evaluate the influence of digitization exerted on different aspects of society and on economic sustainability. The purpose of our research was to analyze the influence of the dimensions of the DESI index of Eastern European countries from 2014-2022 on the CS index selected based on the same criteria. Following the elaboration of the econometric models, the validation occurred for the countries Romania, Bulgaria, Slovakia, Slovenia, Latvia and Estonia with the probability of 95%, the value of Sig. being less than the significance threshold of 0.05. At the Romanian level, it was found that the greatest influence on CS is exerted by the CU dimension, which must be capitalized to increase ITD and SPD. Although the CU score does not exceed the EU average, its effective use can increase the contribution of the other dimensions.

Bulgaria's advantage lies in ITD and SPD. Given that it has these two dimensions, due to the weak or even negative influence of CNT and CU, CS does not show an increase that causes the business environment and the public environment to digitize and optimize activities to increase CD. Unlike Romania and Bulgaria, in Slovakia CNT is the only dimension that positively affects CS, this fact is due to the sustainable technology installed in the last two years. This technology is expected to lead to the specialization of CU and ITD in more and more fields of activity. Concluding in the case of Slovenia, we believe that it must emphasize the CU and ITD dimensions because by improving these dimensions, the country will reach a higher level and benefit from an increase in sustainability. This country can maximize its CU potential by increasing awareness of the need for digital skills and by increasing the level of specialization of the workforce. Latvia excels in ITD, with indicators of this dimension registering significant increases year-on-year. However, Latvia needs to emphasize CU, integrating ICT specialists in the labor market, the valorization of this dimension is materialized by increasing the contribution of the other dimensions to CS. Estonia stands out for its high scores recorded since 2014, managing to stay in the top positions. At the level of this country, the SPD dimension exerts a high influence on CS, being the country with the highest scores on this dimension. We can assume that the low influence of the CNT dimension is reflected in the other dimensions. Thus, Estonia needs to focus on improving infrastructure elements and reducing prices to increase the contribution of the other dimensions to SC.

We consider the main limitation of our research to be the non-validation of the econometric models for the countries of Hungary, Poland, the Czech Republic, Croatia and Lithuania, thus not being able to carry out research at the level of the entire Eastern Europe. As future research directions, we propose the development of econometric models that take into account, among others, variables such as the level of economic development, the degree of digitalization, fiscal and environmental policy, as well as other relevant factors for the analysis of CD and CS. Thus, it will be possible to develop policies and strategies to promote the sustainable and digital development of the economies in this region.

In conclusion, we believe that the concept of "sustainable competitiveness" should lead the EU to develop a common economic policy that is consistent with the interests of the Eastern European member countries and that allows them to fold their national policies according to by the demands of the global market. Otherwise, most of these countries will not be able to play a role in the global arena, risking being completely annihilated by the technology policy of China and the US. Therefore, it is imperative that EU policies and strategies are focused in particular on the formation of technological development centers and the training of human resource excellence skills.

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