

The influence of the digital revolution on sustainable competitiveness. Case study for Eastern European countries

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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 SC through econometric analysis. The results of the research are materialized in the confirmation of the link between digitization 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 SC index in Eastern European countries.

Keywords: *DESI dimensions; digital competitiveness; Eastern; European countries; sustainable competitiveness.*

JEL Classification: M41

I. INTRODUCTION

People's needs are at the heart of new advances in technological development and consumption. Needs are constantly increasing in direct proportion to population growth. As a consequence of satisfying these needs, various processes emerge which over time deplete the Earth's natural resources, which then give rise to new needs and demands. This never-ending chain of production processes has a direct impact on sustainability, which over time will become a new need (Karki et al., 2021).

Amid the booming Fourth Industrial Revolution, the effects of technological change are increasingly visible and felt in the economy and society. Today's transparent and competitive economic environment puts superior digital infrastructure at the heart of the main sectors of activity in developed countries. In the literature, the prospects on which contemporary socio-economic development depends are defined by the terms "digital competitiveness" (DC) and "sustainable competitiveness" (SC) (Ivanovic et al., 2023).

The results of previous studies at European level highlight the low level of Eastern European countries, which are predominantly in the second half of the DC ranking, and the situation is similar for the SC. On these premises, the aim of this research was set to analyze the influence of the four dimensions of the DESI of Eastern European countries in 2014-2022 on the SC index selected based on the same criteria. The achievement of this goal is supported by setting the following objectives: objective 1: to identify the interdependent 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: to determine the influence of the DESI dimensions on SC through econometric analysis. *The results of the research materialize in confirming the link between digitization 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 literature in terms of investigating the relationship between DESI dimensions and SC index in Eastern European countries.*

II. LITERATURE REVIEW

Globalization and new digital technologies are important factors that are driving changes in the 21st century with global implications for the development of a digital and sustainable society. Today's societal problems will be solved by integrating digital technologies, new sustainable technologies are those that offer not only a competitive advantage but also effective solutions (Bohnsack et al., 2022). According to Nasifoglu Elidemir et al. (2020), sustainability and digitalization are two elements that have the power to influence the economy and society. Untapped to their full potential, their contingency gives rise to opportunities and challenges of transition towards sustainable development.

Adapting to the requirements of the digital economy is connected to the economic situation of countries, as the implementation of digital infrastructure depends on it. Europe is a social and political space, which is why the fragmentation of the digital adoption process depends on social and political factors. The development of the digital economy of countries in the eastern part of the EU is interdependent on socio-cultural factors, i.e. the quality of the education system, investment in research and development and support from the political leadership (Tokes, 2022). The European Commission (EC) has been monitoring and analyzing Member States' DC annually through the Digital Economy and Society Index (DESI) since 2014. The DESI and its dimensions facilitate the assessment of the current level of DC and compare the position of each Member State's economy with the EU average. Time series research helps to determine the dynamics and directions of change, so that fluctuations in the development of the digital society of members and the EU as a whole can be assessed. From 2021 onwards, DESI's composition consists of four dimensions: 'connectivity', 'human capital', 'digital technology integration' and 'digital public services' (Borowiecki et al., 2021; Dabbous et al., 2023). Thus, the four dimensions are currently structured into four main areas:

Table 1. Dimensions of the DESI index

Connectivity (CNT)	Take-up of fixed broadband, mobile telephony and their prices
Human Capital (HC)	Internet skills and advanced digital skills
Integration of digital technology (ITD)	Digitization of business and e-commerce
Digital Public Services (DPS)	e-Government

Source: Digital Economy and Society Index (DESI)

SC is composed of several interrelated elements of the concept of sustainable development, which intersect with elements of economic competitiveness, which is attributed the role of driving long-term prosperity and growth, without ignoring social and environmental concerns. Future competitiveness cannot be sustained by accelerated use of environmental resources (Doyle et al., 2017). The interdependent relationship between digitization and sustainability has become a topic addressed in the literature on the basis of which Ordieres-Meré et al. (2020) state that sustainability is among the main benefits of digital expansion, along with productivity growth and knowledge acquisition. Given the reviewed literature, objective 1 was set along with the research hypothesis:

H1: An interdependent relationship is forming between digital competitiveness and sustainable competitiveness.

The SC Index, measures competitiveness through several indicators derived from official databases such as the World Bank, IMF, UN agencies, then 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 interlinked and must be addressed simultaneously to deliver sustainable development. This index can make it easier to assess economic performance in this respect and can generate important information needed for policy and business decision-making (SolAbility, 2022).

To further explore the literature by studying the four dimensions of the DESI, we conducted a bibliometric analysis in VOSviewer using a database of published studies on the respective dimensions. Initially, we formed the database via 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". This search yielded a total of 255,657 papers to which we applied inclusion and exclusion criteria. Thus, the inclusion criteria consisted of selecting the research areas relevant to our study, namely economics, management and business, and selecting certain types of papers, namely articles, books and book chapters. Furthermore, we selected papers that were published between 2014 and 2023, with DESI being introduced from 2014 onwards. The exclusion criteria consist of excluding all areas of research that are not relevant to this study and types of documents not mentioned above. In the end, by applying the inclusion and exclusion criteria, we obtained a total of 8,691 papers, which constitutes the database that will be further processed in the VOSviewer program.

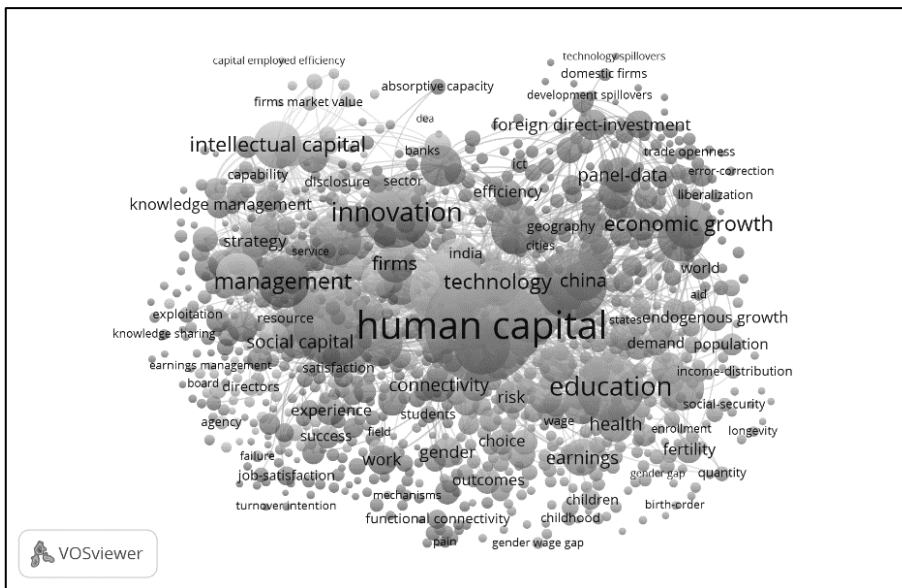


Figure 1 - Network of key terms related to the themes "Connectivity", "Human capital", "Integration of digital technology", "Digital public services"

Source: Own processing in VOSviewer software

Figure 1 illustrates the network of key terms obtained from processing the database in the VOSviewer software. Therefore, the key terms grouped according to their frequency and relevance form a total of five different color clusters. The first cluster, shown in the image in red, contains 288 key terms revolving around the concept of HC, which is one of the components of the DESI index. HU is seen as key to the development of an innovative, knowledge-based and digital economy. Basic digital skills are the core of everyday activities limited to the use of internet and communication resources, while the digital society requires advanced skills that are adaptable to the pace of change in the labor market (Olczyk et al., 2022; Kovács et al., 2022).

The second cluster in the network of key terms is shown in green and totals 212 terms that make up the concept of CNT, another dimension of the Digital Economy and Society Index. CNT is therefore the index that assesses the extent to which a country is connected to the internet. While an increase in the CNT value indicates an increase in the number of people in a country who have access to the Internet, a decrease in the affordability value is caused by technical factors specific to the infrastructure or the far too high cost of expanding the network. Also, within this cluster we find the term "sustainability" which reveals that in order to increase SC, European countries will need both a more developed digital sector and a channel towards digital transformation (Başol et al., 2021).

Cluster number three is represented by the blue color in the keyword network and comprises 190 terms referring to the next two dimensions of the DESI, namely ITD and DPS. ITD expresses the level of integration of new digital technologies in business and e-commerce. The last dimension of the DESI is the DPS, which measures the degree of digitization in public institutions, focusing mainly on e-Government. This dimension stands out for its importance in terms of making both public administration and citizens' work more efficient (Imran et al., 2022).

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

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 supports the idea that the four dimensions of the DESI maintain competitiveness across European countries and increase the sustainability of those countries with high DESI scores. According to the results obtained from the bibliometric analysis, hypothesis H1 is confirmed. Following the above analysis and interpretation, objective 2 was established and the following hypothesis was formulated:

H2: DESI dimensions are factors influencing sustainable competitiveness.

III. RESEARCH METHODOLOGY

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

Table 2. Research strategy

Database: SCindex and DESI dimensions scores for EU Eastern European countries	
Type of research: quantitative, time series econometric analysis method	
Database structure: 11 sections, each with 9 records according to the period analysed	
Period analysed	2014-2022
Inclusion criteria;	Eastern European countries, EU members
Exclusion criteria	non-Eastern European and EU countries
Dependent variable	SC
Independent variables	CNT, HU, ITD și DPS
Date of data processing	03.05.2023
Data processing	SPSS25 application

Source: Own processing

Once the data collection and processing process is complete, the data will be analyzed and discussed in the next section.

IV. RESULTS AND DISCUSSION

The aim of this section is to develop an econometric model for each Eastern European and EU member country and then the results will be analyzed to show the level of influence of the independent variables CNT, HU, ITD and DPS on the dependent variable SC.

Following econometric modelling, the best results were obtained in multiple linear regression models, represented by the following equation for SC:

$$SC = \alpha + \beta_1 * CNT + \beta_2 * HU + \beta_3 * ITD + \beta_4 * DPS + \varepsilon (1)$$

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

Table 3. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
România	0,965	0,932	0,863	1,1448	2,954
Ungaria	0,851	0,724	0,448	1,8122	2,109
Bulgaria	0,968	0,937	0,874	1,0044	2,558
Polonia	0,928	0,862	0,724	1,1004	1,814
Cehia	0,913	0,833	0,666	1,4540	2,651
Slovenia	0,945	0,893	0,785	1,1149	0,930
Slovenia	0,933	0,870	0,739	1,1671	2,495
Croația	0,850	0,723	0,445	2,5154	1,259
Lituania	0,868	0,753	0,505	1,5488	3,391
Letonia	0,965	0,931	0,863	1,3058	2,622
Estonia	0,946	0,895	0,789	1,4003	3,388
Dependent Variable: SC					
Predictor: (Constant), DSP, CNT, ITD, HU					

Source: Own processing based on SPSS data

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

The four independent variables exert positive influences on the dependent variable SC in Romania. Analysing the unstandardized coefficients, the largest influence on the SC is exerted by HU, whose increase by one unit, in the context of the other variables remaining constant, will generate an increase of 0.770 units. HU is a key source of competitive advantage in the process of sustainable development, not only in Romania. Despite being at the bottom of the ranking, Romania has a steady annual growth in the number of ICT specialists, which in 2021 will be 2.6%, but below the EU average of 4.5%. This influence can be harnessed through the NQF, a dimension which has a score of 55.2, placing us in 15th place, close to the EU average of 55.9. ITD has a contribution of 0.196 units on SC, respecting the same conditions mentioned above. At national level, investment projects aimed at digitizing the SME sector with the aim of innovating the current business environment are underway. In terms of low DPS influence, the main category of factors that make it difficult to align this dimension with the EU average are demographic factors. The large rural-urban gap, the ageing population and the relatively low level of public sector investment are important factors that keep the DPS's influence on SC low. In order to improve the level of development of DPS in Romania,

there is a need for an approach involving a significant increase in investment in IT infrastructure, modernization of administrative and bureaucratic processes and increasing ICT skills among the population.

Given the low level of ITD, Bulgaria has made efforts to improve the situation in recent years, which is why this dimension has the greatest influence on the SC. As of 2021, it is supporting micro-enterprises and SMEs in the process of ICT capacity building and has several national cyber security strategy projects underway. Thus, it is found that a one unit increase in ITD, if the 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 DPS, but by 0.071 units due to an increase in HU, if the specific conditions are met. The modest influence of the three variables is a consequence of the negative influence exerted by the CNT variable, i.e. a decrease of 0.06 units in the SC index. Even though Bulgaria is reported to have overtaken fast broadband coverage, and high-capacity networks, it faces problems of adaptation and usage, which is not conducive to sustainable deployment that fosters competitiveness and increases long-term social and economic welfare. Another factor affecting DC is the low level of digital literacy of the population, but also of businesses. In addition to these factors, corruption can also play a role, as well as the economic and social situation in the country.

Performing the same analysis on Slovak data, a positive influence of NTC on the SC index is noted. In recent years, there has been a significant increase in the percentage of households with high-capacity fixed network coverage in Slovakia, but a gap between rural and urban environments remains. From this point of view, the country is close to the EU average, possibly due to low prices. Despite this level of connectivity, the one unit increase in NTC influences the increase in SC by 0.219 units due to faster access to information, research and innovation tools, and effective communication. Although Slovakia is starting to have the necessary infrastructure that benefits both types of competitiveness, the econometric analysis shows a negative influence of the other three variables on sustainability. A multitude of national policy documents raise the need to raise the level of digital skills among the population and to attract specialists in this field. The use of artificial intelligence, cloud services, big data analytics, e-commerce are elements that improve operational efficiency, increase innovation and new product development and reduce environmental impact, but unfortunately ITD is not realized to a large extent in Slovakia, thus not contributing to SC growth. As far as the DPS is concerned, they are at the target stage, with work starting in 2021 with the "National Public Administration Informatization Concept 2021-2026". The main barrier to DPS in Slovakia has been the reluctance of widespread 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 (Grigorescu et al, 2021), as well as adopting policies that promote the development of other sectors of the economy are some proposals to reduce the negative influences of HU, ITD and DPS.

In the case of Slovenia, the biggest influence on SC is given by the size of the NTC, which reaches the EU average of 59.9 in 2021. Slovenia has put emphasis on increasing 5G coverage, which has developed considerably globally in recent years, growing significantly from 0% in 2020 to 98% in 2021. The DPS dimension has a medium influence on sustainable competitiveness in Slovenia, with Slovenia managing to exceed the EU average in 2021. Slovenia has the highest share of eGovernment users, with 77% of internet users accessing the eGovernment platform, while the EU average is 65% of internet users. In 2021, Slovenia has reached its target of creating online medical records on its own zVEM platform, with approximately 20% of all registered users. In the case of the ITD dimension, it has a negative influence on SC. This is due to the fact that Slovenia scores below the EU average on the HU dimension, and this is reflected in the ITD. Although the implementation of new technologies is advanced in Slovenian companies, HU does not have sufficient basic digital skills to use these technologies at the desired level. Therefore, a one unit increase in digital technology integration, while all other variables remain constant, will generate a decrease in HU by 0.067 units.

Analyzing the Latvian data, we can observe a high influence of the ITD dimension on the dependent variable SC. 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 enterprises in Latvia distribute information electronically, one percentage point above the EU average. In this situation, increasing digital technology integration by one unit, with all other variables held constant, will increase the dependent variable SC by 0.700 units. A high influence on SC is exerted by the HU dimension, explained by the continuous growth 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 SC because young graduates are the future of the country and an important factor in Latvia's economic development. The size of the NTC also has a significant influence on the SC. Although Latvia is slightly below the EU average of 59.9, it excels in many of the components of this dimension. For example, in 2021, Latvia stands out with 91% coverage of the high-capacity fixed network, 21 percentage points above the EU average. Moreover, Latvia is 7 percentage points above the EU average for 5G spectrum. A significant share is also found for fibre-to-the-premises coverage, where 89% of Latvian households have it, while the EU average is only 50% of households. A small influence on SC is given by the size of the DPS, although it scores above the EU average, which may be due to the existence of other factors exerting a greater influence on SC such as resource efficiency and intensity or governance efficiency.

Estonia is considered one of the most digitized nations in the world and is called eEstonia. In the case of this country, a high influence on SC is exerted by the size of the DPS. As early as 2014, Estonia stood out on this dimension with a score of 80, ranking 2nd in the EU, and from 2017 to 2021 it will remain in first place with an ascending score

between 85 and 91.2. Estonian citizens have access to a wide range of DPS, such as eID, the electronic ID card held by around 90% of citizens, e-voting, which can be carried out at local, national and European level, and e-health services. Holding the other variables constant, an increase of one unit in DPS will generate an increase of 0.387 units in SC. Estonia has a significant influence of HU on SC. In this respect, Estonia is slightly above the EU average for the share of individuals with basic digital skills and those with above basic digital skills. CNT has a medium influence on SC, with Estonia scoring below the EU average on this dimension due to the lack of 5G spectrum allocation and coverage, but the Estonian government aims to address this by progressively allocating the relevant spectrum bands. A lower influence on SC is given by the ITD dimension, which is explained by low indicators of the CNT dimension. Thus, although enterprises in Estonia have the necessary technologies, the poor internet connection resulting from the above-mentioned factors makes these technologies difficult to use. Therefore, assuming that the other variables remain constant, increasing the ITD size by one unit will increase the SC by only 0.095 units.

Based on the data obtained from the econometric analysis for the countries whose models have been validated, hypothesis H2 is confirmed that the dimensions of the DESI are factors influencing CS.

Analyzing the standardized coefficients for the six countries shows that the order of influence is relatively similar as for the unstandardized coefficients, which confirms the results of the achievement analysis. 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 Sig. value is higher than the significance threshold of 0.05. There are several factors that may cause the econometric models used for the purpose of analyzing the relationship between SC and DC to be invalid, such as unincluded variables that may have a greater influence on sustainable competitiveness among which can be found: 'natural resources', 'favorable business environments', 'innovation capacity'. The lack of correlation may also indicate a focus on other objectives on the agenda of the countries mentioned.

V. CONCLUSIONS

According to literature review, bibliometric analysis and econometric analysis, the DESI dimensions assess the influence of digitization on different aspects of society and economic sustainability. The aim of our research was to analyze the influence of the dimensions of the DESI index of Eastern European countries from 2014-2022 on the SC index selected on the basis of the same criteria.

Following the development of the econometric models, the validation occurred for the countries Romania, Bulgaria, Slovakia, Slovenia, Latvia and Estonia with a probability of 95%, the Sig. value being less than the significance threshold of 0.05. At the Romanian level it was found that the greatest influence on SC is exerted by the HU dimension, which should be exploited to increase ITD and DPS. Although the HU 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 DPS. Having these two dimensions, due to the weak or even negative influence of CNT and HU, SC does not show an increase that would lead business and public to digitize and optimize activities to increase DC. Unlike Romania and Bulgaria, in Slovakia CNT is the only dimension that positively affects SC, which is due to the consistent technology installed in the last two years. This technology is expected to lead to specialization of HU and ITD in more and more business areas. Coming to a conclusion in the case of Slovenia, we believe that Slovenia should focus on the HU and ITD dimensions because by improving these dimensions, the country will reach a higher level and benefit from increased sustainability. This country can maximize its HU potential by raising awareness of the need for digital skills and increasing the skills of the workforce. Latvia excels in ITD, with indicators in this dimension showing significant year-on-year increases. However, Latvia needs to put more emphasis on HU, integrating ICT specialists into the labor market, leveraging this dimension by increasing the contribution of the other dimensions on SC. Estonia stands out with high scores since 2014 itself, managing to stay in the top positions. At the country level, the DPS dimension exerts a high influence on SC, 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 in order to increase the contribution of the other dimensions on SC.

We consider the main limitation of our research to be the non-validation of the econometric models for the countries of Hungary, Poland, Czech Republic, Croatia and Lithuania, thus making it impossible to carry out research at the level of Eastern Europe as a whole. As future research directions we propose to develop econometric models that take into account, among others, variables such as the level of economic development, the degree of digitization, fiscal and environmental policy, and other factors relevant for DC and SC analysis. This will allow the development of policies and strategies to promote sustainable and digital development of the economies in the region.

In conclusion, we believe that the concept of "sustainable competitiveness" should lead the EU to develop a common economic policy that is in line with the interests of the Eastern European member countries and that also allows them to adjust their national policies to the requirements of the global market. Otherwise, most of these countries will not be able to play a role in the global arena and risk being completely annihilated by China's and the US's technology policy. It is therefore imperative that EU policies and strategies focus on the formation of technology development centers and the training of excellent human resource skills.

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