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Modelling the impact of innovation performance on digital competitiveness: The key role of innovation and technologies

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ABSTRACT

The objective of this paper is to evaluate the innovation and digital competitiveness of the EU-27 countries and to reveal the effect of innovation performance on the changes in digital competitiveness. We obtained secondary data from the annual reports of the Global Innovation Index (GII), Summary Innovation Index (SII), and Digital Economy and Society Index (DESI) for the years 2017 to 2021. Using structural equation modeling, the main concept was to develop a new variable, Innovation Performance (IP), which was created by combining the indices of the GII and SII dimensions within a new three-factor model. The modelling findings revealed that both indexes had a statistically significant impact on the variations in the IP value, with the SII exerting a greater influence compared to the GII. The IP variable in the modified model has a significant positive impact on the change in the score of the DESI. We found a positive impact for 10 dimensions (from 19) and a negative impact for firm investments. The highest positive impact was confirmed for research systems, information technologies, and human resources. Our findings also highlight real economic contexts and drivers for EU countries' strategies and policies in the progress of digital competitiveness.

Contribution/ Originality: The main idea is to design innovation performance by combining GII and SII in a new model to reveal the impact of innovation performance on changes in digital competitiveness. The dimensions with the most significant impact represent the key drivers of digital and innovation performance in real economic practice.

1. INTRODUCTION

The macroeconomic notion of digital competitiveness and the digital transformation process are closely intertwined (Małkowska, Urbaniec, & Kosała, 2021; Roszko-Wójtowicz & Grzelak, 2020). Digital competitiveness as a source of competitive advantage and a key element of national strategies affects the achievement of economic growth and socio-economic development and is gaining more and more attention (Laitsou, Kargas, & Varoutas, 2020). The European Union's Digital Strategy highlights the need for the Union to be more assertive in its digital leadership in order to position itself as a global player in digital policies. Research and Innovation Strategies for Smart Specialization are the policies that were put into effect in the EU in 2014 (Lopes, Silveira, Farinha, Oliveira, & Oliveira, 2021) and will be modified for the 2021–2027 timeframe (Bilas, 2020).

The digital transformation represents a comprehensive change in society focused on the use of ICT, with the aim of increasing productivity, economic growth, and competitiveness. New political documents that point to the development of a European approach to digital policies are internationally applicable and, at the same time, strengthen the idea of European technological sovereignty. The digitalization of the economy is imminent and related to the digitalization of society, which focuses (Kraus et al., 2022) on how value is created and structured, how digital technologies are used, how dynamic capabilities are used, how consumers behave, and how to react strategically. To maintain national economies' competitiveness in the global economy, digital transformation has become a global trend. The rate and scope of digitalization have a significant impact on Europe's level of competitiveness in global markets (Garzoni, De Turi, Secundo, & Del Vecchio, 2020). The factor that has the biggest influence on the digital transformation of nations within the European Union is connectivity (Olczyk & Kuc-Czarnecka, 2022). Digital technologies are changing market dynamics, and therefore EU member states must prepare the conditions for increasing digital readiness for the transition to a digital economy. Pan, Xie, Wang, and Ma (2022) argue that the digital economy is multidisciplinary in nature, with the use of information and communication technologies (ICT) being the source of digitalization. The impact of global socio-economic and market changes is forcing digital transformation, the speed of which has an important impact and is significantly influenced by the risks faced by economies, as the authors' state (Papadopoulos, Baltas, & Balta, 2020). The Digital Economy and Society Index is one of the instruments for monitoring progress in digitalization.

Innovation plays a key role in identifying patterns of economic growth. Any economy needs innovation to be competitive and to produce higher value. It is also essential to a knowledge-based economy, which is built on advancing research and development and producing higher added value (Kučera & Fiľa, 2022). Innovative activity and innovative performance are elementary sources of economic expansion and competitiveness and also influence the image of an economy. Innovative applications increase the efficiency of economic and communication processes (Elmassah & Hassanein, 2022). Innovations leading to the widespread adoption of the latest network technologies (block chain, cloud computing, big data, the Internet of Things, and artificial intelligence) can generate new types and forms of production and raise the level of economies, as reported by the authors Melnyk, Shchehliuk, Leshchukh, and Litorovych (2021). According to Bilan, Mishchuk, Roshchyk, and Kmecova (2020) a balanced utilization of all productive resources is necessary, especially through creative work and skill development.

The main idea of our research is to connect the dynamics of changes between innovation performance and digital competitiveness and to define a new variable, Innovation Performance (IP), which was created by combining two global innovation indices (GII and SII). In our opinion, this modelling and linking of indices can help fulfill the research gap in this area and find the digital and innovation gap.

The goal of our study is to evaluate the innovation and digital competitiveness of the EU-27 countries and to reveal the impact of Innovation Performance as the newly created transformed variable on the changes in digital performance. In the first part of the paper, we describe the meaning of innovation performance and the digital competitiveness of economies, as well as their current measurement tools. In the next part of the contribution, there is a description of the main goal and sub-goals of the research, research hypotheses, and also the statistical tools used. The following part of the paper presents the achieved results of the evaluation of innovation performance and digital competitiveness of the EU-27 countries, as well as the construction of a theoretical model and the new modified model together with their achieved results. Finally, we summarized the research results as well as the limitations and future direction of the research.

2. THEORETICAL BACKGROUND

2.1. Tools for Measuring the Digital Competitiveness of Economies

The Digital Agenda for Europe is one of the remaining initiatives of the European Union's strategy.

Digital Economy and Society Index (DESI) is used to measure progress in digitization. It is a combined index that includes selected indicators of the digital competitiveness of European countries in terms of e-business, e-society, and e-government. This index is used to assess digital competitiveness as well as measure its progress among European countries. Liu (2022) determines the regions that exhibit the highest degree of similarity between the index's constituent parts using the DESI. The five dimensions of the DESI have been reduced to four primary areas in 2021 as a result of the revision of the DESI structure by the European Commission (Kovács, Bittner, Huzsvai, & Nábrádi, 2022). Despite its advantages and drawbacks, many practitioners use and cite the DESI index. The universality of the methodology allows for an evaluation of the countries of the European Union; however, the final outputs are unsuitable for in-depth examination, are general, and cannot explain certain phenomena. The heterogeneous selection of factors or the change in the number of dimensions, which makes it difficult to compare time series results, also appears to be a negative. The Digital Economy and Society Index (DESI) tracks the digital transformation of economies through human capital, internet usage, digital technology integration, and digital public services, summarizing digital performance indicators. DESI is an important regressor to explain changes in GDP per capita in EU member states (Olczyk & Kuc-Czarnecka, 2022).

2.2. Tools for Measuring the Innovation Performance of Economies

Recently, several authors in the field of their research have devoted themselves to the connection between two concepts, namely digitization and innovation. Mostaghel, Oghazi, Parida, and Sohrabpour (2022) revealed that to ensure the promotion of efficiency and innovation, it is necessary to focus on the need to develop digitization capacities. The result of the research directions is the need to design a new theoretical framework that would have a connection to digital innovations and would be characterized by growing social inequality as well as changes in business models (Švarc, 2022). According to Simionescu, Pelinescu, Khouri, and Bilan (2021) human capital plays a key role in economic development due to the capabilities of innovative individuals that increase productivity. Marčeta and Bojnec (2020) express the belief that innovation and workforce education are essential factors for competitiveness in the EU. Innovation in enterprises, products, and processes must be translated into green concepts with a view to the sustainability of economies (Gavurova, Schonfeld, Bilan, & Dudas, 2022). Access to external financing and capital capacity supports innovation (Bouwman, Nikou, & de Reuver, 2019). The trend today is to ensure economic growth and social development by introducing innovation into the strategic agendas of both developing and developed countries around the world. We have analyzed the area of innovation performance in this study using the Global Innovation Index (GII) and the Summary Innovation Index (SII).

The Global Innovation Index (GII) helps developing economies catch up with technological advances compared to a country's overall innovation performance. It contains around 80 numerical indicators measuring education, policy environment, knowledge creation at the level of economies, and infrastructure. The area of implementation of this index focuses on research on scientific and creative outcomes (Bielińska-Dusza & Hamerska, 2021). The index is intended to draw attention to the strengths, weaknesses, and gaps in the innovation indicators used. The index can be considered a tool for evaluating the competitiveness of countries from the point of view of past, present, and future periods (Paredes-Frigolett, Pyka, & Leoneti, 2021). Authors Ciarli, Kenney, Massini, and Piscitello (2021) write in their study that digital technologies, innovation, and skills develop in parallel, which requires the reorganization of production processes. The European Commission monitors countries' innovation performance through the Scoreboard EIS – European Innovation Scoreboard. EIS is a relevant tool for benchmarking innovation in Europe, as reported (Jesic, Okanovic, & Panic, 2021). EIS brings together innovators from around the world to share and discuss technology, business, digital, and marketing innovation, as well as research innovation, IoT innovation, innovative education, team innovation, and innovation policy (European Commission, 2021a).

The Summary Innovation Index (SII) provides a comprehensive picture of innovation competitiveness. The Aggregate Innovation Index is a recognized method and instrument for assessing national, international, and regional innovation systems and is an important part of the EU innovation agenda and the EU recovery plan (Jesic et al., 2021). This aggregate indicator consists of four areas of assessment and consists of ten innovation subgroups and 32 indicators.

3. DATA AND METHODOLOGY

The goal of our paper is to evaluate the innovation and digital competitiveness of the EU-27 countries and to reveal the impact of Innovation Performance as the newly created transformed variable on the changes in the digital competitiveness of the analyzed countries.

To fulfill the main goal, we set the following 2 partial goals:

- *Partial goal 1*: Evaluation and mutual comparison of the innovation performance and digital competitiveness of the EU-27 from 2017 to 2021.
- *Partial goal 2*: Revealing the impact of innovation performance on the change in digital competitiveness of the analyzed countries.

3.1. Data for Measuring the Digital Competitiveness and Innovation Performance of Economies

For the processing of the paper, we used the available secondary data, which were published in the annual reports published by the European Commission, where we found data for DESI (European Commission, 2017a, 2018a, 2019a, 2020b, 2021a) as well as for SII (European Commission, 2017b, 2018b, 2019, 2020, 2021b). We obtained GII data from WIPO's annual reports (WIPO, 2017, 2018, 2019, 2020, 2021) for the years 2017 to 2021. For our analysis, we selected the countries of the European Union, which currently consists of 27 countries, and we chose 5 years, which was due to the availability of secondary data. Secondary data from analyzed indices are expressed in the form of a total score and scores for individual dimensions. Table 1 describes the structure of analyzed indices.

Table 1. Structure of analyzed indices.

Variables	Name of variables	Data source
Dimensions of GII		
1st dimension - Institutions	GII_D1	WIPO (2021)
2nd dimension - Human capital and research	GII_D2	
3rd dimension - Infrastructure	GII_D3	
4th dimension - Market sophistication	GII_D4	
5th dimension - Business sophistication	GII_D5	
6th dimension - Knowledge and technology outputs	GII_D6	
7th dimension - Creative outputs	GII_D7	
Dimensions of SII		
1st dimension - Human resources	SII_D1	European Commission (2021b)
2nd dimension - Research systems	SII_D2	
3rd dimension -Digitalisation	SII_D3	
4th dimension - Finance and support	SII_D4	
5th dimension - Firm investments	SII_D5	
6th dimension - Information technologies	SII_D6	
7th dimension - Innovators	SII_D7	
8th dimension - Linkages	SII_D8	
9th dimension - Intellectual assets	SII_D9	
10th dimension - Employment impacts	SII_D10	
11th dimension - Sales impacts	SII_D11	
12th dimension - Environmental sustainability	SII_D12	
Dimensions of DESI		
1st dimension - Human capital	DESI_D1	European Commission (2021a)
2nd dimension - Connectivity	DESI_D2	
3rd dimension - Integration of digital technology	DESI_D3	
4th dimension - Digital public services	DESI_D4	

The basic research problems and questions in terms of the theoretical background of existing literature and previous analyses are to find out whether the innovation performance represented by the global indices GII and SII affects the change in the digital competitiveness value (DESI) in 27 EU countries in the time horizon of 2017 - 2021. To better understand the analyzed relationship, we introduced a new endogenous, unobserved transformed IP (Innovation Performance), which consists of two considered input variables (SII and GII). We would also like to find driving forces in the progress of digitalization and innovation.

3.2. Research Questions, Hypotheses and Description of the Model

Based on this consideration, we modified the basic research questions and arrived at their final form:

- *Research question 1: Who is the European leader in the innovation performance and who is the global EU actor in digital space?*
- Research question 2: *How does Innovation Performance (IP) affect the digital competitiveness of the 27 EU countries in 2017-2021?*
- *Research question 3: Which dimensions of global investigated indices are driving forces of innovation performance and digital competitiveness?*

From the basic research questions, the following research hypotheses were derived:

H_1: The Global Innovation Index (GII) within the selected dimensions has a significant impact on the change in the value of Innovation Performance (IP) at the chosen level of significance $\alpha = 5\%$.

H_2: The Summary Innovation Index (SII) within the selected dimensions has a significant impact on the change in the value of the Innovation Performance (IP) at the chosen level of significance $\alpha = 5\%$.

H_3: Innovation performance (IP) has a significant positive impact on the change in the value of the Digital Economy and Society Index (DESI) at the chosen level of significance $\alpha = 5\%$.

In previous research studies, we used correlation analysis, regression analysis and panel regression analysis to reveal the relationships between selected indices and their dimensions. In this study, we decided to apply structural equation modelling.

The analysis of the new theoretical model itself is carried out using structural equation modelling. We created the new theoretical model, Figure 1, which is based on the structure of the individual investigated indices (SII, GII, and DESI) and the newly introduced variable IP (Innovation Performance).

Structural equation modelling (SEM) is a group of statistical methods designed to model relationships between variables. Although the data from which these relationships are modeled and estimated are observed, the models may contain variables that are unobserved or latent. For this reason, SEM is referred to as latent variable modelling. The primary data for most SEM applications is covariance, which explains why SEM is also referred to as covariance structure modelling. The intent of many uses of SEM is to estimate the causal relationship of effects between variables, which explains why SEM is sometimes referred to as causal modelling. Regardless of the definitions, the group of methods referred to as SEM is becoming an increasingly popular approach to hypothesis testing and modelling in the social, behavioral, economic, and engineering sciences. Unlike more commonly used statistical methods, e.g., analysis of variance, multiple regression analysis, and factor analysis, SEM is not yet fully developed. Although the basic capabilities of SEM were laid down in the early 1970s and have generally been accessible to researchers since the early 1980s, new capabilities are being developed and subsequently incorporated into computer programs for SEM analyses. These ever-expanding SEM capabilities, coupled with powerful and intuitive computer programs for implementation, have fueled phenomenal growth in the number and variety of SEM applications. The fundamental difference between SEM and more well-known statistical models such as Analysis Variance (ANOVA) and multiple regression analysis is the goal of estimating model parameters. In typical applications of multiple regression analysis, for example, regression coefficients are estimated using the method of least squares (OLS). The coefficients in this case define a regression curve that minimizes the mean square of the distance between individual data points (the target) and their guess. The residuals index is the degree to which the estimated regression curve misses each data point, meaning it is a measure of the error in predicting the observed data from the estimated model. The goal of estimation in SEM is the same: to find parameter values that best fit the observed data, given essentially by the model. However, the fundamental difference is what constitutes the observed data or target. In prototypical applications of SEM, the data are the observed covariances between variables and their variances. The goal of estimation is usually to use probabilistic methods to find parameter values that, given the model, maximize the probability of obtaining the observed data. In other words, as in OLS regression, the goal is to minimize the difference between the observed and estimated data, but the observed and estimated data in SEM represent variances and covariances. The residuals are therefore the differences between the observed variances and covariances and those estimated, calculated on the basis of the defined model.

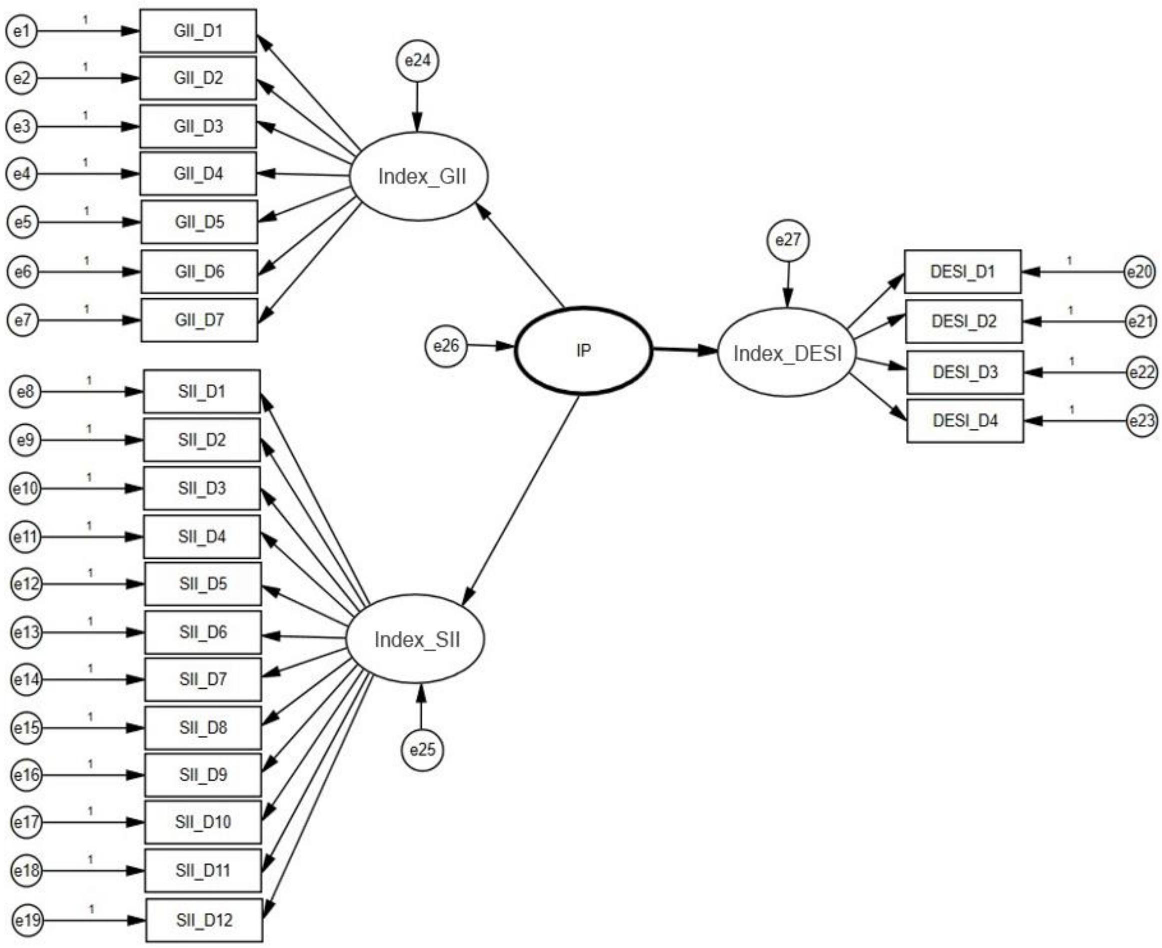

Figure 1. The new theoretical model of the examined indices.

Statistical data processing was carried out using the statistical programs as Amos 22, and Statistics 26 (from IBM SPSS), Statistica 13.5. Confirmatory Factor Analysis was used to verify the assumed factor structure. In the first step, we defined a hypothetical data structure in the form of factors, manifest variables, and mutual relations between them based on the theoretical construct of the structure of the examined indices and their dimensions.

4. RESULTS AND FINDINGS

4.1. Evaluation of the Innovation Performance and Digital Competitiveness of EU-27 Countries

We aimed the following analysis at a mutual comparison of EU-27 countries in terms of innovation performance and digital competitiveness using the average score of selected indices for the period 2017-2021. Figure 2 illustrates the achieved average score of the DESI, GII, and SII index for the years 2017-2021 of the EU-

27 countries in alphabetical order, as well as the average score of the indices of the 27 countries of the European area, which is shown at the end of the graph.

Finland achieved the best evaluation of digital competitiveness (DESI=57.79), whereas Sweden can be considered the leader in the evaluation of innovation performance (GII=63.23 and SII=69.58). Conversely, Romania received the lowest ratings across all global indices (DESI = 22.93, GII = 37.04, and SII = 15.79). The EU-27 DESI digital performance index had the lowest score (40.51), while the GII index had the highest average European score (48.30). The EU-27 SII index came in second with an average score of 46.21.

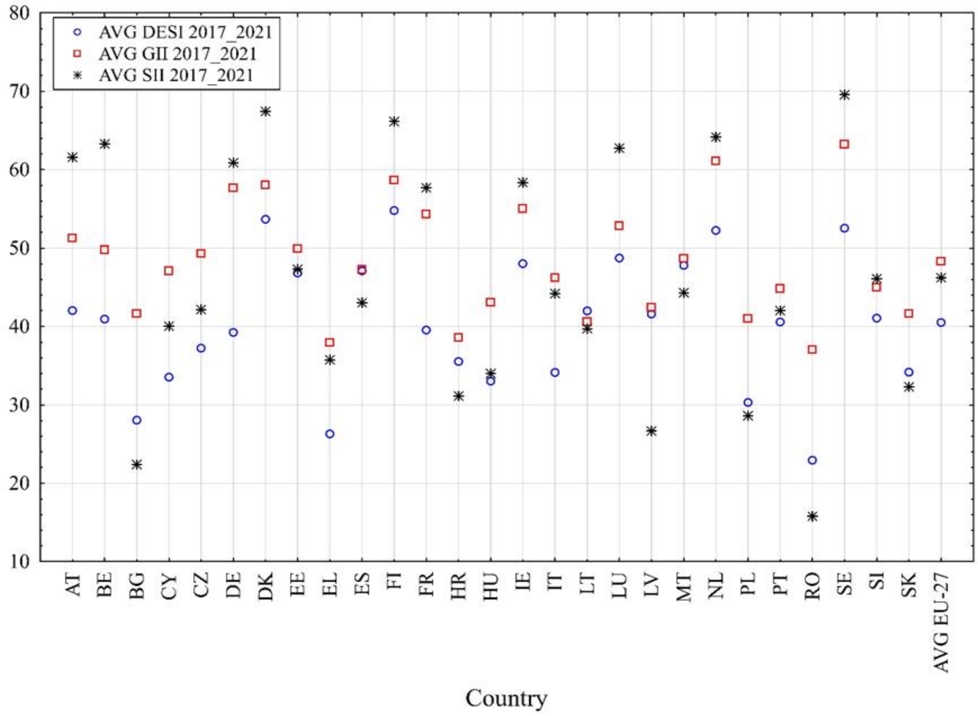

Figure 2. Average scores of analyzed indices of EU-27 countries for 2017 – 2021.

The DESI index (EU-27), which peaked in 2017 at 35.07, has the fastest growth rate. From 2017 to 2021, its overall score climbed by over 35%. In comparison to the other investigated indices, the SII index also showed a very similar development trajectory, with its total score rising by 11.5% and peaking at 48.96 in 2021. For example, the GII index shows a different trajectory of development; its total score dropped with time, reaching a minimum of 46.93 in 2019. The GII index dropped by 4.4% in 2021 over 2017. The DESI index (47.34) and the GII index (47.26) that were the two evaluated indices in 2021 yielded relatively similar overall results.

The GII index is the first index to be evaluated. The scores of the other dimensions, with the exception of dimension 7 – *Creative outputs* show a slightly variable tendency in their development. This particular dimension exhibited a progressive reduction from its 2017 value of 46.86 to a score of 37.94 in 2021. However, in 2021, the score increased to 39.38. With a score of about 79, the first dimension 1 - *Institutions* of the GII index was the highest scored.

The SII index, the second analyzed index, has up to 12 dimensions. All of the dimensions developed positively, with the exception of dimension 9, whose name is *intellectual assets*, whose score was steadily declining. The assessment of dimension 7—innovators—saw the biggest improvement, increasing by more than 26% annually over the course of the last two years under study. Dimension 3: *Digitalization* has the highest score of all the SII index dimensions, and its maximum value was 63.72. Averaging just 38.29 in 2017, the SII index's fifth dimension, firm *investments*, was the lowest rated. It is interesting to see how the development over time changes the position of individual dimensions.

Both the overall score of the analyzed index and the development of the scores for the four dimensions show a growing trend. Unlike the other dimensions, we did not notice any significant changes in the assessment of dimension 1 – *Human capital*, where the values gradually increased from 10.84 to a score of 11.75

After analyzing the EU-27 countries' digital competitiveness from 2017 to 2021, we can conclude that Finland, Denmark, and Sweden are the Nordic nation's leaders in digitalization. Finland held the top spot from 2017 to 2021, but Denmark overtook it in 2021. Throughout the entire period under analysis, Greece, Bulgaria, and Poland were ahead of Romania, which consistently ranked last in the digital ranking.

When examining the V4 countries' digital performance, it is evident that the Czech Republic, which was placed 18th out of the EU-27, had the highest average overall score (37.23). It is followed by Slovakia (20th position with a score of 34.17), Hungary (score 33.02, 23rd position), and the weakest digital performance is recorded for Poland (score 30.31, 24th position).

Using the GII and SII indices, we assessed the innovation performance of a selected group of European nations. With the exception of 2018, when the Netherlands held the top spot, we can categorically regard Sweden as a leader in innovation. Sweden ranked first in both rankings. Romania is the least strong of the analyzed European Union countries, and over the course of the five-year analysis, it ranked lowest in both indexes for innovation performance. Bulgaria, Latvia, and Poland are in the unfavorable position of the SII index, while Greece and Croatia are at the bottom of the ranking ahead of Romania, according to the GII index results.

When using the GII index rather than the SII index to assess innovation performance, the V4 countries produced better results. Hungary came in second with a total average GII score of 43.07, ahead of the Czech Republic (12th place), which had a total average score of 49.30. Slovakia's innovation performance, measured by the GII index, was ranked 21st and achieved a total average score of 41.65. We recorded the same ranking of the V4 in innovation performance but a worse overall average index score for the SII index (Czech Republic 42.16, 16th place; Hungary 34.02, 21st place; Slovakia 32.31, 22nd place). The weakest country in the evaluation of the innovative performance of V4 countries is Poland (GII score 40.98, 23rd position; SII score 28.62, 24th position).

4.2. Construction of a New Modified Model and its Results

The following part of our paper is dedicated to the description of the construction of the new modified model in graphic form as well as the interpretation of the results achieved.

It should be noted that we consider the resulting indices DESI, GII, SII, and *IP* as exogenous, unobserved variables.

As part of our research focus, we addressed the issue of evaluating European digital performance in several research studies. We decided to use the results obtained from the study of Šofranková, Kiseľáková, Širá, and Grzebyk (2022) where the authors conclude that, when applying panel regression analysis, the global GII index is significantly affected only by the *GII_D2* and *GII_D7* dimensions, and simultaneously, the global SII index is affected by the *SII_D1*, *SII_D2*, *SII_D3*, *SII_D4*, *SII_D5*, *SII_D6*, *SII_D7*, *SII_D10*, and *SII_D12* dimensions. However, because the GII global index is made up of a total of 7 dimensions and the SII global index is made up of 12 dimensions, it is not possible to model these global indices as endogenous, directly measured variables.

So we decided to modify the new theoretical model of the examined indices shown in Figure 1 by reducing the number of input variables (2 dimensions of index GII and 9 dimensions of index SII), and the main idea is to define a new factor of innovation performance (IP), which is assumed to be created by combining the global indices GII and SII, and we created a new modified model of the examined indices, which we present in Figure 3.

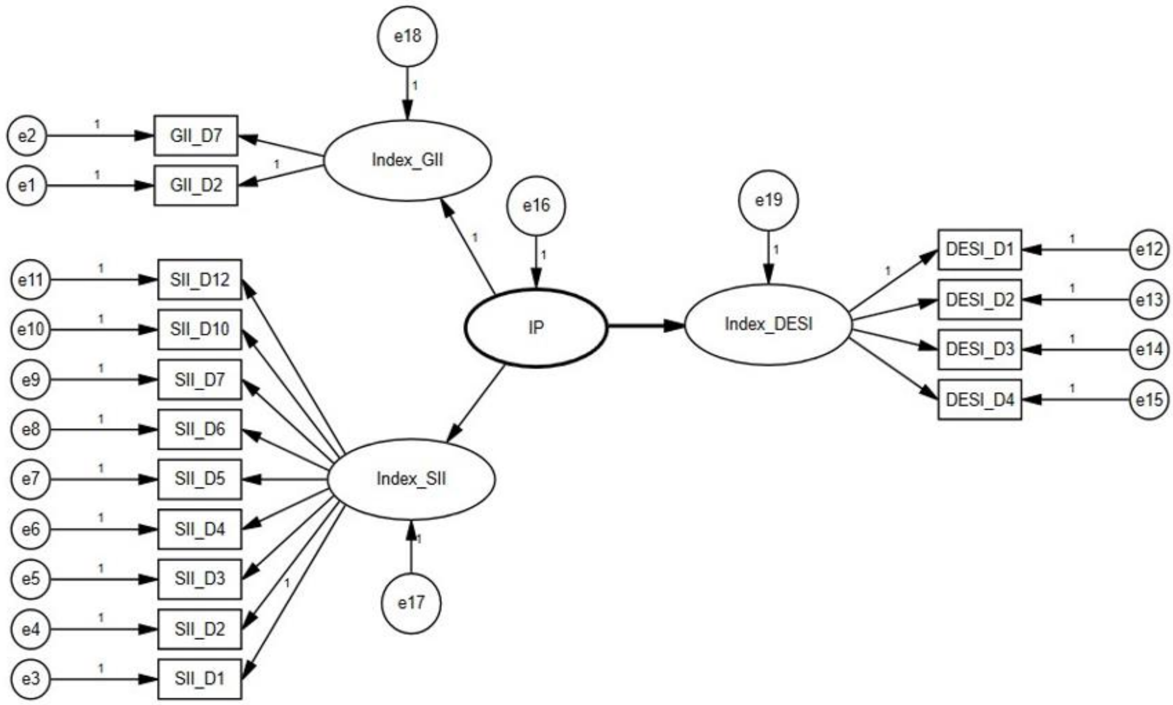

Figure 3. The new modified model of the examined indices.

The Statistica 13.5 program package was used to perform statistical analysis of the evaluated data, and the IBM SPSS Amos 22 program package was used for the SEM modeling itself. The basic evaluation criteria of theoretical model created in Figure 3 in accordance with the recommendations of the author Torun (2020) and the achieved values of these indicators are defined in Table 2.

Table 2. Basic evaluation criteria of the theoretical model and CFA Fit Indices.

Fit indices used	Perfect fit indices	Acceptable fit indices	CFA results	References (Original)
$\chi 2/df$	$0 \leq \chi 2/df \leq 2$	$2 \leq \chi 2/df \leq 3$	2.179	Hu and Bentler (1998)
GFI	0.95≤GFI≤1.00	0.90≤GFI≤0.95	0.913	Marsh, Balla, and McDonald (1988) and Schermelleh-Engel, Moosbrugger, and Müller (2003)
AGFI	0.90≤AGFI≤1.00	0.85≤AGFI≤0.90	0.864	
CFI	0.95≤CFI≤1.00	0.90≤CFI≤0.95	0.971	Bentler and Bonett (1980) and Marsh, Hau, Artelt, Baumert, and Peschar (2006)
NFI	0.95≤NFI≤1.00	0.90≤NFI≤0.95	0.949	
TLI	0.97≤TLI≤1.00	0.95≤TLI≤0.97	0.956	
RMSEA	0.00≤RMSEA≤0.05	0.05≤RMSEA≤0.08	0.064	Browne and Cudeck (1993); Byrne and Campbell (1999); Hu and Bentler (1999) and Schermelleh-Engel et al. (2003)
SRMR	0.00≤SRMR≤0.05	0.05≤SRMR≤0.10	0.0542	
p	p >0.05		0.052	Hu and Bentler (1998)

Note: χ2 - Chi-square, df - Degrees of freedom, GFI - Goodness of fit index, AGFI - Adjusted goodness of fit index, CFI - Comparative fit index, NFI - The Bentler-Bonett normed fit index, TLI - Tucker-Lewis coefficient, RMSEA - Root mean square error of approximation, SRMR – Standardized root mean square residual.

The results of Table 2 show that all the evaluated variables of the three-factor model meet the criteria of an acceptable model, and therefore the new modified model (Figure 3) can be considered adequate and can be analyzed in the next section. The analysis of the new modified 3-factor model itself, where the GII and SII indices as well as the newly considered variable IP are considered exogenous, unobserved variables, is necessary in order to analyze the impact of the dimensions on the individual indices.

Table 3 demonstrates that all of the dimensions of the first index under study (DESI), which we consider to be the dependent variable in the current study, have a significant impact. Other variables are the GII and SII indices, and significant effects of individual dimensions on the total score of the analyzed index were revealed. At the end of Table 3, the results of the revealed interrelationships between the DESI index and the IP variable as well as the influence of the GII and SII indices on the IP variable, are presented. The results of the revealed interrelationships between the DESI index and the IP variable, as well as the influence of the GII and SII indices on the IP variable are presented at the end of Table 3.

Table 3. Resulting regression weights together with the standard errors of the model.

Relationship	Estimate	Std. estimate	Std. error	t -statistic	p- value
Index_DESI <--- DESI_D1	1.000	0.854	0.065	10.558	< 0.000*
Index_DESI <--- DESI_D2	0.847	0.652	0.125	6.798	< 0.000*
Index_DESI <--- DESI_D3	1.124	0.901	0.073	15.373	< 0.000*
Index_DESI <---DESI_D4	1.702	0.833	0.129	13.200	< 0.000*
Index_GII <--- GII_D2	1.000	0.761	0.082	7.891	< 0.000*
Index_GII <--- GII_D7	0.711	0.626	0.077	9.253	< 0.000*
Index_SII <--- SII_D1	1.000	0.834	0.064	9.117	< 0.000*
Index_SII <--- SII_D2	1.239	0.945	0.080	15.581	< 0.000*
Index_SII <--- SII_D3	0.579	0.504	0.075	7.713	< 0.000*
Index_SII <--- SII_D4	0.961	0.795	0.079	12.204	< 0.000*
Index_SII <--- SII_D5	-0.275	-0.244	0.133	-2.434	0.015*
Index_SII <--- SII_D6	1.102	0.834	0.084	13.089	< 0.000*
Index_SII <--- SII_D7	1.153	0.690	0.116	9.959	< 0.000*
Index_SII <--- SII_D10	1.010	0.824	0.075	13.447	< 0.000*
Index_SII <--- SII_D12	0.462	0.457	0.078	5.935	< 0.000*
Index_DESI <--- IP	0.190	0.753	0.021	8.846	< 0.000*
IP <--- Index_GII	1.000	0.948	0.041	9.885	< 0.000*
IP <--- Index_SII	2.486	0.974	0.246	10.101	< 0.000*

Note: * - significant at the level of significance $\alpha = 0.05$, Estimate – estimate, Std. Estimate – standardized regression weight, std. error - standard error, t – t-statistic, p – probability level.

However, we observe the greatest impact on the dimension *DESI_D3 - Integration of digital technology* with a standardized regression weight value of 0.901 (p=0.000). The second most significant dimension influencing the DESI index is its dimension *DESI_D1- Human capital* with a standardized regression weight value of 0.854 (p=0.000), followed by the dimension *DESI_D4 - Digital public services* (0.833, p=0.000). The lowest impact on the DESI index was observed for the dimension *DESI_D2 - Connectivity*, with a standardized regression weight of 0.652 (p=0.000).

The digital performance of countries assessed by the DESI index focuses on 4 main areas (dimensions), namely *Human capital*, *Connectivity*, *Integration of digital technology* and *Digital public services*. The results of our analysis of the interactions between the DESI index and its dimensions confirmed that the most significant impact is the *Integration of digital technology* (*DESI_D3*), which focuses on the assessment of three important areas of digital performance, namely *Digital intensity*, *Digital technologies for business*, and *e-Commerce*. Other important areas influencing digital performance are *Human capital* (DESI_D1), which focuses on the assessment of *Internet user skills* as well as *advanced skills and development*, and digital *public services* (DESI_D4), which addresses *e-government*. The *connectivity area* (*DESI_D2*) has the lowest impact on digital performance, and the focus of this assessment was on *fixed broadband take-up and coverage*, mobile broadband, and *broadband* prices.

The second investigated index within the considered modified model is the GII index. The most significant influence with a value of the standardized regression weight of 0.761 is observed for the dimension *GII_D2 - Human* *capital and research* (p=0.000), followed by the second considered dimension *GII_D7 - Creative outputs* with a value of the standardized regression weight at the level of 0.626 (p=0.000).

The GII index has seven dimensions in total from a structural perspective, but we only found statistically significant effects in two of the evaluation categories for the EU-27 countries' innovation competitiveness. The first area of innovative performance is the area focused on *Human Capital and research* (*GII_D2*), where the assessment included as *Education*, *Tertiary education* as well as *Research and development (R&D)*. The second area of innovation performance of the GII index is the area of *Creative outputs* (*GII_D7*), within which *Intangible assets*, *Creative goods and services*, and the area of *online creativity* are evaluated.

The third considered index of our modified model, the SII index, is to the greatest extent influenced by its dimension *SII_D2 – Research systems*, with the value of the standardized regression weight at the level of 0.945 (p=0.000). It should be noted here that all considered dimensions of the SII index significantly influence the value of the examined SII index at the chosen significance level of α=0.05. The second most significant dimension is the *SII_D1- Human resources* dimension, with a standardized regression weight value of 0.834 (p=0.000), while another significant dimension of the SII global index, *SII_D6 – Information technologies*, has the same standardized regression weight value as *SII_D1 – Human resources*. Another significant dimension of the SII global index is the dimension *SII_D10 – Employment impacts*, with a standardized regression weight value of 0.824 (p=*0.000*). The effect of dimension *SII_D5 – Firm investments*, which acquires a negative value of the standardized regression weight at the level of -0.244 (p=*0.015*), seems interesting.

The results of analyzes focused on the evaluation of innovation performance using the SII index confirmed that the field of *Research systems* (*SII_D2*), which evaluates the field of *International scientific co-publications*, the *Most cited publications*, and *Foreign doctorate students*, has the statistically highest significant impact. Other equally important fields are *Human resources* (*SII_D1*) and *Information technologies* (*SII_D6*). The area of *Human resources* focuses its assessment on the following three areas: *Doctorate graduates*, *Population with tertiary education*, and *Lifelong learning*. The field of *Information technologies* focuses on *Enterprises providing ICT training* and *Employment ICT specialists*. Another dimension of the SII index called *Employment impacts* (*SII_D10*) also significantly influences the evaluation of the innovation performance of the EU-27 countries and evaluates this area through *Employment in knowledge – intensive activities* and *Employment in innovative enterprises*. We register a negative impact for the area of *Firm investments* (*SII_D5*) within which the area of *R&D expenditure in the business sector*, *Non R&D Innovation expenditures* and *Innovation expenditures per employee* are evaluated.

In this research, we found the key dimensions as driving forces in the process of digitalization and innovation performance and can confirm the role of innovation and digital technologies. They are also real economic and significant statistical consequences and links in the progress of digitalization and innovation worldwide.

5. DISCUSSION AND RECOMMENDATIONS

Many studies investigate and analyze the development and position of countries in global innovation and digital indices, using various techniques and models and revealing a digital and innovation gap between countries. Skare, de Obesso, and Ribeiro-Navarrete (2023) examined DESI for SME issues, which allows to link the level between the digital transformation and SMEs business activities using a panel random-effect model. Olczyk and Kuc-Czarnecka (2022) looked into the use of digital transformation by DESI to empirically test the differences between rich and poor countries in the European Union. According to the DESI Martí and Puertas (2023) used GII and digital level to measure innovation. They looked at things in political, educational, infrastructure, and knowledge environments using TOPSIS methods. Pillai and Srivastava (2022) demonstrated how Smart HRM 4.0 practices contribute to the development of dynamic capabilities and took into account the environment, change management, and technology in the model that explains innovation performance and value propositions.

Our research study was focused on the introduction of a new variable, namely Innovation Performance (IP), which was created by combining the global index SII and GII. A lot of the work that went into the analysis was based on the SII and GII global indices from the study by Šofranková et al. (2022). Their final value isn't affected by any of their dimensions, which is how the indices are supposed to work. In further investigation, we model them as endogenous, unobserved variables. We also model the newly introduced transformed variable IP (Innovative Performance) within this study for EU countries. Based on Table 3, both of the investigated global indices (SII and GII) are significant components of innovation performance and both have a significant impact on the change in the value of innovation performance, at the chosen significance level of 5%. SII has a greater influence on the value of innovation performance, with a value of the standardized regression weight at the level of 0.974 (p=0.000) compared to the index GII, where the value of the standardized regression weight is at the level of 0.948 (p=0.000). We can explain these regression weights by saying that if the standard deviation of the global SII index changes by one unit, then the standard deviation of innovation performance changes by 0.948 units. This is because the data was normalized. We found that a total of 11 dimensions out of the total number of 19 dimensions of the GII and SII (2 dimensions of the GII and 9 dimensions of the SII) have a significant influence on the change of the new variable under the name Innovation performance, while 10 dimensions have a positive and 1 dimension a negative influence. We recorded the highest positive impact for the dimension *Research systems* (*SII_D2*), which chose the area of *International scientific co-publications*, *The most cited publications*, and *Foreign doctorate students* for its evaluation. Only 1 dimension has a negative impact on innovation performance, namely *Firm investments* (*SII_D5*).

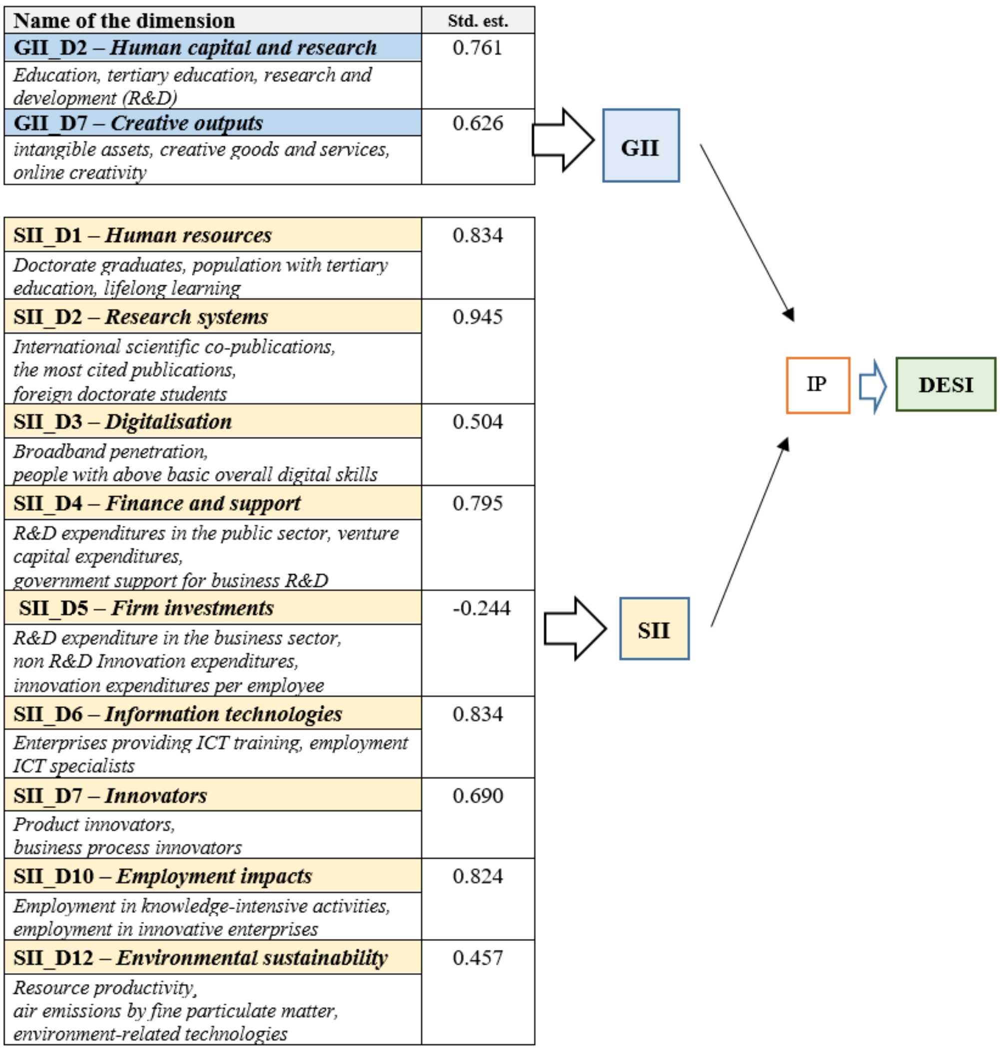

Figure 4. The final modified model of the examined indices with the names and areas of dimension evaluation.

We conclude that the dimension SII_D2 (0.945) has the largest standardized indirect effect on the change in the value of Innovation Performance (IP), followed by the influence of the dimensions SII_D6 and SII_D1 (0.834) and the dimension SII_D10 (0.824), if we also observe indirect effects in terms of the modified structural model (Figure 3). However, a very significant influence can also be observed for the dimension *SII_D4* (0.795). Other dimensions considered within the analyzed global indices indirectly affect the value of innovation performance, as follows: *GII_D2* (0.761), *SII_D7* (0.690), *GII_D7* (0.626), *SII_D3* (0.504), *SII_D12* (0.457), and *SII_D5* (-0.244).

The final modified model, shown in Figure 4, is made up of the dimensions of the applied GII and SII that go into the Innovation Performance (IP) variable. This has an effect on how digitally competitive a country is judged using the DESI index. Below the abbreviation and the name of the individual dimensions of the analyzed indices evaluating innovation performance, we also listed the areas of dimension evaluation with the names of the input variables as key dimensions with factors.

In conclusion, we can state that hypotheses H1 and H2 were confirmed at the level of significance $\alpha = 5\%$. The GII and SII indexes have a significant influence on the change in innovation performance, while the SII (0.974 p=0.000) has a higher influence compared to the GII index (0.948 p=0.000). Innovation performance (*IP*) has a significant positive influence (0.753 p=0.000) on the change in digital competitiveness measured by DESI at the chosen significance level of $\alpha = 5\%$, which also confirmed hypothesis H3.

6. LIMITATIONS AND FUTURE DIRECTION OF RESEARCH

The key pillars of digitization and competitiveness of European economies are the level of the knowledge economy and research support. When conducting our analyses, we also noted several limitations, such as the length of the selected period (influenced by the availability of secondary data), the number of evaluated countries (DESI: only EU countries, SII: 39 countries as EU-27, and others as Bosnia and Herzegovina, Iceland, Israel, Montenegro, North Macedonia, Norway, Serbia, Switzerland, Turkey, Ukraine, and the United Kingdom; GII: 132 economies), and, of course, the number of input indicators included in the individual dimensions of the analyzed indices (DESI: 33 indicators, SII: 32 indicators, GII: 81 indicators) and their frequent changes in terms of number and area of evaluation. All of these limitations have a significant effect on the achievement of relevant results for individual countries and also affect the further direction of our research analyses. The findings of our research study confirmed that the assessment of innovation performance and digital competitiveness in the 27 European countries analyzed had a significant mutual influence. We see a further direction for future research in the fact that we will devote ourselves to the analysis of individual indicators, entering the dimensions of the analyzed indices in even more detail, and at the same time to the disclosure of mutual relations between them as well as their influence on other areas of the evaluation of the economies of the whole world.

7. CONCLUSIONS

The global digital economy continues to grow quickly, and innovation is essential to the expansion of the economy in the modern world. In the contribution, they evaluated the innovation and digital competitiveness of the EU-27 countries, and the effort was also to show how innovation performance affects the shift in the examined countries' digital competitiveness.

Our research findings indicate that Sweden and Finland, the two economies with the highest rankings for digital competitiveness, had the best average innovation performance over the 2017–2021 period. Nordic countries such as Sweden, Finland, and Denmark, together with the Netherlands, are among the leaders in the evaluation of innovation performance as well as digital competitiveness. Romania was placed on the opposite side of the evaluation of innovative and digital competitiveness within all analyzed indices. Our results confirmed the results of many empirical studies in this area of ranking.

In the context of new scientific findings, it was our effort to define a new transformed variable, Innovation Performance (IP), which was created by combining two innovation indices (GII and SII) in the three-factor model. Both selected indices are significant components of innovation performance and have a significant effect on the change in the value of innovation performance at the chosen significance level of 5% ($SII = 0.974$, $GII = 0.948$ $p = 0.000$). A total of 11 dimensions out of the total number of 19 dimensions of the GII and SII indexes (2 dimensions of the GII index and 9 dimensions of the SII index) have a significant effect on the change of the innovation performance variable, while 10 dimensions have a positive impact and one dimension has a negative impact on firm investments *(SII_D5 = -0.244)*. We recorded the highest positive impact for the dimension *Research Systems* (*SII_D2 = 0.945, p = 0.000)*, followed by the dimensions *Information Technologies* (*SII_D6*) and *Human Resources* (*SII_D1 = 0.834, p = 0.000)*. We can state that these dimensions represent the key resources and driving forces of digital competitiveness and innovation performance for the support of EU strategies in real economic practice, as well as practical recommendations and managerial implications for the Digital Decade. We consider this to be a value added to our study.

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REFERENCES

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*, 588-606. https://doi.org/10.1037/0033-2909.88.3.588

Bielińska-Dusza, E., & Hamerska, M. (2021). Methodology for calculating the european innovation scoreboard -proposition for modification. *Sustainability*, *13*(4), 2199. https://doi.org/10.3390/su13042199

Bilan, Y., Mishchuk, H., Roshchyk, I., & Kmecova, I. (2020). An Analysis of intellecutal potential and its impact on the social and economic development of european countries. *Journal of Competitiveness*, *12*(1), 22–38. https://doi.org/10.7441/joc.2020.01.02

Bilas, V. (2020). Smart specialization concept as a tool for improving innovation performance of the European Union member states. *Ekonomski Vjesnik/Econviews*, *33*(1), 217-226. https://doaj.org/article/565fc6a793964a4e91a666e4acb404a6

Bouwman, H., Nikou, S., & de Reuver, M. (2019). Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs? *Telecommunications Policy* *43*(9), 101828. https://doi.org/10.1016/j.telpol.2019.101828

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit in: K. A. Bollen, & J. S. Long (Eds.), testing structural equation models. In (pp. 136-162). Beverly Hills, CA: Sage.

Byrne, B. M., & Campbell, T. L. (1999). Cross-cultural comparisons and the presumption of equivalent measurement and theoretical structure: A look beneath the surface. *Journal of Cross-Cultural Psychology*, *30*(5), 555–574. https://doi.org/10.1177/0022022199030005001

Ciarli, T., Kenney, M., Massini, S., & Piscitello, L. (2021). Digital technologies, innovation, and skills: Emerging trajectories and challenges. *Research Policy*, *50*(7), 104289. https://doi.org/10.1016/j.respol.2021.104289

Elmassah, S., & Hassanein, E. A. (2022). Digitalization and subjective wellbeing in Europe. *Digital Policy, Regulation and Governance*, *24*(1), 52-73. https://doi.org/10.1108/DPRG-05-2021-0060

European Commission. (2017a). *Digital economy and society index (DESI)*. Retrieved from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2017

European Commission. (2017b). *European innovation scoreboard 2017*. Retrieved from https://ec.europa.eu/docsroom/documents/24829/attachments/1/translations/en/renditions/native

European Commission. (2018a). *Digital economy and society index 2018 report*. Retrieved from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-2018-report

European Commission. (2018b). *European innovation scoreboard 2018*. Retrieved from https://data.europa.eu/doi/10.2873/66501

European Commission. (2019). *European innovation scoreboard 2019*. Retrieved from https://www.insme.org/the-european-innovation-scoreboard-2019/

European Commission. (2019a). *Digital economy and society index (DESI)*. Retrieved from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2019

European Commission. (2020). *European innovation scoreboard*. Retrieved from https://ec.europa.eu/docsroom/documents/42981/attachments/1/translations/en/renditions/native

European Commission. (2020b). *Digital economy and society index (DESI)*. Retrieved from https://digital-strategy.ec.europa.eu/sk/node/924

European Commission. (2021a). *Digital economy and society index (DESI)*. Retrieved from https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021

European Commission. (2021b). *European innovation scoreboard*. Retrieved from https://euraxess.ec.europa.eu/worldwide/asean/european-innovation-scoreboard-2021-published

Garzoni, A., De Turi, I., Secundo, G., & Del Vecchio, P. (2020). Fostering digital transformation of SMEs: A four levels approach. *Management Decision*, *58*(8), 1543-1562. https://doi.org/10.1108/MD-07-2019-0939

Gavurova, B., Schonfeld, J., Bilan, Y., & Dudas, T. (2022). Study of the differences in the perception of the use of the principles of corporate social responsibility in micro, small and medium-sized enterprises in the V4 countries. *Journal of Competitiveness*, *14*(2), 23–40. https://doi.org/10.7441/joc.2022.02.02

Hu, L.-t., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to under parameterized model misspecification. *Psychological Methods*, *3*(4), 424–453. https://doi.org/10.1037/1082-989X.3.4.424

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1-55. http://dx.doi.org/10.1080/10705519909540118

Jesic, J., Okanovic, A., & Panic, A. A. (2021). Net zero 2050 as an EU priroty: Modeling a system for efficient investments in eco innovation for climate change mitigation. *Energy, Sustainability and Society*, *11*(1), 1-16. https://doi.org/10.1186/s13705-021-00326-0

Kovács, T. Z., Bittner, B., Huzsvai, L., & Nábrádi, A. (2022). Convergence and the matthew effect in the European union based on the DESI index. *Mathematics*, *10*(4), 613. https://doi.org/10.3390/math10040613

Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management*, *63*, 102466. https://doi.org/10.1016/j.ijinfomgt.2021.102466

Kučera, J., & Fiľa, M. (2022). Expenditure, innovation performance and economic development of the EU countries. *Entrepreneurship and Sustainability*, *9*(3), 227. http://doi.org/10.9770/jesi.2022.9.3(14)

Laitsou, E., Kargas, A., & Varoutas, D. (2020). Digital competitiveness in the European union era: The Greek case. *Economies*, *8*(4), 85. https://doi.org/10.3390/economies8040085

Liu, T.-C. (2022). Digital policy in European countries from the perspective of the digital economy and society index. *Policy & Internet*, *14*(1), 202-218. https://doi.org/10.1002/poi3.274

Lopes, J. M., Silveira, P., Farinha, L., Oliveira, M., & Oliveira, J. (2021). Analyzing the root of regional innovation performance in the European territory. *International Journal of Innovation Science*, *13*(5), 565-582. https://doi.org/10.1108/IJIS-11-2020-0267

Małkowska, A., Urbaniec, M., & Kosała, M. (2021). The impact of digital transformation on European countries: Insights from a comparative analysis. *Equilibrium Quarterly Journal of Economics and Economic Policy*, *16*(2), 325–355. https://doi.org/10.24136/eq.2021.012

Marčeta, M., & Bojnec, Š. (2020). Drivers of global competitiveness in the European union countries in 2014 and 2017. *Organizacija Journal of management, Informatics and Human Resources*, *53*(1), 37−52. http://dx.doi.org/10.2478/orga-2020-0003

Marsh, H. W., Balla, J. R., & McDonald, M. P. (1988). Goodness-of-fit indexes in confirmatory factor analysis: The effect of sample size. *Psychological Bulletin*, *10*(3), 391–410. https://doi.org/10.1037/0033-2909.103.3.391

Marsh, H. W., Hau, K. T., Artelt, C., Baumert, J., & Peschar, J. L. (2006). OECD's brief self-report measure of educational psychology's most useful affective constructs: Cross-cultural, psychometric comparisons across 25 countries. *International Journal of Testing*, *6*(4), 311–360. https://doi.org/10.1207/s15327574ijt0604_1

Martí, L., & Puertas, R. (2023). Analysis of European competitiveness based on its innovative capacity and digitalization level. *Technology in Society*, *72*. https://doi.org/10.1016/j.techsoc.2023.102206

Melnyk, M., Shchehliuk, S., Leshchukh, I., & Litorovych, O. (2021). Digitalization of the economies of Ukraine and Poland: National and local dimensions. *Economic Annals*, *191*(1), 30-42. https://doi.org/10.21003/ea.V191-03

Mostaghel, R., Oghazi, P., Parida, V., & Sohrabpour, V. (2022). Digitalization driven retail business model innovation: Evaluation of past and avenues for future research trends. *Journal of Business Research*, *146*, 134-145. https://doi.org/10.1016/j.jbusres.2022.03.072

Olczyk, M., & Kuc-Czarnecka, M. (2022). Digital transformation and economic growth – DESI improvement and implementation. *Technological and Economic Development of Economy*, *28*(3), 775-803. https://doi.org/10.3846/tede.2022.16766

Pan, W., Xie, T., Wang, Z., & Ma, L. (2022). Digital economy: An innovation driver for total factor productivity. *Journal of Business Research*, *139*, 303-311. https://doi.org/10.1016/j.jbusres.2021.09.061

Papadopoulos, T., Baltas, K. N., & Balta, M. E. (2020). The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice. *International Journal of Information Management*, *55*, 102192. https://doi.org/10.1016/j.ijinfomgt.2020.102192

Paredes-Frigolett, H., Pyka, A., & Leoneti, A. B. (2021). On the performance and strategy of innovation systems: A multicriteria group decision analysis approach. *Technology in Society*, *67*, 101632. https://doi.org/10.1016/j.techsoc.2021.101632

Pillai, R., & Srivastava, K. B. (2022). Smart HRM 4.0 for achieving organizational performance: A dynamic capability view perspective. *International Journal of Productivity and Performance Management*. http://dx.doi.org/10.1108/ijppm-04-2022-0174

Roszko-Wójtowicz, E., & Grzelak, M. M. (2020). Macroeconomic stability and the level of competitiveness in EU member states: A comparative dynamic approach. *Oeconomia Copernicana*, *11*(4), 657–688. https://doi.org/10.24136/oc.2020.027

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research*, *8*(2), 23–74.

Simionescu, M., Pelinescu, E., Khouri, S., & Bilan, S. (2021). The main drivers of competitiveness in the EU-28 Countries. *Journal of Competitiveness*, *13*(1), 129–145. https://doi.org/10.7441/joc.2021.01.08

Skare, M., de Obesso, M. d. l. M., & Ribeiro-Navarrete, S. (2023). Digital transformation and European small and medium enterprises (SMEs): A comparative study using digital economy and society index data. *International Journal of Information Management*, *68*, 102594. https://doi.org/10.1016/j.ijinfomgt.2022.102594

Šofranková, B., Kiseľáková, D., Širá, E., & Grzebyk, M. (2022). Analysis of relationships between innovative and digital performance of EU-27 countries. *Journal of Management and Business: Research and Practice, 14*(2), 11-25. https://doi.org/10.54933/jmbrp-2022-14-2-4

Švarc, J. (2022). Prolegomena to social studies of digital innovation. *Ai & Society, 37*(4), 1323-1335. https://doi.org/10.1007/s00146-021-01220-1

WIPO. (2017). *Global innovation index 2017 innovation feeding the world.* Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2017.pdf

WIPO. (2018). *Global innovation index 2018. Energizing the world with innovation.* Retrieved from https://tind.wipo.int/record/28174/files/wipo_pub_gii_2018.pdf?ln=en

WIPO. (2019). *Global innovation index 2019. Creating healthy lives – the future of medical innovation.* Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2019.pdf

WIPO. (2020). *Global innovation index 2020. Who will finance innovation?* Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020.pdf

WIPO. (2021). *Global innovation index 2021. Tracking innovation through the COVID-19 crisis.* Retrieved from https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2021.pdf