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European Efficiency or Inefficiency in Economic Growth Through Digital Transformation

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Abstract: The current global changes bring to the fore the importance of the innovation and digital transformation for economic development. Under the previous assumption, an objective evaluation of the economic growth discrepancies, considering the digitalization process, is required. The main goal of the present research is to analyse the economic growth of the European countries, based to the digitalization process, by using an input-output method. Under these circumstances, a Data Envelopment Analysis (DEA) was performed, considering the digitalization dimensions of DESI Index as input and the economic growth (annual %) as output. Based on the proposed model, the results highlighted the bidirectional relationship between economic growth and digitalization. Consistent with the research results, the European countries can be divided in two main categories: the efficient and the inefficient. On one hand, we can find the relatively efficient European states in terms of achieving the economic growth through digitalization (Ireland, Romania, Croatia and Greece). On the other hand, there is a numerous list of the inefficient ones, including important countries like Finland, Germany or France. Obviously, a remarkable aspect related to their situation is that, considering the national available inputs, an output maximization will be possible. According to the proposed model, the efficient countries can serve as peers or optimal benchmarks for solving the issue of relative inefficiency, by adapting and implementing their good practices.

Keywords: digitalization; economic growth; European Union.

JEL classification: O33; O52.

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1. INTRODUCTION

Naturally, all processes undertaken at individual or collective level imply the existence of input elements, based on which the achievement of objectives, well-known as outputs, is expected. Over time, the society and economy have been subjected of challenges in the attempt of continuous evolution, under the influence of numerous internal and external factors.

Aiming to establish a competitive position, global economies undertake considerable efforts to identify key potential influencing factors that can affect their development. Directly related to development, the economic growth undoubtedly represents one of the main goals of the world's states. Consistently, increasing the interest on the inputs that can determine the economic growth becomes a compulsory task.

On the other hand, technological progress has revolutionized from narrow fields of activity to entire industries, beneficially contributing to the development of their related activities. The digital transformation gradually happened over the last decades, becoming a real need during the COVID-19 pandemic, which determined a more alert, even forced in some situations, pace of progress.

Hence, digitalization represents the characteristic phenomenon of the modern world, which unsurprisingly called into question the ability to impact the economic development. The fact that the digital progress has a considerable potential to contribute to the economic evolution has been recognized over the years, the economy itself gaining new directions. Nowadays, a key point of interest has thus been reached, namely the transition to the digital economy.

Efforts to enhance the transition to digitalization are constantly undertaken within all world economies but as respects the impact of related transformations on economic growth, a continuous analysis is required. The existing evidence is difficult to synthesize, and it would be inappropriate to consider it enough to determine a general rule regarding the proportion of the impact of digitalization on the economic growth, while the mutual influence is also recognized. Gaps existing between countries, at almost all levels, do not allow the generalization. Therefore, the efforts should be focused on the national level analysis.

The premises of an economic growth determined, to some extent, by the digital progress, as well as reciprocal, have been demonstrated, some of the aspects related to this phenomenon being subsequently discussed within the current paper. However, considering the fact that not all states perform at the same pace, neither from the point of view of economic development, nor regarding the transition to digital, the issue of comparative analysis among states is raised, aiming to identify strategic measures as benchmarks for implementation.

Focused on the analysis at the EU member states level, the present research aims to provide notable insights related to the ability of efficiently use the digital progress of the considered countries, in order to maximize the economic growth. In this regard, the research will provide both theoretical and empirical demonstration. Theoretically, a review of the specialty literature related to the economic growth and digitalization will be provided and, empirically, a Data Envelopment Analysis model will be applied. Performing the Data Envelopment Analysis model will conduct to identifying the relative efficiency or inefficiency of the European countries in achieving economic growth through digitalization.

Starting from the previously mentioned issues, the paper follows a logical structure, using an appropriate methodology for distinguishing the main debates in the literature related to the selected topics and for conducting the empirical demonstration. Finally, the results will

provide a spotlight on the issue of digitalization for economic growth, consistent with the bidirectional relationship between these important drivers of economic development.

2. THE MUTUAL RELATIONSHIP BETWEEN DIGITALIZATION AND ECONOMIC GROWTH

Well-known as a continuous, constant, and extremely fast process, the digital transformation has set, especially in the last decades, the premises of a new world, characterized by more efficient and sustainable development. Under these circumstances, technology has undoubtedly become one of the basic drivers of economic growth and, consequently, of the prosperous society development.

A decade ago, discussing the dissemination of technology and the economic growth (Quah, 2002) asserted, suggesting the reality that would persist with subsequent related developments, that the new economy is based on non-rival and aspatial knowledge. The researcher was referring to the progressive consumption of goods similar to knowledge, at the expense of physical material, mentioning, among others, the computer software, and services and goods provided and delivered through the Internet. The need of increasing the understanding regarding the exchange and dissemination processes of knowledge products, such as the ones previously mentioned, was thus urged, this being considered more important than solving the paradox of productivity.

In the current context, it is widely accepted that the digitalization of the processes carried out by all actors of society, whether they are individuals, business environment or any other intermediate pillar of the supply and demand duo, can undeniably contribute to the economic growth. In fact, technology is often described as a facilitator of goods and services production, which certainly determines the increase of prosperity, thus impacting the economic growth.

Presenting a demonstrated and subsequently reiterated perspective, the study carried out by Sabbagh *et al.* (2013) highlighted the fact that digitalization has the potential to create new jobs, increase productivity and bring improvements in terms of the life quality at the society level. Because of the new jobs' emergence and the increase in productivity, an improvement in economic growth is naturally expected.

According to McKinsey Global Institute (Bughin *et al.*, 2016), the GDP growth at the European level could be stimulated by 1% per year until 2025 as a result of doubling the digital intensity of the lagging sectors, referring to industries such as education, manufacturing, healthcare and mining. The report also highlights that the impact of digitalization is felt on the European economy, there being a certain correlation between the digital progress intensity and growth of productivity in all key sectors.

Actually, the relative strength of the digital economy has quite recently been characterized as a constant contributing factor to the economic growth, while the digital services and goods were considered main determinants of the GDP growth (Barefoot et al., 2018).

Examining the relationship between digital transformation and three key elements, namely labor productivity, employment and economic development, in developing countries, the study carried out by Aly (2020) led to the finding of a positive relationship between digital transformation and labor productivity, respectively economic development.

Concerning the labor productivity, considered a point of real interest in economic growth, the findings presented by Varlamova and Larionova (2020) are similar to those previously presented in the literature. Thus, it was found that the digital transformation of business processes, correlated with the increase in the share of organizations that use Internet technologies, can determine an increase in the labor productivity.

However, the fact that various existing researches still refer to relationship between digitalization and economic growth at the country level can be easily noticed, the phenomenon being almost impossible to generalize. Thus, disparities in terms of progress within different geographical areas are directly recognized.

Through the comparative analysis of Myovella *et al.* (2020), targeting 74 countries, respectively 33 OECD economies and 41 Sub-Saharan African economies, it was proven that digitalization positively influences economic growth in both groups of states under study. Even though, as a whole, the previously mentioned conclusion of the research has a generalizing note, the authors stating that certain element of digitalization, such as mobile telecommunications or broadband internet, exert a different impact in the two groups of the analyzed countries.

The reciprocal is recognized to the same extent, since, at the current level of technology adoption and implementation, existing findings reveal the influence of economic growth or, at least, of economic development on digital progress. For example, the results of the study by Stavytskyy *et al.* (2019), reveal that a more prosperous society determines the implementation and use of more advanced digital services.

Based on the aforementioned study, reference can be made to the need for increasing employability, followed by the growth in consumption, which includes the consumption of digital services and products. The research focused on the analysis of the impact of consumption index growth by the purchasing power parity and unemployment among the active population on the structural elements of the Digital Economy and Society Index.

According to Yuan *et al.* (2021), the digital transformation within the economy has a crucial importance in terms of economic growth at the state level. At the same time, the results of the research in question highlight the existence of a stable long-term relationship between technological innovation and its multiple determining factors, among which GDP is directly considered and analyzed.

Based on the previously presented findings, but also on many other existing research, the digitalization - economic growth relationship can be characterized as mutual, regardless of whether the process itself is direct or indirect. Figure no. 1 describes the synthesized perspective of the mutual influence between the two key elements considered. Therefore, some main considerations can be easily observed, based on which growth or development as processes are bidirectionally mediated.

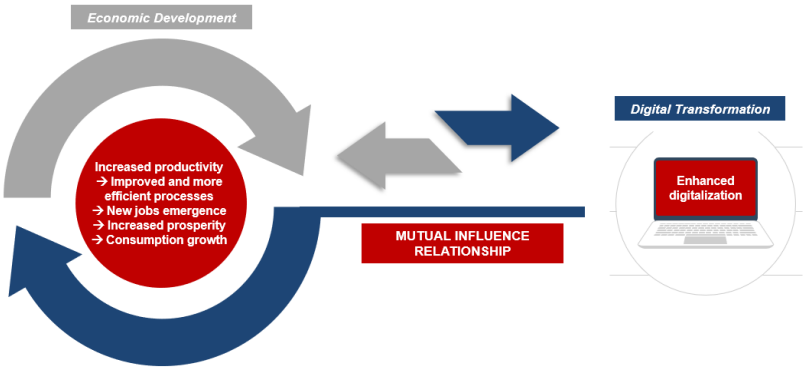

Figure no. 1 – Synthesized Process of the Mutual Relationship Between Digital Transformation and Economic Development

Source: Authors' own sketching

Surely, the previously presented scheme describes in a synthesized manner the relationship between digitalization and economic development, the related sub-processes being much more numerous and extremely difficult to identify. At the same time, referring to the economic development, the figure includes aspects directly related to the economic growth, the two concepts, namely *growth* and *development*, not necessarily having the same meaning in the current reality.

Nevertheless, it can be stated that mutuality characterizes the relationship of influence between the two directions i.e. digital transformation and economic development, but the existing evidence is not enough to determine if a direct proportionality of the impact can be considered. Confidently, decision-makers should take into account the potential benefits of supporting improvements in both areas of interest, a fact already recognized, that has gained real importance at the level of the measures taken for the efficient evolution of global economies and societies.

3. PERSPECTIVES ON THE DIGITAL PROGRESS OF THE EU MEMBER STATES

Technological transformation and the economy, respectively society, are no longer concepts independently handled, but the intense transition to the digital economy and the support of the continuous development of the knowledge-based economy and society are discussed. In fact, improving digitalization in all key sectors of the contemporary society and economy has not remained a subject of interest only for the scientific research field, but represents the phenomenon that underlies the development of numerous government policies and measures.

Currently, most of the objectives set at the world economies level focus, as an important pillar, on digitalization. Thus, many times the achievement of a national goal includes increasing digitalization among the basic directions of action. This situation is also found at the European Union level, which undertakes considerable efforts to enhance the digital progress of the member states.

A well-known tool for measuring the digital progress among the member countries of the European Union is the Digital Economy and Society Index (DESI Index), successfully used for monitoring since 2014. Being a composite index, DESI is currently (following recent updates) focused on four main directions, considered representative of digital evolution, namely: *Human capital*, *Connectivity*, *Integration of digital technology* and *Digital public services*.

With the aim of providing an overall perspective on the digital progress of the EU member states, the DESI Index reports represent a good starting point, more useful for the intended purpose than analyzing the methodology of the index in question. Thus, the last DESI report (European Commission, 2022b), including the results on the areas of interest in terms of digitalization for 2021, highlights the advance for all member states, compared to the previous periods. However, the findings of the DESI Index show gaps in digital skills, a problem constantly encountered over the years, the launch of advanced 5G networks and the digital transformation of SMEs.

In order to provide a better understanding of the digital evolution registered at the EU level, Figure no. 2 illustrates the DESI Index results for each member state, based on the aggregate scores recorded (weighted score - from 0 to 100) in 2021 and 2022.

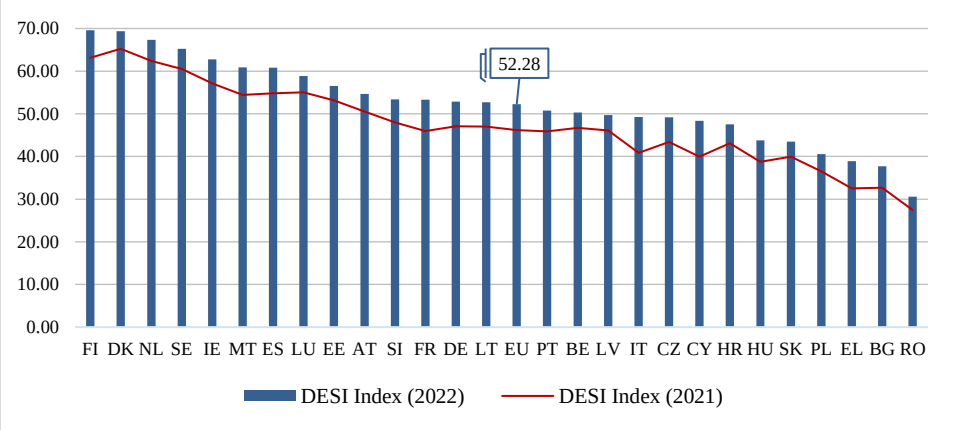

Figure no. 2 – DESI Index by Aggregate Scores 2021 - 2022
Source: authors' own figure - Data provided by European Commission (2022a)

Reiterating the previously mentioned aspects, by following the scores recorded for 2022 (blue columns), compared to those for 2021 (red line), the digital evolution of all countries can be easily observed. Definitely ascertainable, the discrepancies between the countries in terms of digitalization are persistent. However, the weakest digital progress was recorded in Romania, with an increase of only 3.15 in terms of the DESI 2022 aggregated score, compared to the previous year, the growth average at the EU level being 6.08.

There are also countries at the top of the ranking, which have slowed down the progress in terms of digital transformation. For example, in 2022, Estonia registered a higher aggregate score of 3.36 compared to 2021, while the difference between 2021 and 2020 was 4.05 (European Commission, 2022a).

The gaps between countries can be identified from multiple perspectives, whether we are discussing the overall progress, whether we are referring to the components or sub-components included in the DESI Index, or whether we are referring to the speed at which the digital evolution is undertaken at the national level. However, the efforts in the digital transformation within the EU member states are unquestionable, and the forthcoming benefits of the constant progress recorded, from the point of view of economic and society development, denote a promising perspective.

Undoubtedly, considering that the index under analysis focuses on several directions and discussing the digital economy and society, it becomes necessary to take into account all four areas of interest in order to understand the impact of digital transformation on the economic growth.

4. METHODOLOGY

As we mentioned in the previous sections, the main goal of the present research is to illustrate the connection between economic growth and digitalization within the European Union. In order to achieve the stated proposal, both theoretical and empirical approaches were used. The analysis of the specialty literature contributes to a proper understanding of the economic growth in the context of a permanent digitalization and the review of the selected topics conducted us in designing the research method, according to the established goal.

For measuring the efficiency or the inefficiency of European countries in terms of the annual economic growth, by analysing the available resources as regards digitalization, the Data Envelopment Analysis (DEA) will be performed. According to the specialty literature, DEA is non-parametric test, which measure the (in)efficiency of a decision-making unit (DMU) (Charnes *et al.*, 1978, 1981; Charnes *et al.*, 1989). Correspondingly, the available data are distributed in two main categories: inputs and outputs. The obtained results will highlight the relative performance of decision-making units, considering the information related to the degree of input decrease and/or output increase in inactive DMUs (Lábaj *et al.*, 2014), although the units of the parameters are different (Cooper *et al.*, 2011). Within the present study, the following dimensions of the Digital Economy and Society Index constituted the *inputs*: Human Capital, Connectivity, Integration of Digital Technology and Digital Public Services. The *output* is represented by the GDP growth (annual %). Starting from this point, we assume that the annual growth of the GDP can be maximized, using the national available inputs. In the view of the theoretical aspects related both on DEA method and the purposed subject, an output-oriented model will be conducted, presuming Constant Returns to Scale (CRS).

The selected sample is represented by the 27 European countries and the year under analysis is 2021, considering the World Bank data on economic growth and the last report of the European Commission on Digital Economy and Society Index (European Commission, 2022b). Performing Data Analysis Envelopment method was supported by an academic solution, namely Data Envelopment Analysis in R (Benítez *et al.*, 2021).

5. RESULTS AND DISCUSSION

The development of the concept of digital economy brings to the fore the relationship between digitalization and economic growth, which was strongly highlighted in the specialty literature (Dahlman *et al.*, 2016; Pan *et al.*, 2022). Considering the importance of the digitalization process in achieving the economic growth (Cheng *et al.*, 2021) and explaining the discrepancies between the countries, the present research, based on performing a Data Envelopment Analysis, accentuate several cases that must be studied. Forward analysing the empirical results on our selected sample, some theoretical consideration related to Data Envelopment Analysis must be clarified. According to DEA method, a decision-making unit (DMU) is viewed as relatively efficient if the registered value is strictly 1.00. Different values, higher or lower, denote the inefficiency of the analysed DMUs. In order to improve the inefficient state of input-output ratio, the decision-making units must emphasize the practices of the efficient one, which can be seen as peers or optimal benchmarks. Therefore, the efficient units will preserve constant their return to scale (RTS), whereas the inefficient ones will change their returns to scale, specifically increasing or decreasing.

Table no. 1 illustrates the Data Envelopment Analysis results for the selected sample. The first column defines the name of the decision-making units, namely the countries under analysis; the second and the third columns provide the information concerning the efficiency scores; the fourth column specifies the intensities or the weights of a peer DMU. Finally, the last column provides information with regards to the return to scale for each DMU (constant, increasing or decreasing). For the research sample, taking into consideration the output-oriented model, only 4 countries out of 27 are considered efficient in terms of using the digitalization for achieving economic growth. Hence, based on the available resources, merely Ireland, Romania, Greece and Croatia are relatively efficient in improving the economic situation. The previous information can be observed also in Figure no. 3, which highlights with green the optimal benchmarks (peers) and, with red, the inefficient countries.

Table no. 1 – Data Envelopment Analysis – results

DMU	Output oriented efficiency	Efficiency Score	Lambda sum	RTS
Austria	2.44409	40.92%	0.8147	Increasing
Belgium	1.40913	70.97%	0.6472	Increasing
Bulgaria	1.38652	72.12%	0.9118	Increasing
Croatia	1	100.00%	1	Constant
Cyprus	1.63898	61.01%	0.6677	Increasing
Czechia	2.97996	33.56%	0.7284	Increasing
Denmark	2.71633	36.81%	0.9457	Increasing
Estonia	1.17426	85.16%	0.722	Increasing
Finland	3.79443	26.35%	0.9837	Increasing
France	1.49109	67.07%	1.0117	Decreasing
Germany	3.34637	29.88%	0.7188	Increasing
Greece	1	100.00%	1	Constant
Hungary	1.07948	92.64%	1.0187	Decreasing
Ireland	1	100.00%	1	Constant
Italy	1.1959	83.62%	0.5847	Increasing
Latvia	1.89081	52.89%	0.8556	Increasing
Lithuania	1.83307	54.55%	0.6789	Increasing
Luxembourg	1.62948	61.37%	0.9935	Increasing
Malta	1.23768	80.80%	0.8618	Increasing
Netherlands	2.61551	38.23%	1.373	Decreasing
Poland	1.33727	74.78%	0.7987	Increasing
Portugal	2.02011	49.50%	0.7332	Increasing
Romania	1	100.00%	1	Constant
Slovakia	3.00791	33.25%	0.8412	Increasing
Slovenia	1.17945	84.79%	0.7077	Increasing
Spain	2.16924	46.10%	0.8195	Increasing
Sweden	2.75762	36.26%	0.9805	Increasing

Source: authors' own processing based on R results

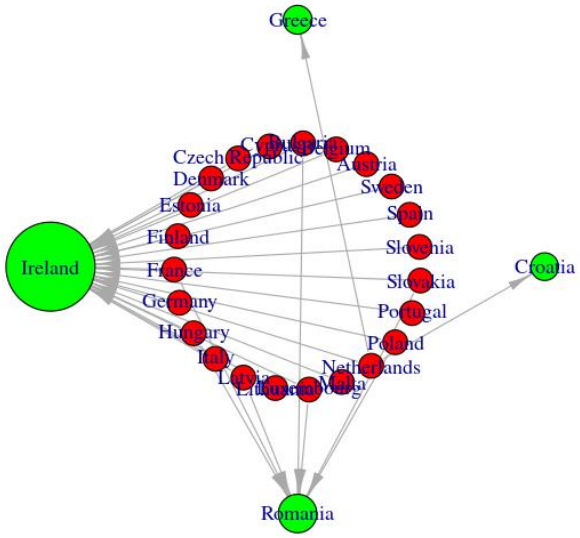

Figure no. 3 – Peer references for each inefficient country
Source: authors' own processing based on R results

At the European level, the issue of economic growth, taking into account the digitalization process divide the countries in two main categories, according to DEA method: the efficient and the inefficient ones. By analysing Table no. 1 and Figure no. 3, the following aspects can be pointed out:

(1) Ireland's results on achieving economic growth through digitalization registered significant progress in the last years (European Commission, 2022d), even though in the last DESI report ranks the fifth at the European level. According to the goal of the national strategy regarding the digitalization, Ireland will become the European leader. Due to its performance related on human capital, connectivity and digitalization of public services, the Irish model can be seen as a peer for all relatively inefficient European countries (see Table no. 2). The changes towards digitalization represent a significant direction for improving the quality of economic activity and, therefore, for economic growth. The Irish optimal benchmark can serve as an important reference for countries like Finland (lambda = 0.9837), Sweden (lambda = 0.9805), Denmark (lambda = 0.9457), but also for Germany (lambda = 0.7188) or France (lambda = 0.588), which are considered the most important economies of the EU.

Table no. 2 – Optimal Lambdas with Benchmarks

DMU	Optimal Lambdas with Benchmarks					
Austria	Ireland	0.8147				
Belgium	Ireland	0.6472				
Bulgaria	Ireland	0.0584	Romania	0.8534		
Cyprus	Ireland	0.6677				
Czechia	Ireland	0.7284				
Denmark	Ireland	0.9457				
Estonia	Ireland	0.7220				
Finland	Ireland	0.9837				
France	Ireland	0.5880	Romania	0.4237		
Germany	Ireland	0.7188				
Hungary	Ireland	0.2177	Romania	0.8010		
Italy	Ireland	0.5847				
Latvia	Ireland	0.4553	Romania	0.4003		
Lithuania	Ireland	0.6789				
Luxembourg	Ireland	0.7082	Romania	0.2853		
Malta	Ireland	0.8618				
Netherlands	Ireland	0.2050	Croatia	0.2932	Greece	0.8748
Poland	Ireland	0.3829	Romania	0.4158		
Portugal	Ireland	0.7332				
Slovakia	Ireland	0.5343	Romania	0.3069		
Slovenia	Ireland	0.7077				
Spain	Ireland	0.8195				
Sweden	Ireland	0.9805				

Source: authors' own processing based on R results

(2) Romania's situation on economic growth, taking into account the available resources in terms of digitalization, ranks the eastern country on the list of the efficient ones. The actual situation of economic growth serves as a reference for seven European countries, no matter the economic situation (see the example of France). According to the existent reports, the situation of digitalization in Romania is still a strong deficiency that places the country on the

last position of the European hierarchy of digitalization (European Commission, 2022e). For example, the problems in respect of the digital skills or the digitalization of public services are still persistent. For some researchers, this generalized situation was explained through the very expensive infrastructure (Aker & Mbiti, 2010). Despite of this, as a result of performing DEA method, it can be stated that Romanian's level of economic growth by using the available resources on digitalization should change the view of the existent perception. In other words, there are significant results in the economic development, in light of the national inputs. In the case of our sample, Romania represents a strong peer or an optimal benchmark for the following countries: Bulgaria (lambda = 0.8534), Hungary (lambda = 0.801) France (lambda = 0.4237), Poland, (lambda = 0.4158), Latvia (lambda = 0.4003), Slovakia (lambda = 0.3069) and Luxembourg (lambda = 0.2853).

(3) Croatia and Greece are also references in terms of attainment the economic growth by digitalization, even if their example can serve as a peer for a narrow group of countries. The performed empirical model showed that the Netherlands can follow the example of good practices implemented by Greece (lambda = 0.8748) and Croatia (lambda = 0.2932).

(4) By analysing the situation of the relatively inefficient countries in terms of economic growth, in the view of the digitalization process, major discrepancies can be identified between the studies that separately address the two topics. It is well known that, for example, Germany or France are the main economic drivers of the European Union but, in terms of achieving the economic growth via digitalization in the selected year, the present research suggests a calculated score of efficiency of 29.88% and 67.07%. Specifically, the digital tools are not properly exploited for improving the economic growth results. A similar observation can be noted in the case of Finland, where the calculated efficiency score is just 26.35%, being the lowest registered value in the purposed model even if, referring to this country, the DESI report states its first place on the digitalization around EU (European Commission, 2022c). Related to this, a possible explanation is strongly connected to the unexploited potential results that the Finish can achieve, by using their intensive digitalized system. Alike, the very low relative efficiency of Germany (29.88%) is mainly explained by the lack of integration of digital technologies, which was described in the specialty literature (Ficarra *et al.*, 2021).

To sum up the previous results, it can be confirmed that the present research highlights that, nowadays, the economic growth can be strongly linked to the digitalization process. The discrepancies in terms of relative efficiency or inefficiency of achieving economic growth through digitalization bring to the fore the importance of a proper exploitation of available inputs. Performing DEA method for a selected sample related on the European Union divided the countries between a small number of relatively efficient (Ireland, Romania, Croatia and Greece) and a large category of inefficient, which includes even if the most important performers in terms of digitalization. However, we must consider the significance of input maximization for improving the present outputs.

6. CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

According to the defined goal, the present research aimed to provide a general snapshot of the European countries in the matter of the relative efficiency or inefficiency in achieving economic growth through digitalization. In this regard, an empirical demonstration was performed, using Data Envelopment Analysis (DEA). The proposed model (output-oriented, with constant returns to scale), assumed as inputs the digital dimensions of DESI Index

(*Human Capital*, *Connectivity*, *Integration of Digital Technology* and *Digital Public Services*) and as output the *annual economic growth*.

The results obtained illustrated that, in the case of the selected sample, only four countries out of 27 can be considered relatively efficient, namely Ireland, Romania, Croatia and Greece. In their situation, a maximization of the output (annual economic growth) can be emphasized using the national available inputs (in this case, these four digitalization dimensions of DESI Index). Considering the specialty literature, the four mentioned European countries can be seen as peers or optimal benchmarks for the inefficient ones, which must adapt their activities in order to enhance the efficiency level. In contrast, for the applied model, the most inefficient countries are Finland (26.35%), Germany (29.88%) and Slovakia (33.25%). The examples like Finland and Germany showcase that, in general, the economic growth and the digitalization cannot be separated. The economic development, without a strong integration of digital technologies, results in a relative inefficiency and vice-versa.

Concluding, the limitations of the present study are certainly admitted, the research being focused only on the European level, by reference to a single year. Additionally, a recognized limit is related to the performed model, that can be criticized for not considering others different variables, which can affect the previous results. Due to these, a further development of the research is assumed, with the aim of expanding the time span under analysis and the group of analysed countries.

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References

Aker, J., & Mbiti, I. (2010). Mobile phones and economic development in Africa. Social science electronic publishing. *The Journal of Economic Perspectives, 24*(3), 207-232. http://dx.doi.org/10.1257/jep.24.3.207

Aly, H. (2020). Digital transformation, development and productivity in developing countries: is artificial intelligence a curse or a blessing? *Review of Economics and Political Science, 7*(4), 238-256.

Barefoot, K., Curtis, D., Jolliff, W., Nicholson, J. R., & Omohundro, R. (2018). Defining and measuring the digital economy. Retrieved from https://www.bea.gov/research/papers/2018/defining-and-measuring-digital-economy

Benítez, R., Coll-Serrano, V., & Bolós, V. (2021). deaR-Shiny: An Interactive Web App for Data Envelopment Analysis, 6774. *Sustainability (Basel), 13*(12), 6774. http://dx.doi.org/10.3390/su13126774

Bughin, J., Hazan, E., Labaye, E., Manyika, J., Dahlström, P., Ramaswamy, S., & Cochin de Billy, C. (2016). Digital Europe: Pushing the frontier, capturing the benefits. *McKinsey & Company*.

Charnes, A., Cooper, W., & Li, S. (1989). Using data envelopment analysis to evaluate efficiency in the economic performance of Chinese cities. *Socio-Economic Planning Sciences, 23*(6), 325-344. http://dx.doi.org/10.1016/0038-0121(89)90001-3

Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444. http://dx.doi.org/10.1016/0377-2217(78)90138-8

Charnes, A., Cooper, W., & Rhodes, E. (1981). Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Program Follow Through. *Management Science, 27*(6), 668-697. http://dx.doi.org/10.1287/mnsc.27.6.668

Cheng, C., Chien, M., & Lee, C. (2021). ICT diffusion, financial development, and economic growth: An international cross-country analysis. *Economic Modelling, 94*(1), 662-671. http://dx.doi.org/10.1016/j.econmod.2020.02.008

Cooper, W., Seiford, L., & Zhu, J. (2011). *Handbook on Data Envelopment Analysis* (2 ed.). New York: Springer. http://dx.doi.org/10.1007/978-1-4419-6151-8

Dahlman, C., Mealy, S., & Wermelinger, M. (2016). Harnessing the digital economy for developing countries. *OECD Development Centre Working Papers*(334).

European Commission. (2022a). DESI by components. Retrieved from https://digital-agenda-data.eu/charts/desi-components#chart={%22indicator%22:%22desi%22,%22breakdown-group%22:%22desi%22,%22unit-measure%22:%22pc_desi%22,%22time-period%22:%222022%22}

European Commission. (2022b). Digital Economy and Society Index (DESI). Retrieved from https://digital-strategy.ec.europa.eu/en/policies/desi

European Commission. (2022c). Digital Economy and Society Index (DESI) 2022 - Country profile: Finland. Retrieved from https://ec.europa.eu/newsroom/dae/redirection/document/88746

European Commission. (2022d). Digital Economy and Society Index (DESI) 2022 - Country profile: Ireland. Retrieved from https://ec.europa.eu/newsroom/dae/redirection/document/88707

European Commission. (2022e). Digital Economy and Society Index (DESI) 2022 - Country profile: Romania. Retrieved from https://ec.europa.eu/newsroom/dae/redirection/document/88758

Ficarra, M., Rückert, D., Virginie, A., & Weiss, C. (2021). *Digitalization in Europe 2020-2021. Evidence from the EIB Investment Survey*: EIB.

Lábaj, M., Luptáčik, M., & Nežinský, E. (2014). Data envelopment analysis for measuring economic growth in terms of welfare beyond GDP. *Empirica, 41*(May), 407-424. http://dx.doi.org/10.1007/s10663-014-9262-2

Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy, 44*(2), 101856. http://dx.doi.org/10.1016/j.telpol.2019.101856

Pan, W., Xie, T., Wang, Z., & Ma, L. (2022). Digital economy: An innovation driver for total factor productivity. *Journal of Business Research, 139*(1), 303-311. http://dx.doi.org/10.1016/j.jbusres.2021.09.061

Quah, D. (2002). Technology dissemination and economic growth: Some lessons for the new economy.

Sabbagh, K., Friedrich, R., El-Darwiche, B., Singh, M., & Koster, A. (2013). Digitization for economic growth and job creation: Regional and industry perspectives. *The global information technology report. Volume The Global Information Technology Report, 2013*, 35-42. Retrieved from https://www3.weforum.org/docs/GITR/2013/GITR_Chapter1.2_2013.pdf

Stavytskyy, A., Kharlamova, G., & Stoica, E. A. (2019). The analysis of the digital economy and society index in the EU. *TalTech Journal of European Studies, 9*(3), 245-261. http://dx.doi.org/10.1515/bjes-2019-0032

Varlamova, J., & Larionova, N. (2020). Labor Productivity in the Digital Era: A Spatial-Temporal Analysis. *International Journal of Technology, 11*(6), 1191-1200. http://dx.doi.org/10.14716/ijtech.v11i6.4429

Yuan, S., Musibau, H. O., Genç, S. Y., Shaheen, R., Ameen, A., & Tan, Z. (2021). Digitalization of economy is the key factor behind fourth industrial revolution: How G7 countries are overcoming with the financing issues? *Technological Forecasting and Social Change, 165*(April), 120533. http://dx.doi.org/10.1016/j.techfore.2020.120533