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Bobenič Hintošová A. PhD., Associate Professor

Бобеніч Гінтошова А. к.е.н., доцент  
<https://orcid.org/0000-0001-8728-6328>

Bruothová M. PhD.

Бруотова М. к.е.н.  
<https://orcid.org/0000-0002-1116-3273>

## DIGITALIZATION AS A TOOL TO SUPPORT INNOVATION: A EUROPEAN PERSPECTIVE

*University of Economics in Bratislava*

Implementation of information and communication technologies has changed several aspects of the economy including innovation processes and their outputs. It is generally stated that the use of information and communication technologies enhances innovation. However, the process of digitalization, especially in transforming economies, is approximately in the middle of its formation and visible effects on innovation may occur only with more developed stages of digitalization. Hence, the aim of the present paper is to investigate the relationship between the digital transformation of the economy and the innovation performance at the level of the European Union member states. For comparison purposes the European countries are divided into the particular groups according to their level of digitalization and innovation performance. The results of analysis show positive interdependence between the Summary Innovation Index and the Digital Economy and Society Index. We take into account three-year values of both indexes with one-year lag in the case of the second one, since we expect a time shift in the innovation performance induced by the development of the digital economy and society. Moreover, the digital development – innovation matrix showed that the most digitalized European countries are the most innovative ones, a vice versa. The majority of the “old” European Union member states belong to the group of digitalized innovators, with relatively high level of digitalization associated with superior innovation performance. On the other hand, for the most of the “new” European Union member states, lower levels of digitalization are associated with below-average innovation performance. Only some exemptions were detected in this regard. Hence, digitalization can be considered as a tool to foster innovation.

*Key words: digitalization, innovation, the European Union*

## ДИДЖИТАЛІЗАЦІЯ ЯК ІНСТРУМЕНТ ПІДТРИМКИ ІННОВАЦІЙ: ЄВРОПЕЙСЬКА ПЕРСПЕКТИВА

*Університет економіки в Братиславі*

Впровадження інформаційно-комунікаційних технологій змінило певні аспекти економіки, включаючи інноваційні процеси та їх результати. Загалом зазначається, що використання інформаційно-комунікаційних технологій сприяє розвитку інновацій. Однак, процес диджиталізації, особливо в країнах з трансформаційною економікою, знаходиться приблизно в середині свого формування, і видимі наслідки для інновацій можуть мати місце лише на більш розвинених стадіях цифровізації. Отже, метою даної роботи є дослідити взаємозв'язок між цифровою трансформацією економіки та інноваційними показниками на рівні держав-членів Європейського Союзу. Для порівняння європейські країни поділяються на певні групи за рівнем їх оцифрування та інноваційними показниками. Результати аналізу показують позитивну взаємозалежність між Зведеним індексом інновацій та Індексом цифрової економіки та суспільства. Ми враховуємо трирічні значення обох індексів із затримкою на рік у випадку другого,

оскільки ми очікуємо зсув у часі інноваційних показників, спричинений розвитком цифрової економіки та суспільства. Більше того, матриця цифрового розвитку та інновацій показала, що найбільш оцифровані європейські країни є найбільш інноваційними, і навпаки. Більшість «старих» країн-членів Європейського Союзу належать до групи оцифрованих інноваторів, із відносно високим рівнем оцифрування, пов'язаним з найвищими показниками інновацій. З іншого боку, у більшості «нових» країн-членів Європейського Союзу нижчий рівень цифровізації пов'язаний з інноваційними показниками нижче середнього. В даному аспекті було виявлено лише деякі винятки. Отже, диджиталізацію можна розглядати як інструмент стимулювання інновацій.

*Ключові слова: диджиталізація, інновації, Європейський Союз.*

**Formulation of the problem in general, and its relation to important scientific and practical tasks.** It is generally considered that emergence of diverse digital technologies and their broad application in economics and society has transformed also the innovation processes and their outputs (e.g. Nambisan et al. [1]; Nambisan et al. [2]). Chernykh et al. [3] highlighted the importance of the strategic aspects of the digital economy development as a prerequisite of macro level development of innovations.

Innovation is fostered by the exchange of information, since it can be expected that geographic concentration of knowledge leads to more significant innovation. This has already been observed e.g. by Feldman [4]. However, the transfer of knowledge can also take an unintentional or accidental form. This means that a company or other subject can benefit from the innovation available on the market without exchanging information or incurring any production costs. An example of this is the Internet industry and the so-called dot-com centred around high-speed network infrastructure [5]. Hence, positive spill-over effects may occur during the transformation process as well as at the diffusion of the innovation outputs.

The interrelatedness of the innovation-growth to information and communication technology (ICT) infrastructure was highlighted by Pradhan et al. [6] who brought robust evidence that among other factors ICT infrastructure cause innovation in the long run. The finding can be explained by the fact that ICT can enhance the quality of decision making by firms, reduce their production costs, help to achieve new value channels, reach new consumers and finally lead to fostering the diffusion of innovation. Hence, they concluded that the use of ICT and innovation can be complementary.

On the other hand, some authors, e.g. Afonsova et al. [7] note that the digital economy is still approximately in the middle of its formation and some of its effects may occur only with more developed stages of the digital economy. With regard to productivity there is, however, the evidence on existence of so called productivity paradox [8] suggesting that digitalization leads to a decline in productivity. Similar doubts may be raised with regard to the effects of digitalization on innovation performance.

In the present paper, a macro approach is applied, considering the national context of the digitalization and innovation at the level of the European Union (EU) member states. For the purpose of the analysis two composite indexes are used. Based on the values of the indexes, the digital development – innovation matrix is constructed, showing positions of the EU member states.

**The purpose of the article.** The aim of our study is to examine the relationship between the digitalization of the economy and innovation performance, namely to find out whether digitalization fosters innovation at the European level. The objects of our analysis are the European Union member states.

**Outline of the main research material with full justification of scientific results.** For the purpose of the evaluation of the level of digital transformation of the economy several indicators, such as ICT Development Index or Network Readiness Index, can be used. Perhaps the most popular indicator of digital development at the European level used also in the empirical literature, e.g. [7], [9], is the Digital Economy and Society Index (DESI) introduced by the European Commission in 2014. It is a composite annual indicator that summarizes selected relevant digital performance dimensions of the EU member states in the context of the Digital Single Market Strategy. DESI comprises of five main dimensions, each divided into a

set of sub-dimensions, which are in turn composed by 44 individual indicators. The five dimensions of the DESI are connectivity (includes both the supply and the demand side of mobile and fixed broadband), human capital (takes into account two sub-dimensions, namely Internet user skills and advanced skills and development), use of Internet (covers activities like active use of Internet to get news, communicate, shop, browse social networks, and other Internet services as well as the use of online banking services), integration of digital technology (includes e-commerce and share of enterprises using business digitalization), and digital public services (captures e-health and e-Government, i.e. e-services that reduce the time spent in public administrations and thus encourage people to use them).

As in the previous case, for the purpose of the innovation performance measurement, we used the composite indicator, namely the Summary Innovation Index (SII) introduced by the European Commission. It is a commonly used indicator of innovation performance within empirical literature, e.g. [10], [11], which provides a comparative assessment of the innovation and research performance of the EU member states and selected third countries. The measurement framework distinguishes among four main types of activities and ten innovation dimensions, namely human resources, attractive research systems, innovation-friendly environment, finance and support, firm investments, innovators, linkages, intellectual assets, employment impacts and sales impacts, capturing in total 27 different indicators.

Before we performed the analysis itself, we compared in detail the construction of both indexes in terms of the extent of their possible content overlap. We identified only a slight overlap between the dimensions connected with human resources; however these are capturing different aspects. While SII takes into account e.g. new doctorate graduates in general, DESI is specifically oriented at ICT field and covers only ICT graduates. Similar can be concluded with regard to broadband penetration captured in general by SII, however in the detailed structure by DESI.

Before we analyse the relationship between the level of digital transformation and innovation performance at a level of individual European countries, we first report development of the EU average values of both analysed indexes.

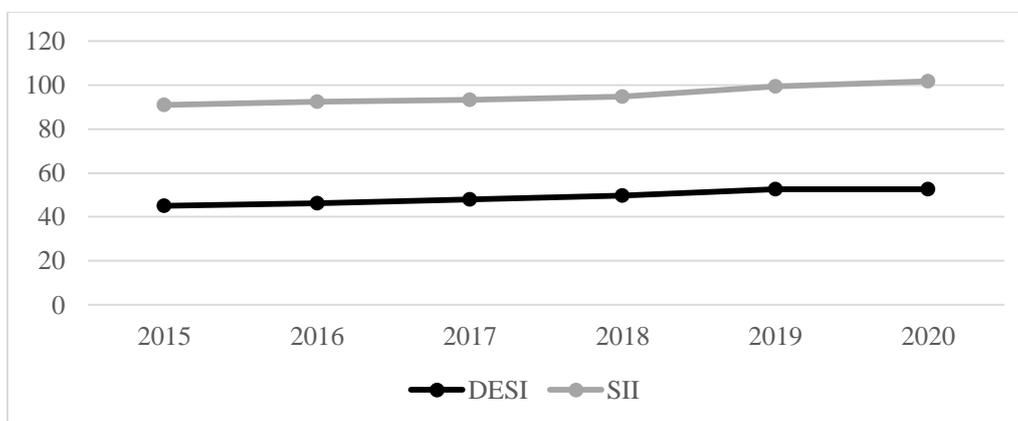


Fig. 1: Development of EU average values of SII and DESI in the European Union  
Source: own processing based on the [12] and [13]

Figure 1 shows development of the EU average values of the Summary Innovation Index as well as the Digital Economy and Society Index in the European Union in the period 2015-2020. Except for the last year, similar small gradual increase in values of both indexes can be observed. In the further analysis we looked in more details at the values of SII and DESI from the individual European countries' perspective, including the United Kingdom as the EU member at the time to which the data refer. We included three-year values of both indexes with one-year lag in the case of DESI, since we expect a time shift in the innovation performance

induced by the development of the digital economy and society. The interdependence between the values of both indexes is shown in the figure 2.

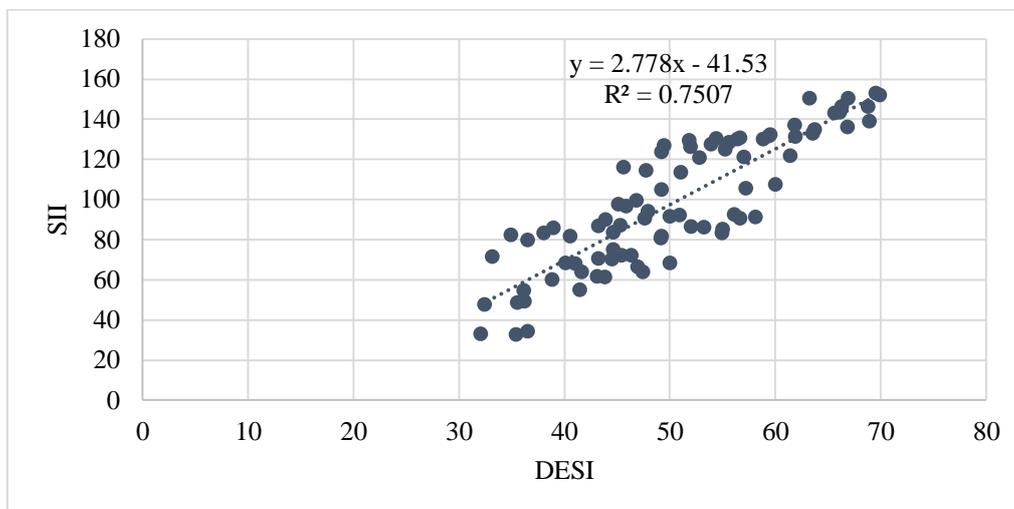


Fig. 2: Interdependence between SII and DESI values

Source: own processing based on the [12] and [13]

Figure 2 shows relationship between SII and DESI indexes in the case of the individual EU member states. As can be seen, the variables are positively correlated, which means that digitally more developed countries report higher level of national innovation performance. However, there are significant differences in the level of digital development as well as innovation performance among European countries. In order to capture these differences in more details, we constructed the digital development – innovation matrix within which positions of the EU member states are obvious. The classification of countries into particular quadrants was performed on the basis of the average values of the individual indexes of all the EU member states. Table 1 shows position of the European Union member states in terms of the development of the digital economy and society, as well as in terms of their innovation performance.

Table 1

The digital development – innovation matrix

Summary Innovation Index	Digital Economy and Society Index				
		relatively low		relatively high	
	relatively high	France		Sweden Finland Denmark Netherlands Luxembourg United Kingdom	Belgium Germany Austria Ireland Estonia
relatively low	Portugal Slovenia Czechia Cyprus Italy Lithuania Greece	Hungary Slovakia Latvia Croatia Poland Bulgaria Romania	Malta Spain		

Source: own processing

The digital development – innovation matrix shows that majority of the “old” EU member states report relatively high level of digital development in combination with superior innovation performance and they can be labelled as digitalized innovators. These countries can be expected to build most of their innovations on digitally based technologies. The leaders in this regard are Sweden, Finland and Denmark, the common strengths of which are human resources, attractive research systems and an innovation-friendly environment that are supported by high level of connectivity and extensive use of Internet services. Extraordinary position in this group of countries achieved Estonia, as the only country from the “new” EU members that recorded significant progress in the digital development accompanied by positive shift in the innovation performance, especially in the field of innovative SMEs collaborating with others, trademark applications, lifelong learning, and non-R&D innovation expenditures. This country can serve as an example of good practice for other “new” EU member states aiming to boost their innovation performance.

The only country that is scoring relatively high in innovation performance due to innovative SMEs collaborating with others, trademark applications, lifelong learning, and non-R&D innovation expenditures, however relatively low in digital transformation, especially with regards to the low share of people with “above basic digital skills” and thus also insufficient use of internet services, is France, which can be labelled as non-digitalized innovator.

The third group of countries that is the most numerous, is formed especially by the „new“ EU members being relatively low digitalized and scoring relatively low also in innovation performance. Hence, this group of countries can be labelled as non-digitalized followers. All four Visegrad countries belong here with common strengths especially in employment impacts, i.e. employment in fast-growing enterprises of innovative sectors. On the other hand, these countries perform relatively low in finance and support of innovation activities as well as in the dimension of SME innovators. This below average innovation performance can be partially attributed to insufficient use of business digitalization and digital public services. The position of these countries in the matrix to some extent confirms conclusions by Kondratiuk-Nierodzińska [14] that despite some positive changes in innovation capabilities related to technology transfer and diffusion, it is still not enough to close the gap between themselves and Western and Northern Europe.

Surprisingly, comparable positions in the matrix achieved also some of the “old” EU members, as Italy, Greece, Cyprus or Portugal, however with different and divergent strong and weak aspects of innovation performance. The worst positions in the matrix are occupied by Bulgaria and Romania, which record almost the same scores in DESI resulting especially from low level of usage of Internet services accompanied by low Internet user skills. These aspects are probably reflected in common weakness of innovation performance that lies in innovators dimension, e.g. SMEs with innovations.

To the last group of countries in the matrix, labelled as digitalized followers, belong Malta and Spain, achieving relatively high scores in DESI, which are, however, not mirrored in higher innovation performance. The relatively weakest DESI dimension in the case of both countries, are human resources, namely development of skills related to the use of information and communication technologies. Despite common strengths in innovation performance lying in employment impacts and innovation-friendly environment, these are outweighed by weak SME innovators and linkages. Similar findings were shown by Alibekova et al. [15] in the case of Kazakhstan, where despite great efforts in digitalization, weaknesses of the country in skills, venture capital, and innovation linkages are detected.

Our results to some extent confirm findings by Borowiecki and Navarrete [16] who based on study under specific circumstances of digitalization of heritage collection concluded that the most important positive factor directly fostering innovation is the country's level of education and indirectly personal access to the Internet. A review study by Matthes and Kunkel [17] further suggested that digitalization forms opportunities especially for developing countries to diversify in traded goods and services and thus also contributes to innovations.

Hence, based on the results the level of digitalization can be considered as an indicator of innovation.

In an attempt to improve innovation performance of the country, besides strengthening factors like educated and creative workforce, an appropriate research system or availability of finances for innovation projects, e.g. [11], also the digitalization of the economy and society shall be supported at local and national level.

**Conclusions.** The present paper investigated the relationship between national level of the digital development and innovation performance from the European Union member states perspective. Findings demonstrate slight improvement in the average EU values of SII and DESI in the last six years. When analysing their relationship, it can be concluded that digitalization fosters innovation. According to the level of digital development and innovation performance, the majority of the “old” EU member states belong to the group of digitalized innovators, with relatively high level of digitalization associated with superior innovation performance. On the other hand, the majority of the “new” EU member states fall into the group of non-digitalized followers, where lower levels of digitalization are associated with below-average innovation performance. Only some exceptions were found in this regard. Digitalization can therefore be seen as a tool to support innovation. Further more detailed research at more disaggregated level, e.g. under specific circumstances of regions, taking into account also geographic concentration of knowledge or industries would enrich the empirical findings in this field.

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