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DIHs AND THE IMPACT OF DIGITAL TECHNOLOGY ON MACROECONOMIC OUTCOMES

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Abstract: The advance of innovation in digital technologies has shifted the focus of theorists' and practitioners' concern towards Industry 4.0. SMEs, as key players in the economies of the world's countries are facing new challenges and are forced to adapt to the consumption behaviour of their customers. The study analyses the degree of digitalisation of the economies of the Visegrád Group countries and assesses the impact on economic and social outcomes in the sample countries. Specific indicators were used to assess the degree of digitalisation of these economies. The econometric analysis was based on cross-sectional data and regression models (fixed effects model). The results of the study indicated that digital transformations have favourable economic and social impacts (results are statistically significant). The practical implications of the study lie in providing support to decision-makers (in business and government) to better understand the benefits of participating in the various associative structures, which facilitate access to innovative digital solutions for all participants.

Keywords: Networked Readiness Index, technology pillar, digital technologies, DIHs - Digital Innovation Hubs, real GDP per capita.

1 INTRODUCTION

The Digital Europe Programme aims to strengthen the competitiveness of Member States' economies and thereby increase the international competitiveness of the Economic Union. Its ultimate objective is to ensure the development of the Union's strategic capabilities by making investments that accelerate the exploitation of the benefits of using new production factors (such as artificial intelligence, knowledge and skills of people and groups, advanced digital skills) and new technologies (based on high-performance computing). The objective also includes ensuring cyber-security, digitising public administration and ensuring interoperability at the level of associative structures.

The focus on the digital transition is embedded in concerns for the resilience of Member States' economies, which have been hit hard by pandemic-induced crises, supply disruptions and military conflicts. An important role is assigned to Digital Innovation Hubs (DIHs),

the reach of which must go beyond the national level. In fulfilling the roles for which they have been created, and for which substantial public funding has been allocated, DIHs must respond to the expectations of citizens (as consumers and solvent demand carriers), business (as a pillar of supply) and the public sector (as guarantor of economic rights and freedoms). Therefore, DIHs must facilitate access to new technologies, to innovative digital solutions for all economic and social actors. National and European institutions have been set up to monitor the extent to which DIHs fulfil their stated purpose.

Against the backdrop of institutional concerns about implementing new technologies and ensuring the digital transition, the interest of researchers has also intensified, as they have tried to find solutions to all the challenges. The proof is in the large number of articles published in recent years. The research objectives undertaken are diverse. Most studies present case studies to facilitate the understanding of the role of DIHs in achieving the digital transition (Di Roma, Minenna and Scarcelli, 2017; Richner, Heer, Largo, Marchesi and Zimmermann, 2017; Campagnolo, Nguyen and Williams, 2019; Gernego, Dyba and Onikiienjo, 2021; Georgescu, Avasilcăi and Peter, 2021; Volpe et al., 2021). Other studies address particular issues such as: the digitalisation of SMEs (Bouwman, Shahrokn and Mark, 2019; Crupi et al., 2020; Georgescu and Bârzu, 2021); the intertwining of physical and digital space (Jocevski, 2020); the assessment of networks of digitally engaged firms (Gupta, Gianchandani and Kajikawa, 2020); business models for associative structures with shared mobility (Coenegrachts, Beckers, Vanelslander and Verhetsel, 2021); interoperability maturity of digital hubs (Semeraro et al., 2021); reorganisation of work in the digital age (Sanson, 2015; Georgescu, Peter and Avasilcăi 2022), access to finance for SMEs (Roman and Rusu, 2015).

The present study aims to assess the interdependencies between the degree of technology use (especially, the digital technologies) and the dynamics of macroeconomic outcomes, as a study case represented by the Visegrád Group member countries. To answer this objective, the research was organized as follows. The second section presents a synthesis of the literature review on the role of DIHs in facilitating access to technology and ensuring the digital transition. The third section highlights the changes caused by the use of digital technologies (at the level of economic activities) and presents the research methodology. The fourth section presents the research results and initiates discussions on the results obtained. The last section summarizes our conclusions.

2 STATE-OF-THE-ART REGARDING DIHS, TECHNOLOGY AND DIGITAL TRANSITION

To highlight the growing research interest, we conducted a search on the Web of Science platform (after the keywords digital innovation hub), which indicated that, as of the second half of May 2022, 124 articles had been published referencing DIHs and their role in ensuring the digital transition, most of which were published after 2017. Refining the search to get closer to what DIHs means, 61 studies published between 2017 and May 2022 were identified. The results of the most striking studies are presented below.

According to the European Commission, the main role of DIHs is to support the digital transition of European small and medium-sized enterprises (SMEs). The focus on the SME area is justified by the fact that 60% of large industries and 90% of small and medium-sized enterprises lag behind in digital innovation (European Commission, 2021).

In terms of conceptualisation, most studies are concerned with defining DIHs. Summarising the results of the literature review on DIHs, the following can be highlighted:

- are strategic tools aimed at boosting the digital transition of SMEs (Asplund et al. 2021; Georgescu et al, 2021);

- are policy instruments of the European Commission aimed at ensuring digital development within the European economy (Maurer, 2021);

- are associative systems that adopt an open innovation strategy being led by non-profit organisations (associations, universities) (Dalmarco, Teles, Uguen and Barroso, 2021);

- function as a one-stop desk (Sassanelli, Gusmeroli and Terzi, 2021a), favouring access for SMEs to exploit new technologies; the same authors also mention that typical digital transformation processes are specific to the two categories of actors involved: users and technology providers; the synchronisation of the two processes is considered a prerequisite for new value propositions;

- are knowledge brokers, providing support for the digital transformation of small and medium-sized enterprises by triggering open innovation practices (Crupi et al., 2020);

- is a response to the need for improvement (of products/processes/services), which forces radical innovations, with the ultimate goal of maintaining/increasing the competitiveness of organisations (Queiroz et al., 2020);

- are important actors that support and promote partnerships at the SME and ICT organisation level, resulting in increased business digitalisation; they usually respond to region-wide needs and adopt their own business models, able to create, deliver and capture value (Dalmarco et al., 2021, Georgescu et al, 2022).

Rundel and Salemink (2022) approach digital hubs from two perspectives: a) associative structures that provide services specific to urban, crowded environments with strong development potential; b) associative structures that have the property to counter digital exclusion - rural areas and small towns with lower development potential are considered. By carrying out a case study research, the authors capture the barriers related to the implementation and configuration change of a rural digital centre and highlight the need to ensure the availability and attractiveness of the space. Taking into account the involvement of different partners of the associative structure, for less developed rural areas, the authors recommend - as a first step - the development of a digital strategy for the municipality and then a region-specific one. In this sequence of actions, the local initiative (to establish the digital strategy for the municipality) is considered a precondition for a sustainable regional initiative.

In view of the above, it should also be pointed out that DIHs are innovation centres initially financed from public funds. After a period of business acceleration, public funding is reduced/stopped; in the maturity phase, the associative systems become self-financing (based on the revenues for the services provided and the fees charged for the use of the various tangible and intangible assets held within the innovation centre).

By analysing the activities of several DIHs, the researchers aimed to identify the most important functions they have to perform. Although the literature focuses more on two functions (supporting the launch of new digital technologies and targeting investment opportunities), the reality is that DIHs have very diverse functions. Given the diversity of the environments in which they operate, researchers have postulated that one function cannot be considered more important than another (Asplund et al. 2021; Georgescu et al, 2021).

In view of the European objectives, DIHs have been given the responsibility to provide four broad types of services ("test before invest"; "support to find investments"; "innovation ecosystem & networking", and "skills and training"). With regard to these services entrusted to DIHs, it should be noted that priority should be given to those services that are of interest to the community they serve.

Focusing their analysis on business models, Dalmarco et al. (2021) asked whether one business model fits all; the authors conclude that each DIH has its own business models (adapted to Industry 4.0), has its own characteristics, uses specific technologies, and offers services tailored to the community it represents. The authors conclude that value creation is achieved through five main activities: a) building associative structures, prospecting, brokering and networking; b) collaborative research; c) training and skills development; d) conceptualisation and prototyping; e) testing and validation. The value created is related to the portfolio of services offered and increases with the maturity of DIH. One DIH can be more efficient than another; this efficiency depends on the individual skills of the members of the collaborative structure.

Shifting the analysis to smart and innovative business, Maurer (2021) values networks of collaborators and co-creators to increase service interaction and system innovation. According to the research findings, cooperation and collaboration of all stakeholders is of paramount importance for the successful functioning of an DIH and - by implication - for increased service interaction.

Using quantitative and qualitative methods, Gernego, Dyba, and Onikiienko (2021) exploit the results of scientific research over the last ten years to identify challenges and opportunities for the development of innovative digital hubs in Europe. Admitting that digitalisation acts as a catalyst for innovation, the authors discuss the premises for the development of innovative digital hubs in rural areas.

Asplund, Macedo, and Sassanelli (2010) opined that DIHs have different levels of maturity, interact with different actors, and develop in different economic, social, and political environments, which forces to the organization of a portfolio of services that allows for adaptability. They draw attention to specific risks specific to DIHs. For example, they may not support all organisations equally (by providing differentiated services for the four standard functions). To minimise this risk, member organisations need to support each other, create collaborative platforms and exploit the synergies of the ecosystem in which they operate.

Queiroz et al. (2020) pointed out that Industry 4.0 is reshaping the way all economic sectors operate. DIHs are intended to support organisations in leveraging digital opportunities. The authors propose the establishment of a cross-regional DIH to foster interaction across regional DIHs. They also present the management strategy of such an interregional DIH, based on cooperation and sharing of digital knowledge/technology and skills across the entire association structure. The authors argue that this strategy can improve the quality of innovation and increase the degree of digitalisation of organisations in a wider territorial area.

Semeraro, Panetto, Serapiao, da Silva and Guédria (2021) assessed the maturity level of collaborations between digital innovation centres and their partners. The ultimate goal of this assessment is to provide the foundation for the creation of an interdisciplinary network of DIHs and solution providers. The authors discuss the main interoperability frameworks identified in the literature: a) legal framework - the extent to which businesses subject to different laws can collaborate to mutual advantage; b) organisational framework - the extent to which public administrations assume roles and responsibilities in managing business processes; c) semantic framework - the extent to which the data transferred is accurate and unambiguous; d) technical framework - the extent to which the technical support and service infrastructure meets the needs of the partners. Based on these frameworks, the authors identify the main types of services provided by DIHs, which they group into macro-classes: a) data (data collection, processing and analysis) and related services (decision support, data sharing, interaction); b) business - support services (including education)

on business, financing, project development, etc.; c) ecosystem - services aimed at creating, engaging, expanding communities based on best practice principles; d) skills/competencies - services to assess and enable the skills of partners in charge with organisational digitalisation; e) technology - services and hardware and software solutions addressed to both technology providers and users (services that are offered throughout the lifecycle of digital technologies). The authors' great merit is to build a prototype for assessing the interoperability maturity of DIHs.

Sassanelli Panetto, Guédria, Terzi, and Doumeingts (2021b) opined that in order to maintain/increase competitiveness, organizations have two possibilities: either to implement digital technologies in their own production centres; or to exploit digital technologies within an associative structure. Either way, organisations must not only deploy new digital technologies, but also use them appropriately and capitalise on them in an optimal timeframe (taking into account moral attrition) so that they can ensure a return on investment (i.e. demonstrate digital maturity). Different from the standard classification of services (ecosystem, technology, business, skills, and data), the authors propose different criteria for classifying the services in a DIH's portfolio; they consider that each type of service can be broken down into different service classes. Their study can be considered as a reference for researchers interested in a comprehensive treatment of the services offered by DIHs. From the perspective of services provided, DIHs take on the following responsibilities: classifying services (to avoid overlaps and inferences); continuously adapting the service portfolio to be ready for future actions; identifying opportunities for collaboration.

The review of the conceptual debates, the functions attributed to DIHs, and the services provided, aimed to assess the state of knowledge but also to familiarise decision-makers with the functionality and usefulness of a digital innovation centre.

3 CONTEXT, DATA AND METHODS

Digitization implies cultural changes (Volpe et al., 2021) which in turn change perceptions about value creation. The business world is also changing. The value of transactions in invisible goods (services) increases. Business products become smart products (Pardo, Ivens and Pagani, 2020), incorporating powerful digital technologies. Moreover, holding and leveraging digital data (structured and unstructured) offers unprecedented opportunities for online communities (Maciulien and Skarzauskien, 2020), and for society and the economy.

Organisational culture (especially that of SMEs) is adapting by taking into account the growth of online activities and the peculiarities of the "millennials" generation, strongly anchored in social networks and SME business operations, and valuing cloud technology more highly. The use of ICT, big data and social media in the digitalisation projects undertaken by organisations are preconditions for their success (Bouwman et al., 2019), but also for the associative structures in which they are integrated. It should not be lost sight of that digitalisation also has costs such as those associated with the use of digital technology (internet, IT, technology in production, e-commerce, social networking platform, etc.).

Referring to three interlinked innovation strands (application experiment, generic experiment and digital challenge), research (Volpe et al., 2021) has found that organisations with lower levels of digital maturity are more likely to implement collaborative projects precisely in order to enjoy the benefits of innovation and digitalisation more quickly (or more easily).

According to the results of previous studies (Viswanathana and Telukdari, 2021), SMEs contribute to the improvement of aggregate indicators measuring macroeconomic outcomes,

generating positive externalities such as increasing employment (and living standards) and boosting productivity, competitiveness and organisational growth. The results of scientific research converge with empirical research findings that have shown that digitally connected SMEs are more active in terms of international transactions (especially on the import side) compared to non-digitally connected SMEs (WTO, 2019).

Taking SMEs as a starting point, the above authors sought to provide: a) a sustainable, digitally-enabled business support that enables SMEs to plan resources and manage operations; b) insights into how digitalisation affects the business process; c) a perspective on digitalisation applied through an innovation hub; d) evidence on the contribution of digitalisation to increasing productivity, reducing costs and increasing opportunities for innovation through new business models. An effective business model is a model (structured and analytical) that defines the logic by which the company delivers value to its customers and makes them pay for the value package they receive (Teece, 2010).

All the ideas presented above are convergent and strongly argue that digitalisation and future skills are key to unlocking an economy; this is because digitalisation and innovation provide support to SMEs to overcome the obstacles induced by cyclical swings in the economy, increasing the prospect of sustainability.

In order to provide further evidence on the impact of digitalisation of economic activities we have chosen a small but homogeneous sample of countries - integrated in the Visegrád Group. This choice was based on the circumstance that the four countries had a common starting point, marked by the moment of signing the mutual support agreement for economic and political integration into the European Union (Romania it is not part of this group). Moreover, the four countries had a common start from a time perspective, marked by the transition to a market economy. For the period under review, all four countries fell into the category of high-income economies.

The literature uses the following indicators to assess the degree of digitalisation of a country (i.e. a country's economy):

a) *ICT Development Index* (IDI) - was developed by the International Telecommunication Union to monitor and compare developments in information and communication technology (ICT) at country and period levels; up to 2017 it combined 11 indicators; it was subsequently revised to better reflect new conditions;

b) The *Networked Readiness Index* (NRI) was developed by the World Economic Forum (WEF) to highlight the extent to which countries are exploiting the opportunities offered by information and communications technology; according to the founders (WEF), the index allows the assessment of the impact of ICT on the competitiveness of nations, and is constructed on three levels: the specific ICT environment, the behaviour and readiness of community members to use ICT, and the degree of actual use; as of 2019, the NRI is managed by the Portulas Institute, which redesigned the determination methodology precisely to reflect the ubiquitous nature of digital technologies (Dutta and Lanvin, 2019).

c) *Market Capitalization* is the key element of a new methodology to measure the performance of firms in the digital economy; this indicator allows comparative analyses at the level of market capitalizations in digital economies (Mueller et al., 2017).

In this study, the *ICT Development Index* (IDI) could not be used because the new methodology for determining the index was not applicable and the index was no longer calculated after 2017. *Market Capitalization was* not used because it measures only the over-digitization of listed organizations and our objective was to include all categories of economic agents in the assessment. The *Networked Readiness Index* (NRI) was the final choice for this study. In 2019 the NRI

was redesigned, based on a new methodology that integrated four pillars, each structured on three tiers: technology (access, content, future technologies); people (individuals, businesses, governments); governance (trust, regulation, inclusion); impact (economy, quality of life, sustainability goals).

From an economic perspective, the combined actions at the level of the four pillars can be interpreted as follows: companies capitalize not only on traditional factors of production (labor, land and capital), but also on new factors (such as digital technologies and human skills); under the premise of effective governance, the human resource use technologies precisely to ensure a just impact on the economy, society and the environment. Therefore, facilitating access to new technologies (including digital ones) produces positive effects both at the level of economic actors and at the level of national economies as a whole.

Taking into account the particularities of the pandemic crisis, the NRI assesses the impact of digital technologies (Dutta and Lanvin, 2019). In the perspective of the previously stated causal relationships, the present study tests the hypothesis of interdependence between digital technologies and macroeconomic results.

Due to the revision of the determination methodology, to better capture the impact of digitization during the pandemic crisis, our research is limited to the period 2019-2021. This limitation is welcome because the period was quite different from previous periods and forced the use of IT&C technology to overcome the period of pandemic restrictions. Data collection sources were: Dutta and Lanvin, (2019), Dutta and Lanvin, (2020) and https://networkreadinessindex.org/ (table 1).

Table 1. Data

	Years	NRI	Technology pillar	Real GDP per capita
Czech Republic	2021	68,11	64,23	17920
	2020	66,33	62,90	17340
	2019	65,09	63,00	18460
Hungary	2021	62,14	57,00	13660
	2020	60,05	56,43	12710
	2019	59,95	57,06	13270
Poland	2021	64,33	56,80	13580
	2020	61,80	52,99	12750
	2019	61,46	57,06	13020
Slovakia	2021	62,45	54,72	15660
	2020	60,78	54,14	15180
	2019	61,95	60,00	15890

Sources: https://networkreadinessindex.org/, Dutta & Lanvin (2019; 2020); https://ec.europa.eu/eurostat /databrowser /view/sdg_08_10/default/table

In order to assess the extent to which digitalisation produces economic and social effects, we opted to use an aggregate indicator of macroeconomic outcomes. Real Gross Domestic Product per capita (Real GDP per capita - euro) and its annual growth rate were considered the best options for assessing economic impacts. Real GDP per capita is used both as a measure of economic activity and as a measure of a country's standard of living. With some reservations, it can be considered a limited measure of economic well-being (the limitation comes from the fact that it does not include a number of elements, such as unpaid work or environmental degradation). EUROSTAT databases have made it possible to collect these indicators. Their dynamics are shown in Figure 1.

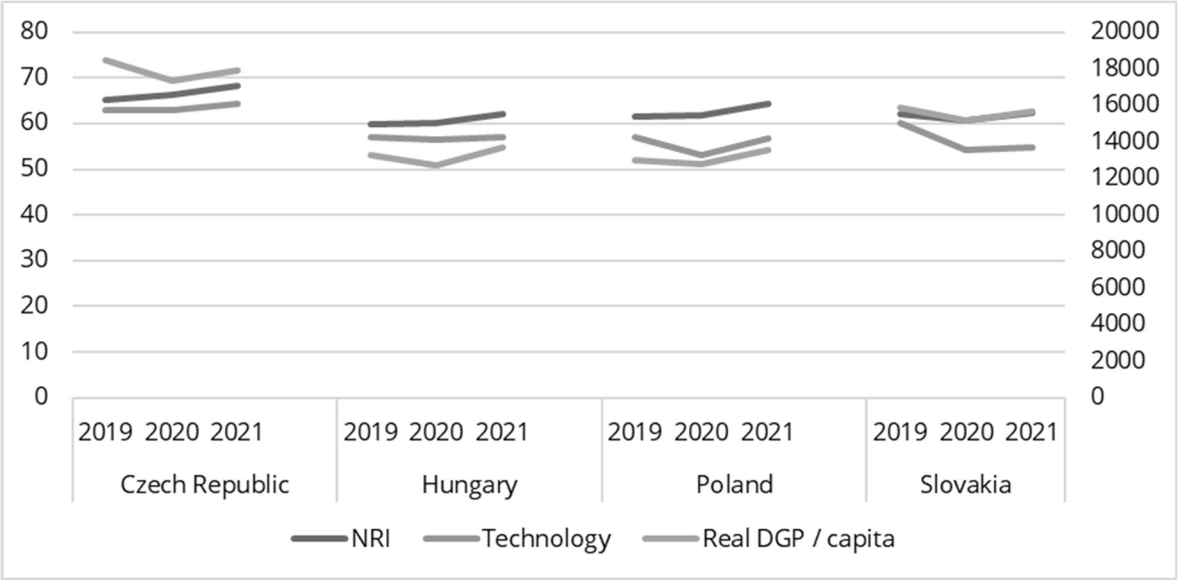

Figure 1. Dynamics of NRI, technology (0-100) and Real GDP per capita (0-20000 euro)

Although a small sample is analysed, the results can be very useful for the following two reasons: homogeneity of the sample and specificity of the period analysed. The results of the first analyses showed the following (as shown in Figure 1):

- The Czech Republic presents a peculiar situation, translated by the fact that the consistent growth of NRI is coupled with an economic revival (Real GDP per capita returning to an upward slope in the period 2020-2021); this country was the most prepared for the impact of the pandemic crisis (in 2019) because the growth slope of NRI is steeper (as compared to the other countries) and maintains its trend over the period analysed;

- Hungary, Poland and Slovakia show relatively similar situations; the NRI shows a trend synchronised with the trend in Real GDP per capita.

- The dynamics of the technology variable follows the trend of the NRI variable, but remains lower than it. For all four countries in the sample, the year 2020 represented a year of economic setback; the same situation is specific to the four pillars of the NRI (with the exception of the Czech Republic). In order to assess the relationship between the NRI (respectively, Technology) and the dynamics of the macroeconomics outcomes, correlation and regression analyses were run. The Data Analysis package (in Excel) was used to process the data.

4 RESULTS AND DISCUSSIONS

The first step in the analysis was to produce descriptive statistics. The data are presented in Table 2.

Table 2. Descriptive statistics

	NRI	*Technology*	*Real GDP per capita*
Mean	62,87	58,03	14953,3
Standard Error	0,74	1,06	604,5
Median	62,05	57,03	14420,0
Standard Deviation	2,56	3,68	2094,1
Minimum	59,95	52,99	12710,0
Maximum	68,11	64,23	18460,0

Source: Own processing

The data in Table 2 indicate that the mean NRI is 62.9 and the standard deviation is only 2.6, which reinforces that the sample shows

homogeneity. Hungary has the lowest recorded values for NRI, followed by Slovakia and Poland. In terms of Real GDP per capita (R_GDP), the data reveal that - at the sample level - the average value was 14953.3 euro (per year). The highest values were recorded by the Czech Republic, and the lowest values were recorded by Poland, followed by Hungary and Slovakia.

Regarding the Technology pillar, which evaluates the level of technology (including digital) of each country, the recorded scores vary between 52.99 (Poland, 2020) and 64.23 (Czech Republic, 2021).

In order to run correlation and regression analysis, since R_GDP has absolute magnitude values, we made a logarithm of these values (using natural logarithm). The correlation analysis showed a moderate relationship between the two variables (NRI and Real GDP per capita) of 0.75 and a closer relationship between the level of technology and Real GDP per capita (0.79). In the regression models the variables are assumed to be independent. Given that the preliminary analyses showed a moderate correlation, we consider the regression model as valid. To validate the regression models, we tested the null hypothesis (H0: coefficients are equal to zero) and the alternative hypothesis (H1: there is at least one non-zero coefficient βi). The values of the significance test F (Table 3) provided null values, indicating that there is at least one non-zero coefficient. At this point it can be stated with certainty that the regression equations are globally significant, with the mention that some coefficients may not be significant. The assumed statistical confidence for the modelling was 95% and the assumed significance threshold was 0.05.

The results of the simple linear regression analysis are shown in Table 4. The values obtained for *R Square* and *Adjusted R Square* indicate that 53% of the variation in Real GDP per capita can be explained by the variation in NRI.

Table 3. Regression statistics

NRI	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,12	0,12	13,29	0,004
Residual	10	0,09	0,01		
Total	11	0,21			
Technology	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,13	0,13	15,34	0,003
Residual	10	0,08	0,01		
Total	11	0,21			

Source: Own processing

Table 4. Regression statistics

	NRI	*Technology*
Multiple R	0,76	0,78
R Square	0,57	0,61
Adjusted R Square	0,53	0,57
Standard Error	0,09	0,09
Observations	12	12

Source: Own processing

Table 5 presents the coefficients of the regression analysis and validates the tested relationship.

Table 5. Model validation

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95% of the total
Intercept	7,059	0,699	10,106	0,000	5,503	8,616
NRI	0,040	0,011	3,646	0,004	0,016	0,065
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95% of the total
Intercept	7,923	0,430	18,424	0,000	6,965	8,881
Technology	0,029	0,007	3,916	0,003	0,012	0,045

Source: Own processing using *Data analysis* (Excel). Statistical confidence 95%.

The results are statistically significant because the *P-value* is less than 0.05 for both the NRI, Technology pillar and the free term. The regression coefficients (shown in Table 5) are positive and indicate the following: for a one-unit increase in the NRI score, real GDP per capita increases by 0.04 units. Also, an increase in technology use has the effect of increasing real GDP per capita by 0.029. The small difference between the coefficients of the independent variables in the two regression models (0.04 and 0.029) reveals the major impact that technology has on the macroeconomic outcome indicator. The coefficient of the free term is also positive and statistically significant, which means that there are other variables that contribute favourably to Real GDP per capita growth.

According to the determination methodology, NRI evaluates three categories of impacts: economic, social and environmental. In this study, the focus was on the economic impact of technology (in this case, the digital technologies, whose importance has increased during the pandemic period). The results of the study confirm the hypothesis regarding the interdependence between NRI (its pillars) and real GDP per capita. The results obtained in the present study confirm the findings of previous research (Grigorescu et al., 2021; Stanley et. al., 2018), which have shown that new digital technologies have a favourable economic impact, contributing to welfare growth and reducing gaps between countries.

5 CONCLUSIONS

The present study focuses on a topical issue on the priority list of authorities (supranational and national) and organisations - increasing competitiveness by capitalizing on new technologies. The digital transition, digital innovation centres and the assessment of the contribution of digitalisation to economic performance are also topics of debate in the researchers' sights. Studies have shown that most small and medium-sized enterprises have difficulties in implementing and leveraging the new technologies especially digital ones. In support of them, measures have been adopted to facilitate the creation of associative structures (DIHs) that facilitate jointly exploit new technologies.

Digital Innovation Hubs, set up with public or private support, are a response to the need to improve processes/products/services with the aim of increasing the competitiveness of organisations. These associated structures have their own characteristics, use specific technologies and offer services tailored to the business community they represent. They develop networks of collaborators and co-creators, foster cooperation and collaboration.

Empirical research has shown that digitalisation and innovation support SMEs to overcome obstacles induced by cyclical swings in the economy, increasing the prospect of sustainability. To provide further evidence along these lines, this study carries out an evaluation on the example of a group of 4 countries (Visegrád Group: Czech Republic, Hungary, Poland and Slovenia). Using the *Networked Readiness Index -NRI, Technology Pillar* (as a measure of the exploitation of ICT opportunities) and *Real GDP per capita* (as a measure of economic activity outcomes), the results of our research confirm the findings of previous studies, showing that an increase of one unit in Technology Pillar score leads to 0.029 increase of the Real GDP per capita. At the same time, the regression analysis also indicated that more than half of the variation in GDP per capita is determined by the variation in the NRI and the technology score.

According to the results, the present study has important practical implications. First, it provides evidence on the impact of technology (and digital technologies) on economic outcomes. Second, it supports decision-makers

(from economics and administration) to better understand the advantages of participating in the various associative structures, which facilitate access to new technologies and innovative digital solutions for all participants.This study has some limitations, being a first approach of this pilot analysis. The period of analysis is limited to three years, the sample is made up of four countries. In order to overcome these limitations, in future research we plan to carry out an EU-wide study assessing (for a longer period of time) the impact of new technologies on economic efficiency (both at the aggregate and organisational level), including here also Romania and other emerging countries, in order to do an extensive and intensive research, introducing also new indicators and new variables.

BIBLIOGRAPHY

Asplund, F., Macedo, H. D., & Sassanelli, C. (2021). Problematizing the Service Portfolio of Digital Innovation Hubs. *22nd IFIP WG 5.5 Working Conference on VIRTUAL ENTERPRISES, PROVE 2021*, Nov 2021, Saint-Etienne, France, 433-440. doi: 10.1007/978-3-030-85969-5_40

Bouwman, H., Shahrokh, N., & Mark R. (2019). Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs?" *Telecommunications Policy,* 43(9), 1018-1028. doi: 10.1016/j.telpol.2019.101828

Campagnolo, G., Nguyen, H., & Williams, R. (2019). The temporal dynamics of technology promises in government and industry partnerships for digital innovation: The case of the Copyright Hub, *Technology Analysis & Strategic Management*, 31(8), 972-985. doi:10.1080/09537325.2019.1580358

Coenegrachts, E., Beckers, J., Vanelslander, T., & Verhetsel, A. (2021). Business Model Blueprints for the Shared Mobility Hub Network. *Sustainability*, 13, 6939. doi:10.3390/su13126939

Crupi, A., Del Sarto, N., Di Minin, A., Gregori, G.L., Lepore, D., Marinelli, L., & Spigarelli, F. (2020). The digital transformation of SMEs – a new knowledge broker called the digital innovation hub. *Journal of Knowledge Management*, 24(6): 1263-1288. doi:10.1108/JKM-11-2019-0623

Dalmarco, G., Teles, V., Uguen, O., & Barroso, A.C. (2021). Digital Innovation Hubs: One Business Model Fits All? *22nd IFIP WG 5.5 Working Conference on Virtual Enterprises*, PRO-VE, Nov 2021, Saint-Etienne, France. 8p. doi: 10.1007/978-3-030-85969-5_41

Di Roma, A., Minenna, V., & Scarcelli, A. (2017), Fab Labs. New hubs for socialization and innovation, *The Design Journal*, 20:sup1, S3152-S3161, doi: 10.1080/14606925.2017.1352821

Dutta, S., & Lanvin, B. editors (2019). *The Network Readiness Index 2019: Towards a Future-Ready Society*, Portulas Intitute, available at https://www.insead.edu/sites/default/files/assets/dept/globalindices/docs/nri-2019.pdf, accessed at 20 April 2022

Dutta, S., & Lanvin, B. editors (2020). *The Network Readiness Index 2020: Accelerating Digital Transformation in a post-COVID Global Economy*, Portulas Intitute, available at https://www.tralac.org/documents/resources/covid-19/4228-the-network-readiness-index-2020-accelerating-digital-transformation-post-covid-global-economy-portulans-institute-october-2020/file.html, accessed at April 20, 2022

European Commission, 2021. *European Digital Innovation Hubs in Digital Europe Programme*, Brussels (Belgium), Programme, 2021. [Online]. Available: https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs-dihs-europe, accessed at Mai 28, 2022

Georgescu, A., Avasilcăi S., & Peter M. K. (2021). Digital Innovation Hubs—The Present Future of Collaborative Research, Business and Marketing Development Opportunities. In: Rocha Á., Reis J.L., Peter M.K., Cayolla R., Loureiro S., Bogdanović Z. (eds) *Marketing and Smart Technologies. Smart Innovation, Systems and*

Technologies, vol 205. Springer, pp. 363-374. doi: 10.1007/978-981-33-4183-8_29

Georgescu, A., & Bârzu, S., (2021). The Impact of the Digital Channels in Increasing the Marketing Capabilities and the Networking Potential between Companies during the COVID Period. The Case of Local Romanian SMEs, In: *Proceedings of International Conference Strategica. Shaping the Future of Business and Economy,* C. Bratianu, A. Zbuchea, F. Anghel, B. Hrib (Eds.), 9th edition, Tritonic, pp. 262-272

Georgescu, A., Peter M. K., & Avasilcăi, S. (2022). Associative and Non-associative Business Structures: A Literature Review for the Identification of Business Development Opportunities for SME in the Digital Age, In: Reis J.L., Peter M.K., Cayolla R., Bogdanović Z. (eds) *Marketing and Smart Technologies. Smart Innovation, Systems and Technologies,* vol 280, Springer, Singapore, pp. 337-348. doi: 10.1007/978-981-16-9272-7_28

Gernego, I., Dyba, M., & Onikiienko, S. (2021). Challenges and opportunities for digital innovative hubs development in Europe, *Management theory and studies for rural business and infrastructure development*, 43 (2), 298-306, doi:10.15544/mts.2021.26

Grigorescu, A., Pelinescu, E., Ion, A. E., & Dutcas, M. F. (2021). Human Capital in Digital Economy: An Empirical Analysis of Central and Eastern European Countries from the European Union. Sustainability, 13, 2020. doi: 10.3390/ su13042020

Gupta, R., Mejia, C., Gianchandani, Y. B., & Kajikawa, Y. (2020). Ambidextrous Firm Strategy Insights From Internet of Things Linked Interfirm Deals, *IEEE Transactions on Engineering Management*, doi: 10.1109/TEM.2020.3041250

Jocevski, M. (2020), Blurring the Lines between Physical and Digital Spaces: Business Model Innovation in Retailing, *California Management Review*, 63(1), 99-117. doi: 10.1177/0008125620953639

Maciulien, M., & Skarzauskien, A. (2020). Building the capacities of civic tech communities through digital data analytics, *Journal of Innovation & Knowledge,* 5, 244–250. doi: 10.1016/j.jik.2019.11.005

Maurer, F. (2021). Business Intelligence and Innovation: A Digital Innovation Hub as Intermediate for Service Interaction and System Innovation for Small and Medium-Sized Enterprises, *Working Conference on Virtual Enterprises*, Smart and Sustainable Collaborative Networks 4.0, 629, 449-459. doi: 10.1007/978-3-030-85969-5_42

Mueller, S., Bakhirev, A., Böhm, M., Schröer, M., Krcmar, H., & Welpe, I. (2017). Measuring and mapping the emergence of the digital economy: a comparison of the market capitalization in selected countries, *Digital policy, regulation and governance, Regulation and Gouvernance*, 19(5), 367-382

Pardo, C., Ivens, B.S., & Pagani, M. (2020). Are products striking back? The rise of smart products in business markets, *Industrial Marketing Management*, 90, 205-220

Queiroz, J., Leitão, P., Pontes, J., Chaves, A., Parra-Domínguez, J., & Perez-Pons, M. (2020). A Quality Innovation Strategy for an Inter-regional Digital Innovation Hub, *Advances in Distributed Computing and Artificial Intelligence Journal*, 9(4), 31-45. doi: 10.14201/ADCAIJ2020943145

Richner, P., Heer, P., Largo, R., Marchesi, E., & Zimmermann, M. (2017). NEST – una plataforma para acelerar la innovación en edificios. Informes De La Construcción, 69(548), e222. doi:10.3989/id.55380

Roman, A., & Rusu, V. D. (2015). Access to Finance of SMEs in CEE Countries and Supportive Measures, *The Journal of Accounting and Management*, 5(3), 37-48

Rundel, C., & Salemink, K. (2022). Hubs, hopes and high stakes for a relatively disadvantaged low tech place, *Local Economy*, 36(7-8), 650-668. doi:10.1177/02690942221077120

Sanson, K. (2015), Corresponding Geographies: Remapping Work and Workplace in the Age of Digital Media, *Television & New Media*, 16(8), 751-768. doi: 10.1177/1527476414559289

Sassanelli, C., Gusmeroli, S., & Terzi, S. (2021a). The D-BEST Based Digital Innovation Hub Customer Journeys Analysis Method: A Pilot Case, 22nd IFIP WG 5.5 Working Conference on Virtual Enterprises (PRO-VE) 2021. *Smart and sustainable collaborative networks 4.0* (PRO-VE 2021) 629, 460-470

Sassanelli, C., Panetto, H., Guédria, W., Terzi, S., &Doumeingts, G. (2021b). Towards a Reference Model for Configuring Services Portfolio of Digital Innovation Hubs: The ETBSD Model. 21st IFIP WG 5.5 Working Conference on Virtual Enterprises (PRO-VE). *Boosting Collaborative Networks 4.0,* 598, 597-607

Semeraro, C., Panetto, H., Serapiao, L., da Silva, G., & Guédria, W. (2021). Interoperability Maturity Assessment of the Digital Innovation Hubs, Proceedings of the 2nd *International Conference on Innovative Intelligent Industrial Production and Logistics* (IN4PL 2021), 67-74, doi: 10.5220/0010653800003062

Stanley, T. D., Doucouliagos, C., Steel, P. (2018). Does ICT Generate Economic Growth? A Meta-Regression Analysis. *Journal of Economic Surveys,* 2018, 32(3), 705–726. doi: 0.1111/joes.12211

Teece, D. J. (2010). Business Models, Business Strategy and Innovation. *Long Range Planning*. Elsevier BV, 43 (2–3): 172–194. doi:10.1016/j.lrp.2009.07.003

Viswanathana, R., & Telukdari, A. (2021). A systems dynamics approach to SME digitalization, International Conference on Industry 4.0 and Smart Manufacturing, *Procedia Computer Science,* 180 (2021), 816–824

Volpe, M., Veledar, O., Chartier, I., Dor, I., Silva, F. R., Trilar, J., Kiraly, C., Gaffuri, G., Hafner-Zimmermann, S. (2021). Experimentation of Cross-Border Digital Innovation Hubs (DIHs) Cooperation and Impact on SME Services. 22nd IFIP WG 5.5 Working Conference on *Virtual Enterprises*, PRO-VE 2021, Nov 2021, Saint-Etienne, France. 423-432. doi: 10.1007/978-3-030-85969-5_39

WTO (2019). The digital economy, GVCs and SMEs, Global Value Chain Development Report 2019. WTO. doi: 10.30875/2894deeb-en

https://ec.europa.eu/eurostat/databrowser/view/sdg_08_10/default/table

https://networkreadinessindex.org/