THE RELATIONSHIP BETWEEN HUMAN DEVELOPMENT AND THE LEVEL OF DIGITALIZATION IN THE COUNTRIES OF THE EUROPEAN UNION AND LATIN AMERICA

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Abstract: The purpose of this article is to compare the level of digitization and technical development of LA countries and Europe based on the correlation coefficient between CISCO and HDI countries from these regions. The descriptive statistics summary of used variables, along with the correlation coefficients, measured on both regions separately to compare them together have been calculated. The countries' selection in each of the regions fulfilled the criteria of values presence simultaneously in the Cisco Digital Readiness Index of 2019 and the Human Development Index of 2019, as the most recent time horizon of calculated indicator. The hypothesis tests have been tested whether the regression parameters were significant, and the p-values were analysed, indicating the smallest level of significance for the null hypothesis (non-significant parameters) to be rejected. The results were analysed according to the countries that are part of each region and their level of development to justify them. The results show that the variables have been correlated and that Europe has demonstrated higher average values for both indexes compared to the Latin America. The main results have been commented accordingly to the levels of development of the member countries of both regions, together with the consequences of digitalization.

Keywords: Digitalization, digital adoption, human development, Europe, Latin America

1 Introduction

The Fourth Industrial Revolution has come, and the world must adapt to innovations. It changes the way it interacts in society, the way people consume, live and work. However, this agile process represents a new stage that is taking place in connection with the new digital age and involves people, technology, sustainability, risks and opportunities (de Hoyos Guevara et al., 2020). The rapid technological progress of the 21st century is already becoming a reality, leading to the digitization of simple routine tasks in changes, both in industrial processes, and in the daily lives of the population.

Technologies, such as the internet of things, the internet of services, augmented reality, smart factories, or artificial intelligence, affect significantly not only production processes and business operations, but also the way of life and behaviour of the entire population (Bag et al., 2018). Since the initial German conceptualization in 2011, the technological environment and understanding of Industry 4.0 have evolved distinctly. At the same time, similar terms often used as synonyms, such as "smart manufacturing", "digital transformation" or "fourth industrial revolution" have increased the confusion about the extent and characteristics of this phenomenon (Culot et al., 2020). The current industrial revolution is driven by data, also referred to Industry 4.0.

Industry 4.0 has attracted significant attention from academia and industry professionals (Tiwari, 2020). The size of a company and the level of information system coverage are two factors affecting the level of acceptance of a company´s technology (Zheng et al., 2021). The ongoing discussions on the „digital revolution – and – disruptive competitive advantages" have led to the creation of a business vision such as Industry 4.0. However, the timing, and its true impact on businesses is still unclear (Glas & Kleemann, 2016).

Strategies for Industry 4.0 should be refined and described in detail in order to develop economic and social systems that can respond flexibly to sudden changes in the system (Bag et al., 2018). Through populations, governments and businesses, countries have achieved varying degrees of current adoption of technologies. This level of acceptance affects the way each country deals with it and how it is affected by it.

In addition to knowledge and innovation, human capital is the most frequently mentioned factor that makes it possible to gain a market advantage in modern economies. This concept is defined as a derivative of education, acquired qualifications and practical skills. The currently observed dynamic development of advanced technologies requires the involvement of high quality human capital in this process. Human capital is a condition for the development of Industry 4.0 (Pilichowska, 2021).

The introduction of digital production technologies in Latin America faces diverse, heterogeneous, and decentralized conditions. After several years, there was no comprehensive view of the situation in the region (Scheeren et al., 2019). In Latin America, it is very important to start training professionals in the vision of Industry 4.0 (I4.0) Developed countries share a leading role in producing research in Industry 4.0, while Latin America and Asia are far behind. (technical competences) (Cardillo & Chacon, 2020).

Previous studies have not paid attention to comparing the two very few comparing economies compared to the emphasis on the need for digitization within Industry 4.0. The purpose of this paper is to compare the level of digitization and technical development of LA and Europe countries based on the correlation coefficient between CISCO and HDI countries from these regions.

This paper deals with the relationship between human development and the level of digitalization in the countries of the European Union and Latin America. The paper includes four parts. After a short introduction, the theoretical interface for the issue follows, focusing on the construction of the Index measure and its integration into the issue of Industry 4.0. Then the methodology and research methods follow. The results and discussion section compares the Correlation Coefficient between CISCO and the part of HDI for the countries of Latin America and the countries of the European Union. The fourth part – conclusions – summarizes the paper, includes implications for practice and defines research limitations and suggestions for the future research.

2 Literature Review

2.1 Indexes measure the adoption of Industry 4.0

For the research purpose the data from the Human Development Index by The United Nations Development Programme (Human Development Reports, 2019) and the Cisco Digital Readiness Index by Cisco Systems, Inc., both related to the 2019 as the latest available data have been used. (see figure 1)

Figure 1: Structure of Human Development Index

Sources: The United Nations Development Programme - Human Development Reports, (2019).

Accordingly to (The United Nations Development Programme - Human Development Reports, 2019), The Human Development

Index (HDI) represents a measure of achievement in important dimensions of human development in 189 countries and is aggregated into a composite index using geometric mean of normalized indices for each one of the three dimensions. These dimensions are as follow: a long and healthy life, being knowledgeable and have a decent standard of living. The health dimension is evaluated by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. Moreover, the standard of living dimension is evaluated by gross national income (hereinafter GNI) per capita. The index uses income logarithm to reflect the diminishing importance of income with increasing GNI. In the present study, the indexes of Latin American and European countries were analysed.

The Cisco Digital Readiness Index (hereinafter CISCO) has been created by Cisco Systems, Incorporation to allow nations understand their own positioning and limits into taking an advantage of the benefits of digitization. A holistic view of digital readiness examined multiple factors indicating the progress that a nation has made towards digital maturity has been adopted. The digital readiness can demonstrate areas of strength while providing guidance as to how the nations can invest to improve their overall readiness (Cisco Digital Readiness Index, 2022).

This indicator takes values from 0-25 and has been compiled based on seven different components, which are intended to illustrate the digital readiness of the country. These components have been set as follows. The indicator, called Basic Needs, contains information on demographic data such as life expectancy, under-5 mortality and access to basic services, water and electricity. The Human Capital component contains information on the level of digital skills among human resources, including information on literacy rates, quality of education or average length of schooling. The Ease of Doing Business indicator includes factors such as the ease of business index, legal business standards and the Logistics Performance Index infrastructure rating. Building digital infrastructure and capabilities requires significant investment by government and the business community. Various sources of private and public investment are considered to measure these investments, including foreign direct investment, R&D expenditure, and investment freedom. These investments are included under the corporate and government investment indicator. The Start-Up Environment indicator includes information on the availability of investment and capital in each country to start a business. For the Technology Infrastructure indicator, information related to broadband and Internet access has been examined. The last component of the CISCO index is Technology Adoption, consists of examine data relating to mobile cellular penetration, internet usage, and cloud services and characterizes the general demand for digital products and services was assessed (Cisco Digital Readiness Index, 2022).

2.2 Adoption and adaptation to Industry 4.0

The technology development has changed not only the production process but also people's way of life (World Bank Group, 2016). Accordingly to a research from (Deloitte, 2018), most executives believe Industry 4.0 will lead to more social and economic equality and stability.

Accordingly to (Guryanova et al., 2019) resulted that the economic development in regions is established on the adoption of digital innovations. Additionally, (Semyachkov, 2019) has found that the transition to a digital economy, the introduction of digital technologies and the creation of effective business models has been prioritised from perspectives of socio-economic development for most developing countries (Latinobarómetro, 2018). Moreover the research of (Kristine Rozite et al., 2019) demonstrate that European Union broadband infrastructure, digital competences, use of internet, business technology integration and digital public services has delivered a significant positive effect on GDP growth.

Another important effect can be seen into dissimilarity of influences of technology utilization between developed and developing regions and between the continental regions which leads to the situation that the emerging countries have higher ICT divergence than developed countries (Rath, 2016; Pollak, 2020). Furthermore, Cortés & Navarro (2011) as well as Kubielas et al. (2014) and Ibujés Villacís et al. (2019) found that in European countries the different levels of economic development, productivity, and human development have been based on the level of ICT implementation as the fast broadband connections, social media, and mobile applications have created the digital transformation engine for Europe. The established European model enables the preservation of a sustainable industry, develop qualified employees, support energy transition and adapt to large-scale customization Besides these findings, the analyse of the market capitalization value of the world's 70 largest digital platforms shows that Africa and Latin America's together share is only 1 percent, while the Europe's share have reached 4 percent (United Nations, 2019).

The digitization of production is still lagging in Latin America, which negatively affecting its productivity levels. Pratama and Al-Shaikh, (2012) have study digitalization and human development, concluding that the correlation between human development level and the internet penetration rate is positive and that the Internet penetration rate grows faster in the developed countries than in the developing countries. However, Miranda and Lima (2013) found that in countries with HDI less than or equal to 0,6 improvements in their operational ICT index are not linked to the corresponding improvements in the human development, whereas for countries with HDI greater than or equal to 0,75 can be found a close correlation between the two indices. The study of De La Hoz-Rosales et al., (2019) has evidenced that there is a positive impact of the individual use of ICT on human development, regardless of the country's level of development. Additionally, also the findings of (Jovanović et al., 2018), presenting that, for European countries, the higher level of digitalization tend to contribute to humanity and that the process of digitalization influences positively countries social components.

The lack of digital literacy is among the biggest barriers to connectivity, as ITC allows people to lead the life they want and allow them to expand their own capabilities. The literature sources consensus that it is important to invest in people's training and development, to be reached both advantages, the digital assets (e.g. hardware, software) and digital capabilities (e.g. managerial skills, strategy) to be able to use the digital technology as an competitive advantage (De La Hoz-Rosales et al., 2019).

3 Methodology

The indexes of Latin American and European countries have been analysed. The values used refer to the year 2019 because it is the most recent time horizon in which this indicator was calculated.

It is important to note that in this article the narrowest definition of Latin America was used, which includes the countries of the American Continent where Latin Languages are spoken. The analyses have been made between the countries of Latin America and Europe with data in both indexes HDI and CISCO. Thus, the countries analysed in Latin America were as follows: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. The countries analysed in EU covered: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. The countries' selection in each of the two regions fulfilled the criteria of the presence of values simultaneously in the Cisco Digital Readiness Index of 2019 and the Human Development Index of 2019. The data of

each region were analysed separately, in order to be able to identify the differences and similarities between them. The maximum value of HDI as a classic index is 1. The maximum value of the CISCO index is 25.

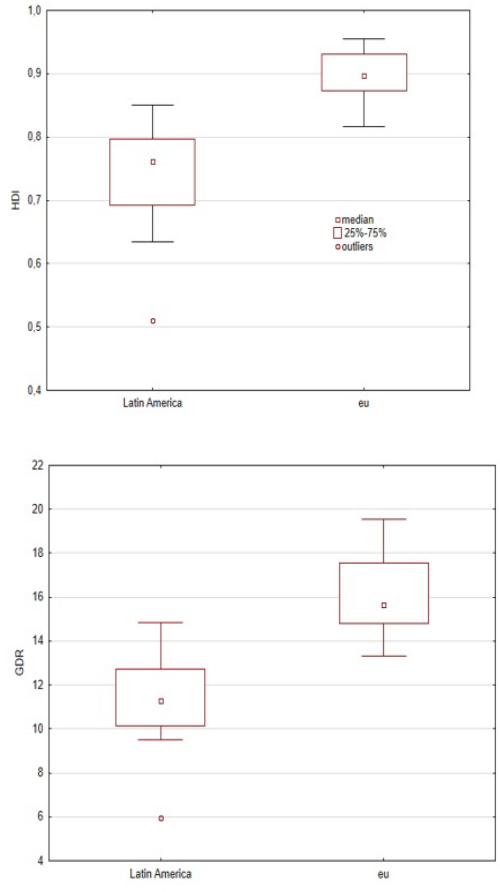
To detect discrepant countries concerning their region, the minimum and the maximum values of a box plot were calculated for each index and each region. Values that are smaller than the minimum value or higher than the maximum value are considered outliers. In the following step, the next data statistical analysis has been performed with the Statistica and Gretl. Using normality tests, it has been verified whether the data have a normal distribution, so the Pearson's correlation coefficient has been used to examine the dependence.

The correlation coefficients have been also measured between the CISCO index and each one of the indices that form the HDI index to identify the factors of greatest influence for the correlation. A multinomial regression based on the least-squares method has been performed for each region, after that, with HDI index as a dependent variable and as factors of CISCO index an independent variable. Then, the hypothesis tests have been performed to test whether the regression parameters were significant, and the p-values were analysed, indicating the smallest level of significance for the null hypothesis (non-significant parameters) to be rejected. Finally, the results were analysed according to the countries that are part of each region and their level of development to justify them.

4 Empirical results and discussion

The following figure (fig.1) shows the box of HDI and CISCO and each region, in which it is possible to analyse the inferior limits and the superior limits to find discrepant countries.

Figure 2: Box-plot HDI and CISCO



Sources: Author's own compilation.

Analysing the graphs in Figure 2 shows that in Latin America, one country is identified as an outlier. This country in both cases is Haiti.

Regarding the CISCO and HDI indexes, the European mean is higher than Latin America mean and Europe has higher maximum and minimum values, which indicates that in general the countries of the European continent have reached a higher degree of adoption of digitization. In addition, Latin America's standard deviation is bigger than the European's one, indicating greater variability, which can be interpreted as higher inequality about the adoption of digitization. Analysing the skewness (tab.1), it is notable that the values of HDI are less than zero on both regions, showing that the left tail of the probability density function is higher, with a higher concentration of values below the average. For the CISCO indicator, the skewness value differs for both regions. In the case of the buckling coefficient, both regions differ in both indicators. For the Latin America region, we get a result in which the sharpness is positive and is therefore above normal, and the values of the indicators are therefore much more similar for individual countries than for EU countries, where the sharpness is below normal.

Table 1: Descriptive characteristics

Variable	HDI	CISCO	HDI	CISCO
Location	Latin America	Latin America	EU	EU
Averagea	0,741	11,425	0,898	16,036
Minimum	0,51	5,96	0,816	13,34
Maximum	0,851	14,86	0,955	19,54
Standard deviation	0,082	1,987	0,037	1,755
Skew	-1,16	-0,834	-0,383	0,387
Kurtoisis	1,86	2,044	-0,504	-0,93

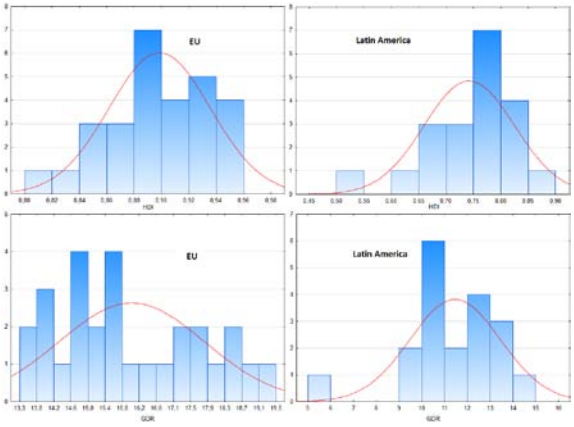
Sources: Author's own compilation.

Regarding the HDI, the European mean is higher than Latin America mean, with higher maximum and minimum values, indicating that, in general, the countries of the European continent have a higher human development index. In addition, Latin America's standard deviation is greater than the European's one, indicating greater variability, which can be interpreted as higher social inequality between countries.

Data from both countries were subjected to normality testing using the Kolmogorov-Smirnov Test. The correlation between HDI and CISCO for both regions were p-value> 0.05 and therefore the hypothesis of normality of the data cannot be rejected. (see figure 3)

The following figures show the data histograms.

Figure 3: Histograms HDI and CISCO



Sources: authors' own elaboration

The correlation coefficients between the CISCO and the HDI analysis indicates that there is a greater correlation in the European continent than in Latin America, but both have a strong positive correlation (p-value of test is smaller then 0,05) since they have coefficients greater than 0.8. The following table shows the Pearson correlation coefficient values.

Table 2: Correlation Coefficient

	Correlation coefficient
Latin America	0,938
Europe	0,845

Sources: Author's own compilation.

In addition, it is feasible to analyse the correlation between the part of CISCO and HDI. The correlation coefficients for each region can be found into following tables (tables 3 and 4).

Table 3: Correlation Coefficient between CISCO and part of HDI

	Latin America	Europe
Basic Needs	0,861	0,757
Business and Gov't Investment	0,325	0,817
Ease of Doing Business	0,676	0,877
Human Capital	0,891	0,699
Start-up Envir	0,628	0,323
Tech Adoption	0,921	0,795
Tech Infrastructure	0,861	0,724

Author's own compilation.

Pearson correlation coefficient values from tab. 3 have been tested. In all cases, the null hypothesis has been rejected. In the case of Latin American countries, can be seen that the relationship is significantly stronger than in the EU, apart from GNI and CISCO.

Table 4: Correlation Coefficient between HDI and parts of CISCO

	Latin America	Europe
Life Expectancy at Birth	0,93	0,576
Mean of Years of Schooling for Adults Aged 25 Years and More	0,819	0,488
Expected Years of Schooling for Children of School Entering Age	0,647	0,459
GNI per capita	0,862	0,892

Sources: Author's own compilation.

The independence testing has shown that Table XX shows a p-value greater than 5% for Business and Government and CISCO in LA and Start-up and CISCO in the EU. It is important to note that, to compose the GNI index, the HDI uses income logarithm to reflect the diminishing importance of income with increasing GNI. Also, the education index consists of "Mean of Years of Schooling for Adults Aged 25 Years and More" and "Expected Years of Schooling for Children of School Entering Age". Lastly, the multinomial regressions were calculated (HDI as a dependent variable and part of CISCO as an independent variable).

The summarized results are in the following table 5.

Table 5: Regression analysis – OLS for HDI

Latin America			
	coefficient	**t**	**p-value**
Const	0,268	6,02	<0,001
Ease of Doing Bussiness	0,035	2,099	0,053
Human Capital	0,105	4,569	<0,001
Tech Adoption	0,138	3,665	0,002
Europe			
	coefficient	**t**	**p-value**
Const	-0,158	-1,314	0,201
Basic Needs	0,193	6,245	<0,001
Human Capital	0,083	5,796	<0,001
Tech Adoption	0,041	2,619	0,015

Sources: Author's own compilation.

The coefficient of determination shows that more than 85 % of variability HDI in both regions has been explained.

The step wise regression has been used for the modelling and a model with three explanatory variables has been obtained for both regions. All assumptions (heteroscedasticity, multicollinearity, specifications, and normality) have been met and the models are therefore plausible. The explanatory variables Human Capital and Tech Adoption have been identified as statistically significant parameters for both regions. The increase in the value of the Human Capital indicator, which contains information on education, has been reflected in the HDI more than the increase in the Tech Adoption indicator in the case of EU countries. In contrast, in the Latin American region, Tech Adoption has a greater impact on the change in HDI than the change in education described in Human Capital.

In contrast, in the Latin American region, Tech Adoption has shown a greater impact on the change in HDI than the change in education described in Human Capital. The indicator with the greatest impact on the HDI has been identified the indicator of Basic Needs in the countries of the European Union. This relationship may be due to the demographic structure of the countries of the European Union. From a demographic point of view, Europe is facing problems with a low natality index, leading to an aging population that is increasing life expectancy. At the same time, the technical knowledge of school graduates is being increased. In the case of Latin American countries, such significant changes in the structure of the population have not been apparent and the relationship between the Human Development Index and Basic Needs therefore have not been so high. In the regression model, this indicator has been identified as statistically insignificant. In Latin American countries, the HDI has been further found to be depending on the ease of business factor named The Ease of Doing Business indicator. The economic situation in the regions of Europe and Latin American are significantly different and this situation has been reflected in this indicator.

4.1 Summary of findings

According to The United Nations Development Programme - Human Development Reports (2019). HDI has been classified as Low, Medium, High and Very High. The following table shows the number of countries in each classification among those analysed, as well as the percentage in relation to the total.

Table 6: Human Development Classification Level

	Latin America		**Europe**	
	Number of countries	**%**	**Number of countries**	**%**
Low	1	5	0	0
Medium	6	29	0	0
High	11	52	4	14
Very High	3	14	24	86

Sources: Author's own compilation.

While 86% of the European countries analysed have reached the very high HDI, only 14% of Latin American countries have reached this level. In addition, all the European countries analysed have been outreached their HDI rated as high or very high, while 34% of Latin American countries have been spread below that rating. The information provided in the table is consistent with the statistical summary, since, in general, European countries are better classified. The fact that Haiti is the only country among the selected countries classified as Low is

following the analysis made previously, in which it was considered an outlier. Besides that, the correlation coefficients show that HDI has a strong positive correlation with CISCO, which agrees with the Human Development Report (The United Nations Development Programme, 2019) as it indicates that higher levels of human development keep up with greater access to technology.

The largest standard deviation of the CISCO among Latin American countries seems to be consistent with Katz and Callorda (2018), who studied that Latin America and the Caribbean contain countries with substantially different digital ecosystems, which is in accordance with economic development differences. Regarding the CISCO standard deviation, can also be possible to relate inequality in Latin America as a historical consequence of the colonial period.

The important fact stated, is that the rate of perception of justice in the distribution of wealth in Latin America fell from 16% in 2018 to 12% in 2020 (Latinobarómetro, 2022). Additionally, Latin America DAI index prove its strongest correlation with the GNI per capita, representing that the gross income become a relevant factor for the digitalization. According to The United Nations Development Programme (2019) the Latin American countries have belonged to the developing economies.

Despite the average adoption of digitization being higher in Europe than in Latin America, has been Employers should satisfy their employees with new career opportunities (Nangoy et al., 2020). Too many of young people still leave education without having the necessary preparation to enter the labour market (Frey & Osborne, 2017). Thus, it is necessary to improve the quality and relevance of skills formation and improve skills and information for better career choices (McKinsey Global Institute, 2017). Another relevant factor for Europe, is the replacement of jobs as the gap between demand and supply of ICT educated specialists has been expected to increase. Furthermore the lower the level of education required, the more likely the job is to be automated (Nangoy et al., 2020).

However, while some jobs will be lost, others will be generated. The level of cooperation between humans and machines will increase significantly (Muscio & Ciffolilli, 2020). Although it requires difficult transitions and investments, the increased demand for new roles will compensate for the decreasing demand for others (Lass & Gronau, 2020). Moreover, the greater productivity and competitiveness generated by technology will increase the demand of labour (Kadir and Broberg, 2020, Habanik et al., 2019). Thus, it is necessary to create an environment supporting education, requalification and know how sharing, so that the negative effects of digitalization are suppressed by the positive impacts. The resulting changes are estimated to affect both, the total performance of work systems, and the well-being of people who work in and interact with work systems (Kadir & Broberg, 2020). Governments, companies and educational institutions can enable the higher qualification of workers alongside with the expansion of internet and other technological and communication tools access. In addition to rapid and often uncertain advances in technology, there is a long-term and predictable trend of aging populations and labour force worldwide. Current trends in life extension, together with rapid technological innovation, will change significantly the way we will work in the future, posing challenges for governments, enterprises and individuals (Changing Demographics and Ageing Workforces — Future of Work Hub, 2022). The human development and digital adoption within the society can be achieved through a careful mix of market competition, public-private partnerships and effective regulation of the internet and telecommunications sector.(Grencikova et al., 2019)

5 Conclusion

The countries of Europe and Latin America regions prove significant differences in terms of human development and digital adoption. However, in both regions has been evidenced a strong positive correlation between HDI and CISCO, indicating that countries with higher HDI also prove higher CISCO and vice versa. In addition, Latin America region only has been reported the outliers. The correlation seems to be stronger on the Latin America, which prove less variability in the data, indicating less inequality. The stepwise regression has been used in the construction and verification of the regression model and it has been proved that in the selected regions the most important component influencing the HDI is the education of the population likewise the possibility of adapting new technological procedures.

The benefits of work for (not only) managerial practice are relevant to selected countries of the European Union and Latin America, especially for the management of multinational companies and government agencies. The results of the work point to the differences in the evaluation of countries for the fourth industrial revolution, and thus also to the readiness of individual countries for the ongoing changes.

A certain limitation of research can be seen in the scope and focus of both indices, especially their individual components. The absence of an analysis of the environment, which determines the components of both indices in individual countries, especially the challenges directly related to the Fourth Industrial Revolution and its effects on society and the economy, may also appear to be a limiting research. However, supplementing the analyses would significantly expand the limited scope of the article.

Continuation of research

Due to the research findings, authors state that income has been proven as an important influencing factor on digitalization in both regions. The further research focused on the relations of income can be beneficial to recognize the sphere of human development and digital adoption.

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Primary Paper Section: A

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