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SMART ECONOMIC DEVELOPMENT IN EUROPEAN COUNTRIES

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Abstract:

Industry 4.0 is a set of digital and physical technologies and cyber-physical systems that create new values at the macroeconomic and microeconomic levels. It is causing significant changes and developments in the industrial sector worldwide. This research aims to determine the impact of Industry 4.0 on socio-economic development by establishing the correlation between Industry 4.0 Index and the UNDP Human Development Index (HDI). Following the correlation analysis, country clusters will be formed based on the implementation of I4.0 and socio-economic development. There is a strong correlation between the implementation of Industry 4.0 and socio-economic development at the European level, while all countries can be placed within three significant clusters. This paper confirms the positive impact of Industry 4.0 on socio-economic development. It also provides institutional and business stakeholders with an objective incentive to implement the core I4.0 technologies faster.

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INTRODUCTION

Over the centuries, the world has gone through three major industrial revolutions and recently has entered the fourth one, widely known as Industry 4.0 (I4.0). Every industrial revolution has profoundly changed the world economy and social dynamics. However, the potential of Industry 4.0 to change the socio-economic landscape has been proven through the implementation of many disruptive technologies connecting people, machines, and objects (Müller *et al.*, 2018). These technologies are transforming business practices and aspects of human well-being through smart, informed, and sustainable solutions, leading to increased productivity, lower costs, and overall, a more sustainable economy and society (Author 1, 2020; Stock & Seliger, 2016; Stock *et al.*, 2018).

Cyber-physical systems and their integration into socio-economic systems define the present and future of economic development (Schwab, 2016; Lasi *et al.*, 2014). Due to this fact, most countries have adopted the strategic approach towards developing, implementing, and utilising I4.0 technologies to

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increase their competitiveness on the global scale and in the regional integration process (Soltovski *et al*., 2020; Zhou *et al*., 2015; Czifra & Molnar, 2020; Author 1, 2020). Even though Industry 4.0 has been accepted as the way forward, the operationalisation and evaluation of this process are yet to be clearly defined.

Many authors and companies have tried to establish a framework to evaluate the readiness for Industry 4.0 and provide guidelines for successful implementation of this concept (Vrchota & Pech, 2019; Lucato *et al*., 2019; Machado *et al*., 2019; PwC, 2020; BCG, 2020; Deloitte, 2020). However, most of the work was done at the micro level. The emphasis was mainly on the readiness evaluation based on the internal factors, enabling companies to estimate their position and following steps for successful integration of digital and physical systems. The macro-level approach was avoided due to the nature of I4.0 technologies and a lack of adequate aggregated data at the national and regional levels. On the other hand, Atik & Ünlü (2019) defined Industry 4.0 Index to evaluate the performance of European economies in the transition towards Industry 4.0 and made a step forward in the detailed empirical analysis of the effects of I4.0 on the overall socio-economic performance. However, the research and the empirical evidence at the macro level is still scarce.

This paper aims to improve understanding of the impact of I4.0 technologies at the national and regional level, putting particular emphasis on the effects on European countries. Relying on the Industry 4.0 Index, this paper will estimate the correlation between the implementation of Industry 4.0 and socio-economic development represented by the Human Development Index (HDI) (UNDP, 2021). Additionally, analysed countries will be divided into clusters to determine whether the strong performance in implementing I4.0 technologies coincides with high socio-economic standards and establish good benchmarks for the countries lagging behind.

LITERATURE REVIEW

Ever since it was formally named "Industry 4.0" in 2011 (Zhou *et al*., 2015), the Fourth Industrial Revolution has been a topic of interest for academics, businessmen, and policymakers. Within a decade, both theoretical and empirical research focused on Industry 4.0 provided frameworks, guidance, and models for faster and more effective implementation of I4.0 technologies.

Theoretical discussions and inquiries about the effects of the technological transformation of Industry 4.0 comprised the main body of research over the last decade (Schwab, 2016; Li *et al*., 2017; Soltovski *et al*., 2020; Author 1, 2020). However, in the last couple of years, the interest in the actual results of the implemented technologies has started a new wave of empirical research. The scope of the research has been narrowed down, focusing both on the industry and the wide spectre of effects on socio-economic development.

One significant endeavour in the academic and business community was to develop an adequate indicator for measuring the readiness for the implementation of I4.0 and its effects. With regard to establishing the readiness check framework, the business community was faster. Many international organisations and companies offer different evaluation models primarily oriented towards companies (PwC, 2015; BCG, 2020; Deloitte, 2020; Acatech, 2020).

On the other hand, the academic community was not hasty and took its time to establish statistical foundations before offering models and indicators for Industry 4.0 performance evaluation. In their attempts to develop guidelines for assessment, some authors took micro-perspective with a focus on a specific national economy (Zhou *et al*., 2015; Vasin *et al*., 2018). Multiple authors relied on a micro-level approach but did not constrain their research by national borders. Machado *et al.* (2019) narrowed the focus of their research down to seven companies, disregarding their country of origin and international presence. Lucato *et al.* (2019) developed a micro-oriented I4.0 readiness check model based on lean manufacturing practices. Vrchota & Pech (2019) designed the Industry 4.0 Index (VPi4) that companies can use for self-evaluation.

Even though the academic and business communities have moved forward in assessing the implementation and effects of Industry 4.0, there is still a lack of research on the impact at macro level. With the exception of Atik & Ünlü (2019), who designed the Industry 4.0 Index based on the ten indicators observed within 33 European countries, authors rarely take a birds-eye view on the overall socio-economic effects of I4.0. This research gap offers multiple research paths which can contribute to the understanding of this encompassing contemporary phenomenon.

METHODOLOGY

This paper aims to provide an insight into the effects of Industry 4.0 on the socio-economic development represented by the Human Development Index (HDI), measured by the Industry 4.0 Index (Atik & Ünlü, 2019),. For this purpose, the research relies on quantitative and qualitative approaches to analyse the secondary data collected from the UNDP Human Development Data Center and the research conducted by the Atik & Ünlü (2019).

Taking into consideration the lack of statistical data for the underlying 10 indicators within the last 10 years, we will rely on the derived Industry 4.0 Index data provided by the aforementioned authors. This index was built on the following indicators (Atik & Ünlü, 2019):

- Enterprises that have ERP software package
- Enterprises using Customer Relationship Management (CRM)
- Sharing supply chain management information
- Enterprises giving portable devices for a mobile connection to the internet
- Enterprises having received orders online
- Enterprises using software solutions like Customer Relationship Management (CRM)
- Enterprises that have ERP software package to share information between different functional areas
- Enterprises with broadband access
- Enterprises using the internet in communication with public institutions
- Enterprises using the Cloud Computing applications

Additionally, instead of analysing individual aspects of economic development, this paper focuses on widely accepted and encompassing Human Development Index (HDI). "HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living" (UNDP, 2021). Both indicators represent 2016 to preserve data and analysis reliability.

The two underlying hypotheses tested in this paper can be expressed as follows:

H1. There is a strong correlation between Industry 4.0 and socio-economic development.

H2. European countries can be grouped into major clusters based on the implementation of Industry 4.0 and economic development

Based on the selected indicators, the research in this paper is structured as follows:

1. Correlation analysis between selected indicators
2. Simple Linear Correlation for the pair of selected indicators
3. K-Means Cluster Analysis
4. Descriptive Statistics for Defined Clusters

The correlation analysis will provide information about potential correlation and the extent of the correlation between the implementation of Industry 4.0 and economic development. In this phase of research, selected indicators need to fulfil normality requirements. Since both indicators are measured on a scale from 0 to 1, there is no need for additional transformation of variables.

Depending on the results, we will perform a regression analysis subsequently to determine the model representing the connection between these two composite indexes. Firstly, we will be testing the assumptions needed for performing linear regression, including *linearity of data, normality of residuals, homoscedasticity, and independence of residuals error terms* (Freedman *et al*., 2003). Only if the assumptions are met will we perform linear regression.

Following these two analyses, K-means clustering will be performed for the data sample. Based on the results, countries will be divided into the most suitable number of clusters. Afterwards, we will apply descriptive statistics to each Cluster.

For the purposes of the analysis, we have used R Statistical Software (version 4.1.0) and R Studio (version 1.4.1717).

RESULTS

This section of the paper provides an overview of the collected data and statistical analysis, and it is broken down into four parts. The first segment introduces the results of the correlation analysis between the Industry 4.0 Index and HDI. The second segment presents the linear regression results, the third one shows the K-means clustering results, and the fourth will provide descriptive statistics for each Cluster.

Correlation Analysis

In order to determine whether the variables to be used for the correlation analysis follow a normal distribution the Shapiro-Wilk test was used (Shapiro & Wilk, 1965). Based on the Shapiro-Wilk test results presented in Table 1, both indicators have a p-value higher than the significance level of alpha (.05). We can conclude that both Industry 4.0 Index and HDI are suitable for the correlation analysis.

Table 1. The Shapiro-Wilk Test Result.

Variable	W	p-value
Industry 4.0 Index	.979	.7479
Human Development Index	.947	.1081

Source: Data analysis performed by the author using R

We have performed a Pearson correlation analysis between Industry 4.0 Index and HDI. We have used Cohen's standard to evaluate the correlation coefficient for determining the strength of the relationship. A weak association is represented by the absolute values of correlation coefficients between .10 and .29, coefficients between .30 and .49 represent a medium association, and a strong correlation is represented by the coefficients of .50 and above (Cohen *et al.*, 2014).

The correlation analysis shows a significant positive correlation between Industry 4.0 Index and HDI ($r_p = .7546$, $p < .001$). The correlation coefficient between the two variables was .7546, indicating a large effect size. This correlation indicates that as Industry 4.0 Index increases, HDI tends to increase. The correlation was examined on the basis of the significance level of alpha (.05), and the results are shown in Table 2.

Table 2. Pearson Correlation Results

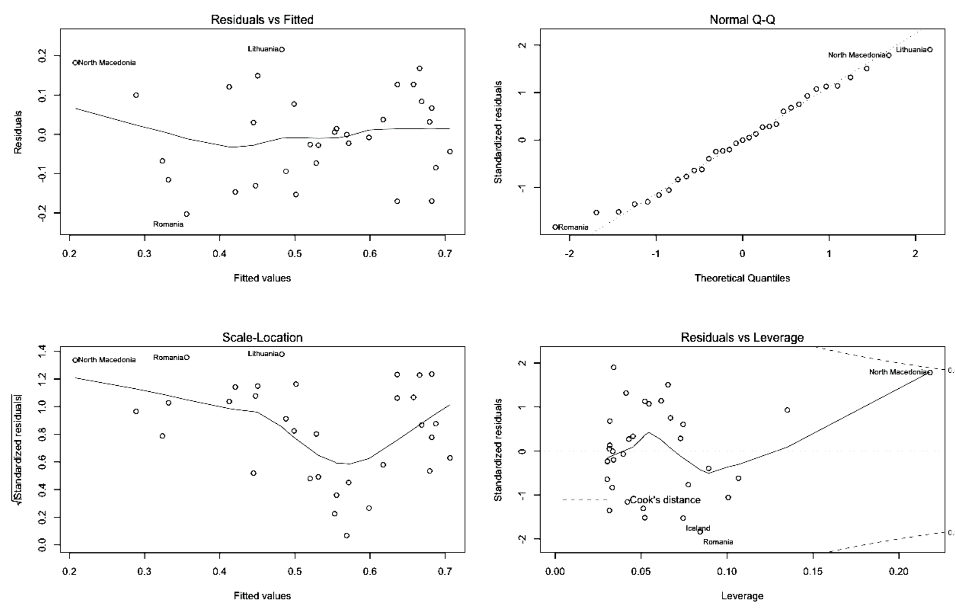
Variable 1	Variable 2	p-value	Correlation coefficient (rp)	Confidence interval	
				Lower	Upper
Industry 4.0 Index	HDI	3.924e-07	.7546	.5551	.8720

Source: Correlation analysis performed by the author using R

Regression Analysis

In order to perform a regression analysis, a simple linear regression model needs to meet the assumptions of *linearity of data, normality of residuals, homoscedasticity, and independence of residuals error terms* (Freedman *et al.*, 2003). Therefore, we have tested the data for these assumptions, and the results are shown in Figure 1.

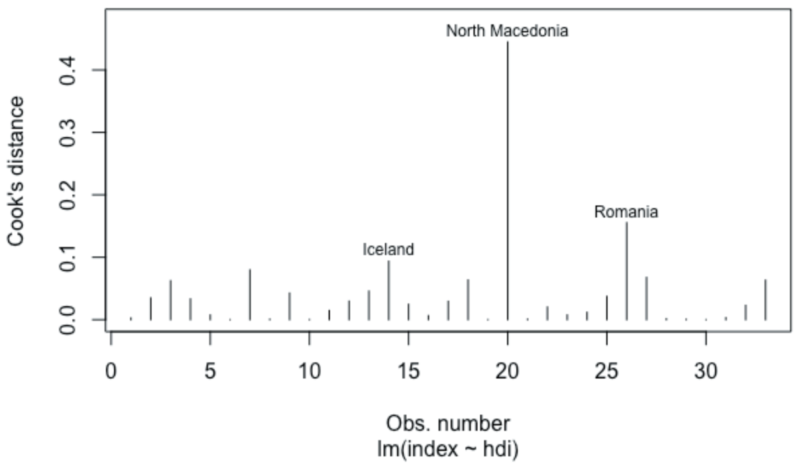
Figure 1. Assumptions for Linear Regression



Model HDI = $\beta_0 + \beta_1$*·(Industry 4.0 Index):* Considering the sample size, Figure 1 provides necessary information for testing the assumptions that Model 1 needs to meet.

- Residuals vs Fitted Plot shows no visible pattern. Therefore, we can assume the linear relationship between variables.
- Normal Q-Q Plot shows that residuals follow the straight line, meaning that we can assume normality.
- Scale-Location Plot shows that in Model 1 residual points are scattered relatively equally along the line. Thus, we can assume homoscedasticity.
- Residuals vs Leverage Plot shows that there are no observations with absolute values exceeding three standard deviations identified by Gareth *et al.* (2013) as possible outliers. Furthermore, according to Bruce & Bruce (2017), and based on the leverage statistic 2(p+1)/n, where p is the number of independent variables, and n indicates the number of observations taken into consideration, there are two possible leverage points with leverage statistic above .1212. These possible leverage points are North Macedonia and Romania (Figure 2). However, due to the nature of the research and composition of indicators, we can assume independence of residuals error terms.

Figure 2. Assessment of Leverage Points



Having concluded that the assumptions for a simple linear regression are met, the analysis was performed. The results are presented in Table 3.

Table 3. Simple Linear Regression (Industry 4.0 Index ~ HDI Model).

Independent Variable	Dependent Variable	β_0	β_1	Std. Error	R^2	P (t-test)	N
Industry 4.0 Index	HDI	-1.8554	2.6957	.4212	.5694	3.924e-07	33

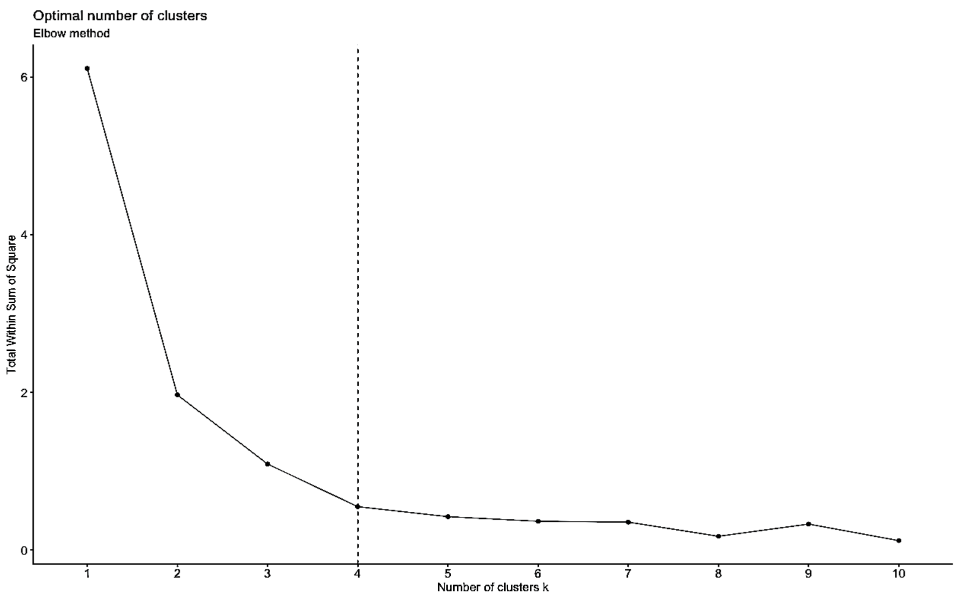
Source: Correlation analysis performed by the author using R

A simple linear regression was calculated to predict HDI based on Industry 4.0 Index. A significant regression equation was found ($F (1,31) = 40.99$, $p < .000$), with an R^2 of .5694. Predicted HDI is changing for -1.8554 + 2.6957 (Industry 4.0 Index) % when Industry 4.0 Index is measured in %. In other words, this model shows that a 0.01 change in Industry 4.0 Index will cause a .026957 change in HDI.

K-Means Clustering

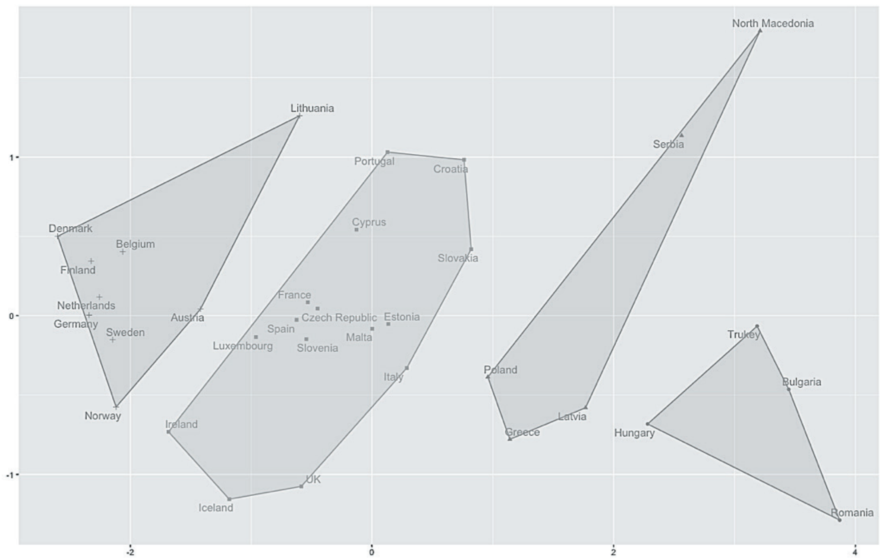
Clustering is a broad set of techniques for identifying subgroups of observations in a set. K-means clustering is one of the most commonly used clustering methods (Friedman, 2017). It aims at separating *n* observations into *k* clusters in which each observation belongs to the Cluster with the closest average, serving as a sample of the Cluster. Clustering will allow us to identify subgroups among European countries based on Industry 4.0 Index and HDI.

Figure 3. Optimal Number of Cluster - Elbow Method



The first step in K-means cluster analysis is identifying the number of clusters. The optimal number of clusters can be identified by using the Elbow method, and based on the analysis shown in Figure 3, the optimal number of clusters for the analysis in this paper is four.

Figure 4. Clusters



After running the K-Means algorithm through R, we have identified four groups of countries (Figure 4) that significantly differ in terms of the implementation of Industry 4.0 and slightly less pronounced differences in economic development.

Cluster 1. Bulgaria, Hungary, Romania, and Turkey

Cluster 2. Greece, Latvia, North Macedonia, Poland, and Serbia

Cluster 3. Croatia, Cyprus, Czech Republic, Estonia, France, Iceland, Ireland, Italy, Luxembourg, Malta, Portugal, Slovakia, Slovenia, Spain, and the UK

Cluster 4. Austria, Belgium, Denmark, Finland, Germany, Lithuania, Netherlands, Norway, and Sweden

Clusters – Descriptive Statistics

Considering that identified clusters vary in size and that they are relatively small for more complex analysis, only the basic descriptive statistical results will be presented in this part (Table 4).

Table 4. Clusters - Descriptive Statistics

Clusters	Industry 4.0 Index			HDI		
	Min	Mean	Max	Min	Mean	Max
Cluster 1	.1532	.2249	.2742	.8080	.8207	.8440
Cluster 2	.3168	.3674	.3938	.7650	.8314	.8740
Cluster 3	.4554	.5370	.6026	.8410	.8917	.9430
Cluster 4	.6552	.7346	.8340	.8670	.9269	.9500

Source: Correlation analysis performed by the author using R

Results presented in Table 4 show that in Cluster 1 the lowest implementation of I4.0 is recorded in Romania, while the highest level is recorded in Hungary. On the other hand, in terms of socio-economic development, Turkey ranks last, following closely behind Bulgaria, while Hungary holds the top spot in this regard.

Within Cluster 2 Latvia has the lowest Industry 4.0 Index, while Poland has the highest level of I4.0 implementation. We should note that the gap regarding the level of adoption of I4.0 is relatively narrow. In terms of development, North Macedonia ranks lowest, while Greece is leading the Cluster.

Cluster 3 shows a more significant gap between the countries in terms of the operationalisation of Industry 4.0. Ireland is leading the group, while Italy is lagging behind. It is important to note that this Cluster is structured from countries showing high levels of development on the HDI scale. Ireland is leading in this regard as well, while Croatia is lagging behind.

Powerful and highly industrialized countries comprise Cluster 4. Within this Cluster, the lowest level of the implementation of I4.0 technologies is recorded in Austria, while surprisingly, the highest level of adoption is not recorded in the origin country of Industry 4.0 (Germany), but Denmark. In terms of socio-economic development, with the exception of Lithuania, which has a slightly lower HDI, all other countries are amongst the most developed countries in the world.

DISCUSSION AND CONCLUSION

Through this research, we have aimed to prove a correlation between the implementation of I4.0 technologies into economies, measured by Industry 4.0 Index, and socio-economic development measured by HDI. Additionally, we have developed a linear model to assess the effects of Industry 4.0 implementation on the HDI and, based on the values of Industry 4.0 Index and HDI, have performed cluster analysis identifying four major country clusters.

Having analysed the current literature and available data sources regarding the implementation of Industry 4.0 and evaluation of the readiness and effects on the national economies, we have noticed a lack of comprehensive systems and models which can provide reliable and comprehensive estimates. The data for monitoring Industry 4.0 implementation is scarce and inconsistent, limiting the possible research to specific points in time instead of continual development (Zhou *et al.*, 2015; Stock *et al.*, 2018; Lucato *et al.*, 2019; Vrchota & Pech, 2019; Atik & Ünlü, 2019). On the other hand, socio-economic development data have a long track record, and are continually improved by introducing additional aspects relevant to human development (UNDP, 2021).

The available data indicate that European countries widely differ in terms of the implementation of Industry 4.0. Traditional innovators, Central and Western European, are leading the pack based on Industry 4.0 index, while Bulgaria, Hungary, Romania, and Turkey are lagging behind. However, the direct effect of Industry 4.0 on individual countries is questionable due to overlapping results within clusters. There are countries with intermediate Industry 4.0 Index with high HDI and vice versa. The results relating to individual countries are understandable, considering the fact that both indicators used are composite indexes.

Correlation analysis and simple linear regression conducted on the sample of 33 European countries showed a strong positive correlation between Industry 4.0 Index and HDI, which can be expressed by the following model $HDI = - 1.8554 + 2.6967\ (Industry\ 4.0\ Index)$. Based on these results, we can conclude that there is a strong positive correlation between Industry 4.0 and socio-economic development at the European level.

The subsequent K-means cluster analysis showed that it is possible to group countries based on the Industry 4.0 Index and HDI. We have identified four major clusters, which can be classified as Innovators and Early Adopters (Cluster 4), Early Majority (Cluster 3), Late Majority (Cluster 2), and Laggards (Cluster 4). Based on cluster analysis, we can conclude that fast implementation of Industry 4.0 might be significantly beneficial for countries with lower levels of socio-economic development, as opposed to the ones with higher levels of development, where the benefits are diffused due to the influence of other factors.

In short, we can conclude the following:

- Data and scientific framework regarding the implementation of Industry 4.0 and its effects on socio-economic development are lacking.
- There is a strong correlation between Industry 4.0 Index and HDI at the European level, although the same cannot be confirmed at the national level.
- For each 0.01 ratio change in Industry 4.0 Index, we can expect a 0.026967 change in the ratio of HDI.
- Countries can be grouped within four major clusters based on the levels of Industry 4.0 implementation and socio-economic development (Innovators and Early Adopters, Early Majority, Late Majority and Laggards).

The results of this paper are relevant for academic and business communities, as well as policymakers. From a scientific standpoint, this paper contributes to an attractive but shallowly researched area. The research has been primarily focused on the micro-level, while the macro-level orientation has been neglected. This paper aims to narrow the gap between these two levels of inquiry. Contribution to the business community can be seen through the indication of future development in the European area. Thus, business leaders can base their decisions on reliable and scientific data. Finally, perhaps the most significant contribution is to policymakers. This research is an inquiry into the impact of technologies on the overall development and provides relevant data for the development of future policies.

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REFERENCES

Atik, H., & Ünlü, F. (2019). The measurement of industry 4.0 performance through industry 4.0 index: an empirical investigation for Turkey and European countries. *Procedia Computer Science, 158*, 852-860. https://doi.org/10.1016/j.procs.2019.09.123

Boston Consulting Group. (2020). *Industry 4.0.* Retrieved August 19, 2021, from: https://www.bcg. com/capabilities/manufacturing/industry-4.0

Bruce, P., & Bruce, A. (2017). *Practical statistics for data scientists: 50 essential concepts.* Farnham, UK: "O'Reilly Media Inc.

Cohen, P., West, S. G., & Aiken, L. S. (2014). *Applied multiple regression/correlation analysis for the behavioral sciences*. New York, Psychology press. https://doi.org/10.4324/9781410606266

Czifra, G., & Molnár, Z. (2020). Covid-19 and industry 4.0. *Research Papers Faculty of Materials Science and Technology in Trnava, 28(46)*, 36-45. https://doi.org/10.2478/rput-2020-0005

Deloitte Development LLC. (2020). *Industry 4.0: At the intersection of readiness and responsibility*. Retrieved August 15, 2021, from: https://www2.deloitte.com/za/en/pages/about-deloitte/articles/ industry-4-0-readiness-report.html

Freedman, D., Pisani, R., & Purves, R. (2007). *Statistics (international student edition)*. Hoboken, USA: John Wiley & Sons Inc.

Gonçalves Machado, C., Winroth, M., Carlsson, D., Almström, P., Centerholt, V., & Hallin, M. (2019). Industry 4.0 readiness in manufacturing companies: challenges and enablers towards increased digitalisation. *Procedia Cirp, 81*, 1113-1118. https://doi.org/10.1016/j.procir.2019.03.262

Hastie, T., Tibshirani, R., & Friedman, J., (2017). *The elements of statistical learning: Data mining, inference, and prediction*. Cham: Springer Nature Switzerland AG. https://doi.org/10.1007/978-0-387-84858-7

Industry 4.0: Self Assessment. (2020). Berlin: PwC. Retrieved August 15, 2021, from: https://i40-self-assessment.pwc.de/i40/

James, G., Witten, D., Hastie, T., Tibshirani, R., (2013). *An introduction to statistical learning: with applications*. Cham: Springer Nature Switzerland AG. https://doi.org/10.1007/978-1-4614-7138-7

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & information systems engineering, 6(4)*, 239-242. https://doi.org/10.1007/s12599-014-0334-4

Li, G., Hou, Y., & Wu, A. (2017). Fourth Industrial Revolution: technological drivers, impacts and coping methods. *Chinese Geographical Science, 27(4)*, 626-637. https://doi.org/10.1007/s11769-017-0890-x

Lucato, W. C., Pacchini, A. P. T., Facchini, F., & Mummolo, G. (2019). Model to evaluate the Industry 4.0 readiness degree in Industrial Companies. *IFAC-PapersOnLine, 52(13)*, 1808-1813. https://doi.org/10.1016/j.ifacol.2019.11.464

Müller, J. M., Kiel, D., & Voigt, K. I. (2018). What drives the implementation of Industry 4.0? The role of opportunities and challenges in the context of sustainability. *Sustainability, 10(1)*, 247. https://doi.org/10.3390/su10010247

Popović, A., (2020). Implications of the Fourth Industrial Revolution on sustainable development. *Economics of Sustainable Development, 4(1)*, 45-60. DOI: 10.5937/ESD2001045P

Schuh, G., Anderl, R., Dumitrescu, R., Krüger, A., & Ten Hompel M., (2020). I*ndustrie 4.0 Maturity Index Managing the Digital Transformation of Companies*. Munich: ACATECH – National Academy of Science and Engineering. Retrieved August 29, 2021, from https://boundarysys.com/wp-content/uploads/2021/03/Acat-ech_Maturity_Index_2020-IAN.pdf

Schwab, K. (2016). *The Fourth Industrial Revolution*. Cologny, Switzerland: World Economic Forum.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika, 52(3–4)*, 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Soltovski, R., Rodrigues, T. V., De Resende, L. M. M., Pontes, J., & Tadashi Yoshino, R., (2020). Industry 4.0 risks: a theoretical framework from the perspectives of sustainability. *The Journal of Engineering and Exact Sciences, 6 (5)*, 0695-0703. https://doi.org/10.18540/jcecvl6iss5pp0695-0703

Stock, T., & Seliger, G. (2016). Opportunities of sustainable manufacturing in industry 4.0. *Procedia Cirp, 40*, 536-541. https://doi.org/10.1016/j.procir.2016.01.129

Stock, T., Obenaus, M., Kunz, S., & Kohl, H. (2018). Industry 4.0 as enabler for a sustainable development: A qualitative assessment of its ecological and social potential. *Process Safety and Environmental Protection, 118*, 254-267. https://doi.org/10.1016/j.psep.2018.06.026

Human Development Index. (2021). New York, USA: Human Development Data Center, United Nations Development Programme. Retrieved August 14, 2021, from: http://hdr.undp.org/en/data

Vasin, S., Gamidullaeva, L., Shkarupeta, E., Palatkin, I., & Vasina, T. (2018). Emerging Trends and Opportunities for Industry 4.0 Development in Russia. *European Research Studies Journal, 21(3)*, 63-76. Retrieved August 14, 2021, from: https://www.ersj.eu/dmdocuments/2018_XXI_3_5.pdf

Vrchota, J., & Pech, M. (2019). Readiness of enterprises in Czech Republic to implement industry 4.0: Index of industry 4.0. *Applied Sciences, 9(24)*, 5405. https://doi.org/10.3390/app9245405

Zhou, K., Liu, T., & Zhou, L. (2015). Industry 4.0: Towards future industrial opportunities and challenges. In Tang, Z., *et al*. (Eds.) *12th International Conference on fuzzy systems and knowledge discovery - FSKD* (pp. 2147-2152). Zhangjiajie, China: IEEE Circuits and Systems Society.

PAMETAN PRIVREDNI RAZVOJ U EVROPSKIM ZEMLJAMA

Rezime:
Industrija 4.0 je skup digitalnih i fizičkih tehnologija i sajber-fizičkih sistema koji stvaraju nove vrednosti na makroekonomskom i mikroekonomskom nivou. To izaziva značajne promene i razvoj u okviru industrijskog sektora širom sveta. Ovo istraživanje ima za cilj da utvrdi uticaj Industrije 4.0 na društveno-ekonomski razvoj uspostavljanjem korelacije između Indeksa industrije 4.0 i Indeksa humanog razvoja UNDP-a (HDI). Nakon analize korelacije, biće formirani klasteri zemalja prema njihovim rezultatima u implementaciji I4.0 i društveno-ekonomskom razvoju. Postoji jaka korelacija između implementacije Industrije 4.0 i društveno-ekonomskog razvoja na nivou evropskih zemalja, dok se sve zemlje mogu svrstati u tri značajna klastera. Ovaj rad potvrđuje pozitivan uticaj industrije 4.0 na društveno-ekonomski razvoj. Takođe pruža institucionalnim i poslovnim akterima objektivan podsticaj za bržu primenu osnovnih tehnologija I4.0.

Ključne reči:
Industrija 4.0,
Privredni razvoj,
Indeks Industrije 4.0,
Pametan razvoj,
Evropa.

Klasifikacija JEL:
O140, O330.