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Vector model of digital economy in the process of increasing the competitiveness of countries and regions

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Modelo vectorial de economía digital en proceso de incrementar la competitividad de países y regions
Modelo vetorial de economia digital em processo de aumento da competitividade de países e regiões

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The paper aimed to identify and assess the impact of the economy digitalization vectors that directly affect the competitiveness of countries and regions. Thus, to evaluate the level of digital competitiveness, the study graphically displayed competitiveness vectors in a three-dimensional space, using three axes (knowledge, technology, and future readiness) as integral indicators. For this, the analysis of variance was applied. The investigation was based on the materials for 63 countries, grouped by region. A comparison of their overall economy and digital competitiveness levels enabled the conclusion on these indicators' close correlation. The analysis of the central factors and trends in increasing digital competitiveness at the sub-regional level contributed to determining integral indicators.

El trabajo tuvo como objetivo identificar y evaluar el impacto de los vectores de digitalización de la economía que inciden directamente en la competitividad de países y regiones. Así, para evaluar el nivel de competitividad digital, el estudio mostró gráficamente los vectores de competitividad en un espacio tridimensional, utilizando tres ejes (conocimiento, tecnología y preparación futura) como indicadores integrales. Para ello se aplicó el análisis de varianza. La investigación se basó en los materiales de 63 países, agrupados por región. Una comparación de su economía general y los niveles de competitividad digital permitió llegar a una conclusión sobre la estrecha correlación de estos indicadores. El análisis de los factores centrales y tendencias en el aumento de la competitividad digital a nivel subregional contribuyó a determinar indicadores integrales.

O trabalho teve como objetivo identificar e avaliar o impacto dos vetores de digitalização da economia que afetam diretamente a competitividade de países e regiões. Assim, para avaliar o nível de competitividade digital, o estudo apresentou graficamente vetores de competitividade em um espaço tridimensional, utilizando três eixos (conhecimento, tecnologia e prontidão futura) como indicadores integrais. Para isso, foi aplicada a análise de variância. A investigação baseou-se em materiais de 63 países, agrupados por região. Uma comparação de sua economia geral e níveis de competitividade digital permitiu a conclusão sobre a estreita correlação desses indicadores. A análise dos fatores centrais e tendências no aumento da competitividade digital no nível sub-regional contribuiu para determinar indicadores integrais.

1. Introduction

Despite the widespread opinion on the benefits of digital transformation, in recent years, concern about the serious management challenges in the digital economy has sharply risen at the global level. These days, digitalization is deemed an integral component of the modern global economy and a characteristic of the country's development. Information and communication technologies (ICT) are being incorporated in almost all areas of economic activity, which results in the emergence of new forms of business, new professions, new markets, and new legal relations between the government and the entities (e.g., taxation in a digital economy).

Under the current background, highly digitalized countries can have significant competitive advantages compared to those nations whose investment in innovation is insufficient (Zhang, 2018). Considering the fact that digitalization is a complex process, its thorough study is of particular interest to the international scientific community. Due to the widespread adoption of digital solutions, innovative technologies are of fundamental importance in many spheres of social activity: from the production, sale, and consumption of digital goods and services to the creation of an interactive digital environment for social communication, the formation of digital culture, and the emergence of e-democracy. The relevance of this study stems from the need to identify a set of indicators that can be used in the country's digital profiling (this refers to the strength of the digital economy). In addition, it is aimed to expand the range of approaches to assessing the country's competitive advantages in the international market.

Antitrust policy in the digital economy should be based on a solid theoretical foundation and evidence-based analysis, best embodied in the "law and economics" approach. Notwithstanding many concerns to the contrary, digital markets are not prone to anti-competitive behavior, and the influence of economic theory and evidence offers little support for the anticipated risk of harm. Therefore, intervention in the competition should consider the harm uncertainty, the presence of compensatory benefits, and the difficulties of devising an effective remedy (Auer, Manne, Portuese, and Schrepel, 2018).

The rapid growth of online market sales and its industry concentration increase interest in competition law research (Colangelo and Torti, 2018; Mandrescu, 2018). The dominant role of a small number of very large digital companies (with their vast access to the new key data resources and their capabilities in data analytics and artificial intelligence) has triggered a new policy discussion. This discussion does not only ask whether antitrust authorities should apply the existing competition laws more aggressively for protecting competition and innovation. It also expresses concerns about whether current competition laws are still capable of dealing with the digital transformation challenges or whether significant reforms of competition policies are necessary (Kerber, 2019). The rise of e-commerce has been on antitrust authorities' agenda since they began mixing online and offline markets and setting a challenge to law enforcement officials in terms of assessing the competitive interaction between online and offline sales. Indeed, technological advances have led many retailers to establish hybrid distribution channels and offer their products and services both online and offline. However, such an amalgamation of online and offline markets has raised the issue of how to define the relevant product market

in such cases (Gurkaynak, Aktüre, and Çoşkunoğlu, 2019). The development of artificial intelligence networks creates new problems for competition law, directly related to the large data concentration and storage capabilities generated by artificial intelligence networks (Nihoul and Van Cleynenbreugel, 2018; Domazet, Zubović, and Lazić, 2018).

Investments in the digitalization of the economy give countries the opportunity to gain competitive advantages and thus improve their competitiveness and possibility to produce high-quality goods and services on demand in the current social, economic and political circumstances, thereby meeting internal and external demand (Miethlich, Belotserkovich, Abasova, Zatsarinnaya, and Veselitsky, 2020). At the same time, the digital economy's impact on the competitiveness of countries and regions has been studied insufficiently. Besides, the concept of a country's competitiveness itself is poorly investigated. This fact can be proved by the absence of consensus on the factors affecting it. For example, some researchers tend to associate competitiveness with economic efficiency (Reyes and Useche, 2019). Besides, it is often defined as a country's ability to provide its citizens with a high quality of life (Birnie, Johnston, Heery, and Ramsey, 2019), achieve a higher economic growth (Möbius and Althammer, 2020), and is referred to as a set of institutions, policies, and factors determining the nation's productivity level (Żmuda, 2020). Nevertheless, these definitions take into account neither the quality of goods and services produced in the country nor the country's ability to ensure that goods are produced in quantity enough to satisfy the internal and external demand. The present study intends to fill this gap and make a contribution to the identification of the relationship between the digital economy and the nations' competitiveness in the global market. Consequently, the research purpose is to identify and assess the impact of those vectors of the digital transformation of the economy, which directly affect the competitiveness of countries and regions. To achieve the goal set, the following hypotheses are formed:

H1. Digital development in the context of knowledge has a significant impact on the competitiveness of countries.

H2. Digital development in the context of technology has a significant impact on the competitiveness of countries.

H3. Digital development in the context of future readiness has a significant impact on the competitiveness of countries.

2. Materials and Methods

The research material was presented by ratings for 63 countries grouped according to the world region. Their choice was associated only with the availability of data on competitive indicators in open access. Thus, to compare digital and general competitiveness indicators, the study used data retrieved from the IMD World Digital Competitiveness Ranking (WDCR) and the Global Competitiveness Index 4.0 (GCI 4.0). The WDCR is compiled as a result of an overall analysis of economic performance. Its rankings are calculated according to 51 indicators, and the countries included are ordered from the most to the least digital competitive. It assesses the economy's performance over time for nine sub-factors composing

the three Digital Competitiveness Factors (knowledge, technology, and future readiness) (International Institute for Management Development, 2020). GCI 4.0 was used in this study for the reason that it combines traditional factors of competitiveness with new emerging ones critical for productivity in the Fourth Industrial Revolution (4IR). This indicator implies a holistic approach that makes better use of new technologies to improve countries' welfare and well-being. The factors GCI 4.0 evaluates collectively determine the level of a country's productivity. They are organized into 12 pillars and are grouped into four categories: human capital, innovation, resilience, and agility (World Economic Forum, 2020).

In order to determine the level of digital competitiveness of a country or region, the study drew upon a graphical method of results' presentation. Thus, the tendencies observed were described in the form of a vector in a three-dimensional space, using three axes as integral indicators in such areas as knowledge, technology, and future readiness. Therefore, if the country or region seeks to increase its competitiveness, it is to increase the length of the vector and, correspondingly, its level of knowledge, technologies, and future readiness for digital innovations. Using the proposed methodological approach, one can determine in which direction a given country or region has competitive advantages or weaknesses. With the aim of assessing these strong and weak sides, the study evaluated the length of the digital competitiveness vector according to the following formula:

$$\overline{VL_i^c} = \sqrt{(KI_i^c)^2 + (TI_i^c)^2 + (FRI_i^c)^2} \qquad (1)$$

where VL_i^c – is the digital competitiveness vector of the i-country;
KI_i^c – is the level (index) of digital knowledge development in the i-country;
TI_i^c – is the level (index) of digital technology development in the i-country;
FRI_i^c – is the level (index) of future readiness for digitalization in the i-country.

This formula allows one to accurately evaluate the competitive advantages of a particular country/region and, as a consequence, compare them with each other. The longer the digital competitiveness vector $\overline{VL_i^c}$, the more competitive the country or region is at the moment.

Accordingly, when assessing the possible digital development impact on the competitiveness, changes in three indicators, and the vector length were calculated as follows:

$$\overline{VL_{icons}^c} = \sqrt{(KI_i^c + \Delta KI_i^c)^2 + (TI_i^c + \Delta TI_i^c)^2 + (FRI_i^c + \Delta FRI_i^c)^2} \qquad (2)$$

where ΔKI_i^c – is the change in the level (index) of digital knowledge development in the i-country;
ΔTI_i^c – is the change in the level (index) of digital technology development in the i-country;
ΔFRI_i^c – is the change in the level (index) of future readiness for digitalization in the i-country.
When predicting the level of competitiveness of countries or regions, the efficiency criterion will be represented by the maximum value of the digital competitiveness vector, that is, max $\overline{VL_{icons}^c}$.

This methodological approach was proposed to assess digital competitiveness or its effectiveness for a country or region. It is seen as a tool for shaping a political strategy and supporting the decision-making on the economy digitalization aimed at taking leadership positions in the global competitiveness rankings.

The study used analysis of variance (ANOVA) to determine the relationship between the components of digitalization and competitiveness. In this case, the Global Competitiveness Index was used as the dependent variable y, independent variable x_1 was for knowledge, x_2 – for technology, and x_3 – for future

readiness. The initial data are given in **Table 1**.

Table 1 – Initial data for analysis of variance

Country	Global Competitiveness Index	Knowledge	Technology	Future readiness
Austria	0.70	0.84	0.49	0.63
Belgium	0.57	0.63	0.67	0.60
Cyprus	0.35	0.13	0.06	0.37
Denmark	0.87	0.90	0.83	0.97
Finland	0.76	0.86	0.87	0.89
France	0.51	0.68	0.75	0.54
Germany	0.73	0.81	0.51	0.75
Greece	0.08	0.16	0.14	0.16
Iceland	0.68	0.54	0.68	0.59
Ireland	0.89	0.62	0.56	0.92
Italy	0.30	0.35	0.27	0.51
Luxembourg	0.81	0.46	0.81	0.73
Netherlands	0.90	0.79	0.90	0.95
Norway	0.83	0.75	0.95	0.87
Portugal	0.38	0.51	0.40	0.46
Spain	0.43	0.56	0.54	0.57
Sweden	0.86	0.94	0.89	0.90
Switzerland	0.94	0.97	0.84	0.84
United Kingdom	0.63	0.78	0.71	0.79
Bulgaria	0.24	0.27	0.33	0.24
Czech Republic	0.48	0.41	0.46	0.38
Estonia	0.44	0.52	0.65	0.52
Croatia	0.05	0.33	0.21	0.05
Hungary	0.25	0.30	0.43	0.10
Latvia	0.37	0.43	0.63	0.29
Lithuania	0.54	0.59	0.60	0.49
Poland	0.40	0.48	0.41	0.48
Romania	0.22	0.25	0.29	0.19
Slovak Republic	0.16	0.24	0.30	0.25
Slovenia	0.41	0.57	0.44	0.43
Ukraine	0.14	0.37	0.03	0.02
Israel	0.62	0.87	0.52	0.70
Jordan	0.10	0.22	0.16	0.17
Qatar	0.84	0.29	0.48	0.65
Saudi Arabia	0.59	0.38	0.37	0.40

South Africa	0.11	0.14	0.19	0.30
Turkey	0.19	0.05	0.24	0.35
UAE	0.92	0.44	0.97	0.86
China	0.78	0.71	0.59	0.67
Hong Kong SAR	0.97	0.89	0.94	0.76
Japan	0.52	0.60	0.62	0.62
Kazakhstan	0.46	0.49	0.38	0.44
Korea Rep.	0.56	0.83	0.73	0.94
Mongolia	0.02	0.02	0.02	0.03
Russia	0.29	0.65	0.32	0.33
Taiwan. China	0.75	0.73	0.86	0.81
Australia	0.71	0.76	0.78	0.78
India	0.32	0.40	0.22	0.27
Indonesia	0.49	0.11	0.25	0.08
Malaysia	0.65	0.70	0.70	0.56
New Zealand	0.67	0.67	0.76	0.68
Philippines	0.27	0.19	0.13	0.14
Singapore	0.98	0.95	0.98	0.83
Thailand	0.60	0.32	0.57	0.21
Argentina	0.03	0.08	0.11	0.11
Brazil	0.06	0.06	0.10	0.32
Canada	0.79	0.92	0.79	0.71
Chile	0.33	0.21	0.35	0.41
Colombia	0.17	0.10	0.05	0.13
Mexico	0.21	0.17	0.17	0.22
Peru	0.13	0.03	0.08	0.06
USA	0.95	0.98	0.92	0.98
Venezuela	0.00	0.00	0.00	0.00

Source: developed by the authors based on data retrieved from (International Institute for Management Development, 2020; World Economic Forum, 2020).

3. Results

Each country has its strengths and weaknesses in terms of competitiveness, which, as a rule, have mostly resulted from the peculiarities of its economic structure or development process. Besides, the nation's position in the global competitiveness rankings may change for the better or worse despite

its successful development as it depends on other states' economic performance. Therefore, a higher ranking position cannot surely mean an increase in competitiveness if other economies' results have also improved. In a similar way, a decline in competitiveness may happen – depending on the results obtained by other economies, the country's ranking in relation to others may or may not drop. This fact has become a prerequisite for comparing the nations' economic and digital competitiveness (**Figure 1**).
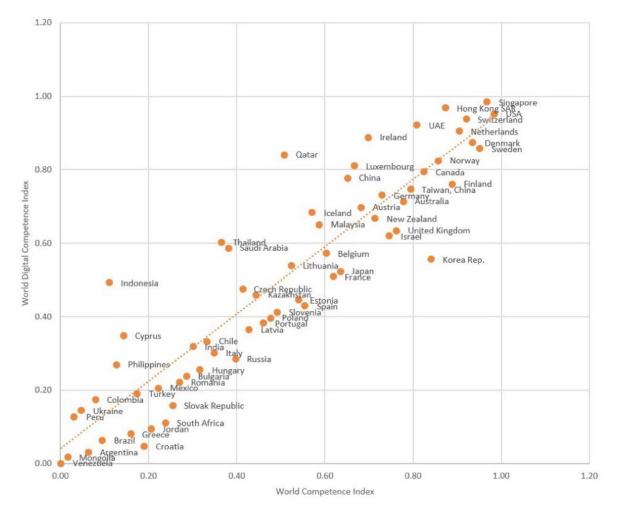
Figure 1 – Competitiveness indicators of countries reviewed

Source: developed by the authors

Highly ranked economies in terms of their overall competitiveness usually also place high in the digital ranking. Notwithstanding this, for many countries, these rankings' positions differ. In particular, the US, Canada, Sweden, Norway, Denmark are placed better in the digital ranking than in overall competitiveness. This fact confirms that now the digital economy remains an indispensable part of the state's competitiveness in the global arena. Therefore, nations whose digital competitiveness significantly exceeds the economic competitiveness indicator (South Korea, Russia, South Africa, and Croatia) have a good chance to increase the latter significantly.

In 2019, the United States (US) topped the WDCR, with the other five economies unchanged: US, Singapore, Sweden, Denmark, and Switzerland. These countries share a common thread in terms of their focus on knowledge generation, but they each approach digital competitiveness differently. The US and Sweden follow a balanced strategy paying equal attention to knowledge generation, the creation of a supportive environment for technology development, and future readiness for innovations. Singapore, Denmark, and Switzerland prioritize one or two factors. Among the Asian economies, only several have shown striking results: the Republic of Korea, Hong Kong SAR, and China, and Taiwan. All these countries have made considerable progress in their technological infrastructure and business agility. India and Indonesia have significantly advanced their positions in terms of talent development and training and education, as well as improved technological infrastructure.

The next step of the investigation is a review of the main facts and trends in digital competitiveness at sub-regional and country levels (**Figures 2-4**).
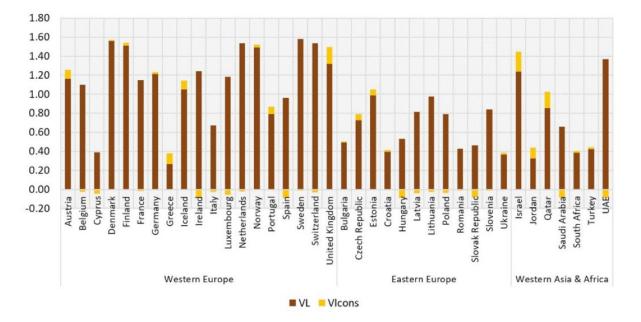
Figure 2 – Integrated Digital Competitiveness Index: Europe, the Middle East, Africa

Source: developed by the authors

Sweden ranks third in overall competitiveness rating, with good results for knowledge, technology, and future readiness. Its highest rank at the sub-factor level is for personnel training and education, while the lowest – for business agility. In the meantime, it also demonstrates good results in terms of the scientific and regulatory framework. Denmark shows high performance in knowledge, technology, and readiness for the future at the factor level. Its highest scores among the sub-factors are in adaptive attitude and information technology (IT) integration, though it also performed well in talent and training and education. The Netherlands scores the best in future readiness, thereby ranking among the top ten in IT integration, business agility, and adaptive attitudes. As for Finland, its best performance at the sub-factor level is in IT integration and adaptive attitudes, while the lowest – in business agility. Norway's strength is in the technology sub-factor, and the weakness is similar to Finland's – business agility. France is

among the top ten leaders in education and training, R&D, and the use of robots in industry. Its strengths stem from a favorable regulatory environment (regulatory framework sub-factor) and a focus on R&D (scientific concentration sub-factor). As for Germany, despite a significant drop in the country leaders' perceptions about companies' flexibility and adaptability to changing market conditions, it has strengthened its position in scientific concentration, training, and education, as well as in the adoption of digital technologies by its citizens (adaptive attitudes sub-factor). Ireland has experienced significant improvements in e-government performance, as well as its leadership's positive perceptions of aspects related to legislation that supports innovation and talent, and capital availability. Since 2018, Ireland's R&D, as well as average internet bandwidth speed and wireless broadband penetration, have decreased. Austria has experienced a decline in the technological framework sub-factor, especially in the export of high-tech goods. Its business agility is influenced by adverse leaders' perceptions of how well enterprises are managing opportunities, threats, and the use of big data and analytics. The digital competitiveness of the United Kingdom (UK) has been impacted by negative perceptions about access to relevant talent, in particular the country's attractiveness for overseas highly-skilled workers, managers with international experience, and digital or technological skills. Furthermore, the UK's business agility and IT integration also declined.

In Estonia, some indicators associated with education and technological infrastructure (for instance, internet bandwidth) show quite positive results. However, this progress is leveled by negative country leaders' perceptions concerning support from relevant regulators and declining indicators of e-participation and e-government. In the Slovak Republic, improvements are observed across all three factors, especially in terms of future readiness due to positive developments in the online services' adoption and application (e-government and e-participation). The drop in Croatia's performance is predominantly provoked by a decrease in the regulatory framework, especially with regard to the process of business setting up. Moreover, when the country has faced a drop in e-participation and IT integration, its adaptive attitude also decreased, especially in terms of e-government.

Israel holds the position of a central regional player in digital competitiveness. Even though its business agility and e-government performance have decreased, Israel leads in talent development (training and education sub-factor) and R&D intensity (scientific concentration). The progress of the United Arab Emirates (UAE) is driven by improvements in the training and education sub-factor, as well as in some aspects of the regulatory framework (business setting up and scientific legislation effectiveness). The development of IT integration has occurred mainly in the wake of e-government improvement. Advancements in Saudi Arabia's performance have resulted from increasing positive perception of the business community as concerns regulatory support for technology adoption and the availability of capital for investment. In turn, the country's R&D intensity and e-government performance showed the opposite trend.

The improvement in Kazakhstan's performance is connected with progress in several sub-factors: training and education, regulatory framework, adaptive attitudes, and business agility. The increase in Russia's digital competitiveness is driven by an improvement of future readiness for innovations, scientific concentration, and training and education. At the same time, the talent sub-factor of the Russian Federation has experienced a significant decrease (**Figure 3**).
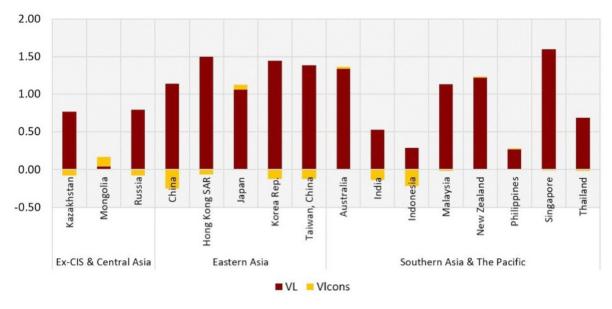
Figure 3 – Integrated Digital Competitiveness Index: Asia-Pacific region

Source: developed by the authors

Singapore holds the top regional place in technology, knowledge, and future readiness, performing best in talent and technological framework sub-factors. Besides, the country has shown high results in the field of training and education, as well as IT integration. Thailand has improved its knowledge and technology performance, thereby experiencing a drop in future readiness and indicators related to public investments in education, business agility, and big data and analytics utilization. India's high performance is especially noted for the talent, training and education, and e-participation sub-factors. Indonesia has made significant progress mainly thanks to its technologies (technology factor) and improvement in the country leaders' perceptions about the regulatory framework's effectiveness and capital availability for technology development.

The US leads the digital ranking but also has the lowest training and education results (**Figure 4**). The highest US performance at the sub-factor level is in future readiness. Nevertheless, the country is strong in adaptive attitudes, business agility, and IT integration, as well. The decline in Canada's performance is mainly due to the country's leadership's perceptions about the availability of the relevant talent and regulatory framework effectiveness. Its performance is negatively impacted by the prioritization of employee training and issues associated with the technological framework (for instance, the export of high-tech goods). Mexico shows the highest rates both in terms of R&D and in operative robots in the industry. Though, a number of indicators related to the education quality (shares of students and teachers in higher educational institutions), technological infrastructure, and country leaders' perceptions about business agility indicate a notable decline compared to last year.
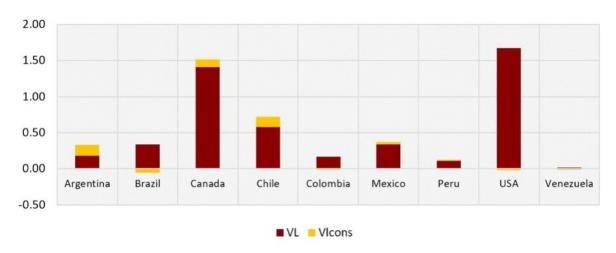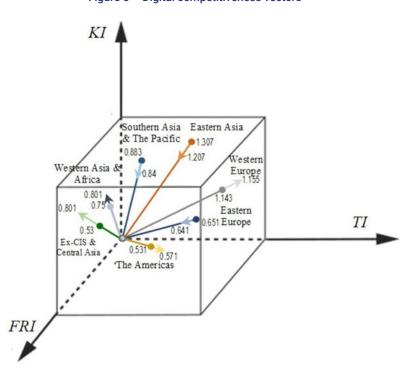
Figure 4 – Integrated Digital Competitiveness Index: North and South America

Source: developed by the authors

Chile's drop in digital competitiveness ranking is influenced by negative executives' perceptions about supportive regulation of innovations, business agility, employee training, as well as talent and capital availability. Colombia is the only South American country under study to show advancement in digital competitiveness. Its progress is provoked by the increased business confidence in the talent and capital availability and improved technological performance (enhanced number of mobile broadband subscribers). As for Brazil, its indicators related to education and R&D (knowledge factor) and technology adoption (adaptive attitude sub-factor) also showed improvements. Peru has seen significant advancements in technology absorption by citizens (adaptive attitudes) and in education (public expenditures on education and the proportion of individuals in science who graduated from higher educational establishments have increased).

Based on the digital competitiveness analysis, it is possible to assess this indicator by determining the length of the digital competitiveness vector in 2019 and compare it with data available for the previous period (Figure 5). The key indicators for determining the level of the world regions' competitiveness in the context of the digital economy are represented by the averaged indicators for countries included in those regions according to the criteria of knowledge (KI), technology (TI), and future readiness (FRI).

Figure 5 – Digital competitiveness vectors

Source: developed by the authors

The length of the digital competitiveness vector for East Asia, despite its reduction in 2019, exceeds the length of the vectors for the rest of the regions under consideration. At the same time, calculations performed allow the conclusion that Western Europe tends to increase its competitiveness in the digital context. However, today Western Europe's vector length is approximately the same as that of leading East Asia. The largest increase in the competitiveness vector length is observed in the region comprising the countries of the Ex-CIS and Central Asia (26%). At the same time, there is a notable drop in competitiveness for the Asia-Pacific region, as well as for East Asia and Eastern Europe. Despite the Americas' top position in digital competitiveness, this region has the shortest vector. Although the small rise observed for their economies stems from the high rankings of Argentina, Canada, and Chile, while the increase in the vector length for West Asia is based on the strong competitive positions of Israel and Qatar.

In order to determine the degree of dependence between competitiveness and digitalization, an analysis of variance was carried out. For this, the Global Competitiveness Index was used as a dependent variable, while knowledge (x_1), technology (x_2) and future readiness (x_3) were used as independent variables. The results of this analysis are presented in **Table 2**.

Table 2 – Analysis of variance (with allowance for three independent variables)

Indicator	df	SS	MS	F	Significance F			
Regression	3	4.4882	1.4961	117.5988	0.0000			
Residual	59	0.7506	0.0127					
Total	62	5.2388						
Indicator	Coefficient	St. error	t-Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Y-intercept	0.0207	0.0291	0.7119	0.4793	-0.0375	0.0790	-0.0375	0.0790
x_1	0.0504	0.1047	0.4816	0.6318	-0.1591	0.2600	-0.1591	0.2600
x_2	0.4609	0.1138	4.0483	0.0002	0.2331	0.6887	0.2331	0.6887
x_3	0.4465	0.1147	3.8948	0.0003	0.2171	0.6760	0.2171	0.6760

Source: developed by the authors.

Based on the results obtained, one can argue about an insignificant correlation between the dependent variable y (competitiveness level) and the independent variable x_1 (knowledge) since the P-value>0.05. Therefore, to form a real regression model, it is necessary to exclude this factor (**Table 3**).

Table 3 – Analysis of variance (with allowance for two independent variables)

Indicator	df	SS	MS	F	Significance F			
Regression	2	4.4853	2.2426	178.5679	0.0000			
Residual	60	0.7535	0.0126					
Total	62	5.2388						
Indicator	Coefficient	St. error	t-Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Y-intercept	0.0230	0.0286	0.8037	0.42473	-0.0342	0.0801	-0.0342	0.0801
x_2	0.4834	0.1032	4.6858	0.00002	0.2770	0.6897	0.2770	0.6897
x_3	0.4700	0.1032	4.5559	0.00003	0.2636	0.6763	0.2636	0.6763

Source: developed by the authors.

Data above indicate that the key components of digitalization that affect the level of competitiveness are technology and future readiness (P-value <0.05). Given that the knowledge factor failed to have a significant impact on competitiveness, one can insist on the rejection of hypothesis H1 and acceptance of hypotheses H2 and H3. In view of this, the regression equation has the following form:

$$y = 0.4834 \, x_2 + 0.47 \, x_3.$$

The model formed is adequate since R^2 = 0.86, which confirms the high degree of impact of the considered factors on countries' competitiveness. Apart from this, F_{crit} = 3.15, so $F_{crit} < F$ and F_{tabl} = 2, which also designates the applicability of the proposed model. Hence, it can be declared that countries with a high level of digitalization (in the context of the development of technology and future readiness) are more competitive.

4. Discussion

Together with other works in the field, the present study acts as a model for the development of scientific and methodological support. It allows assessing the digital competitiveness of a region and enables the assessment completeness and high accuracy and objectivity to obtain systematic and reliable results (Abdulkadyrov, Zhigulina, and Samokhvalova, 2020). The proposed vector model for assessing the level of digital competitiveness makes it possible to determine the key directions for the economy's digitalization and compare the results obtained (Miethlich et al., 2020). This vector model demonstrates that the current economic transformations in Western European countries strengthen their digital competitiveness. Based on the formation of a modern IT infrastructure, the states of Western Europe have raised the productivity of their citizens, gained access to new markets, and entered a phase of long-term economic development (Weresa, 2019). IT, services rendered, and systems created are of great importance for social development. Their use can contribute to economic growth and the creation of new jobs in all sectors of the market and in a variety of companies: from the most traditional to the most advanced ones (Negrea, Ciobanu, Dobrea, and Burcea, 2019; Shvydanenko, Sica, and Busarieva, 2019).

For countries experiencing a drop in digital competitiveness, improvement of the state investment strategy in terms of digital development is especially relevant. However, this strategy must meet the modern challenges of the global network society. Its elaboration should cover much more issues than just ICT development. Given this, it is necessary to create a favorable political, economic, and institutional environment for the development of technologies that will be able to maximize the benefits from the transition to digital solutions. Consequently, a solid foundation should be laid for digital technologies to benefit everyone and everywhere (Diaconu, 2019). To achieve the best digital revolution outcomes, countries with a reduced competitiveness vector need to strengthen regulations that ensure competition among businesses, adapt workers' skills to the demands of the new economy, and ensure that institutions are accountable (Al Hoderi, 2019).

In the meantime, it should be borne in mind that the formation of competitive advantages depends on the specific features and development pace of the individual economy. A country's competitive position does not necessarily depend on its own evolution. It is constantly affected by the performance of other economies. Therefore, the rise in competitiveness may not be reflected in a country's higher position if other states have also demonstrated improved results (Sepashvili, 2020).

Testing the proposed methodological approach on the example of 63 countries from different regions of the world showed significant quantitative and qualitative differences. In the course of their systematic analysis, it was possible to identify the most objective, comprehensive, clear, and reliable results, according to which the highest level of competitiveness in the digital economy is characteristic of East Asia and Western Europe. Based on the intermediary assessment results, the strengths and weaknesses of all regions can be identified, as well as highly effective strategies for ensuring the country's competitiveness in the digital economy can be developed and implemented (Haddad and Binder, 2019). The proposed methodological approach allows one to track the changes in the country's digital competitiveness potential and compare various economies both at the regional and global levels. The digital economy vector model enables a more detailed investigation of specific aspects of digital transformation, which can be used to make judgments on a country's technological base or justify international investment decisions (Götz, 2020).

Whereas the overall economy's competitiveness evaluation can be based on data on the level of education, healthcare, quality of life, and other indicators relevant statistical information for which is constantly available and sufficiently reliable, the assessment of digital competitiveness is more complicated. It requires more data that are usually limited in access or volume (Mueller and Grindal, 2019). Therefore, this study can be supplemented with additional qualitative indicators to ensure a comprehensive scientific and methodological support for assessing competitiveness in the digital economy of both an individual country and a whole region (Negrea et al., 2019).

5. Conclusion

The comparison of the economy and digital competitiveness levels across 63 countries made it possible to determine the close relationship between these indicators. It was noted that in the USA, Canada, Sweden, Norway, and Denmark, the level of digital competitiveness considerably exceeds that of other countries. This fact indicates that these five states give the utmost importance to the digital economy while shaping their competitiveness at the global level, and other economies can use this case as a good example of how to raise their overall competitiveness.

The highest scores for the digital competitiveness index were identified for the US, Singapore, Sweden, Denmark, and Switzerland. They share a common direction in focusing on knowledge generation, but each approach digital competitiveness in a different way. For Hong Kong SAR, the Republic of Korea, and China, and Taiwan, the strongest points were technological infrastructure and business agility. India and Indonesia improved their positions by positive results in talent, training, and education.

The analysis of the main factors and trends in increasing digital competitiveness at the sub-regional level contributed to the determination of integral indicators of digital competitiveness of the studied countries, grouped by region. Thus, it was revealed that Western Europe is characterized by the comprehensive development of the digital economies of countries. Among the nations of West Asia and Africa, Israel was a key regional player in terms of digital competitiveness. Despite the fact that its business agility and e-government performance declined, the country topped the ranking in talent development and R&D intensity. The progress of the UAE's resulted from its high performance in training and education and some aspects of the regulatory framework such as business start-up and the scientific legislation effectiveness. In Central Asia, improvements in Kazakhstan's digital competitiveness arose from progress in learning and education, regulatory framework, adaptive attitudes, and business agility. The increase in Russia's digital competitiveness was due to its readiness for future development, scientific concentration, and training and education. Among the countries of South Asia and the Pacific region, Singapore secured a top place in the technology factor technology, knowledge, and future readiness. Indonesia made significant progress mainly driven by its highly developed technologies (technology factor) and improved executives' perceptions about the regulatory framework's effectiveness and capital availability for technology development.

Despite the leading position of the US in digital competitiveness among the countries of the Americas, it was characterized by the lowest results in digital training and education. Mexico was on the first spot

of the regional ranking in both the number of operative robots in the industry and R&D. Colombia was the only South American country with enhanced digital competitiveness compared to the previous year. This may stem from improved business confidence in the talent and capital availability and increased technological performance.

Based on the results obtained after preliminary analysis, digital competitiveness was assessed by determining the length of the digital competitiveness vector. Thus, in East Asia, its length exceeded those of other regions under study. A tendency to increase in digital competitiveness was also noted for Western Europe – the region gradually coming up to East Asia's indicator. The largest rise in the length of the digital competitiveness vector was observed among the nations of Ex-CIS and Central Asia (Russia, Kazakhstan, and Mongolia). Notwithstanding the Americas' top position in digital competitiveness, this region showed the shortest vector. Its slight improvement is most likely associated with the high rankings of Argentina, Canada, and Chile, while the enhanced length of West Asia's vector resulted from the high competitiveness of Israel and Qatar. As for the Asia-Pacific region, as well as East Asia and Europe, their countries experienced a notable decrease in digital competitiveness.

The analysis of variance allowed determining a very strong relationship between the technological advancement, future readiness, and competitiveness of countries under study. Accordingly, it was proved that countries developed in the context of digitalization are more competitive.

This research was limited only to the consideration of 63 countries as individual actors in the digital arena. In parallel, it should be borne in mind that many of them function in the form of associations or put common efforts to enhance digitalization at the regional level. Therefore, future research in this field can be focused on the effectiveness of digital policy and regulatory steps of the nations under consideration, as well as on the impact of the states' autonomy or collaboration in the context of digital competitiveness.

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