doi: 10.36689/uhk/hed/2023-01-050

Interrelations between Digital Development and IT & Hi-Tech, R&D sectors, Labor Market in EU Countries

Tetiana POLOZOVA[1], Irina KOLUPAIEVA[2]* and Iryna SHEIKO[1]

[1] Kharkiv National University of Radio Electronics, Kharkiv, Ukraine; tetiana.polozova@nure.ua; irina.sheiko@nure.ua

[2] Linkoping University, Linkoping, Sweden, irina.kolupaieva@liu.se

* Corresponding author: irina.kolupaieva@liu.se

Abstract: The paper presents a methodical approach to analyzing the interrelations of the digital development indicators and the indicators of IT & Hi-tech and R&D sectors as well as the labor market. The authors of the article have conducted analyses of the interrelations of the digital indicators and the indicators of IT & Hi-tech, R&D sectors as well as the labor market. Based on canonical correlation analysis, the results of the research have proved the existence of a stable correlation between the indicators of each pair. The regional peculiarities of EU countries of the relations between the analyzed groups of indicators for the period 2016-2020 were singled out; namely most of Eastern European countries were placed below the average European level while Scandinavia and Northern Europe belonged to the group of leading countries. The results of the interrelations between digitalization indicators and indicators of the IT & Hi-tech, R&D sectors as well as the labor market made it possible to draw conclusions regarding the choice of directions for digital government policy.

Keywords: digitalization; IT sector; research and development; labor market indexes; canonical correlation analysis; EU countries

JEL Classification: J24; O14; 032

1. Introduction

Digitization and transformation of business processes is essential for any company that wants to grow and succeed in a rapidly digitalizing business environment. At the same time, automation can lead to significant changes in the structure of the labor market. Many leading companies use digital solutions and artificial intelligence to increase productivity and to optimize the production process. According to PricewaterhouseCoopers (Rao & Verweij, 2017), artificial intelligence is becoming a major trend in the global market. The level of GDP will increase threefold (+14%) by 2030 due to implementation of artificial intelligence. The development of digital technologies, such as IoT, mobile or Internet technologies promote the further progress in the IT & Hi-tech sector. In consideration of the foregoing, it becomes obvious that digital transformation needs to be managed. Effective digitalization management is possible on the basis of a thorough analysis of the interrelations of digitalization with the main indicators of the R&D, IT & Hi-tech sectors, as well as labor market.

2. Theoretical Part

Numerous scientific papers, as well as regulatory documents, recommendations of national and international agencies are devoted to the development of digital technologies.

A number of programs for the development of digital technologies have been implemented at the European Union level. For instance, Digital Europe program (Regulation (EU), 2021) is focused on building the strategic digital potential of the EU and promoting the wide deployment of digital technologies. Special attention is paid to the development of the science and innovation sector and digital technologies as a basis for ensuring competitiveness at the global level and strategic autonomy of the EU (European Commission, 2020). A significant number of scientific papers are devoted to the analysis of digital indicators. Kotarba et al. (2017) analyzed the indicators used to measure digitization activities at the level of the economy to society, industry, enterprise, as well as customers. The authors conducted the detailed comparative analysis between the indicators' metrics and their components.

The basic indicator for determining the level of digital development in EU countries is the integrated indicator of DESI. Data of the report (European Commission, 2021) show that the IT sector has higher labor productivity and the IT sector grew faster during 2006-2018. Labor productivity in the IT sector in the EU is at a high level, but lower than in USA. Therefore, such important sectors as R&D, as well as the sector of information technology and high-tech production should become a priority while their analysis and correlation with digitalization requires further research.

Many authors conduct a comparative analysis of EU countries regarding their progress in the direction of digitalization, using different methodological approaches. Becker et al. (2018) conducted a study of the use of ICT technologies in the countries of Central Europe on the basis of a multi-criteria ANP-based analysis.

A number of works focuses the digital impact on sustainability. The authors (Jovanović et al., 2018) investigated how EU digital indicators affect the main components of sustainable development: economic, social and environmental, based on correlation analysis. While Polozova et al. (2022) pointed out that according to the radical technological changes the approach to the assessment of investment attractiveness require a significant transformation.

Kergroach (2017) explored the impact of digital technologies on the labor market and concluded that ensuring the adaptability and efficiency of the labor market is a necessary prerequisite for social stability and security.

Studying the impact of digital technologies on the poverty level of the population in EU countries Kwilinski, Vyshnevskyi, and Dzwigol (2020) found that in most cases countries with a higher level of digitalization showed a more significant reduction in the level of poverty and social isolation.

During their analysis of the digitization level of the economy and society, the authors (Zaharia et al., 2020) conducted a cluster analysis of EU countries considering the DESI index, as well as the level of education and life satisfaction of the population. Based on the results of the analysis, the authors presented the EU countries according to the relevant clusters. This approach makes it possible to determine the tools of state regulation to ensure the functioning of the single digital market. Cluster approach was also used in the research (Polozova et al., 2021) to analyze the impact of digital technologies on the level of competitiveness of the countries.

The authors in the research (Vrabcova & Urbancova, 2022) analyze the activities of organizations in the context of human resource management. Authors proved that the greatest effectiveness of cooperation between all age categories of employees consists in improving the motivation and productivity of employees (67%).

The authors (Georgescu et al., 2022) evaluated the relationship between the economic growth and digitalization in the EU-27 countries through a canonical correlation analysis, and concluded that digitalization provides 70.33% of economic growth, but also resource productivity depends on a high level of digitization. Therefore, it is necessary to investigate the degree of interrelations between indicators of digitalization and indicators of labor market development in more detail.

An analysis of scientific research and the general trends of digitalization made it possible to determine the insufficiency of the research on the relations between digitalization, the IT & Hi-tech sector, the R&D sector, and labor market.

The purpose of the research is to explore the nature of the interrelations between the digital development and the R&D, IT sectors as well as labor market.

2. Methodology

The approach applied in the conducted analysis is presented in Figure 1.

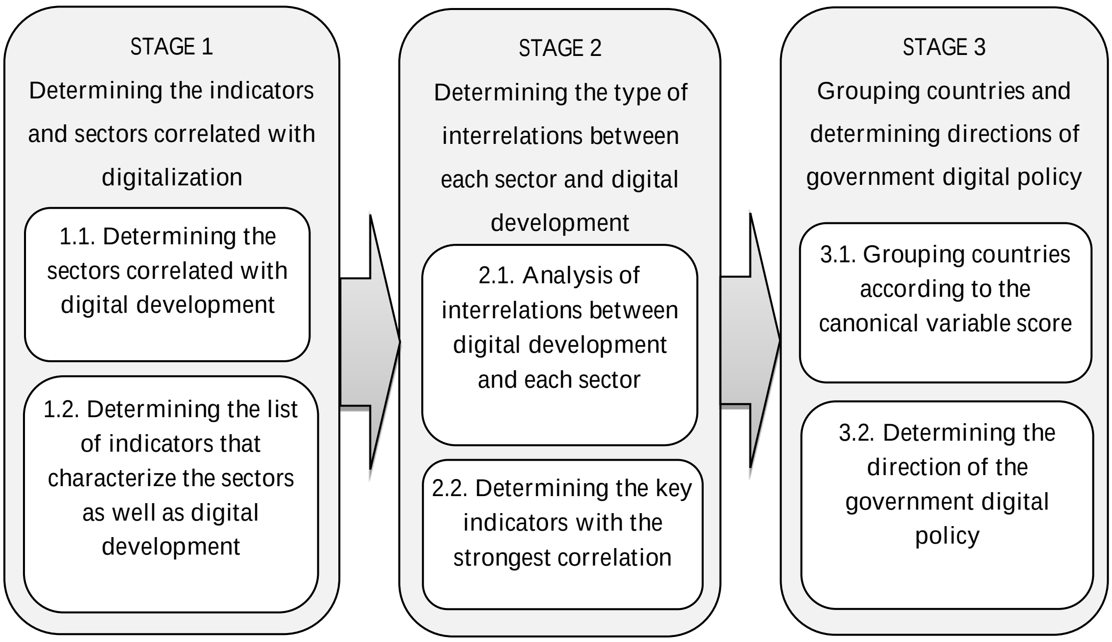


Figure 1. Scheme of the methodical approach to analyzing the interrelations between the digital development and IT & Hi-tech, R&D sectors, and labor market

To conduct the research, the data was grouped in 4 categories: digital development indicators; indicators of R&D sector; indicators of IT & Hi-tech sector; and labor market development indicators. The detailed compositions for each group of indicators as well as descriptive statistics are presented in Table 1.

Table 1. Variables used and their descriptive statistics

Group	Name	Description	Valid cases	Mean	Min	Max	STD
Indicators of digital development	HSIC	High speed Internet coverage, % of households	140	45.3057	0.0000	100.000	26.9719
	FBC	Share of households, that have fixed broadband connection	140	74.5071	55.0000	98.000	10.1425
	IntUs	Internet users, percentage of population	140	85.0214	62.0000	99.000	8.2326
	Mobsub	Mobile subscribers per 100 inhabitants	140	122.6571	99.0000	153.000	12.3666
	DSbasic	Percentage of individuals with basic or above basic overall digital skills	140	55.6571	26.0000	86.000	12.8560
	Ecom	Value of E-commerce sales, percentage of turnover	140	16.7786	4.0000	44.000	7.9640
Indicators of R&D sector development	GERD	Gross domestic expenditure on R&D, % of GDP	140	1.6596	0.4400	3.490	0.8748
	lnBERD	Business enterprise expenditure on R&D, Euro per inhabitant	140	5.3417	2.6174	7.069	1.1745
	HRST	Share of scientists and engineers in labor force, %	140	7.3914	3.2000	12.300	1.9956
	JobMob	Job-to-job mobility in R&D sector, % of labor force	135	6.8407	1.4000	11.600	2.3966
Indicators of IT & Hi-tech sector	ITGDP%	Share of IT sector in GDP, %	112	4.8094	1.9600	13.400	1.9927
	HTExp	Exports of high technology products as a % of total exports	140	12.2250	4.0000	42.500	7.0445
	ITstaff	Employed ICT specialists, in % of total employment	140	4.0579	1.8000	7.600	1.2546
	ITvacant	Job vacancy rate for Information and Communication sector	135	2.5393	0.3000	6.600	1.4967
Indicators of labor market	Indicators	Total unemployment rate, percentage of active population 15-74 years	140	7.2400	2.0000	23.600	3.7750
	Lcost	The total hourly labor costs, Euro	140	103.3764	89.1000	127.300	5.7460
	Lprod	Real Labor productivity per person, index 2015 = 100	140	22.2164	4.5000	45.300	12.0833
	Gen_pg	Gender pay gap, in % of average gross hourly earnings of male paid employees	140	13.0479	0.7000	24.900	5.4723

The research was conducted on the data of EU countries for 5 years (2016-2020). Due to the large root mean square deviation of the values of the real indicator BERD (R&D sector) modification was made, and the natural logarithm was taken. The same approach is used by Heidy (2020), Park (2019). There are no values for the indicator of the share of the IT & Hi-tech sector in GDP (ITGDP%) in 2020. The values of individual indicators are also missing for two countries: the IT vacant indicator is not available for France, and the JobMob indicator is missing for Ireland. According to that, the smaller sample of determined indicators is taken.

Canonical Correlation Analysis (CCA) used to analyze the correlation between two sets of data was chosen for the research. Thus, to fulfill the research objectives, it is necessary to perform the CCA procedure three times to analyze the correlation of digital development indicators with each of the three sectors separately. When comparing CCA with the principal component method (PCA), the choice has made in favor of the first method: while PCA focuses on finding linear combinations that account for the greatest variance in one data set, CCA focuses on finding linear combinations that account for the greatest correlation in two data sets. It corresponds to the intended purpose (Härdle & Simar, 2015).

Data sources were Eurostat. The calculations were made using the Statistica software.

3. Results

To use CCA, it is necessary to follow the rules of a close to normal distribution of variables in the general population, a sufficient length of the sample, and the absence of significant outliers among the population of analyzed values. Statistica uses the Kolmogorov-Smirnov Test to determine the closeness to a normal distribution.

Stevens (2009) recommends that there be at least 20 times more cases than variables in the analysis to obtain reliable estimates of canonical factor loadings. The number of indicators in the largest sample is 6 (Table 1), and the sample length exceeds 6 × 20 = 120 cases, which corresponds to the condition of sufficient sample length.

When analyzing indicators of two groups, CCA creates canonical roots (variates) with each as a linear combination of indicators included in the analyzed groups that have the highest possible correlation. If two groups with different numbers of indicators are compared, the number of roots (variates) is equal to the smaller number (Andrew et al., 2013; Fan, 1996). In presented research, the number of canonical roots is equal to 4 for three pairs of indicators: Digital + R&D, Digital + IT & Hi-tech, Digital + labor market. As with PCA, the first root is the most significant.

According to the results of the calculations, it was found that the overall canonical R is quite significant (> 0.85) and very significant ($p < 0.0001$). Canonical R, indicated in the first line of each section in Table 2, refers to the first and most important canonical root (variate). This value can be interpreted as a simple correlation between the weighted sums of the scores in each set with the weights belonging to the first (and most significant) canonical root. Significance is checked by Chi2 test and p-value test. According to the data presented in Table 2, the results of the first two most important roots (variates) are significant.

CCA of the digital sector with the three investigated groups (sectors) of indicators determined that the significant correlation with the first root (variate) has following digital indicators (Table 3):

- in the R&D sector: DSbasic (negative correlation), IntUs (negative correlation), FBC (negative correlation), Ecom (negative correlation);
- in the IT & Hi-tech sector: DSbasic, IntUs, Ecom (for all: positive correlation);
- in the labor market: IntUs, DSbasic, Ecom, FBC (for all: positive correlation).

According to the canonical weighting coefficients in the analysis of relations with R&D and IT & Hi-tech, the only significant indicator is, however, the share of the population with a basic or higher than basic level of digital skills. The rest of indicators of digital development

Table 2. Common canonical correlation coefficient and test of significance of estimates

Root removes	Canonical R	Canonical R^2	Chi^2	Df	p	Lambda Prime
Digital development and R&D sector						
0	0.853043	0.727682	267.8262	24	0.000000	0.124400
1	0.658012	0.432979	100.6751	15	0.000000	0.456821
2	0.422688	0.178665	27.7695	8	0.000522	0.805651
3	0.138186	0.019095	2.4775	3	0.479386	0.980905
Digital development and IT&Hi-tech sector						
0	0.869702	0.756382	217.4879	24	0.000000	0.117333
1	0.685472	0.469872	74.1544	15	0.000000	0.481627
2	0.243963	0.059518	9.7389	8	0.283877	0.908510
3	0.184379	0.033996	3.5106	3	0.319412	0.966004
Digital development and Labor market						
0	0.859821	0.739293	232.7531	24	0.000000	0.174913
1	0.473332	0.224044	53.2815	15	0.000004	0.670915
2	0.326298	0.106470	19.4181	8	0.012796	0.864630
3	0.179844	0.032344	4.3893	3	0.222406	0.967656

Table 3. Factor loadings and canonical weights of digital development indicators with the 1st root

Relation with	Root 1 structure	Variables of digital development					
		HSIC	FBC	IntUs	DSbasic	Mobsub	Ecom
R&D	Factor loading	-0.018	-0.66	-0.901	-0.959	-0.144	-0.624
	Canonical weight	0.105	-0.138	-0.292	-0.565	-0.023	-0.163
IT & Hi-tech	Factor loading	0.011	0.531	0.929	0.937	0.137	0.638
	Canonical weight	-0.051	-0.078	0.357	0.558	0.050	0.283
Labor market	Factor loading	-0.052	0.529	0.923	0.889	0.017	0.591
	Canonical weight	-0.244	-0.089	0.721	0.359	-0.107	0.088

with a significant level of correlation (IntUs, Ecom, and FBC) have low weighting coefficients. When analyzing the correlation with the labor market, there are two significant and weighty indicators: the level of digital skills, as well as the share of Internet users. The rest of indicators with a high factor loading (Factor loading) but a low weight coefficient (FBC, Ecom) do not take a significant part in influencing the indicators of the group to which they are compared. Two indicators of digital development, HSIS and Mobsub, have a low canonical correlation coefficient and a low weight coefficient: they determine the second, third and fourth canonical variables (roots).

Table 4 indicates the factor loadings and weighting coefficients for three sectors of indicators when conducting the CCA procedure between them and indicators of digital development.

The results of the calculations of factor loadings and canonical weighting coefficients (Table 4) demonstrated that the following indicators are most correlated with the first root (variate):

- in the group of R&D sector indicators: lnBERD GERD, HRST (for all: negative correlation);
- in the group of IT sector indicators: ITstaff, ITvacant (for both: positive correlation);
- in the group of labor market indicators: only Lcost (positive correlation).

Table 4. Factor loadings and canonical weights of 3 groups of variables with the 1st root

R&D sector			IT & Hi-tech sector			Labor market		
Variable	Factor Loading	Weight	Variable	Factor Loading	Weight	Variable	Factor Loading	Weight
GERD	-0.808	0.181	ITGDP%	0.208	-0.323	Unempl	-0.269	-0.182
lnBERD	-0.942	-0.893	HTExp	0.391	0.275	Lprod	0.003	-0.006
HRST	-0.786	-0.138	ITstaff	0.936	0.842	Lcost	0.917	0.932
JobMob	-0.670	-0.294	ITvacant%	0.794	0.216	Gen_pg	0.286	0.337

However, only lnBERD (R&D sector group), ITstaff (IT & Hi-tech sector group) and Lcost (labor market group) have a high factor loading and weighting factor. The rest of indicators for groups with a low factor load and a small weighting coefficient determine the 2nd, 3rd and 4th canonical variables (roots).

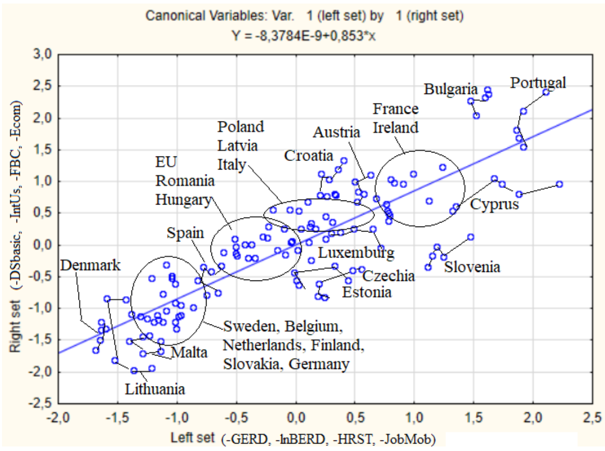
A correlation analysis between three pairs of sectors of indicators made it possible to assess the dynamics of the development of the indicators of the four analyzed sectors, as well as to identify the leading countries and backside ones.

Thus, the combination of indicators of digital and scientific development revealed a negative correlation of both groups of indicators with the first canonical variable, but the canonical correlation between the indicators of the two sectors is positive (Fig. 2a). Thus, the countries that lead in the digital and R&D development are located in the lower left corner (negative values of the canonical variables) (Denmark, Lithuania, Malta) and the backside ones are placed in the upper right corner (positive values of the canonical variables) (Portugal, Bulgaria).

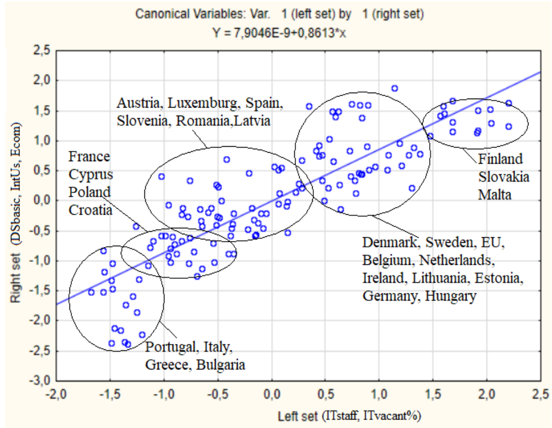
Analyzing the correlations between the indicators of digital development and the IT&Hi-tech sector, a positive correlation of both groups of indicators with the first canonical variable and between the two sectors of indicators was revealed.

The dependence graph of digital IT & Hi-Tech development indicates the greatest density of data, which makes it impossible to build individual development trajectories for individual countries. The leaders among the EU countries were Finland, Slovakia and Malta, the opposite edge was occupied by a group of Eastern and Southern European countries: Portugal, Italy, Bulgaria, and Greece.

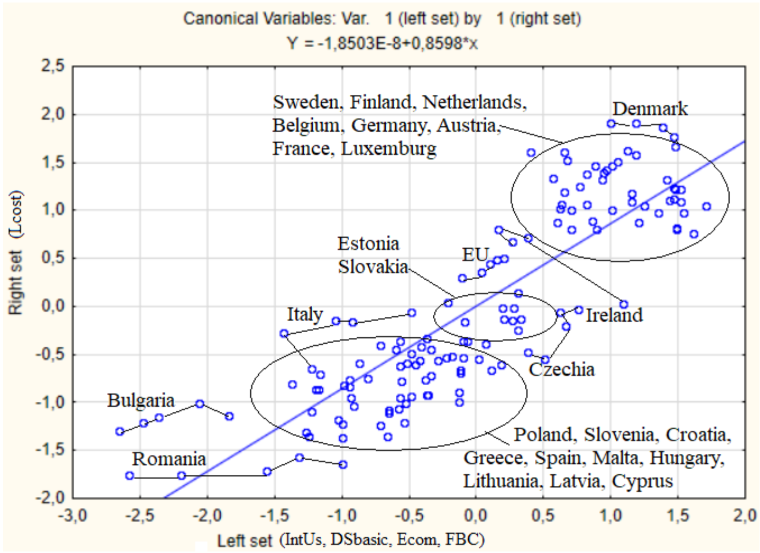
According to the results of CCA (Fig. 2c), the higher level of digital development is associated with an increase in personnel costs (Lcost); so that more qualified personnel with a sufficient level of digital skills require higher compensation. The leader among indicators of digital development and the level of personnel costs is Denmark, at a slight distance from it are 8 countries: Austria, Finland, France, Germany, Belgium, Luxembourg, the Netherlands, Sweden. A separate position is occupied by Italy and Ireland which have a higher wage rate than countries with a similar level of digital development. Portugal, Poland, Greece, Croatia, Bulgaria, and Romania have indicators of both digital development and wages at a level significantly lower than the average European parameters. However, during the analyzed period, Bulgaria and Romania significantly improved their indicators of digital development but leaving the Lcost wage indicator almost unchanged.



a) Digital development and R&D sector



b) Digital development and IT & Hi-tech sector



c) Digital development and Labor market

Figure 2. Scatterplot of canonical correlations for 3 pairs of CCA: digital + R&D (a), Digital + IT & Hi-tech (b), Digital + labor market (c) on the base of 1st root for left and right set

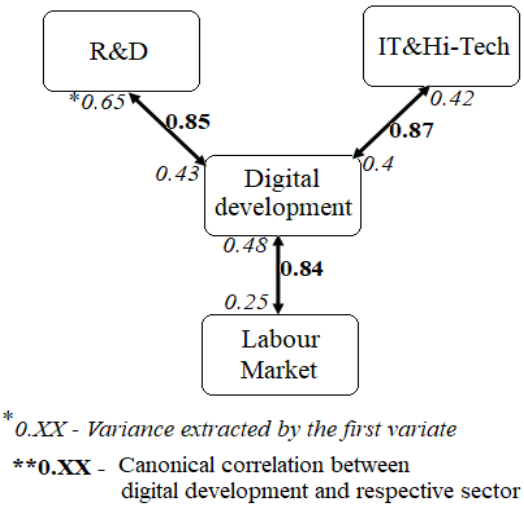


Figure 3. Summary of canonical correlations and variance extracted

4. Discussion

The final data of the interrelations between digital development indicators and the three analyzed sectors of indicators are presented in Figure 3.

Besides the canonical correlation (which is indicated in the center of each arrow), the indicator of the share of the variation of the variables has significant information, that has explained by the first variate. Thus, the first R&D variate explains 65% of the variation of the four indicators included in the group. Accordingly, the first variate of the IT & Hi-tech sector determines 42% of the variation of the group's indicators, and the first variate of the labor market finds out only 25% of the variation of the indicators. In turn, when analyzed with the indicators of the three analyzed sectors, the first variate of digital development finds out 40-50% of the variation of the input indicators by sector.

In the paper (Gavkalova et al., 2017) authors proved, that the cumulative impact of policy leverages and instruments create conditions for the environment in which the government must take measures in order to ensure effective implementation of its regulatory policy based on the integrated index of socio-economic development. Such approach could be taken into account. Concerning the CCA of investigated indicators, the results allow developing directions of government regulatory policy.

The data in Table 3 determined that among the indicators of digital development, the most significant are the number of Internet users and the level of individuals of digital skills. Therefore, the government digital policy should be aimed at supporting education in the IT field. In order to attract a larger number of users, the focus of government policy should lay on expanding the access network and the quality of Internet services.

The only significant indicator among the indicators of the labor market sector is the level of wages, which is positively correlated with digital development. Therefore, companies need to pay attention when planning the costs of paying staff with new digital skills. Other indicators of the labor market sector have weak connection with digitalization. For instance, the correlation index for the level of unemployment has a value of -0.269, which means that digitization has weak interrelation with unemployment. Unemployment is a complex phenomenon and digitization affects the labor market indirectly.

The results of the calculations (Table 4) did not reveal a stable relationship between digitalization indicators and the level of labor productivity, which may indicate that digitalization is a more socially significant phenomenon.

As for the R&D sector, all indicators are strongly correlated with digitalization indicators, which should be taken into account when developing a government digital strategy. The most important indicator in the R&D group is the indicator of business enterprise expenditure on R&D. This means that increasing funding for digitalization should become a priority for business. Government support of research funding is also important in order to ensure the competitiveness of business and the national economy as a whole. There is experience of Sweden (Statistics Sweden, 2021), which pays significant attention to the R&D sector. In Sweden, important research has strong support through funding programs both public and private initiatives. These are such foundations as Vinnova, Swedish Research

Council, Swedish Agency for Innovation Systems, Formas, Forte, Knut and Alice Wallenberg Foundation and others. Such policy allows Sweden to take a leading position in terms of digital and socio-economic development indicators and at the same time ensure the competitiveness of the national economy at the international level.

5. Conclusions

As a result of the study, the approach to analyzing the interrelations of the digital development indicators and the indicators of IT & Hi-tech, R&D sectors as well as the labor market was developed based on the method of canonical correlation analysis. The results of the research have proved the existence of a stable correlation between indicators of digital development and indicators of three sectors: R&D sector, IT high-tech sectors, as well as labor market. Canonical correlation of indicators of digital development with indicators of each of three sectors exceeds 0.8. Correlation analysis between three pairs of sectors of indicators made it possible to identify the leading countries and propose directions of government digital policy.

The indicators of digital development that mostly correlate with the indicators of each sector were identified. Thus, the indicators of the digital skills level, the share of Internet users and the share of e-commerce in the turnover are involved in the formation of the first variate compared with the indicators of all three analyzed groups. The indicator of the share of users with a fixed broadband FBC connection is involved in two of the three comparisons (with indicators of each sector). However, the two indicators of High-speed Internet coverage (HSIC) and Mobile subscribers (Mobsub) are weakly related to the first variate.

The regional peculiarities of EU-countries were explored based on correlation between investigated indicators in the period of 2016 to 2020. Thus, the countries of Scandinavia region and Northern Europe belong to the group of leading countries when compared with each of the three analyzed sectors, but in each comparison, there are countries joining them. For instance, in the canonical analysis of indicators of digital development and R&D sector, Estonia and Malta joined the leading countries; in the canonical analysis of indicators of digital development and IT & Hi-tech sector, Slovakia and Malta joined the leading countries. Most of the countries of Eastern Europe have indicators correlation for the analyzed groups below the average European level.

The proposed approach enables to conduct effective government digital policy as well as to choose necessary policy instruments on the basis of the current digital development of the country as well as taking into account correlations between other sectors of the economy. The proper use of government regulatory policy instruments determines further effectiveness of the steps taken.

The prospects for further research in this area are the study of factors influencing the government digital policy taking into account internal and external environment as well as hybrid treats. Further research will focus on developing a cognitive model of factors that influence the government digital policy and applying it as a basis for the development of impact scenarios.

Acknowledgments: This paper is an outcome of (i) research "Project Ukraine-EU: Digital Innovations making connections 4 changes" 101047751 — EUDI4C (Erasmus Jean Monnet) of the National University of Radio Electronics, Ukraine; (ii) research grant funded by All European Academies (ALLEA), Linkoping University of Sweden.

Conflict of interest: none

References

Andrew, G., Arora, R., Bilmes, J., & Livescu, K. (2013). Deep Canonical Correlation Analysis. *Proceedings of Machine Learning Research, 28*(3), 1247–1255.

Androniceanu, A. M., Georgescu, I., Tvaronavičiene, M., & Androniceanu, A. (2020). Canonical correlation analysis and a new composite index on digitalization and labor force in the context of the Industrial Revolution 4.0. *Sustainability*, *12*(17), 6812. https://doi.org/10.3390/su12176812

Becker, J., Becker, A., Sulikowski, P., & Zdziebko, T. (2018). ANP-based analysis of ICT usage in Central European enterprises. *Procedia Computer Science*, *126*, 2173–2183. https://doi.org/10.1016/j.procs.2018.07.231

European Commission. (2021*) Digital economy and society index 2021. The EU ICT Sector and its R&D Performance.* https://digital-strategy.ec.europa.eu/en/policies/desi-rd-ict

European Commission, & Directorate-General for Research and Innovation. (2020). *Science, research and innovation performance of the EU, 2020: 11 recommendations for a fair, green and digital Europe*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/520136

Eurostat. (2022). *Key figures on Europe*. Publications Office of the European Union. https://doi.org/10.2785/851035

Fan, X. (1996). Canonical correlation analysis as a general analytic model. In B. Thompson (Ed.), *Advances in social science methodology* (Vol. 4, pp. 71–94). JAI.

Gavkalova, N., Kolupaieva, I., & Barka, Z. M. (2017). Analysis of the efficiency of levers in the context of implementation of the state regulatory policy. *Economic Annals-XXI, 165*(5–6), 41–46. https://doi.org/10.21003/ea.V165-09

Georgescu, I., Androniceanu, A. M., Kinnunen, J., & Dragulanescu, I. V. (2021). Correlative approach to digitalization and economic growth. *Proceedings of the International Conference on Business Excellence*, *15*(1), 44–57. https://doi.org/10.2478/picbe-2021-0006

Härdle, W. K., & Simar, L. (2015). *Applied Multivariate Statistical Analysis* (4th ed.). Springer, Berlin, Heidelberg.

Heidi, A. (2022). Digital transformation, development and productivity in developing countries: is artificial intelligence a curse or a blessing? *Review of Economics and Political Science*, *7*(4), 238–256. https://doi.org/10.1108/REPS-11-2019-0145

Jovanović, M., Dlačić, J., & Okanović, M. (2018). Digitalization and society's sustainable development – measures and implications. *Zbornik radova Ekonomskog fakulteta u Rijeci*, *36*(2), 905–928. https://doi.org/10.18045/zbefri.2018.2.905

Kergroach, S. (2017). Industry 4.0: new challenges and opportunities for the labour market. *Foresight and STI Governance*, *11*(4), 6–8. https://doi.org/10.17323/2500-2597.2017.4.6.8

Kotarba, M. (2017). Measuring digitalization: key metrics. *Foundations of Management*, *9*(1), 123–138. https://doi.org/10.1515/fman-2017-0010

Kwilinski, A., Vyshnevskyi, O., & Dzwigol, H. (2020). Digitalization of the EU economies and people at risk of poverty or social exclusion. *Journal of Risk and Financial Management*, *13*(7), 142. https://doi.org/10.3390/jrfm13070142

Małkowska, A., Urbaniec, M., & Kosała, M. (2021). The impact of digital transformation on European countries: insights from a comparative analysis. *Equilibrium*. *Quarterly Journal of Economics and Economic Policy*, *16*(2), 325–355. https://doi.org/10.24136/eq.2021.012

Park, H., & Choi, S. O. (2019). Digital Innovation Adoption and Its Economic Impact Focused on Path Analysis at National Level. *Journal of Open Innovations: Technology, Marketing and Complex*ity, *5*(3), 56. https://doi.org/10.3390/joitmc5030056

Polozova, T., Kolupaieva, I., & Sheiko, I. (2021). Digital Gap in EU Countries and its Impact on Labour Productivity and Global Competitiveness. In J. Mačí, P. Marešová, K. Firlej, & I. Soukal (Eds.), *Hradec Economic Days* (pp. 659–671). University of Hradec Králové. https://doi.org/10.36689/uhk/hed/2021-01-065

Polozova, T., Kutsenko, Yu., & Kanova, O. (2022) Formation of Sustainable Investment Attractiveness of Regions Under the Conditions of COVID-19. *Problemy Ekorozwoju / Problems of Sustainable Development*, *17*(1), 16–22. https://doi.org/10.35784/pe.2022.1.03

Rao, A. O., & Verweij, G. (2017). *Sizing the prize: what's the real value of AI for your business and how can you capitalise? (Report 170905-115740-GK-OS).* PricewaterhouseCoopers (PwC). https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf

Regulation (EU) 2021/694. *Regulation of the European Parliament and of the Council of 29 April 2021 establishing the Digital Europe Programme and repealing Decision (EU)*. European Union, The European Parliament and The Council of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0694

Statistics Sweden. (2022, October 27). *Increased expenditures for R&D in Sweden.* https://www.scb.se/en/finding-statistics/statistics-by-subject-area/education-and-research/research/research-and-development-in-sweden/pong/statistical-news/research-and-development-in-sweden-2021/

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). University of Cincinnati.

Zaharia, M., & Bălăcescu, A. (2020). Digital economy and society. Comparative cluster analysis of EU states. *Journal of Applied Computer Science & Mathematics*, *1*(14), 30–36. https://doi.org/10.4316/JACSM.202001005

Urbancová, H., & Vrabcová, P. (2022). Activities of the human resources department influenced by the organizational culture. *Ekonomický časopis, 70*(1), 76–93. https://doi.org/10.31577/ekoncas.2022.01.05