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DIGITAL COMPETENCES AND HUMAN DEVELOPMENT: A CANONICAL CORRELATION ANALYSIS IN ROMANIA

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Abstract: The acceleration of digital transformations in the administrations of the EU member states is influenced by the digital skills of citizens and civil servants alike. The Romanian administration is part of this extensive resilience process. The purpose of this research is to discover the basic and relevant correlations between human development and the digital skills and competencies of both citizens and public servants in Romania in the period 2015 - 2021. For this, six research variables were selected from Eurostat, UNDP, and other specialized databases. The main method used for analyzing and correlating variables is Canonical Correlation Analysis. The results of applying CCA confirmed a negative relationship between internet use and human development and a positive impact of human development on digital skills. On the other hand, it was observed that the number of public servants in Romania is in an inverse relationship with the digitization of the administration.

Key words: digitalization, public servants, canonical correlation analysis

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Introduction

Expediting the enhancement of digital skills and competencies among civil servants in the EU member states aligns with a key objective outlined by the European Commission in 2021 as part of the European Union's six identified priorities. In Romania, the Ministry of Public Administration and National Agency for Civil Servants support the national implementation of four of the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda, adopted by the UN General Assembly Resolution A/RES/70/1, and subsequent to the National Strategy for the Sustainable Development of Romania 2030, adopted by HG no. 877/2018. Regarding digital skills, DESI 2022 shows that currently, 54% of Europeans have at least basic digital skills. Romania, Bulgaria, Poland, and Italy are in the last places. As for Romania, the ranking in 27th place by the dimension of human capital reflects the lack of basic digital skills among the population, the results obtained being well below the EU average in terms of at least basic digital skills (28% compared to 54%) and digital skills above elementary level (9% vs. 26%). Although the digital world has rapidly increased the usage of information and communication technologies

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(Hernández-Garrido et al., 2022) and organizations need to apply these technologies to increase their efficiency and to minimize their costs (Agboola et al., 2023), Romania also scores below average in terms of the proportion of employed ICT specialists at 2.6% compared to 4.5% at the EU level.

In order to reduce the reported gaps, the Government of Romania developed the National Strategy regarding the Digital Agenda for Romania 2020 (SNADR 2020), adopted by Government Decision no. 245/2015 - the sub-field of ICT (Informational Communication Technology) in education provides for the permanent training of specialized ICT skills of public administration human resources (Li and Wang, 2023; Gonos et al., 2023), "Identity, Human Capital and Poverty Reduction Effects: An empirical study based on China Family Panel Studies", Montenegrin Journal of Economics, Vol. 19, No. 3, pp. 7-20). One of the indicators established for the sub-fields of e-government and cyber security refers to the share of public system civil servants with basic digital skills among all human resources within the public administration. The Digital Economy and Society Index (DESI) 2022 shows that digital transformation is growing in the EU states and influences human development. As reliance on the internet and digital technology advances, the workforce must keep pace with evolving skills demands (Sun et al. 2022a, 2022b). Promoting the enhancement of digital skills among both civil servants and citizens is an imperative requirement for expediting the digital transformation within governmental administrations and society as a whole (Horváthová et al., 2022; Shava and Vyas-Doorgapersad, 2023). The use of digital skills contributes to increasing the quality of life and the level of human development knowledge sharing and organization types in a country (Zsigmond and Mura, 2023; Mura et al., 2022; Lavrinenko et al., 2022). Digital skills such as the usage of innovative technologies included in digital transformation also stimulate the development of businesses' competitiveness, performance (Rigelsky et al., 2022), and service quality (Zamir and Kim, 2022).

Starting with the year 2025, it is expected that civil servants in Romania will be evaluated annually. The evaluation of the individual digital skills will be done through the IT system of the National Agency of Civil Servants (NAPS).

Figure 1 displays the 2022 DESI ranking with the four DESI components: human capital, connectivity, integration of digital technology, and digital public services. In this ranking, Finland, Denmark, the Netherlands, and Sweden occupy the first positions, followed by Ireland, Malta, and Spain. Greece, Bulgaria, and Romania are in the last positions in the 2022 DESI ranking.

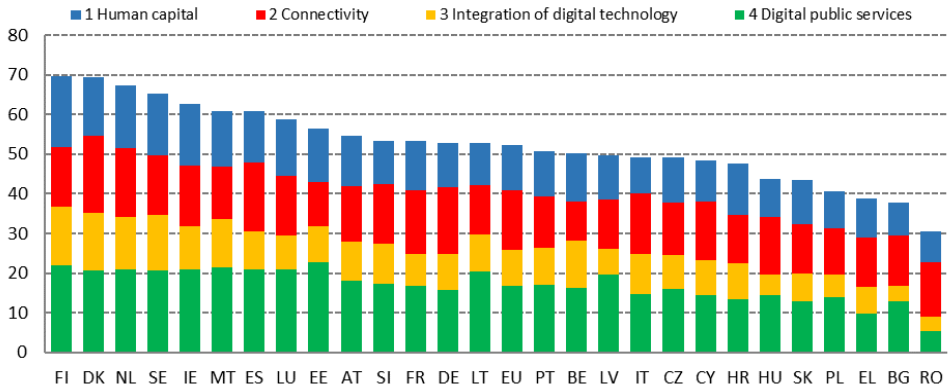

Figure 1: The ranking of EU countries according to the DESI index
(**Source:** European Commission, 2022)

This paper uses Canonical Correlation Analysis (CCA) to find a relation between two sets of indicators, as described in Table 1. Among the six chosen indicators, HDI was chosen to describe the quality of life. By considering the three dimensions together, HDI offers a more nuanced understanding of life quality in a country (Islam, 2010). HDI extends its scope beyond economic indicators such as GDP per capita.
The paper contains a literature review section followed by a brief description of the research methods and methodology. Then, a consistent part with research results discussions, and representations are developed. The paper ends with limitations and conclusions.

Literature Review

The effective transformation of public administrations and economies through digitization necessitates a fundamental reevaluation of how e-government, digital services, and the growing engagement of citizens can collectively foster the reduction of corruption and drive social progress.
Digital skills consist of a set of knowledge and practical skills for working with tools and applications in the field of digital technologies and communications (Głodowska et al., 2023). Many organizations in Europe face many troubles because of a lack of specialists who have digital skills (Krajcik et al., 2023). The following competence areas can be identified: (1) informational and data literacy; (2) communication and collaboration; (3) creating digital content; (4) safety; and (5) problem-solving. Informational literacy means that the user is able to use databases for simple searches on the Internet, save information, can evaluate the credibility of some sites (Afonsova et al., 2019; Zabala and Ślusarczyk, 2020). If he can vary some search strategies, i.e., change keywords, search on different sites, or use local cloud data and information storage systems, he can be considered an advanced user at this level of skills digital. To be an advanced user from the point of view of digital skills, it is

necessary to be an advanced user in at least two of the five areas of competence. According to the second area of digital competencies, namely communication and collaboration, a public official or a citizen can be a basic user if he can identify the correct ways of communication in a certain context (Ślusarczyk et al., 2021; Bejtkovský et al., 2018; Monteiro et al. 2022; Szczepańska-Woszczyna and Gatnar, 2022, Basuki et al., 2022). For advanced officials it was considered that they should know how to organize an online event in the institution where they work, and advanced citizens should be able to organize online meetings with other citizens for issues related to the communities in which they live and know how to use hashtags and cloud services, to know how to organize meetings with colleagues and upload or transmit data to obtain the necessary services. The third area of digital competencies refers to the creation of digital content. The basic level of digital skills means a user's ability to create and edit content in Word or PowerPoint format and to apply some HTML instructions. Advanced-level users are those who can use original content creation programs, for example, posters, etc., choosing the right copyright rules for the content they want to create (Wach et al., 2023). The fourth area of digital competence is safety. For an official or a citizen, safety means knowing how to protect oneself in the digital space. From the perspective of this component, a basic user needs to know how to protect his passwords, and the digital space, to be able to identify the elements of the privacy policy of a site (such as that warning bar for the collection of cookies) or if he can recognize the environmental impact of information technologies. An advanced user develops and sends promotional video messages, various animations, etc. The fifth area of digital skills aims to solve problems that may arise in the use of digital technologies and tools.

People's digital skills can influence the level of human development (Alaeddin et al., 2018; Al-Lafi et al., 2023). But the reciprocal is also valid. Human development is a concept that refers to the elements necessary for a person to develop his qualities and capacities, without any discrimination. However, even if the per capita value increases, this does not mean that the majority of the population has a better quality of life (Dańska-Borsiak, 2023). The Universal Declaration of Human Rights (UDHR) was approved by all member countries of the United Nations (UN) in 1948. The UDHR has established itself as a key element for global governance and international cooperation. However, it has been very difficult to quantify progress in fulfilling human rights. To correct the situation, an indicator was designed that is easy to implement in different countries of the world. The Human Development Index (HDI) is a composite index with three dimensions: life expectancy, schooling years, and the living standard measured by GDP per capita. Since 1990, the HDI Report has been prepared and published annually by the UN. HDI is considered one of the best indicators to know what is the state of a country's population, beyond its level of production. The three variables of the HDI (health, education, and production) capture well the general welfare conditions in a country. But there are various aspects of development - which are ignored by neoclassical economic theory - that make a difference. These aspects include political freedom, religious freedom,

gender equality, and security, among others. The research that is the basis of this work analyses the correlations between digital skills and human development in Romania.

Previous research (Androniceanu et al., 2022) is centered around examining the interconnectedness and distinctions between the multifaceted concepts of administrative corruption and digitalization within the EU member states. To achieve this, Androniceanu et al. (2022) employ two analytical methods: CCA and Principal Component Analysis (PCA). The findings unveiled a significant enhancement in the quality of public administration and a notable decline in corruption due to digitalization. Bratianu et al. (2022) or Dinu (2022) also highlight the importance of organizational knowledge dynamics and intellectual capital in the processes. In this regard, the scope and features of the professional duties of civil servants can be considered with further training according to the digital skills deficit revealed (Bilan et al., 2023a). Information technology should be regarded as an institutional priority from two main standpoints: regarding the necessity to adopt emerging technologies and promote innovation and secondly, regarding the transition of training activities into the online environment (Hajdukiewicz and Pera, 2023 Digitalization is a cornerstone in achieving effective administration and by extension, good governance. However, the population's digital skills remain insufficient even in industries with high demand for this type of labour force competencies (Jurczuk and Florea, 2022). The same is true regarding the readiness to develop and use digital skills which are not ubiquitous even in the face of the strategic benefits of digital technologies (Siderska et al., 2023). The studies by Androniceanu et al. (2022a), and Androniceanu and Georgescu (2023a; 2023b) center their attention on a range of elements that exert influence on the economic progress and overall welfare of the EU states. Analyses are made on how EU nations have advanced concerning digital transformation, using Principal Component Analysis (PCA), different clustering methods and fixed and random effects model (Małkowska et al., 2021; León-Gómez et al., 2022). The results of these studies prove that Romania and Bulgaria are among the lowest-ranking EU states with respect to the human capital dimension and digital skills, emphasizing the digital divide among EU countries. The digital divide arises due to the absence of the Internet among marginalized populations, leading to socio-economic disparities (Mesa, 2023; Singh SK and Singh VL., 2023). Consequently, the EU countries should implement initiatives aimed at closing this technological gap. This contributes to the development of a knowledge-based economy and innovations progress (Bilan et al., 2023b; Kuzior et al., 2021).

Research Methodology

Canonical Correlation Analysis (CCA) has been applied to the selected research variables, both presented and explained below.

CCA proposed by Hotelling (Hotelling, 1936) is a statistical technique utilized for discerning relationships between two groups composed of at least two variables. It

employs pairs of canonical variates to capture both the inter- and intra-set variability. Of these variates, the first one holds the utmost significance. The correlation coefficients are considered meaningful when their absolute values exceed 0.45. CCA enables us to condense complex relationships into smaller sets of statistics while retaining their essential aspects. The rationale behind canonical correlation closely parallels that of PCA, making it another method for reducing dimensionality. CCA is often introduced as a broad framework that serves as a foundation for other multivariate techniques. These methods include multivariate analysis of variance (MANOVA) and multivariate multiple regression, as suggested by Baggaley (1981). We present briefly the theoretical framework of the CCA, by Johnson and Wichern (2007). Assume we have the sets $X = \{X_1, \ldots, X_p\}$and $Y = \{Y_1, \ldots, Y_q\}$, with $p \leq q$. From these we build two sets $A = \{A_1, \ldots, A_p\}$ and $B = \{B_1, \ldots, B_p\}$. $A_i, i = 1,.., p$ is a linear combination of the elements of X as seen in equation (1) and $B_i, i = 1,.., p$ is a linear combination of the elements of Y as seen in equation (2):

$A_i = a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{ip}X_p, i = 1, \ldots, p$ (1)

$B_p = b_{j1}Y_1 + b_{j2}Y_2 + \ldots + b_{jq}Y_q, j = 1, \ldots, p$ (2)

The pairs (A_i, B_i), $i = 1, \ldots, p$ are called canonical variate pairs. The aim is to discover linear combinations that maximize the correlations among the elements within each pair of canonical variates.

The variance of A_i has the form (3):

$Var(A_i) = \sum_{k=1}^{p} \sum_{l=1}^{p} a_{ik}\, a_{il}\, cov(X_k, X_l), i = 1, \ldots, p$ (3)

The variance of B_j has the form (4):

$Var(B_j) = \sum_{k=1}^{p} \sum_{l=1}^{q} b_{jk}\, b_{jl}\, cov(Y_k, Y_l), j = 1, \ldots, p$ (4)

The covariance between A_i and B_j has the form (5):

$Cov(A_i, B_j) = \sum_{k=1}^{p} \sum_{l=1}^{q} a_{ik}\, b_{jl}\, cov(X_k, Y_l), i, j = 1, \ldots, p$ (5)

The canonical correlation of the canonical variate pair (A_i, B_i), $i = 1, \ldots, p$ is computed as the correlation coefficient between A_i and B_i as described by equation (6):

$\rho_i = \frac{Cov(A_i, B_i)}{\sqrt{Var(A_i) Var(B_i)}}, i = 1, \ldots, p.$ (6)

CCA determines the linear combination that maximizes the canonical correlation $\rho_i *$ for the canonical pairs $(A_i, B_i), i = 1, \ldots, p$.

The Frame of the Research Process

In the upcoming paragraph, we will formulate the purpose, the objective, and the research hypotheses.

The objective of the study is to uncover the fundamental correlations between HDI and the digital proficiency of both citizens and public servants in Romania.

The specific objectives (O) of the research are:

O1: to identify the degree of correlation between HDI and digital competencies;

O2: to discover the type of correlation between e-government and Internet usage;

O3: to identify the extent to which the proficiency in digital skills among public servants in the Romanian government influences the level of engagement in e-participation;
O4: to discover the degree to which digital transformation in Romania is influenced by citizens' use of the internet and their digital skills.
Our study includes the following research hypotheses (H):
H1: HDI in Romania is influenced by citizens' level of digital skills and internet usage.
H2: There is a direct and strong correlation between the number of national public servants in Romanian central administration and EGDI.
CCA was applied for the period 2015-2021 for Romania considering two sets of three indicators. The next steps of the methodology follow previous research on CCA (Georgescu and Kinnunen, 2021). Table 1 contains the two sets of indicators: V1-V3 represents the independent set and V4–V6 is the dependent set.

Table 1. The main research variables

Variable	Variable Label	Measurement unit	Acronym	Source
V1	Human Development Index	[0,1]	HDI	hdr.undp.org
V2	E-participation index	[0,1]	EPI	publicadministration.un.org
V3	E-government and development index	[0,1]	EGDI	publicadministration.un.org
V4	Internet use by individuals	Percentage of individuals	INTUSE	Eurostat
V5	Individuals' level of digital skills	% of the total number of individuals aged 16 to 74	DS	Eurostat
V6	National civil servants in central public administration	persons	CV	Eurostat

Source: Our selection based on various databases

The goal of CCA is to predict three variables: INTUSE, DS and CV based on three independent variables: HDI, EPI and EGDI. The left matrix of Figure 2 represents the correlation matrix of the independent set V1-V3. One can see very high correlations coefficients between any pair of indicators from Set 1.

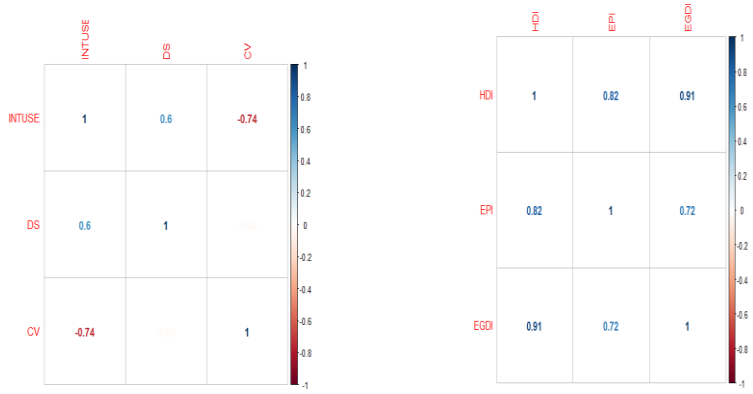

Figure 2: Set 1 (independent set) and set 2 (dependent set)
Source: Own elaboration

The right matrix in Figure 2 is the correlation matrix of the indicators of set 2. One can see an uncommon relationship between CV and INTUSE in Figure 2. A high number of civil servants might cause limited investment in infrastructure, training and technology adoption. Both the administration's ability to provide efficient online services and the civil servants 'personal internet use might be hindered. The bureaucratic or traditional approach to governance, leading to a slower adoption to digital tools and online platforms. It means that the Romanian administration relies more on conventional methods of communications; thus, the need for extensive internet use is reduced, especially in provincial cities. If a greater part of civil servants is older and have a lower level of digital literacy, their use of internet is limited. The digital divide also contributes to this negative relation between CV and INTUSE. One also notices from Table 2 a lack of correlation between DS and CV. Civil servants occupies different positions within public administration, positions which require different levels of digital skills. Because various positions require an advanced degree of digital proficiency, the total count of civil servants does not always reflect the overall digital skills level. It also seems that digital skills training programs are lacking, or some civil servants have limited access to training opportunities, because of the digital divide. Social factors such as age, education, and experience may justify this lack of correlation. The digital skills of civil servants might not keep pace with the extent to which the administration has adopted digital technologies.

The independent set is $X = (V_1, \ldots, V_3)^T$ and the dependent set $Y = (V_4, \ldots, V_6)^T$. $(A_i, B_i), i = 1, \ldots, 3$ are the pairs of canonical variates. $A_i, i = 1, \ldots, 3$ is a linear combination of the elements of X (equations (7)-(8)) and $B_i, i = 1, \ldots, 3$ is a linear combination of elements of Y, respectively (equations (9)-(10)):

$$A_1 = a_{11}V_1 + \ldots + a_{13}V_3 \quad (7)$$

$$\ldots$$

$$A_3 = a_{31}V_1 + \ldots + a_{33}V_3 \quad (8)$$

$$B_1 = b_{11}V_4 + \ldots + b_{13}V_6 \quad (9)$$

$$\ldots$$

$$B_3 = b_{31}V_4 + \ldots + b_{33}V_6 \quad (10)$$

The canonical correlation for the i^{-th} canonical pair (A_i, B_i) is $\rho_i * = \frac{cov(A_i, B_i)}{\sqrt{var(A_i)\, var(B_i)}}$, $i = 1, \ldots, 3$. One has to determine the linear combination that maximizes the canonical correlation $\rho_i *$ for the canonical pairs $(A_i, B_i), i = 1, \ldots, 3$. Initially, we determine the presence of a connection between the two sets of variables, *X* and *Y*. Subsequently, a multiple regression model is built with the aim of predicting set *Y* from set *X*. Our approach encompasses three distinctive multiple regression equations (11)-(13), each designed to anticipate a particular *Y* variable from the three variables contained in set *X*:

$$V_4 = \beta_{10} + \beta_{11}V_1 + \beta_{12}V_2 + \beta_{13}V_3 \quad (11)$$

$$V_5 = \beta_{20} + \beta_{21}V_1 + \beta_{22}V_2 + \beta_{23}V_3 \quad (12)$$

$$V_6 = \beta_{30} + \beta_{31}V_1 + \beta_{32}V_2 + \beta_{33}V_3 \quad (13)$$

The null hypothesis (NH) posits that the regression coefficients derived earlier are equal to zero. This hypothesis (14) is analogous to assessing the independence between the two sets of indicators X and Y:

$$H_0: \beta_{ij} = 0, i, j = 1, \ldots, 3. \quad (14)$$

Discussion of the Research Results

Using SPSS 26, we examine the primary outcomes of CCA. Hotelling's trace test and Wilk's lambda criteria are significant, with *p*- values < 0.10. Two of the three test results presented in Table 2 demonstrate a statistically significant linear relationship between the two sets of indicators X and Y.

Table 2. Multivariate tests of significance (S = 3, M = -1/2, N = 0)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	1.74	1.86	9	12	0.15
Hotellings	179.63	13.30	9	2	0.07
Wilks	0.002	6.49	16	5.02	0.02
Roys	0.99				

Source: Own elaboration

The CCA analysis resulted in three roots, as outlined in Table 3, with the eigenvalues arranged in decreasing order.

Table 3. Eigenvalues and canonical correlations

Root No.	Eigenvalue	Pct.	Cum. Pct.	Canon Cor.	Sq. Cor
1	178.29	99.25	99.25	0.99	0.99
2	1.00	0.55	99.81	0.70	0.50
3	0.33	0.18	100.00	0.50	0.25

Source: Own elaboration

The calculation of eigenvalues involves taking the ratio of the squared correlation to the difference between 1 and the squared correlation. Canonical correlations represent correlation coefficients between pairs of canonical variates. The first canonical correlation, 0.99 is the correlation coefficient between the first pair of canonical variates. 99.25 % of the variation in A_1 is explained by the variation in B_1.

In Table 4, we verify the NH (15) that all correlations are 0, which corresponds to the scenario where no pairs of canonical variates exhibit correlations:

$$H_0: \rho_1 *= \rho_2 *= \rho_3 *= 0. \quad (15)$$

Wilks lambda test is significant (0.02<0.05) and the canonical correlations are decreasing. Thus, it can be said that $\rho_1 *\neq 0$. Hypothesis (16) is verified, by which correlation exists among the remaining pairs of canonical variates:

$$H_0: \rho_2 *= \rho_3 *= 0. \quad (16)$$

Since 0.49 > 0.05, the second canonical variate pair is not correlated, $\rho_2 *= 0$.The third test is not significant: 0.31 > 0.05. Therefore, the third canonical variate pair is not correlated either.

Table 4. Dimension reduction analysis

Roots	Wilks L.	F	Hypoth. DF	Error DF	Sig. of F
1 TO 3	0.002	6.49	9	5.02	0.02
2 TO 3	0.37	0.95	4	6	0.49
3 TO 3	0.74	1.35	1	4	0.31

Source: Own elaboration

Tables 5 and 6 display the raw and standardized canonical coefficients pertaining to the dependent variables.

Table 5. Raw canonical coefficients for dependent variables

Variable	1	2	3
INTUSE (V4)	-0.16	-0.03	-0.21
DS (V5)	0.30	-0.28	1.04
CV (V6)	-0.0001	-0.0001	-0.0001

Source: Own elaboration

The canonical variates can be understood in a similar way to outcome variables in linear regression. A one-unit increase in INTUSE leads to a -0.16 increase in the first variate of set 2 (Table 5). An increase in one standard deviation in INTUSE leads to a -1.80 standard deviation increase in the first variate of set 2 (Table 6).

Table 6. Standardized canonical coefficients for dependent variables

Variable	1	2	3
INTUSE (V4)	-1.80	-0.34	-2.31
DS (V5)	0.54	-0.50	1.84
CV (V6)	-0.71	-0.97	-2.02

Source: Own elaboration

The first canonical variable for set 2 is written as equation (17):

$$B_1 = -0.16V_4 + 0.30V_5 - 0.0001V_6 \quad (17)$$

The value of the coefficients indicates variables' contribution to that canonical variable. In Table 7, the first canonical variable for set 2 is strongly dominated by, CV, with a correlation coefficient 0.61 and negatively dominated by DS and INTUSE. DS and CV dominate the second canonical variable for set 2. DS dominates the third canonical variable for set 2 Correlations with absolute values greater than 0.45 are deemed significant.

Table 7. Correlations between dependent and canonical variables

Variable	1	2	3
INTUSE (V4)	-0.95	0.06	0.30
DS (V5)	-0.52	-0.68	0.51
CV (V6)	0.61	-0.69	-0.37

Source: Own elaboration

In Table 8, 51.63% of the variance among the dependent set is explained by the first dependent canonical variate, while 51.34% is explained by the first covariate canonical variate. 33.04% of the variance among the dependent set is explained by the second dependent canonical variate, while 16.03% is explained by the second covariate canonical variable.

Table 8. Variance in dependent variables explained by canonical variables

CAN. VAR.	Pct Var DEP	Cum Pct DEP	Pct Var COV	Cum Pct COV
1	51.63	51.63	51.34	51.34
2	33.04	83.67	16.03	67.38
3	16.32	100.00	4.12	71.50

Source: Own elaboration

The raw and standardized canonical coefficients for the covariates are contained in Tables 9 and 10. A one-unit increase in HDI leads to a 26.32 increase in the first variate of set 1 (Table 9). An increase of one standard deviation in HDI leads to a 0.19 standard deviation increase in the first variate of set 1 (Table 10). The first canonical variable for set 1 is expressed as equation (18):

$$A_1 = 26.32V_1 - 2.87V_2 - 10.03V_3 \quad (18)$$

Table 9. Raw canonical coefficients for covariates

Covariate	1	2	3
HDI (V1)	26.32	-332.87	240.18
EPI (V2)	-2.87	-0.43	-15.29
EGDI (V3)	-10.03	24.83	-1.96

Source: Own elaboration

Table 10. Standardized canonical coefficients for covariates

Covariate	1	2	3
HDI (V1)	0.19	-2.40	1.73
EPI (V2)	-0.32	-0.04	-1.70
EGDI (V3)	-0.92	2.29	-0.18

Source: Own elaboration

The correlations presented in Table 11 illustrate the proportional influence of each covariate on each canonical variable.

Table 11. Correlations between covariates and canonical variables

Covariate	1	2	3
HDI (V1)	-0.91	-0.35	-0.18
EPI (V2)	-0.82	-0.36	-0.41
EGDI (V3)	-0.98	-0.05	0.18

Source: Own elaboration

The first canonical variable for set 1 (Table 11) is strongly negatively dominated by HDI, EPI, and EGDI. Correlations with absolute values greater than 0.45 are deemed significant. In Table 12, 82.59% of the variance among the covariate set 1 is explained by the first dependent canonical variate, while 83.06% of the variance is explained by the first covariate canonical variate.

Table 12. Variance in covariates explained by canonical variables

CAN. VAR.	Pct Var DEP	Cum Pct DEP	Pct Var COV	Cum Pct COV
1	82.59	82.59	83.06	83.06
2	4.42	87.02	8.84	91.90
3	2.04	89.07	8.09	100.00

Source: Own elaboration

4.42% of the variance among set 1 is explained by the second dependent canonical variate, while 8.84% is explained by the second covariate canonical variate. Table 13 displays the outcomes of regression analysis, depicting how the indicators from set 1 influence each indicator within set 2. The significance of each covariate is gauged by its corresponding beta values.

Table 13. Regression analysis for cells error term

Covariate	B	Beta	Std. Err.	t-Value	Sig. of t	Lower - 95%	CL-Upper
Dependent variable: INTUSE (V4)							
HDI (V1)	-48.98	-0.03	620.01	-0.07	0.94	-1770.41	1672.45
EPI (V2)	4.27	0.04	23.46	0.18	0.86	-60.87	69.42
EGDI (V3)	114.50	0.95	40.49	2.82	0.04	2.08	226.91
Dependent variable: DS (V5)							
HDI (V1)	370.84	1.51	239.30	1.54	0.19	-293.57	1035.26
EPI (V2)	-3.94	-0.24	9.05	-0.43	0.68	-29.08	21.20
EGDI (V3)	-12.95	-0.67	15.62	-0.82	0.45	-56.34	30.43
Dependent variable: CV (V6)							
HDI (V1)	802731.63	-0.98	718614.24	1.11	0.32	-1192461.36	2797924.63
EPI (V2)	7832.5	0.14	27196.44	0.28	0.78	-67676.92	83341.93
EGDI (V3)	-106538.25	-1.66	46929.63	-2.27	0.08	-236835.82	23759.39

Source: Own elaboration

Drawing from the outcomes presented in Table 13, the ensuing deductions come into light:

-The effect of EGDI is more important in absolute value than the effect of HDI when predicting INTUSE. A higher EGDI score indicates a mode advanced digital environment, often associated with better access to online services, digital literacy and a supportive digital ecosystem. Therefore, a change in EGDI would result in notable shifts in internet use due to the direct relation between digital development and online engagement. Broader indicators comprised in HDI, health, education and income have a less pronounced influence on INTUSE. Changes in HDI might impact INTUSE indirectly through factors such as educational attainment and income levels. When INTUSE is the dependent variable, from Table 13 one can see its negative relation with HDI, confirming hypothesis H1. In some cases, governments might prioritize investments in areas such as education, healthcare and infrastructure to improve HDI. The resource allocation may come at the expense of investing enough in digital infrastructure and internet connectivity.

-The effect of HDI dominates in absolute value the effect of EPI and EGDI when predicting DS. The HDI components indicate a population's overall well-being and

capabilities. A change in HDI is likely to exert a significant impact on various dimensions of society. In contrast, EPI reflects the level of digital interaction between the government and the public. EPI measures a specific aspect of digital engagement rather than the broader spectrum of HDI. EGDI is focused on the efficiency of digital service delivery and the accessibility of government information and online services. With these considerations, the predominance of HDI's effect in predicting DS is logical due to its overall coverage of factors that play a crucial role in shaping individuals 'abilities in a digital context. When DS is the dependent variable, HDI has a positive impact on it, confirming Hypothesis H1 (see Table 13). Countries with higher HDI scores invest in education, a HDI component, and also in digital literacy programs. Better access to educational resources enhances digital skills development. Improving the standard of living, another HDI component, involves investments in technology infrastructure, facilitating the development of DS.

-The effect of HDI dominates in absolute value the effect of EPI and EGDI when predicting CV. Changes in HDI reflect the shifts in healthcare systems, educational attainment and economic development, elements which can significantly impact a country's employment landscape, including CV. EPI is relevant for understanding the level of digital involvement in governance and it might not comprise the broader socio-economic factors that influence the demand for CV. Similarly, EGDI regards the administrative and technological aspects of governance, rather than the development factors that could influence the need for a CV. According to Table 13, hypothesis H2 is contradicted. CV negatively impacts EGDI. EGDI is not a direct cause of the number of civil servants, but there can be indirect effects on the Romanian public workforce. The adoption of e-government services can lead to efficiency in public administration, reducing the demand for a large number of civil servants.

Even the current paper is the first study about the digital competences, internet infrastructure of public administration and human development in Romania there are a few limitations. One limitation is the fact that a few statistics about civil servants in Romania are available and accessible. Another limitation of the research is the unavailability of long time series on data about Romanian public administration, which makes the quantitative methods based on time series inapplicable. As long-term time series become available, these research efforts will be continued with advanced econometric methods.

Conclusion

CCA was applied for Romania for two datasets, each of them with three indicators. The objective of CCA was to make predictions for three variables: INTUSE, DS, and CV based on three independent variables: HDI, EPI and EGDI. The first root obtained by CCA explained 99.25% of the variations between the two sets of indicators, with a canonical correlation of 0.99. The independent set explained 82.59% of the first canonical variable, while the canonical variables explained

51.63% of the dependent set. The research was based on two hypotheses: first, that HDI is influenced by the level of digital skills among citizens and internet usage (Hypothesis H1), and second, there is a direct correlation between the number of Romanian public servants and EGDI (H2).
The results of applying CCA confirmed Hypothesis H1: a negative relation between internet use and HDI; and a positive impact of HDI on digital skills. Concerning Hypothesis H2, it was noted that the number of civil servants in Romania exerts a detrimental influence on EGDI, thereby contradicting H2. The inference is that the adoption of digitalization and e-government services has led to a reduction in the number of CV.
This work aimed to apply quantitative methods regarding the number of public servants and their digital skills, correlated with the efficiency of Romanian public administration.

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KOMPETENCJE CYFROWE A ROZWÓJ LUDZKI: ANALIZA KORELACJI KANONICZNEJ W RUMUNII

Streszczenie: Na przyspieszenie transformacji cyfrowych w administracjach państw członkowskich UE jest wpływają umiejętności cyfrowe zarówno obywateli, jak i urzędników publicznych. Administracja rumuńska uczestniczy tym szeroko zakrojonym procesie zwiększania odporności. Celem tego badania jest odkrycie podstawowych i istotnych zależności między rozwojem ludzkim a umiejętnościami cyfrowymi obywateli i urzędników publicznych w Rumunii w okresie 2015-2021. W tym celu wybrano sześć zmiennych badawczych z Eurostatu, UNDP i innych specjalistycznych baz danych. Główną metodą analizy i korelacji zmiennych jest Analiza Korelacji Kanonicznej. Wyniki zastosowania AKK potwierdziły negatywną zależność między korzystaniem z Internetu a rozwojem ludzkim oraz pozytywny wpływ rozwoju ludzkiego na umiejętności cyfrowe. Z drugiej strony zauważono, że liczba urzędników publicznych w Rumunii ma odwrotną zależność od stopnia zdigitalizowania administracji.

Słowa kluczowe: digitalizacja, urzędnicy publiczni, analiza korelacji kanonicznej