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THE IMPACT OF ICT EDUCATION ON GDP EVOLUTION AT LOCAL LEVEL. A ROMANIAN CASE STUDY

Dimitrie-Daniel PLĂCINTĂ ✉, Andrei TOMA, Lorena BĂTĂGAN, Corina-Marina MIREA, Florin-Valeriu PANTELIMON

Faculty of Economic Cybernetics, Statistics and Informatics, The Bucharest University of Economic Studies, Romana Square No.6, Bucharest, Romania

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Abstract. *Purpose* – This article focusses on the impact generated on GDP growth by the number of graduates in the ICT domain of Romanian counties in the period 2014–2020.

Research methodology – We have collected the number of ICT graduates, the GDP per inhabitant in EUR per Romanian county, the number of ICT employees, the number of information service activities employees from the National Institute of Statistics (Romania) and Eurostat. Additionally, we consolidate the correlation matrix and regression analysis for previous statistics indicators.

Findings – We have revealed a strong correlation (85,77%) between the number of ICT graduates and the GDP per inhabitant in EUR per Romanian county, and very strong correlations between the number of ICT graduates and the number of ICT employees (94,80%) and the number of employees of information service activities (97,38%).

Research limitations – The data set from the National Institute of Statistics (Romania) does not contain entries for every county, due to its statistical methodology, and other socioeconomic phenomena which contribute to the development of the ICT field were just enumerated, such as natality, immigration, and emigration.

Practical implications – The study revealed that investment in ICT education (number of graduates) contributes to the local prosperity of communities, counties, and, in general, at the national level as GDP growth. Romanian government can utilize the outcomes of this paper to engage additional resources, funds from Ministry of Education, to develop a long-lived learning culture of ICT skills for the entire population.

Originality/Value – The article methodologically highlights the most important ICT hubs in Romania, which are correlated with the existence of an ICT educational infrastructure (high schools and universities) and the measure of impact on GDP growth for the number of highly skilled graduates in the ICT domain. The selected national and European indicators contributed to the novelty of this study.

Keywords: ICT education, GDP growth, impact, regional development, ICT employees, Romania.

JEL Classification: C81, I25, P25.

✉Corresponding author. E-mail: *daniel.placinta@csie.ase.ro*

1. Introduction

In the context of an economic expansion in Eastern Europe, the Romanian economy has evolved well in the last 30 years, passing from a centralized economy to a market economy, starting with the EU accession, new rules were introduced to facilitate the movements of people, goods, and services. A more digital connected economy was developed smoothly on the backbone of IT & C infrastructure. This evolution was done by Romanian human capital,

which was well prepared in major universities, high schools with mathematics-informatics profile, together with a government policy for protecting the high-tech sector.

Our study aims to reinforce and validate the idea that investment in ICT education is having a real impact on the economy, especially in the ICT sector, the sector with the highest growth rate of the Romanian economy (Asociația patronală a industriei de software și servicii, 2021).

The ICT (Information and Communication Technology) sector is a significant contributor to Romanian GDP (4.25% in 2020, from 3.31% in 2014) (Eurostat, n.d.-c), due to a mixture of factors such as the implementation of digital education from secondary school to master and doctoral studies, the creation of a set of fiscal policies (income tax deduction of 10% from gross salary), a multiplier factor in the economy, etc.

Starting with November 2023 the income tax deduction is applied till the level of 10 000 RON gross salary and for a limited time, end of 2028, the rest of the gross salary over the 10 000 RON is taxed with 10%, we will evaluate in time the impact of this measure on the ICT sector.

ICT education in Romania starts officially with dedicated classes in Informatics and IT & C in secondary school, from fifth to eighth grade, with one hour per week, assigned in the common curriculum, according to the latest curriculum adopted in 2017 (Ministerul Educaţiei Naţionale, 2017). Half of the time budget should be dedicated to developing algorithms and programming skills throughout secondary school. As a general overview of the proposed general competencies, we can enumerate responsible use of IT & C, solving elementary problems through intuitive information processing methods, building of creative mini projects related to social, cultural, personal aspects, respecting copyright rules, etc.

In recent years, the exponential growth of technologies offers new opportunities for students that is an essential element for improving the quality of life. The evolution of digital devices, the networks that connect them and automated feedback systems are generating new perspectives for education and for the country's development.

In this context, Information and Communications Technology (ICT) stands for real support during the educational process. In our age modern technologies confer an important advantage in improving quality of life. ICT has profoundly changed how people work, communicate, learn, and live. These technologies have important applications in our life to assess progress towards the priority of the 2030 Agenda for Sustainable Development (United Nations Development Programme, n.d.): quality education, decent work and economic growth, industry, innovation, and infrastructure, etc.

We live in a smart society where the efficient use of resources is a priority of the digital economy. According to Economist Intelligence Unit (2021), global ICT spending has grown steadily at a rate of 4% annually for several years. The next step for evolution will be the efficient use of our planet's resources using new technologies. To achieve this goal, all countries need to invest more in ICT.

Researchers worldwide are interested in the educational process by implementing the latest innovations. The free exchange of ideas, information and knowledge is a real support for society development in our age. The use of ICT by people worldwide will ensure equal access to education, health, security as well as evolution for all (Economic and Social Council, 2020).

In the above context, our paper aims to analyze the impact generated on GDP growth by the ICT education concept, which will include the number of graduates the ICT domain from Romanian counties in the period 2014–2020.

The first part presents the literature review of the ICT human capital and economic development. The examples highlight that the human capital of ICT influences the GDP per capita within the countries of the European Union, what is the return of education using the concept of opportunity cost, the relationship between ICT investment and GDP growth in different areas (Central Asian, Middle East and North Africa, Sub-Saharan, Western Balkan countries), countries (South Korea), which countries are impacted more or less by ICT, and the place of Romania within Digital Economy and Society Index (DESI) 2022. Smart solutions are an essential element for future development. All of these emphasize economic development, excellent quality of life and friendly environment.

The second part highlights the research hypothesis that the number of ICT graduates influences the number of ICT employees, the GDP per inhabitant in EUR at the county level, and the number of information service activities employees. It is essential for the government and the citizens to analyze these because they stand for real support for economic development and future evolutions.

The third part of the paper presents the statistical data. In our paper, we manipulated, validated data from Eurostat and the National Institute of Statistics (Romania) for the period 2014–2020 divided by Romanian counties.

The fourth part underlines the results. To validate our research hypothesis, we have constructed the correlation matrix between the number of ICT graduates and the GDP per inhabitant in EUR per Romanian county, where we achieved a strong correlation, and remarked similar results like in literature review section, that ICT education contributes to GDP growth.

The fifth part presents the research findings and the interpretation of these results. We compiled a strong correlation between the number of ICT graduates and the number of ICT employees, also emphasize the practical application of our study. After identification of the most important ICT hubs in Romania, we did a short presentation of Bucharest, Cluj-Napoca, and Iași hubs. The paper ends with the conclusion and future aims about country development.

2. Literature review

The Software and Services Industry Employers Association in the study Asociația patronală a industriei de software și servicii (2021) identifies a 10 000-employee deficit gap for the software workforce, software and IT services had the highest growth rate for the number of employees, from 80 000 in 2015 to 130–135 000 in 2020, also grew up close 3 times faster than the national economy.

In the study Vu et al. (2020) are consolidated conclusions from literature review and future research direction related to ICT domain as a driver for economic growth, like: 'ICT capital contributes to GDP growth from 0.1 to 1.0 percentage points, significant disparities among countries about the impact of ICT for GDP growth, an ICT platform can produce growth after is realized a critical mass, learning, technology diffusion, and innovation can fuel GDP

growth, investment in ICT generate growth, the significant positive effect of ICT on economic performance was validated', etc.

The Czech Republic is one of the countries that wants GDP growth to be driven by the expansion of an information society, but as presented in Maryska et al. (2012) it faces a shortage of specialists in the field and a decreasing number of ICT students.

Therefore, without ICT specialists, it is not possible to achieve an increase in GDP not only through the contribution of the ICT sector but from all sectors that contribute to the growth of this indicator. What the Czech Republic highlights are the improvements in the university system, which is designed to prepare future people in the field.

In the study Krajňáková et al. (2020) was revealed a strong correlation, 0.977, between the employment of tertiary educated and the level of GDP in the Slovak Republic and 0.953 in the Czech Republic, also a moderately strong correlation, 0.733, between the employment of tertiary educated graduates and the indicator GERD (Gross domestic expenditure and R & D) (Eurostat, 2022) only for the higher education sector in the Slovak Republic, and a strong correlation, 0,861, in the Czech Republic.

The paper Fernández-Portillo et al. (2019) validated the hypothesis that "there is a causal and positive relationship between ICT human capital and economic development". In short, the human capital of ICT influences the GDP per capita within the countries of the European Union. The study Fernández-Portillo et al. (2019) analyzed EU countries from 2014–2017 using the partial least squares (PLS) method, where it was shown that the 'variance of GDP per capita is explained by 8.22% by human capital related to ICT'.

An example of a correlation between higher education (qualitative and quantitative) and economic growth was also found in the case of Uzbekistan (Ochilov, 2014). To measure the quality of education, the final average of the exam grades obtained by the students was considered. At the same time, the number of graduates was considered to measure the quantity. Economic growth was represented by the GDP growth rate.

The research concluded that both the number of educated population and their level of education have an impact on economic growth. Among the qualitative and quantitative factors that influence economic growth, it can be said that, in the long term, the quality of education has a significant impact.

Although the relationship between the educated labor force and economic growth is positive, it is not very stable or tight, and therefore increasing the number of educated people does not have the same effects as increasing the quality of education. Several ways to improve the quality of education are presented by encouraging research and improving educational institutions.

In terms of relationship between the rate of return to investment in education in Lithuania, the Potelienė and Tamašauskienė (2014) paper showed that "individual with a higher education (i.e., who graduated at least the first cycle studies) has earned on average an additional 366 Euros per month more than an individual without a higher education, a difference of 4 400 EUR per year".

On the same approach, in the Marinič (2021) study is highlighted the return of education using the concept of OC (opportunity cost), where for the upper-secondary education the 'highest return rate is for Bulgaria (20.85% with OC €10,028) and Romania (16.73% with OC €9,312), the

lowest return rate is for Iceland (1.41% with OC €164.444) or Finland (1.77% with OC €97,460)', and for the tertiary education 'the highest return rate is in Romania (17.07% with OC €19,430) and Bulgaria (15.8% with OC €22,990), the lowest for Sweden (2.17% with OC €239,655)'.

Two studies on economic growth in Korea discovered that for the 1999–2016 period there existed a bidirectional causal relationship between ICT investment and GDP growth according to Sawng et al. (2021), also that "ICT accounted for almost 40% of Korean economic growth from 2000 to 2012", as concluded on Hwang and Shin (2017) paper.

A different study Shodiev et al. (2021) related to Central Asian Countries and for the 2000–2018 period "showed that ICT affects to GDP per capita positively and significantly: one percent increase in ICT contributes to GDP per capita 0.1669 percent (fixed broadband subscriptions) and 0.2218 percent (Internet usage)".

Very closer to Central Asian Countries, a study Bahrini and Qaffas (2019) focused on MENA (Middle East and North Africa) and SSA (Sub-Saharan Africa) countries for the 2007–2016 period presented that "mobile phone, Internet usage, and broadband adoption are the main drivers of economic growth in MENA and SSA, with a superiority of MENA countries over SSA countries related to Internet usage and broadband adoption".

In a different region, but for the 2000–2019 period and for Western Balkan countries (North Macedonia, Albania, Serbia, Montenegro, Bosnia and Herzegovina and Croatia) the study (Ibrahimi & Fetai, 2022) identified that "fixed telephone subscriptions and Internet access have a positive impact on the GDP growth, compared with broadband subscriptions, mobile cellular subscriptions, and general government final consumption which have a negative impact on the GDP growth", with the remark that future research should focus on ICT investment, the development of human capital, innovation, and education.

Romania is mentioned in the middle-income country list within the study Appiah-Otoo and Song (2021) who concluded that "both rich and poor countries are impacted by ICT, but especially poor countries benefit more from ICT expansion, and again is suggested to policymaker the importance of ICT education, political stability, promote reforms for facilitating the ICT investment".

Within the Digital Economy and Society Index (DESI) 2022 (European Commission, 2022), which covers the next dimensions, human capital, connectivity, integration of digital technology, and digital public services, Romania is on the last place for human capital – digital skills, digital public services, and on the same place for DESI 2022, as per Figure 1.

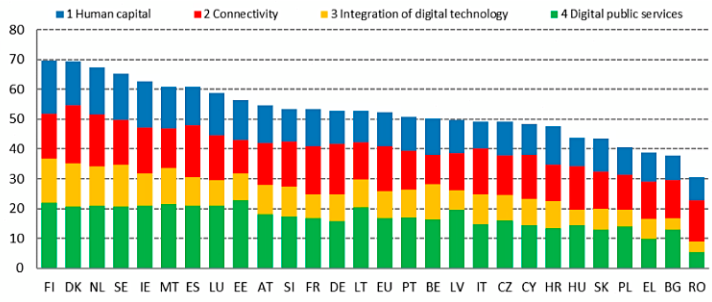

Figure 1. Digital Economy and Society Index (DESI), 2022 (source: European Commission, 2022)

The percentage of the ICT sector in GDP in Romania increased considerably from 3.31% in 2014, to 3.72% in 2019 and 4.25% in 2020; it was an evolution of 28% in seven years for this important sector, as per Table 1.

Table 1. Percentage of the ICT sector on GDP in Romania (source: Eurostat, n.d. b)

Year	2014	2015	2016	2017	2018	2019	2020
%	3.31	3.35	3.62	3.56	3.71	3.72	4.25

The budget for education in Romania as a share of GDP Ministerul Educaţiei (2022) for the period 2014–2020 increased from 0.6% (2014) till 2.72% (2020), an increase of 4 times and half, according to Figure 2, which was used for teacher salaries, teacher trainings, development of ICT infrastructure, Internet access, etc.

For the same period 2014–2022, the value of GDP in Romania rose from 150 billion euros to 220 billion euros, an increase of 46% in 7 years, as per Table 2.

As per the above details we can surmise that the contribution of the ICT sector to GDP evolved in a consistent and persistent way.

In the 2021–2022 university year, more than 15 000 places were available for bachelor level within 150 programs from the domains of study documented in Table 3 and Table 4.

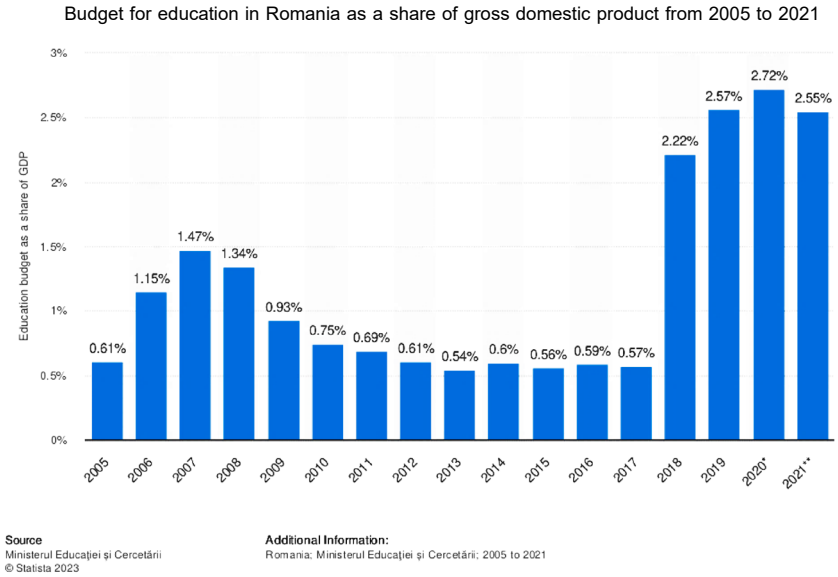

Figure 2. Budget for education in Romania as a share of GDP from 2005 to 2021 (source: Statista, 2024)

Table 2. GDP and main components in Romania (Eurostat, n.d. c)

Year	2014	2015	2016	2017	2018	2019	2020
Billion EUR	150.2	160.2	167.4	186.3	206.0	224.1	220.4

Table 3. Number of bachelor programs per field of study for 2021–2022 university year, adaptation after (Ministerul Educației, 2022)

#	Domain of study	Number of bachelor programs at state universities	Number of bachelor programs at private universities	Number of bachelor programs at foundations	Total number of programs
1	Computers and information technology	30	1	2	33
2	Cybernetics, statistics, and economic informatics	21	5	0	26
3	Informatics	33	13	1	47
4	Electronic engineering, telecommunications, and information technologies	42	1	1	44
5	Grand total				150

Table 4. Maxim number of bachelor level students that can be enrolled in 2021–2022 university year, adaptation after (Ministerul Educației, 2022)

#	Domain of study	Maximum number of bachelor level students that can be enrolled at state universities	Maximum number of bachelor level students that can be enrolled at private universities	Maximum number of bachelor level students that can be enrolled at foundations	Total number of students
1	Computers and information technology	3350	50	125	3525
2	Cybernetics, statistics, and economic informatics	2750	495	0	3245
3	Informatics	4140	905	30	5075
4	Electronic engineering, telecommunications, and information technologies	3235	50	50	3335
5	Grand total				15180

As we have observed above, the evolution of ICT education supported by education budget relates to the GDP growth, and the development of human capital and return of education is also playing an import factor for economic prosperity. The consolidated set of measures makes the Romanian ICT field very competitive in the region, which is in a permanent evolution with more room for sustainable growth.

3. Research hypotheses

Our research hypothesis is that the number of ICT graduates influences the GDP per inhabitant in EUR at the county level, and implicitly the number of employees from ICT sector. We will analyse the information available on (National Institute of Statistics – Romania, n.d.-a)

as a starting point for our investigation, in correspondence with (Eurostat, n.d.-a), (National Institute of Statistics – Romania, n.d.-b, n.d.-c), as per Table 5. Table 5 presents the indicators of Eurostat and the National Institute of Statistics (Romania) for 2014–2020, per Romanian countries.

The phenomenon of immigration plays an important role in filling available ICT jobs, where employees from China, India, or other countries come for a long or short period to work for subsidiaries of the larger corporations.

Due to the high demand for ICT employees, companies are forced to qualify graduates from different fields for the field of ICT, needing 2–3 years of training and work-related activities, which are necessary to gain sufficient immersion under appropriate parameters.

For the retention of ICT employees, there is a real battle for talent and the annual cost per employees in addition to salary can contain the cost for training (in class or subscriptions to learning platforms la LinkedIn Learning, Udemy, Pluralsight, Udacity, etc.), health insurance, sport benefits, meal tickets, additional days of vacancy, telephony subscription, sick days, free birthday, pension plan, books subscription (Bookster), flexible workplace, etc.

Table 5. Eurostat and National Institute of Statistics (Romania) indicators used in study

Name of statistical indicator	Details	Code of statistical indicator	Source
Number of ICT graduates	SCL109H – Tertiary education graduates, by group of specializations, ownership type, macroregions, development regions and counties	ICT_GRAD	National Institute of Statistics – Romania (n.d.-a)
GDP per inhabitant in EUR per Romanian county	Gross domestic product (GDP) at current market prices by NUTS 3 regions	GDP_INH_EUR	Eurostat (n.d.-a)
Number of ICT employees	FOM105F – Employees at December 31 by economic activities at level of CANE Rev.2 (section and division), sex, macroregions, development regions and counties – J INFORMATION AND COMMUNICATION Employees	ICT_EMPLOYEES	National Institute of Statistics – Romania (n.d.-c)
Number of information service activities employees	FOM105F – Employees at December 31 by economic activities at level of CANE Rev.2 (section and division), sex, macroregions, development regions and counties – 62–63 Computer programming, consultancy and related activities; Information service activities	PC_INF_SERV_EMPLOYEES	National Institute of Statistics – Romania (n.d.-b)

Birth in Romania Eurostat (n.d.-d) is on a downward slope, from 20.2 million in 2013 to 19.03 million in 2022, together with the second emigration at the global level in the period, negatively impacts human capital in general, also the foundation for the human capital of ICT, and expats highly skilled in ICT are welcome to contribute to the Romanian economy. The inflow of ICT specialists is affected by these socioeconomic phenomena, natality, emigration, immigration.

The paper Antonescu et al. (2022) aims to estimate the relationship between GDP and two indicators specific to digitalization: e-Commerce and broadband Internet infrastructure and reveals that between 2010 and 2021, urban areas had a rate of 84.8% of the households having an internet connection, while rural areas had only 69.7%. Furthermore, the highest rate of households connected to the Internet was in the Bucharest-Ilfov region, with a rate of 78.5%. followed by the West with 67.8% and the North-West with 67%.

The paper used both qualitative and quantitative methods to estimate the statistical impact of the share of households using broadband Internet connection in total households at regional level and individuals shopping online in total population at regional level, both data being expressed as percentage. Conclusions of the paper show that the values of the coefficients in the fixed model equation are statistically significant and have a positive influence on GDP.

The research paper Bran et al. (2020) analyses the factors that contribute to the level of development of various areas and proposes different solutions and ideas to overcome these challenges. According to the article, solutions to the issue of underdeveloped areas involve developing programs and projects for local communities and small and medium enterprises to solve environmental degradation and unemployment problems, focusing more on local communities, and understanding the challenges they face from different standpoints, such as economic, financial, social, and technological.

Moreover, the article suggests that each locality, whether rural or urban, has its own characteristics that make it unique; therefore, strategies for developing it should be tailored to the problems inhabitants face.

The report The Adecco Group (2022) analyses various aspects of Romania from an investor point of view. Official data shows that 6% of GDP is generated by the ICT sector. In terms of European funding, the European Union offers funding according to several policies that focus on reducing regional discrepancies among member states.

The main five areas of focus are research and innovation, digital technologies, supporting the low-carbon economy, sustainable management of natural resources and small businesses. In terms of foreign direct investment, the ITC sector is 4.161 million euros, representing 4.1% of total foreign direct investment.

Of the total population of 19.3 million citizens, 5.1 million represent the number of employees, 4% of them active in the ICT sector. In terms of education, in Romania there are 198,295 students enrolled in secondary vocational schools, of which 16,769 study the dual education format, where schools partner with private companies to provide hands-on experience in their field of study. The percentage of students enrolled in domains of interest for our paper are 3% in the electrical sector, 2% in electromechanics, 2% in electronic automation, and 2% in informatics.

In addition, Romania has 84 higher education institutions that offer bachelor, master, and Ph.D. degrees. Of the total number of students enrolled in higher education, 3% study Informatics, 5% study Systems engineering, computers, and information technology, 5% study electrical, electronic, and telecommunications engineering, 8% study mechanical engineering, mechatronics, industrial engineering, and management, and 1% study mathematics.

The survey Organization for Economic Cooperation and Development (2022) offers a comprehensive analysis of economic developments in Romania, with chapters covering key economic challenges and policy recommendations that address these challenges. One of the challenges is represented by the labor shortage amplified by the COVID-19 crisis in different sectors. As stated in the report, the shortages were particularly large in labor intensive sectors and ICT was one of them.

Although the decrease in activity during the pandemic has eased tensions in some of the sectors involved, labor demand has remained strong in sectors such as construction and ICT. According to the report, the impact of the COVID-19 crisis on the composition of the labor market cannot be precisely measured, but there are likely to be some preexisting conditions and trends. Recruitment of ICT specialists is expected to grow as companies are still recovering and the digitalization of the economy is still in progress.

The report Wagner et al. (2022) provides an analysis of certain aspects of the Romanian society and economy. According to the report, the Romanian education system is struggling to raise its standards. One of the main issues of the education system in Romania is the lack of adequate funding. Furthermore, Covid-19 has brought to public attention the challenges faced by different categories of students in Romania.

Approximately 400,000 children in Romania do not attend school or complete compulsory education requirements, and the percentage of 15-year-olds who cannot read or write properly is as high as 44%. Although the funding for the education system is legally mandated at 6% of GDP, it now stands at only 3.4%.

Report Agenția pentru Dezvoltare Regională Sud-Est (n.d.) for the South-East Region 2021–2027) represents a strategy report that aims to raise the level of development in the South-East Romanian region. One of the points of interest relevant to our study is the IT & C Cluster in the Lower Danube (Clusterul IT & C Dunărea de Jos).

The cluster was established in 2015 and aims to sustainably develop its members and increase cooperation between research – development and innovation institutions (RDI) and enterprises. Some of the objectives of the group include capitalizing on the potential of ICT applications in both the public and private sectors.

Moreover, other strategies are represented by increasing the regional competitiveness in IT education, providing representation of the ITC environment before the state bodies, and identifying and promoting investment projects, as well as supporting entrepreneurship and small to medium sized enterprises in the ITC field in the region.

4. Statistical data

In our paper, we manipulated validated data from Eurostat and the National Institute of Statistics (Romania) for the period 2014–2020 divided by Romanian counties. We built the

database starting with the data available for (National Institute of Statistics – Romania, n.d. a) with the name of column (ICT_GRAD), then we completed the next columns (GDP_INH_EUR, ICT_EMPLOYEES, PC_INF_SERV_EMPLOYEES). From the Eurostat database we extracted the details on 'Gross domestic product (GDP) at current market prices by NUTS 3 regions' (Eurostat, 2023b) and built the GDP_INH_EUR indicator.

From the National Institute of Statistics (Romania), we consolidated the information related to indicators: "SCL109H – Tertiary education graduates, by group of specializations, ownership type, macroregions, development regions and counties" (National Institute of Statistics – Romania, n.d. a) and "FOM105F – Employees at December 31 by economic activities at level of CANE Rev.2 (section and division), sex, macroregions, development regions and counties – J INFORMATION AND COMMUNICATION (National Institute of Statistics – Romania, n.d.-c) and 62–63 Computer programming, consultancy and related activities; Information service activities (National Institute of Statistics – Romania, n.d.-b)".

For National Institute of Statistics – Romania (n.d.-a) there are no data for all administrative counties of Romania, due to the methodology used. The methodology used is described in the further guidelines: "Data for tertiary education are provided by the place (locality) of each faculty, also since 2012, data on graduates by specialization are broken down by macro regions, regions and counties" (National Institute of Statistics – Romania, n.d.-a).

In the built data set, there is a data limitation for Harghita county where we have data from the 2016–2020 years, and not like the rest of counties where we have data for period 2014–2020.

5. Results

To validate our research hypothesis, we have constructed the correlation matrix between the number of ICT graduates and the GDP per inhabitant in EUR per Romanian county, where we achieved a strong correlation, over 85% according to Table 6 and Figure 3.

Table 6. Correlation matrix for ICT_GRAD and GDP_INH_EUR indicators, authors' calculations

	ICT_GRAD	GDP_INH_EUR
ICT_GRAD	1	
GDP_INH_EUR	0.857733	1

For an exhaustive analysis of the above indicators, we represented them in Figure 3, drew the regression line and, with the regression equation, calculated the square value R = 0.7357. This calculated R values shows a strong correlation between the number of ICT graduates and the GDP per inhabitant.

Also, in Table 7 we exposed the is represented the summary output for the build regression, which was done for 159 observations, we can see R Square value = 0.7357, the coefficients for the regression model, intercept value = 7231.6 and ICT_GRAD value = 6.2488, etc.

Our approach continued with a very strong and expected correlation that we observed between the number of ICT graduates and the number of ICT employees, almost 95%, as per Table 8.

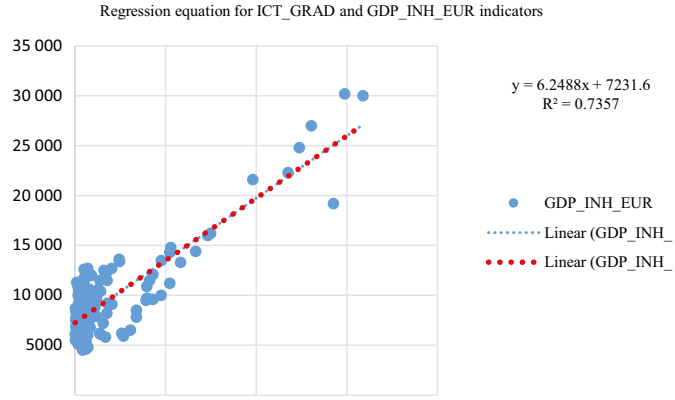

Figure 3. Scatter plot with ICT_GRAD and GDP_INH_EUR indicators (source: authors' own research results/contribution)

Table 7. Summary output for regression for ICT_GRAD and GDP_INH_EUR indicators, authors' calculations

Regression Statistics								
Multiple R	0.857733397							
R Square	0.73570658							
Adjusted R Square	0.734023183							
Standard Error	2199.35641							
Observations	159							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1	2114020376	2114020376	437.0367344	3.18236E-47			
Residual	157	759435472.9	4837168.617					
Total	158	2873455849						

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	7231.638696	200.7507555	36.02297126	8.49658E-78	6835.117979	7628.159413	6835.117979	7628.159413
ICT_GRAD	6.248831022	0.298909563	20.90542356	3.18236E-47	5.658428092	6.839233952	5.658428092	6.839233952

The visual representation of the indicators is very explanatory after applying the LOG function in Excel; an increase for the ICT_GRAD will produce in a similar proportion a raise for ICT_EMPLOYEES and vice versa, as per Figure 4. This shows that on the one hand, ICT programmes reach their intended goal of educating future workers in the field, coupled with a high degree of absorption in the market of said workers.

Table 8. Correlation matrix between ICT_GRAD and ICT_EMPLOYEES

	ICT_GRAD	ICT_EMPLOYEES
ICT_GRAD	1	
ICT_EMPLOYEES	0.948081005	1

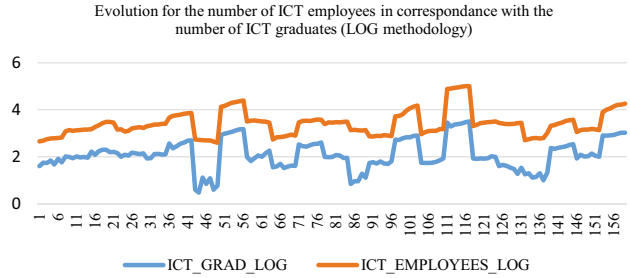

Figure 4. Correspondence for the number of ICT employees with the number of ICT graduates (source: authors' own research results/contribution)

The third and the last investigation from the current study had generated an expected very strong correlation between the number of ICT graduates and the number of information service activities employees, almost 98% as per Table 9.

Table 9. Correlation matrix between ICT_GRAD and PC_INF_SERV_EMPLOYEES

	ICT_GRAD	PC_INF_SERV_EMPLOYEES
ICT_GRAD	1	
PC_INF_SERV_EMPLOYEES	0.973895001	1

As a result of our study, we synthesised all the results (correlation matrix) by adding all the indicators in Table 10.

Table 10. Consolidated correlation matrix for all indicators

	ICT_GRAD	GDP_INH_EUR	ICT_EMPLOYEES	PC_INF_SERV_ EMPLOYEES
ICT_GRAD	1			
GDP_INH_EUR	0.857733397	1		
ICT_EMPLOYEES	0.948081005	0.873942889	1	
PC_INF_SERV_ EMPLOYEES	0.973895001	0.885578886	0.976649819	1

As per Figure 5, for Brașov ICT hub, there was an increase of 33% for ICT_GRAD in 7 years, and the GDP_INH_EUR increased by 47%. As per (Invest Romania, 2021) study, in 2019, 487 ICT students graduated, the average salary was 1168 EUR, Transylvania University being an important ICT educational actor, more than 7000 specialists worked for Elektrobit, Siemens, Tremend, Dell, EBS, etc.

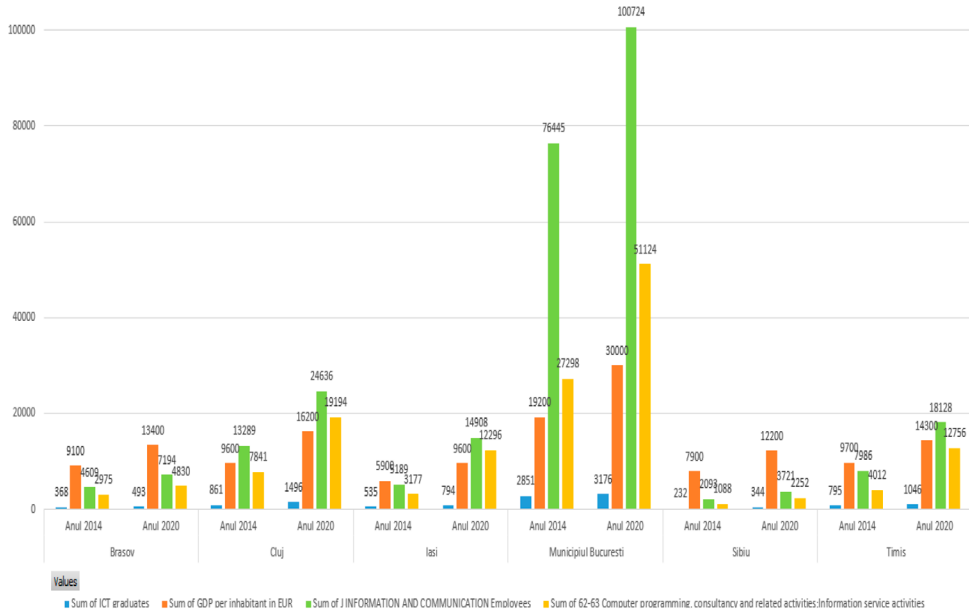

Figure 5. Summarized chart with the most important ICT Romanian hubs, period 2014–2020 (source: authors' own research results/contribution)

For the Cluj ICT hub, an increase of 73% was reported for the number of ICT graduates for the same period, and an increase of 68% was reported for the GDP per inhabitant. Same report mentioned 1464 ICT graduates in 2019, the average salary was 1599 EUR, the Babeș-Bolyai University, the Technical University of Cluj Napoca, over 24500 specialists activated for Genpact, Emerson, Bosch, Microsoft, Endava, Continental, etc.

For the Iași ICT hub, the number of ICT graduates increased by 48% and the GDP_INH_EUR indicator increased by 62%. Specialists prepared by the Alexandru Ioan Cuza University, the Technical University, the Gheorghe Asachi University worked for an average salary of 1191 EUR, in total, 14500 specialists from Amazon, Arobs, Continental, Oracle, etc.

For the Bucharest ICT hub, the most important ICT hub from the Southeast Europe region, the ICT_GRAD indicator increased by 11%, GDP_INH_EUR evolved at 56%, ICT_EMPLOYEES increased by 31%, and PC_INF_SERV_EMPLOYEES with 87% for the 2014–2020 period. In 2019 the average salary in ICT was 1461 EUR, the Bucharest University, the Polytechnic University of Bucharest, and the Bucharest University of Economic Sciences offered 2975 ICT specialists, which were integrated by the most important ICT players: Oracle, IBM, Microsoft, Google, Dell, Wipro, Endava, etc. In 2020, the milestone for the 100 000 ICT_EMPLOYEES indicator was reported to be greater than 100 000, 100 724, from 76 445 in 2014.

For Sibiu ICT hub, the ICT_GRAD raised with 48%, and the GDP_INH_EUR increased by 51%, and for Timișoara hub the ICT_GRAD raised with 31%, and the GDP_INH_EUR with 47%. For Timișoara ICT hub the consolidated data are represented by an average salary of 1426 EUR in 2019, where over 18 000 ICT employees activated for Continental, Hella, Alcatel-Lucent, Atos, Avaelgo, etc. The West University of Timișoara, the Politehnica University of Timișoara represented the most important educational hubs of ICT specialists.

As per CAEN (Classification of Activities in the National Economy) code 6201 (custom software development activities) (CoduriCaen.ro, 2024b) there are reported for 2021 fiscal year, 14580 companies, 88242 employees, and in the top 10 ICT companies we can enumerate in order the big players: Endava Romania (Cluj-Napoca), Ericsson Telecommunications Romania (Bucharest), Oracle Romania (Bucharest), Cognizant (Cluj-Napoca), Amazon (Iași), Oracle Global Services (Bucharest), Luxoft (Bucharest), ING Business (Bucharest), NTT Data (Cluj-Napoca), Ubisoft (Bucharest).

As per CAEN (Classification of Activities in the National Economy) code 6202 (consulting activities in information technology) (CoduriCaen.ro, 2024a) there are reported for 2021 fiscal year, 5644 companies, 17522 employees, and in the top 5 ICT companies we can enumerate in order the big players: IBM Romania (Bucharest), DB Global Technology (Bucharest), S & T Romania (Bucharest), Rasirom (Bucharest), Provision Software Division (Bucharest).

6. Practical implications

From a practical point of view, the results of our study can be used by Romanian authorities to refine their public policies related to the digital agenda, by encouraging, funding continuous long-lived learning of ICT skills within license, master, doctoral studies, or other stakeholders focused on developing basic or high ICT skills.

We obtained similar results, comparable to the studies mentioned above, and in a scientific way we proved the strong correlation between the number of ICT specialists and GDP growth. These results can constitute real arguments for the Ministry of Education to request a supplementary budget for the development of ICT infrastructure (modern ICT laboratories, Internet connection), training of ICT teachers, etc.

7. Conclusions

Even if on Digital Economy and Society Index (DESI) (2022) Romania is in the last place, and the ICT education can offer annually the same number of ICT graduates, due to the limited number of ICT teachers, we remarked that Romania profited by the evolution of ICT technologies, investment, and educational curriculum quickly adopted the latest trends.

The contribution of the field to GDP permanently evolved in 2014–2020 period (28%), the budget for education raised four and a half times, in combination with GDP growth, helped by government facilities, profit tax deduction, and the total return of these factors contributed to local and national growth.

We have noticed in our study a strong correlation, more than 85%, between the number of ICT graduates and the GDP per inhabitant in EUR per Romanian county. This is an expected result because ICT graduates are highly skilled persons, their technical skills are well paid by the ICT industry, and implicitly the GDP per inhabitant in EUR per Romanian county is influenced accordingly.

Similarly, we compiled a very strong and expected correlation for the number of ICT graduates and the number of ICT employees, almost 95%, and for the number of ICT graduates and the number of information service activities employees, almost 98%. These results

are expected, because ICT graduates are interested in continuing their journey in the same domain, highly paid, challenged from the professional point of view, and visionary for the future of workplace environments.

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Author contributions

Dimitrie-Daniel Plăcintă and Lorena Bătăgan realized the introduction. Corina-Marina Mirea, Lorena Bătăgan, Andrei Toma, and Florin Pantelimon contributed to the literature review. Andrei Toma reviewed the paper from a scientific point of view, and some aspects from data interpretation. Corina-Marina Mirea did the correction of the paper. The initial draft, introduction, data collection, data analysis, data interpretation, conclusions, references, and final paper document were implemented by Dimitrie-Daniel Plăcintă. All authors have read and agreed to the published version of the manuscript.

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Ministerul Educației. (2022). *Raport privind starea învățământului superior din România - Anexa 1. Distribuția numărului de programe de studii universitare de licență pe domenii de licență, pe forme de proprietate și pe total în anul universitar 2021-2022 | Anexa 2. Distribuția număr maxim de studenți care pot fi școlarizați în anul I la programele de studii de licență pe domenii de licență în anul universitar 2021-2022*. EDU.RO.

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