The relation between digitalization and regional development in Romania

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THE RELATION BETWEEN DIIGITALIZATION AND REGIONAL DEVELOPEMNT IN ROMANIA

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Abstract:

Digitalization is an essential element for the development of today's society, in the context of actual geo-political challenges. Moreover, the COVID-19 pandemic has accelerated the process of digitalization, offering new perspectives on sustainable and inclusive development. From the point of view of the regional approach, digitalization can have an important impact on the level of territorial development and on the reduction of economic and social inequalities. This paper proposes to identify the relationship between a series of indicators specific to digitization and regional GDP, with the help of panel models. The objective of the research is to estimate the relationship between GDP and two indicators specific to digitalization: online commerce and broadband internet infrastructure, the level of the eight development regions in Romania. Dependency modelling, based on econometric equations, offers the possibility of highlighting the way in which the two indicators of the digital economy contribute to the growth of GDP per capita. This analysis aims to illustrate the fact that broadband technologies and the increase in the number of people using the Internet for commercial purposes can have a positive impact on the growth of the regional economy. The results of the analysis highlighted the direct relationship of the indicators between the three variables related to the digitalization process at the level of Romania's regions and the strong influence of broadband internet and online trade on GDP per capita, proving that any growth among independent variables will lead to an increase amongst the dependent variables.

Key words: Digitalization, GDP, regional inequalities, Panel model, OLS model.

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1. INTRODUCTION

Digital transformation is a complex process that helps to increase the quality of life and make services more efficient without which the economy could not function. For the digital technology to remain relevant, it must be used and to create added value.

In the context of the emergence of different crises (COVID-19 pandemic, geopolitical, climate, etc.), digitalization appears as an absolute necessity, supported by an intense R&D-innovation process (R-D-I). The health crisis has made digitalization a priority for businesses, public authorities, regions, States and nations. Advanced digital technologies have been associated with survival during lockdown, with firms that have invested in this area more likely to stay afloat.

Given the increasing importance of digitalization in a global economy that puts pressure on different territorial levels, this article aims to analyze the relationship between regional GDP and a number of indicators specific to digitalization, using panel regression models, trying to provide a global picture of how it is understood and approached at Community level and in Romania.

In order to achieve the objective set out in this article, the literature on digitization was consulted and a database with specific data was set up/processed at the level of the eight development regions (NUTS 2) of Romania, taken from official EU sources (Eurostat). The data processing was carried out on the basis of econometric modeling, with the help of Eviews 9.5 software, which offers the opportunity to highlight how the selected indicators contributed to regional economic development.

2. LITERATURE REVIEW

At present, it can be said that there is no generally accepted definition of the concept of digital transformation, and terms such as digitalization, digital age or digital transformation are often used in an interchangeable way [1].

The digital transformation process involves the skills needed in order to use innovative new digital technologies to increase economic performance and improve/simplify people's lives. At the same time, quantifying the influence of digital technologies on economic development is one of the important concerns of scientific studies and analysis.

There is a direct relationship between digitalization and economic growth, analyzed in the literature and presented in Table 1.

Table 1. Digitalization - literature review.

Auhors	Year	Results
Andrey P. Hardy	1980	He analyzed the relationship between telephone services and economic development; the role of the telephone as a contributing agent to economic development has been investigated. The time series for 60 countries over a period of over 13 years were used to quantify how the phone contributed to economic development. Analysis of dynamics and cross-correlation techniques showed that the telephone has systematically contributed to economic development.
Gary Madden and Scott Savage	1998	The impact of investments in telecommunications infrastructure on economic growth has been assessed. The study's findings suggested that telecommunications infrastructure played an important role in economic development, with the causal link between nominal investment in telecommunications and GDP growth in

		both directions, which concluded that there was an interdependence between the two indicators.
Leonard Waverman and Kalyan Dasgupta	2005	Mobile telephony has been shown to have had a positive and significant impact on economic growth, especially in developing countries.
Herbert G. Thompson and Christopher Garbacz	2011	The Article builds the stochastic frontier based on the Cobb-Douglas production function, obtaining results related to the efficiency of using the digital potential in the analyzed countries.
Christine Zhen-Wei Qiang, Carlo Maria Rossotto and Kuniko Kimura	2009	The impact of fixed/mobile broadband on economic development was analyzed. Thus, it had been found an association between fixed broadband access and per capita GDP growth in both developed and developing countries.
Harald Gruber and Pantelis Koutroumpis	2010	The analysis was carried out for a group of 192 countries and revealed that investments in mobile telecommunications infrastructure have made a considerable contribution to economic growth and productivity.
Nina Czernich, Oliver Falck, Tobias Kretschmer and Ludger Woessmann	2011	The conclusions showed that a 10 percentage point increase in fixed broadband penetration results in annual GDP per capita growth of 0.9-1.5 percentage points.
Herbert G. Thompson and Christopher Garbacz	2011	There was a significant impact of mobile broadband on GDP per household based on the analysis of indicators in 43 countries between 2005 and 2009.
Neil Townsend and Chris Ahlfeldt	2017	Studies have shown that fixed broadband speed affected property prices in England between 2005-2010. It was found that disconnecting a common property from a first-generation high-speed broadband connection would depreciate its value by 2.8%.
A. Hikmaturokhman, K. Ramli, M. Suryanegara, A.A.P. Ratna, I.K. Rohman and M.A. Zaber	2022	The study shows a correlation between broadband speed and variables associated with quality of life. In addition, fixed broadband speed was found to be associated with better maths and English skills.
Harald Edquist	2022	Based on panel analysis of data from 116 countries between 2014 and 2019, the paper investigates the association between broadband internet speed and labor productivity. The authors identified a significant and robust relationship when a one-year gap is introduced for the series defining mobile broadband infrastructure. The interpretation of the results shows that a 10% increase in mobile broadband infrastructure in the period t-1 is associated with a 0.2% increase in labor productivity in the period t. The results are robust only for non-OECD and low-income countries.

Source: [2–9].

Internet connectivity has enabled businesses to access global markets, and through the openness of perspective it provides it helps to improve quality of life, working conditions, especially for small businesses and rural or marginalized communities.

Connectivity also plays an important role in increasing interest in investing or innovating complementary hardware and software technologies. The World Bank's digitalization Index shows that a 10 percentage point increase in its value has a 3% increase in the GDP ratio. This aspect is also supported by an analysis of 75 countries, which, on a subsequent update, showed that a 1% increase in fixed broadband penetration results in a 0.08% increase in GDP, while for the penetration of mobile broadband connectivity, a 1% increase translates into a 0.15% increase in GDP [10–12].

The analysis of the positive economic implications of online commerce clearly shows that there are a number of economic benefits: Increased efficiency, reduced costs (costs related to the search, administration and/or distribution of goods and services), price differences, etc. [13,14].

3. STUDY AREA – A BRIF ANALYSIS

In Romania, development regions are "areas which correspond to county groups, established by their voluntary association based on agreement signed by the representatives of county councils, as well as by those of the General Council of Bucharest; regions represent the framework of design, implementation and evaluation of regional development policies, as well as collection of specific statistical data, in accordance with European regulations issued by Eurostat for the second territorial classification level, NUTS II, existing within the EU" [15].

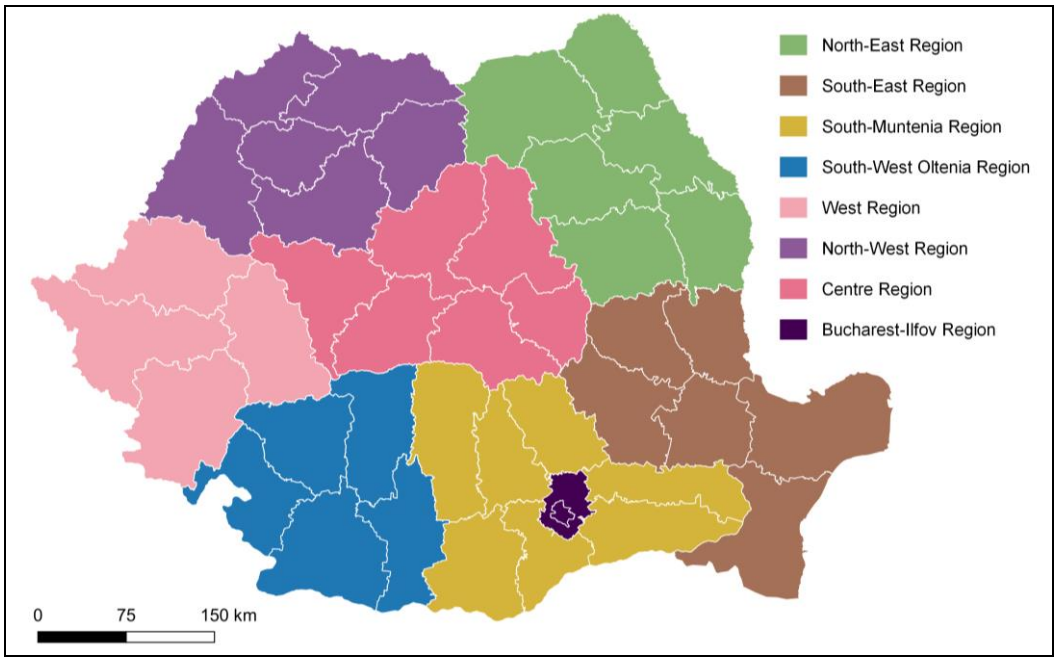

Figure 1. The development regions of Romania.
Source: Marin V.A., 2022

The regional policy in Romania is implemented by development regions, made up of counties formed by voluntary association based on a convention signed by the representatives of the county councils and of the General Council of the Bucharest Municipality, respectively.

The context of analysing is represented by the eight development regions (statistical regions) created after the accession to the European Union (in 2007). These regions were established considering the potential functional integration criterion around some polarising centres (Iasi, Timisoara, Craiova, etc.), corresponding to the NUTS 2 system of the European

Union. On setting-up the regions other criteria were taken into account as well, such as: resource complementarity, economic and social activities, functional links, etc. The eight development regions created in accordance with the Regional Development Law no. 151/1998 (amended by Law no. 315/2004). These regions were created taking into account the potential functional integration criterion, around some polarizing centers (Iasi, Timisoara, Craiova, etc.), having correspondence with NUTS 2 system of the European Union. When creating regions, it was also considered other criteria such as: criterion of complimentarily of resources, of economic and social activity, functional connection, etc.

The eight development regions created according to Regional Development Law no. 151/1998 (amended by Law 315/2004) are the following (Table 2).

Table 2. Development regions in Romania Eurostat Code.

Eurostate Code	Regions NUTS 2	Counties
RO11	North-West	Bihor, Bistriţa-Năsăud, Cluj, Maramureş, Sălaj, Satu-Mare
RO12	Center	Alba, Sibiu, Braşov, Covasna, Harghita, Mureş
RO21	North-East	Bacău, Botoşani, Iaşi, Neamţ, Suceava, Vaslui
RO22	South-East	Brăila, Buzău, Constanţa, Galaţi, Tulcea, Vrancea
RO31	South Muntenia	Argeş, Călăraşi, Dâmboviţa, Giurgiu, Ialomiţa, Prahova, Teleorman
RO32	Bucharest-Ilfov	Bucharest, Ilfov
RO41	South-West Oltenia	Dolj, Gorj, Mehedinţi, Olt, Vâlcea
RO42	West	Arad, Caraş-Severin, Hunedoara, Timiş

Source: Eurostat.

For next, we use the regional GDP (per capita) for the regional analysis regardin to the territorial development level. This indicator representing the basic criterion to establish both the contribution of the member-state to the community budget, and also the level of allocations from structural funds (the average GDP/capita, computed for a period of three years represents the criteria for establishing the eligible regions). In 2020, at regional level, the average value of GDP per capita were 21,937.5 euro/capita, 44.44% higher compared to 2014, but decreasing compared to 2019 (-1.07%) (Table 3).

Table 3. Dynamics of average GDP per capita at regional level, 2014-2021 (euro per capita).

	2014	2015	2016	2017	2018	2019	2020
GDP per capita	15,187.9	15,987.5	17,312.5	19,125	20,362.5	22,175	21,937.5

Source: Own processing.

The analysis by regions showed a maximum value of GDP per capita in the Bucharest-Ilfov region, of 49,200 euro per capita, and a minimum in the North-East region, of 13,600 euro per capita. In evolution, the largest increase was recorded by the South Muntenia region (+58.5%), followed by the North-West (+52.7%) and the North-East (+49.5%) (Table 4).

Table 4. Evolution of GDP per capita at regional level, 2010-2021 (euro per capita).

Regions / Years	North-West	Center	North - East	South - East	South Muntenia	Bucharest - Ilfov	South-West Oltenia	West
2010	10,900	11,400	7,400	9,700	10,300	28,000	9,100	13,200
2011	11,000	11,800	7,500	9,900	9,900	28,800	9,300	13,700
2012	10,800	11,800	7,300	10,600	10,800	31,500	9,100	13,900
2013	12,200	13,400	8,800	12,000	10,700	32,700	10,600	14,800
2014	12,300	13,400	8,900	12,800	11,200	33,500	10,600	14,900
2015	13,100	13,700	9,100	13,300	12,500	34,200	10,600	15,000
2016	13,600	14,500	9,500	13,300	12,300	37,300	11,300	16,100
2017	15,200	16,000	10,300	14,100	13,500	39,400	12,100	17,900
2018	17,400	17,700	11,700	15,400	14,400	43,200	13,900	19,300
2019	18,300	19,000	12,500	16,500	15,500	45,300	15,400	20,400
2020	20,200	20,400	13,600	17,300	16,500	50,100	16,900	22,400
2021	20,000	20,100	*13,600*	17,200	16,400	*49,200*	16,800	22,200

Source: Own processing.

The development differences between regions are relatively large, with the coefficient of variation reaching 0.517%, when taking into account the Bucharest-Ilfov region (Table 5). In the situation without the Bucharest-Ilfov region, this coefficient is 0.160% (relatively constant in the analyzed period).

Table 5. Dynamics of Variation Coefficient - GDP per capita at regional level, 2014-2020 (%).

	2014	2015	2016	2017	2018	2019	2020
Var_Coeff_With Bucharest-Ilfov Region	0.520	0.553	0.533	0.524	0.509	0.524	0.517
Var_Coeff_Without Bucharest-Ilfov Region	0.160	0.167	0.178	0.166	0.158	0.163	0.160

Source: Own processing.

As result of analysing GDP/capita evolution a trend is given by more marked disparities between the eight regions NUTS-2, as result of increased economic concentration in areas regarded as attractive by population or investors, areas that can ensure a better living standard and activities with higher profitability.

Another important aspect analysed is the demographic one. Several times, the existence of a numerous population in a region can be an advantage, provided that it has the competences and skills necessary to an advanced society. In the period 2014–2021, the variation of the population at the level of the eight development regions registered a decreasing trend for 6 regions and increase for two regions (North-East and Bucharest-Ilfov). The region South-East recorded a minimum rate (-6.47%) population, while the maximum growth was registered in the capital of country, Bucharest-Ilfov region (+6.81%) (Table 6).

Table 6. Dynamics of Variation Coefficient – Legally Resident Population at regional level, 2014-2021 (no, %).

Regions	2014	2021	2021 vs. 2014 (%)
North-West	2,837,677	2,807,762	-1.05
Center	2,638,500	2,602,817	-1.35
North-East	*3,908,257*	*3,988,412*	+2.05
South-East	2,892,498	2,756,531	-4.70
South Muntenia	*3,289,404*	*3,076,503*	-6.47
Bucharest-Ilfov	2,481,789	2,650,691	+6.81
South-West Oltenia	2,228,738	2,092,212	-6.13
West	2,022,867	1,967,793	-2.72

Source: Own processing.

With respect to classifying a region within the NUTS-2 category, the limits are given by the numbers of population: between 800,000 and 3 million inhabitants. These limits are not complied with and compliance failure occurred already on their set up in the year 1998 by all development regions from Romania which have values over the maximum one established by the EU. The regions with a population of over three million inhabitants (1998) were North-East (3.7 milion inhabitants) and South Muntenia (3.2 million inhabitants). Now, these regions register 3.99 milion inhabitants, respectively 3.1 milion inhabitants. Otherwise, the two regions and in particular the North-East region are on the last positions within the EU-27 in relation to GDP dimension.

Another important field taken into account on analysing of study area is the labour force employed population growth was negative for all regions (exception Bucharest-Ilfov), the maxim value was registerd in South Muntenia region (-13.8%) and minimum in Center region (-7%) (Table 7).

Table 7. Civil employment population at regional level (thous. Inhabitants).

Regions	2016	2017	2018	2019	2020	2021	2021 vs. 2016 (%)
North-West	1,168	1,179.8	1,182.6	1,193.1	1,187.4	1,065	-8.8
Center	1,036.2	1,045	1,051.8	1,055.9	1,048.4	963.9	-7.0
North-East	1,116.1	1,124.1	1,134.8	1,143.9	1,136,7	965.3	-13.5
South-East	9,45.2	949.6	949.4	956.2	947.8	837.4	-11.4
South-Muntenia	1,095.9	1,101.8	1,107.6	1,109	1,100.1	945.0	-13.8
Bucharest-Ilfov	1,360.3	1,368.7	1,373.1	1,425	1,420.9	1,416.6	4.1
South-West Oltenia	761.3	767.3	778.3	782.9	780.1	657.6	-13.6
West	834.6	830.5	829.9	826.6	819.4	749.4	-10.2

Source: Own processing.

The regional innovation degree characterized by the number of innovative enterprises is also in favour of the Bucharest-Ilfov region, which has a share of 43.03% from total 2,900 enterprise (2020), the last place being held by the region South-West Oltenia with only 2.3% from total. With respect to the regional evolutions, we presented the following conclusions: Bucharest-Ilfov region registered 10.54% on increase in 2020 as compared with the year 2014. Another regions registered decresee in number of innovative enetrprises: in South-East by about -82.32%; South Muntenia region 52.12% decrease as compared with the year 2014; the region with the lowest degree is the West region, -6.29% (Table 8).

Table 8. Innovative enterprises (no., %).

Regions	2014	2016	2018	2020	2020 vs. 2014 (%)	% of total (2020)
North-West	401	592	940	386	-3.74	13.3
Center	463	280	429	409	-11.66	14.1
North-East	444	424	436	357	-19.59	12.3
South-East	560	508	313	99	-82.32	3.4
South Muntenia	353	132	201	169	-52.12	5.8
Bucharest-Ilfov	1,129	714	1,691	1,248	10.54	43.0
South-West Oltenia	120	57	81	68	-43.33	2.3
West	175	218	107	164	-6.29	5.7
Total	3,645	2,925	4,198	2,900	-20.44	100.0

Source: Own processing.

4. DIGITALIZATION IN THE EUROPEAN UNION AND IN ROMANIA

4.1. Digitalization in EU-27

At the European Union level, digital transformation is one of the Community priorities opening up new opportunities for business and consumers, new horizons for networking with other economic areas worldwide, supporting the green transition and climate neutrality by 2050.

There is a specific policy addressed directly to digitalization, which funds actions and measures that support the acquisition of digital skills and training based on the digitization of services (public or private), while respecting the fundamental rights and values of its citizens. At the same time, the report on shaping *Europe's digital future* (2021) supports the integration of digital technologies in private companies and the implementation of digital services in public administrations, with a direct impact on quality of life [16].

Digital platforms, the Internet, cloud computing and artificial intelligence are among the technologies that influence many sectors, such as financial services, transport, energy, agri-food, telecommunications, industrial production, health, etc. Technologies can optimize production, help reduce greenhouse gas emissions and waste, increase competitive advantages and bring new services and products to the market.

Digitalization is a cross-cutting field, playing a key role in almost all EU policies, and the health crisis has emphasized its importance. Digital solutions have provided important opportunities, becoming essential in ensuring Europe's recovery and regaining a competitive position in the global economy. Programs supporting investment, such as Horizon Europe (Research and Innovation) or the Connecting Europe Program (infrastructure), allocate considerable funds to digitization (Table 9).

Table 9. European Union Programs with a Digital component.

Program	Description
Digital Europe Program	Investments: €7.6 billion funds are allocated for: supercomputer production (€2.2 billion), artificial intelligence (€2.1 billion), cybersecurity (€1.6 billion), advanced digital skills (€577 million), use of digital technologies in society and the economy (€1.1 billion).
Online platform creation program	offers significant opportunities for markets, which are important communication channels
Cyber Security Program	Cybersecurity is becoming important for consumer online safety. In 2021, the Directive was adopted to ensure a high level of cybersecurity at EU level, and Parliament recently adopted rules for the new European

Program	Description
	Cybersecurity Center and the fight against the dissemination of terrorist content online.
Artificial Intelligence (AI)	Specific legislation must create a framework for action that inspires trust, introduces ethical standards, supports job creation, helps build competitive "AI made in Europe", and also influences the global standards.
Digital skills and Education Program	Aims to bridge the gap in IT knowledge and support the need for digital education.
Fair taxation of the digital economy	A global minimum tax rate and new tax rules are advancing to ensure fair taxation where surplus value is created through digital processes.

Source: [17].

The Recovery and Resilience Facility has been launched at EU level, which supports individual Member States' recovery plans (NRPs).

The Recovery and Resilience Mechanism is the main pillar of the NextGenerationEU program, with €723.8 billion in loans and grants available to support reforms and investments by EU countries. The aim of this mechanism is to support investments and key reforms in order to achieve sustainable recovery and to improve the economic and social resilience of EU Member States [18].

At the end of the investment period in 2027, European economies and societies will be better prepared for the challenges and opportunities resulting from green and digital transitions.

In the recovery mechanism, digitalization has an important place. In 2021, the European Commission presents the vision and prospects for Europe's digital transformation by 2030 with the so-called "compass for the digital dimension", which focuses on:

1. skills (increasing number of ICT specialists, increasing share of the population with digital skills, etc.);
2. digital transformation of enterprises (increasing the share of EU enterprises using cloud computing /AI/big data, increasing innovation, etc.);
3. digitalization of public services;
4. digital transition focused on the citizen.

In order to achieve the digital targets and objectives, the launch of large-scale multinational projects that no Member State could develop on its own will be accelerated and facilitated. These projects combine investments from the EU budget, including the Recovery and Resilience Mechanism, with those from the private sector. We mention here: Data infrastructure, low-power processors, 5G communications, high-performance computing, secure quantum communications, public administration, blockchain technology, digital innovation centers and digital skills. It is noted that for digital transformation, about 24.17% is allocated to the first pillar and 4.67% to the second [17] (Table 10).

Table 10. Analysis of digitalization in the context of the EU-27 Recovery and Resilience Facility.

Pillar	First pillar	Second pillar	Total
Green Transition	38.22%	11.67%	49.89%
Digital Transformation	24.17%	4.67%	28.84%
Smart growth, sustainable and inclusive	13.53%	35.92%	49.45%
Social and Territorial Cohesion	9.90%	33.07%	42.97%
Health	6.74%	10.61%	17.35%
Policy for the next generation	7.44%	4.06%	11.50%

Sursa: [17].

Moreover, the European Union promotes the people-centered *Digital Agenda*, guaranteeing the security and resilience of digital supply chains, based on viable solutions.

The Digital Agenda will be implemented through regulatory cooperation, capacity and skills building, investments in international cooperation and research partnerships. Investments in the digital economy bring together Member States, private companies, and other partners who share the same vision of digitalization. Potential areas of partnership are: Wi-Fi networks, 6G networks, quantum technologies, the use of technologies to combat climate change and environmental issues, etc. [17].

4.2. Digitalisation in Romania

In 2021, according to Eurostat data, Romania ranks 27 within the European Union in terms of the Digital economy and society Index (DESI) and the digitalization of public services (interaction with public authorities, obtaining information from public authorities' websites, downloading official forms, submitting completed forms, etc.) [18].

In terms of human capital in the field of digitalization, Romania ranks 26, obtaining a below average score on most indicators. Although Romania has a large number of ICT graduates (ranking 4 in this respect), the shortage of ICT specialists limits the country's ability to innovate and take advantage of the benefits of digital transformation [18].

As for the number of female ICT people, Romania ranks 3, and in terms of connectivity, some progress was made in 2021 in terms of fixed broadband coverage. However, the adoption of broadband has progressed at a slow pace. Romania ranks seventh in the EU regarding broadband internet use (at least 100 Mbps) [18]. Around 30-31% of people aged 16 to 74 have basic digital skills, below the EU average (56% in 2021) [18].

As for ICT specialists, Romania holds about half of the EU-27 average, namely 2.2% (2019), 2.3% (2020) and 2.4% (2021), compared to the EU-27 average of 4.3% (2021).

At institutional level, the Authority for the Digitalization of Romania (ADR) was established in 2020, being subordinated to the Ministry of Research, Innovation and Digitalization.

For the period 2021-2030, the Romanian Government has allocated EUR 100 [19].

The NRRP targets 64 reforms, 107 investments, 500 milestones and has an EU funding of 29.1 billion euros (14.2 billion euros in non-reimbursable funds and 14.9 billion euros in loans) [19].

The financial allocations through NRPP are as follows [19].

- 57.17% for the "green energy transition" (eliminating coal from energy production by 2032, reducing carbon emissions, subsidizing zero-emission vehicles, increasing energy efficiency in buildings).
- 20.64% for the digitalization of public administration (including id cards) and business environment, healthcare, education, improving connectivity and cyber security.

Within NRRP, the digitalization of enterprises plays an important role, being considered an important factor in increasing the competitiveness and innovation potential of both SMEs and large enterprises. The proposed investments in digitalization will support the digitalization of small and medium-sized enterprises and public administration, including citizens, subsequently contributing to increased competitiveness, fostering innovation in some areas and facilitating new working arrangements [19].

5. DIGITALIZATION AT REGIONAL LEVEL IN ROMANIA

5.1. Broadband infrastructure

Relevant data presented by a study developed by ANCOM (National Authority for Management and Regulation in Communications) shows that in Romania, there were 5.7 million fixed internet connections at the end of 2020 (+8% annual evolution), of which 4.5 million (80%) were very high-speed connections (over 100 Mbps) [18].

Driven by the health crisis, total fixed internet traffic recorded an exceptional growth in 2020 (+51%), with the average monthly fixed internet traffic per capita of 44 GB/month. Mobile internet traffic grew by 30%, lower than in previous years.

At the national level, on average, 7 in 10 households have a fixed internet connection, meaning 8 in 10 households in urban areas and 6 in 10 households in rural areas. This gap decreased during 2020, the growth rate of the number of connections in rural areas (+16%) being much higher than that in urban areas (+4%).

At the end of 2020 there were 20.4 million active mobile internet connections (+3%), two-thirds (13.6 million) being 4G or 5G connections (+13%), and the total mobile internet traffic increased by 30% compared to 2019, so the average traffic reached 4.9 GB/month/inhabitant.

Between 2010 and 2021, over three quarters of Romanian households (78.2%) had access to the home internet network (Figure 2). In urban areas, 84.8% of the households are connected to the internet, and in rural areas, 69.7% of the households.

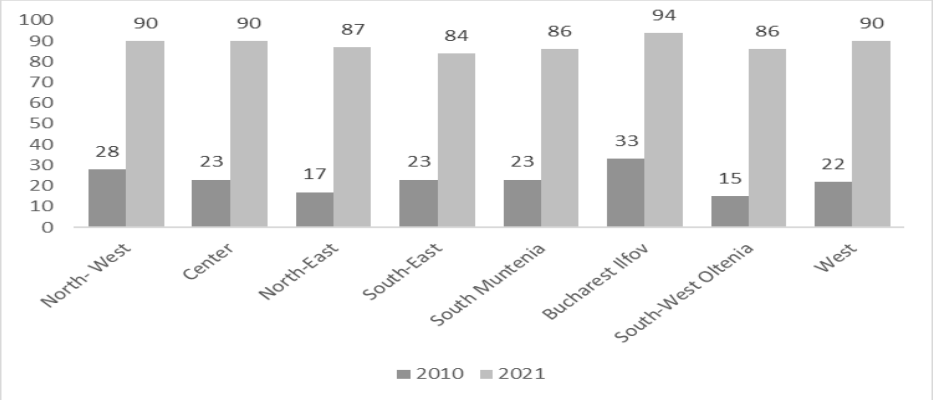

Figure 2. Comparison between the year 2010 and 2021 for the broadband infrastructure by development regions in Romania (% in total housing).
Source: Authors computations from Eurostat data.

At regional level, internet connection was more widespread among households in the Bucharest-Ilfov region (78.5% of the population), followed by the West (67.8%) and North-West (67%) regions. Regarding broadband internet connection, the situation at regional level is as follows: South-West Oltenia 61%, Center 60.8% and South 60.3%. The lowest shares are recorded by the South-East (59.8%) and North-East (55.8%) regions.

The types of connections used to access the internet from home are 77.5% in favor of fixed broadband connections (fixed broadband connections), followed by mobile broadband connections (66.3%) and narrowband connections (13.6%).

Table 11. Broadband infrastructure by development regions in Romania in the period 2010-2021
(% in total housing).

Regions	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
North-West	28	31	51	61	60	70	72	80	87	85	89	90
Center	23	28	46	52	53	65	67	68	76	80	82	90
North-East	17	17	41	47	51	57	62	68	69	77	77	87
South-East	23	25	52	56	57	57	67	71	69	77	79	84
South Muntenia	23	35	48	50	51	61	65	70	74	79	82	86
Bucharest-Ilfov	33	54	71	78	79	80	88	88	94	91	92	94

South-West Oltenia	15	31	48	53	52	62	71	69	80	83	82	86
West	22	30	53	61	63	75	74	85	85	87	89	90

Source: Authors computations from Eurostat data.

The share of households in total households with access to broadband internet is shown in table 6. It can be seen that all regions have increased the value of this indicator, with a tendency to reduce territorial inequalities (Table 11, Figure 2).

5.2. E-commerce

Amid the slowdown in physical operational processes registered by companies during the COVID-19 pandemic, there has been a significant increase in online commerce [18]. Moreover, the Internet, along with advances in information technology and logistics/delivery, has allowed companies to rethink their business in a way that can continue their business efficiently.

Through online commerce, companies have been able to operate anywhere and anytime, eliminating multiple barriers. Also, many companies have implemented mixed sales systems, thus obtaining the anticipated results. During the COVID-19 pandemic period, there were changes in management approached by companies, many of them targeting distribution channels. As a result, companies have implemented their own promotional sites, thus expanding their activities to a higher level of coverage.

In 2020, Romania became the EU leader in terms of the growth rate of online commerce (45% of Romanian internet users bought online) [18].

The e-commerce market in 2020 reached EUR 5.6 billion and registered an annual growth of 30%, in the context of the COVID-19 pandemic and the previous modest performance of this sector compared to the situation of online commerce in other countries.

The e-commerce market in Romania was estimated at 6.2 billion euros in 2021, with local sales accounting for half of the total achieved in Eastern Europe [18].

The analysis of the online commerce indicator by development regions in Romania in 2021 shows that the first places are occupied by the most developed regions, namely: Bucharest-Ilfov with 58%, Center with 43%, West with 41% and North-West with 37% (Table 12).

Table 12. Online commerce in Romania's development regions during 2010-2021 period (%).

Regions	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
North-West	2	4	5	9	9	14	16	16	23	29	40	37
Center	5	8	6	7	7	9	11	17	18	27	39	43
North-East	3	5	7	7	7	9	9	16	17	18	32	33
South-East	3	3	4	4	8	7	10	11	16	19	30	31
South Muntenia	2	4	5	6	7	11	10	15	18	20	32	33
Bucharest Ilfov	8	14	10	20	25	19	19	22	36	31	56	58
South-West Oltenia	3	6	1	10	8	9	12	15	14	22	36	35
West	4	3	3	7	11	8	8	17	15	23	39	41

Source: Authors computation on Eurostat data.

6. METHODOLOGY

The research methodology used in this article was mixed being used both quantitative and qualitative methods in order to to estimate the statistical impact of share of households using broadband infrastructure in total households at regional level (%) and individual persons shopping online in total population at regional level (%) on the GDP per capita (euro/inhabitant) indicator, at the level of development regions (NUTS 2) in Romania, using data available at Eurostat for the period 2010-2021.

The quantitative method involved identifying and selecting this specific indicators and running a panel analysis on them by using EViews 9.5 , thus comparing the OLS method, OLS with fixed effect and OLS with random effects using AIC (Akaike information criterion measuring the quality of the econometric model), R^2 (a statistical measure representing the proportion of the dependent variable variance in our case, which is explained by independent variables in the regression model), RMSE (Average Square Error Root, a measure of differences between sample or population values predicted by a model or estimator and observed values), Hausman test in order to selecting the optimal model and discussing the results. Once the best method was established, we made an analysis of the regional heterogeneity.

7. RESULTS AND DISCUSSIONS

In order to achieve the targets proposed for the econometric analysis GDP per capita was chosen as the dependent variable, and online commerce and broadband infrastructure as the independent variables.

The term "panel data" refers to the pooling of observations on a cross-section of households, countries, firms, etc., over several time periods" [14]. This can be achieved by surveying a number of households or individuals just like in the analysis made in this article and following them over time.

The model set out below is a particular form shown in Equation 1, adapted to the objective of this article:

$$GDP\_PER\_CAPITA = a_1*BROADBAND + a_2*ONLINE\_COMMERCE + c + \varepsilon_i \quad (1)$$

where:

a_1, a_2 = coefficients of the independent variables;

c = the constant of the regression equation;

ε_i = residual variable;

i = 2010, ..., 2021.

7.1. OLS model

By applying the OLS model, we can explain the dependency of GDP per capita on important factors of the digital economy (broadband internet infrastructure and online commerce). Moreover, the validity of the model was demonstrated by the prob(f-statistic) which was 0.0000. The value of R-square was 0.421127. The attached probability of the broadband was of 0.2421 above the 5% threshold and of the online commerce of 0.0001 below it which indicates that the model does not explain the relationship between variables well, and we will explore two other methods: panel with random effects and panel with fixed effects. The attached coefficients for the OLS method can be observed in Equation 2.

$$GDP\_PER\_CAPITA = 64.00942*BROADBAND + 377.7075*ONLINE\_COMMERCE + 6485.240 + \varepsilon_i \quad (2)$$

7.2. Panel model with random effects

In the case of the ols model with random effects, the online commerce has a positive effect on the GDP per capita (t-statistic=11.24878>3 and prob=0.0000), proving a direct and positive relationship between those two variables. Thus, from the model and from equation 3 it is shown that a 1% increase in online commerce leads to an increase in GDP per capita by 247.13 euros.

The final Equation (3) of this method is:

GDP_PER_CAPITA = 32.5671650702*BROADBAND + 247.134798226*ONLINE_COMMERCE + 10589.9047142 (3)

The other independent variable has also a direct and positive relationship with the dependent variable (t-statistic=2.527939>2 and prob=0.0000), as shown from the equation with the increase of 1% in broadband infrastructure, the GDP per capita will increase with 32.567 euros. The constant is also significant as its attached probability is p=0.0000<0.05. R^2 is 0.761754, almost double than in the previous applied method.

But in order to see if this type of panel model with random effect is appropriate or not and that a fixed effect would be better it is needed for the Hausman test to be used. The hypothesis used in order to test are: H0: the panel model with random effects is adequate and H1: the panel model with fixed effects is adequate. According to the attached probability of the Chi-Square of 46.8740 is 0.0000 so we will accept the second hyphotesis, namely H1.

7.3. Panel model with fixed effects

According to this model there can be observed a positive and direct relationship between the online commerce and GDP per capita (a 1% increase in online commerce will lead to an increase of 192.76 euro/inhabitant) and broadband and GDP per capita (a 1% increase in the broadband infrastructure will lead to an increase of 39.04 euros/inhabitant).

As shown by the R^2, which is 0.96, the influence of the independent variables upon the dependent one is very high. The attached probabilities of all the coefficients are 0.0000, showing that they are significant for the 5% threshold. Furthermore, the Prob(F-statistic)=0.0000 proves the validity and the F-statistic test 259,2516>0, the significance of the model.

The final equation of the panel model with fixed effects is shown below:

GDP_PER_CAPITA = 39.0437564071*BROADBAND + 192.762233534*ONLINE_COMMERCE + 11048.9379175 (4)

This model shows a conclusive picture of the influence of indicators in the implementation of digitalization at regional level. The results of the analysis highlighted the direct relationship of the indicators between the three variables related to the digitalization process at the level of Romania's regions and the strong influence of broadband internet and online trade on GDP per capita, proving that any growth among independent variables will lead to an increase amongst the dependent variables.

7.4. The regional heterogenity

By applying the fixed effects model, we can determine the regional heterogeneity for the eight regions of Romania by computing the longitudinal effects and their regression equations taking into consideration that the slope is the same. By replacing the constant term in equation there have been obtained the following equation for every region:

GDP_PER_CAPITA (B-I) = 29594 + 39.04376*BROADBAND + 192.7622*ONLINE_COMMERCE

GDP_PER_CAPITA (W) = 11459 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

GDP_PER_CAPITA (C) = 9727 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

GDP_PER_CAPITA (S-E) = 8830 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

GDP_PER_CAPITA (N-W) = 8.690 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

GDP_PER_CAPITA (S) = 7859 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

GDP_PER_CAPITA (S-W) = 7013 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

GDP_PER_CAPITA (N-E) = 5218 + 39.04376* BROADBAND + 192.7622* ONLINE_COMMERCE

As it is shown from the equations on the first place there is situated the Bucharest-Ilfov region with a constant term of 29,594 euro/capita followed by the West region with 11,459 euro/capita, Center region with 9,727 euro/capita, South-East (8,830 euro/capita), North-West (8,690 euro/capita), South Muntenia (7,859 euro/capita), South-West Oltenia (7,013 euro/capita) and on the last the North-East region with 5,218 euro/capita.

The results are as expected especially because of the Bucharest-Ilfov region which is the most developed region of the country and also contains the capital of Romania and the West region which during 2000-2007 has registered the fastest growth amongst all the other regions.

In Equation 4 if both of the independent variables would be null, then the resulted value of GDP/capita would be 11,048.94 euro/capita. The highest value for the GDP/capita would be of Bucharest-Ilfov Region with 29,594 euro/capita and the lowest of 5,218 euro/capita would be the one of North-East region (Figure 3). Comparing the obtained results with the constant term of the fourth equation it is shown that the Bucharest-Ilfov region has a value of 2.6 higher than the average of the eight regions, followed by the West region with a value of 1.03 higher. All the other regions are below average.

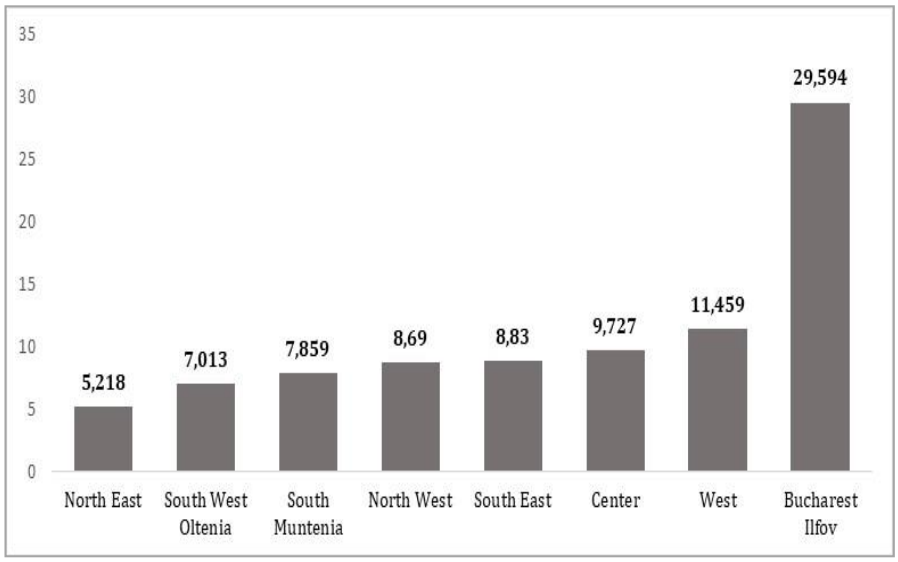

Figure 3. Free term (euro per capita)
Source: Authors computations.

The variance coefficient has a value of 69.84% showing a high etherogenity at national level but if we eliminate the Bucharest-Ilfov region this would decrease to 23.7%. This proves the fact that amongst the regions of Romania there is maintained a relatively reduced inequality, the situation changing when the Bucharest-Ilfov region is taking into consideration.

8. POLICY IMPLICATION FROM REGIONAL POLICY PERSPECTIVE

The regional development concept of Romania (adopted in the year 1999) is the basis of the National Regional Development Strategy and of the strategies at territorial level and pursues: diminishing regional disparities, stimulating balanced development, reviving disfavoured areas, correlating regional development with the sectoral one, and cooperation between regions. These objectives are found again in the Regional Operational Programme financed both by Structural Funds and national funds, and they are based on the strategic development priorities [20,21].

In accordance with these objectives, the general principles at national and local level were outlined (promoting market economy mechanisms at regional level, improving competitiveness and realising sustained economic growth, promoting harmonious development in the territory), to which we can add the principles of the EU Structural Funds and cohesion policy (subsidiarity, programming, partnership, additionality, co-financing, concentration, monitoring and evaluation) [22].

In present programming period, EU regional policy works to make a difference in 5 key areas:

- investing in people by supporting access to employment, education and social inclusion opportunities;
- supporting the development of small and medium size businesses;
- strengthening research & innovation through investment and research-related jobs;
- improving the environment through major investment projects;
- modernising transport and energy production to fight against climate change, with a focus on renewable energy and innovative transport infrastructure.

Romania will receive a total of €31.5 billion from Cohesion Policy in 2021-2027 in the framework of its Partnership Agreement with the Commission to promote the economic, social and territorial cohesion of its regions and its green and digital transition. The EU funds will also support the development of a competitive, innovative and export-oriented Romanian economy.

For the current programming period, the European Union has allocated to the cohesion policy €4.33 billion from the European Regional and Development Fund (ERDF) that will support Romania's innovative and smart economic transformation. Funds will increase the competitiveness of small and medium-sized enterprises (SMEs), and support research and innovation, in particular through business-academia collaboration. Innovative enterprises and innovative activities in traditional SMEs will also be supported.

The EU will also invest in the digitalisation of companies and the development of innovative digital public services. The digital skills of the population, particularly students and teachers, will also be improved [23].

9. CONCLUSIONS

Digitalization is an essential element for the current structure of society, given the COVID-19 pandemic and geopolitical challenges. From the point of view of the regional approach, digitalization has an important impact on the level of territorial development and on reducing economic and social inequalities.

At European level, it can be said that the digital economy and society are in a high dynamic, which is amplified and accelerated by post-COVID-19 pandemic recovery attempts. Thus, in order to achieve the digital objectives, the EU will accelerate and facilitate the launch of national and multinational projects combining different types of funding (EU budget, recovery and resilience mechanism, private funds, etc.).

The analysis of the digital domain in Romania shows that, between 2010 and 2021, over three quarters of households (78.2%) had access to the internet at home: In urban areas, 84.8% of households are connected to the internet, and in rural areas, only 69.7% of households.

In the territorial aspect, the internet connection was more widespread among households in the Bucharest-Ilfov region (78.5% of the population), followed by the West (67.8%) and North-West (67%) regions. The regions representing the average broadband internet connection are South-West (61%), Center (60.8%) and South (60.3%).

Also, in 2020, Romania became the EU leader in terms of the growth rate of online trade. The e-commerce market reached 5.6 billion euros and registered an annual growth of 30% in the context of the COVID-19 pandemic and the previous modest performance of the sector compared to the situation of online commerce in other countries.

As regards the econometric model used to highlight the relationship between the three proposed indicators (GDP, broadband and online trade), it demonstrates a conclusive picture of the indicators' influences on regional development. The resulting equations show the direct and positive link between broadband infrastructure and e-commerce with GDP per capita, proving that any growth among independent variables will lead to an increase among dependent variables.

From the analysis of the panel regression model, it was shown that the fixed effect model is best suited to illustrate the regional GDP dependence on the two regressors (internet infrastructure and online commerce). The values of the coefficients in the fixed effect model equation are statistically significant and have a positive influence on GDP. For example, as online commerce grows by 1%, GDP per capita will increase by 192.76 euros. In the case of broadband internet infrastructure, a significantly positive relationship with GDP per capita can also be observed. The high value of R^2 shows that the two endogenous variables explain 96% of the variation of the dependent variable.

In terms of supporting digitization in Romania, the National Recovery and Resilience Plan focuses on the digital transition and addresses challenges in all its sectors. The measures contained in the Romanian strategy cover five of the seven priority areas identified by the European Commission: connectivity, human capital, digital public services, the digitalization of the business environment and investments in digital capacities and advanced technologies.

The funded investments will contribute to increasing Romania's progress in digital competitiveness, in areas such as human capital, broadband connectivity, the integration of digital enterprise technologies and digital public services.

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