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JFSE Journal for Future Society and Education

JFSE | eISSN: 3078-6010 | Vol. 2 No. 3 (2025) | OPEN ACCESS

https://doi.org/10.3991/jfse.v2i3.55429

PAPER

Regional Development in the Context of Cyber-Physical Systems

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ABSTRACT

The theme presents a mix between two consonant elements, the physical territory and the cyber territory. The first is the real space, which we use, divided into spatial structures or territorial systems, the second is metaphysical, the experienced space, a territory of knowledge, which influences the first. Cyber physical systems (CPS) can be autonomous in decisions, they are systems of systems, taking over from the repetitive part of human actions, simplifying and creating time and space for the individual's creativity. Understanding virtuality and the automation of physical processes is necessary to prospect new methods of anticipating future processes, as well as simplifying actions and decisions in the physical, every day. In this paper, economic development is analyzed, by development regions, with a statistical database, and then an illustrated, systemic, meta-approach is proposed to process data through cyber physical systems.

KEYWORDS

economy, regional development, innovative technologies, knowledge

1 INTRODUCTION

Innovative technologies simplify human physical processes, taking over the repetitive part and leaving the individual the opportunity to invent and to create value. Just as throughout history, industrial revolutions have made it possible for one individual to produce for many so that others can later concentrate their activity in art and music. The physical territory generates information, its valorization is the new gold represented by big data and open cloud, the knowledge of returning to the old guilds as the prerogative of trade through the manufacturing industry and then of services by transforming the final products into value. They are also called cultural industries or the creative economy [35], a spring that never dries up, the prerogative of the industry of the future, with resilience to crises because it uses the inexhaustible human resource: creativity and the desire to learn permanently, to which is added the complementarity with the digital economy and regionalization,

Manta, O., Petreanu, T. E. (2025). Regional Development in the Context of Cyber-Physical Systems. *Journal for Future Society and Education (JFSE)*, 2(3), pp. 40–54. https://doi.org/10.3991/jfse.v2i3.55429

Article submitted 2025-03-09. Revision uploaded 2025-04-29. Final acceptance 2025-04-29.

through which people can conceive, produce, and export globally, staying in their areas of origin, letting capital run for them.

Developed countries, such as those in Western Europe and the United States of America, focus more on knowledge and innovation [12], and countries in the East, such as Romania, have an inexhaustible resource of tradition and untapped culture. Also, the rural environment, which in Romania is 54%, the largest in the European Union, is conducive to the development of niche businesses and old guilds, through manual or mechanized production, having as a competitive advantage on foreign markets that tradition and local footprint. Regionalization, a concept and EU policy, which receives funding of 1/3 of the total allocated funds, has as a component the smart specialization strategy, which includes the definition of the distinctive skills of these regions, natural resources, and human resource qualification. The three industrial revolutions took over from the physical work of the individual and built the physical framework for free, creative expression.

Cyber-physical systems (CPS) simplify work, take over what is repetitive, help with territorial planning, can make forecasts regarding upcoming events, and influence regional development [2], having their own virtual territory with other borders and networks of contacts.

The general context is given by the fact that the physical territory is formally represented and analyzed under different statistical indicators in the specialized literature. This paper wants to extend the interest for this technical, quantifiable approach to take the analysis to a level of proposal, prospecting of future processes, using new technologies and systems of systems. The lived territory is built from data that are projected in a virtual environment, similarly each process can be destructured into data clusters that can be analyzed and correlated to anticipate phenomena of manifestation in the near future.

This paper deals with the elements of the society-economy-technology trinomial, with applicability to the Danube region, at a regional level. CPS will completely change the way of approaching the human factor, simplify processes, and anticipate directions for development. An intelligent cyber system can coordinate other systems on its own and generate rapid solutions to problems that arise territorially. The virtual territory models data and represents a top-down, overview view of the processes in the physical.

Moreover, the objectives of the work are oriented towards a better understanding of the particularities of the Romanian economy and the mechanisms for carrying out economic processes, through the analysis of economic, demographic and social indicators, the identification of relevant and determined physical factors on macroeconomic imbalances, prediction mechanisms in the context of interdependent regional development, the reconversion of industrial areas and the influence of port areas on economic dynamics, the identification of a cyber-physical approach to interpreting the existing and simplifying the economic and territorial process, based on the processing of data volumes, and the use of automatic processes, through systems that coordinate other systems.

The paper is structured in three stages of study, each of them having research sub-criteria, with a focus on the following sections: physical territory, regional development in Romania through statistical data analysis, knowledge region and creative industries economy, perceived territory and experienced city, and virtual. In the first section, we analyzed statistical indicators in the economy of regional development, and we studied the virtual space of the economy and business models, physical space and statistical region, and population migration by regions. In the second section, we studied the cyber physical space, virtual, and came up with a

proposal to use resources as efficiently as possible, and in the third section, we studied the virtual territory, illustrating a behavior of points that can be localities in the territory as a digital twin to the regions adjacent to the Danube.

2 LITERATURE REVIEW

The concept of regional development in the context of CPS is based on the interconnection between technology, economy, and society, having a significant impact on territorial processes. Innovative technologies have fundamentally transformed the global economy, allowing the automation of repetitive processes and the creation of a more flexible and adaptable economic environment [34]. This chapter explores the relevant literature in the field of regional development [41] through the use of CPS and their impact on the creative and regional economy [3].

2.1 Regional development and the creative economy

The creative economy is an essential factor of regional development [39], representing a sector resilient to crises due to its capacity to capitalize on human creativity and the digital economy [34]. In developed countries, such as those in Western Europe and the United States of America, there is an increased emphasis on knowledge and innovation, while Eastern countries, such as Romania, have a rich cultural and traditional resource that is still untapped [10]. This approach is consistent with the smart specialization strategy promoted by the European Union [38], which emphasizes defining the distinctive competencies of regions in order to maximize competitive advantages.

2.2 The role of innovative technologies in regional development

Innovative technologies simplify economic processes by taking over repetitive tasks, allowing individuals to focus on creative and strategic activities. According to the specialized literature, technological progress has allowed throughout the history of industrial revolutions to increase productivity and reduce human physical effort [35]. In this context, cyber-physical systems represent a major step towards making territorial development more efficient by analyzing and interpreting data in real time, facilitating the decision-making process, and optimizing regional resources [4].

2.3 Regionalization and digitalization of the territory

Regionalization, as a strategy of the European Union, benefits from significant funding, with the objective of reducing economic and social disparities between regions [26], [31]. A central aspect of this policy is the digitalization of the territory [36], which involves the integration of cyber-physical systems into regional processes in order to obtain a better understanding of economic and social dynamics [4]. By using big data and cloud computing technologies, a favorable environment is created for the analysis and forecasting of economic processes, offering innovative solutions for the sustainable development of regions and macroeconomic level [12], [13].

2.4 Cyber-physical systems and the future of regional development

Cyber-physical systems are capable of coordinating complex economic processes, having a significant impact on regional development by optimizing resources [32] and anticipating economic changes. These systems allow a data-driven approach to the territorial planning process, facilitating informed decision-making and the efficiency of regional infrastructures [42]. In addition, they contribute to the modeling of the virtual territory, providing an integrated perspective on economic and social dynamics [33].

The specialized literature reveals that regional development in the context of CPS offers significant opportunities for optimizing economic and social processes [9]. By integrating innovative technologies into regionalization strategies, an environment conducive to sustainable development is created [43], favoring the creative economy and increasing competitiveness at a global level.

3 RESEARCH METHODOLOGY

In this paper, we employed a mixed-methods approach, combining both quantitative and qualitative research to explore the dynamics of regional development in Romania. The quantitative aspect focused on data collection and analysis, utilizing data from the Tempo-online website of the National Institute of Statistics. This data was processed and interpreted in tables, from which we derived conclusions and forecasted trends. The qualitative component was based on the analysis of literature, case studies, and the experiences and interpretations of other authors, which were analyzed in a descriptive, analytical, and causal manner.

To understand the current state of research, we conducted a comprehensive literature review, which provided a foundation for our analysis and interpretation. Additionally, we used case studies to contextualize the results and gain deeper insights into the regional development processes [28], [29], [30]. Our approach was also informed by introspection and observation, offering a constructive way to translate abstract processes into real-world phenomena at both the human and macro-territorial levels.

The quantitative data used in the study was primarily derived from secondary sources, including open-source statistical databases, alongside primary data collected from various case studies and articles referenced in the bibliography. These data were carefully processed and interpreted to support the development of our arguments and findings. This dual approach—qualitative and quantitative—was selected to ensure a well-rounded understanding of the subject, as it allowed for a comprehensive examination of regional development, grounded in both empirical data and theoretical frameworks.

3.1 Mathematical foundations and assumptions

To further enhance the rigor of our analysis, we propose to model the regional dynamics of Romania as a system consisting of multiple interconnected regions. The relationships between these regions are described using a state equation that incorporates key economic indicators, such as gross domestic product per capita (GDP), migration, and urbanization rates. The mathematical model was designed to capture the interactions between regions and their impact on national development, based

on the hypothesis that regional convergence occurs as regions strive towards a common level of well-being.

In terms of the mathematical foundations [8], we have made certain assumptions regarding the behavior of economic indicators and their interdependencies. For instance, we assumed that the impact of migration and GDP per capita on regional development can be represented by linear functions, and we applied weighting factors to adjust for the relative importance of different variables. To account for noise and outliers in the data, we utilized robust statistical techniques, including regression analysis and data smoothing methods, to ensure that the results were not skewed by extreme values.

3.2 Model validation

To validate the proposed models and enhance the scientific rigor of the study, we plan to further refine the equations and assumptions using simulated data and real-world case studies. The models will be tested against existing regional development studies to assess their accuracy and predictive power. This step will provide additional credibility to our conclusions and help us refine our understanding of regional development dynamics in Romania.

By employing these methodological strategies, we aim to provide a thorough, data-driven analysis of regional development, while also contributing to the broader academic discourse on the use of quantitative models in economic geography and regional studies.

4 RESULTS AND DISCUSSION

As an overall assessment, framing Romania in the European context for an analysis of the economic and demographic environment, I present a series of data analyses that include the inflation rate, GDP, population, and migration, both for Romania and the European Union as an average and ranking.

Thus, in January 2024, Romania recorded an inflation rate of 7.4% [21], compared to 13.4% in the same period of 2023 [22], and 8.4% in 2022 [36]. By comparison, the EU average inflation rate stood at 3.1% in January 2024, down from 10% in 2023 and 5.6% in 2022. For Romania, local data show an inflation of 7.2% in the 1st quarter of 2024 [7], ranking 10th among the 27 EU member states, with a monthly increase around 0.3%. Inflation pressures have eased compared to 2022, when geopolitical tensions and food, and energy prices heavily influenced rates.

The top three countries with the lowest inflation rates in 2024 have an average of approximately 2.2%, while Romania's inflation remains significantly above the 1.5% Maastricht convergence threshold required for Eurozone accession [15]. In the process of real convergence, levers are used that activate the human and financial capital, harmonizing the local market with that of the EU in terms of economic development and the recovery of gaps [1]. The ratio of GDP/place to purchasing power (PCS) is the most important indicator when analyzing convergence.

For a better understanding of the concept of GDP), the paper will detail the two components separately, with all the adjacent elements and nuances of the case. Thus, nominal GDP, real GDP, comparison with the European average, and world ranking will be studied, along with the characteristics of the inhabitants, through the demographic component.

Table 1. GDP/capita analysis (in thousands of dollars)

		1990	2000	2007	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
EN	PfP	5.3	5.8	13	19.8	19.7	20.6	21.6	23.9	26.9	29.6	32.1	32.7	35.9
EN	LCU	3.7	3.6	20.4	31	31.6	33.6	36	38.2	43.5	49.2	55	55.4	61.8
EU	HLG	14.7	22.1	30.9	35	36.2	37.1	38.1	40.5	42.7	44.7	46.1	44.9	48.5

Source: World Bank: https://data.worldbank.org/country/romania.

Table 2. Presentation of tests based on macroeconomic indicators

Item 1	Item 2	Item 3	Item 4	Item 5
Test 1	.001	.004	.341	.01
Test 2	4.5	3.4	12	21
Test 3	28	30	41	65

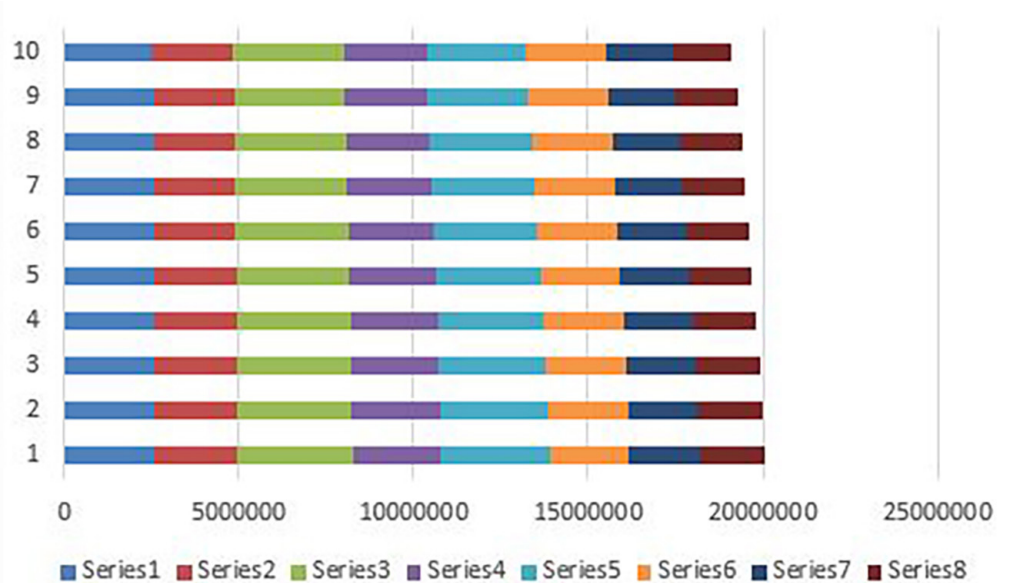

Fig. 1. Demographic evolution, by regions, in Romania (S1–S8), interval 2012–2021 (1–10)

Also from these World Bank analyses, the situation in Romania is presented as follows:

Table 3. Analysis of living standards and quality of life

2021	GDP ($)	GDP/Person	GDP Growth	Unemployment	Inflation	Remittances
Romania	284.1 billion	14.86 thousand	5.1	5.2%	5.1%	3.2
EU	17.18 trillion	38,411	5.4	7.0%	2.6%	0.8

Source: https://data.worldbank.org/region/romania.

Table 4. Population and migrations (evolution) in Romania and the EU

2021	Population	Life Expectancy	Pop. Evolution	Net Migration	HCI Index
Romania	19.12 million	74	–0.8%	–12,724	0.6
EU	447.2 million	80	–0.1%	910,755	–

Source: https://data.worldbank.org/region/european-union.

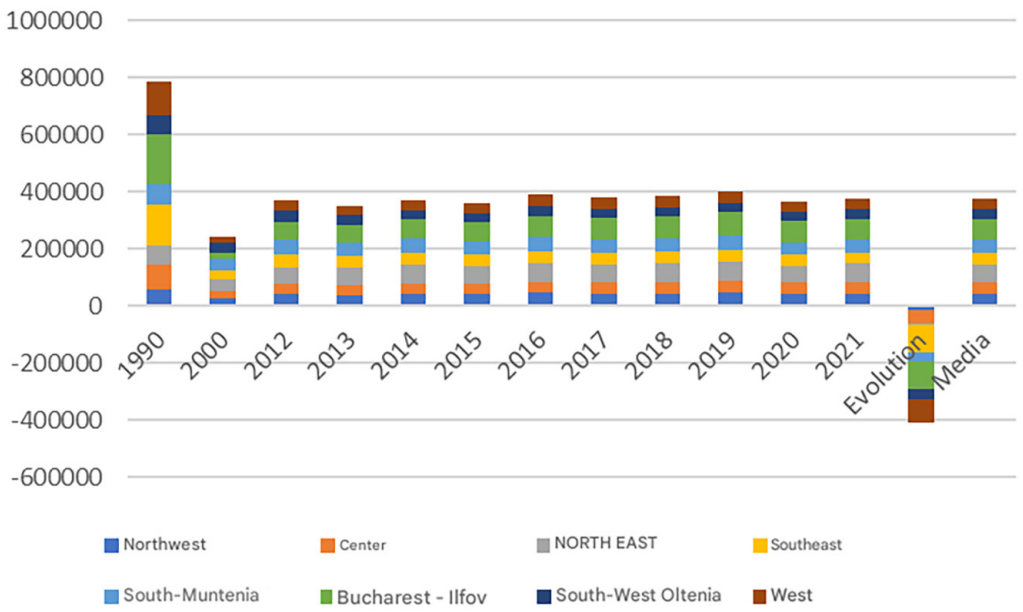

Fig. 2. Changes in residence by region and internal migration

Source: Data processed by the author, data from Tempo-online.ro.

Table 5. Annual growth rate of GDP/capita and EU average

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
RO-BM	9.3	–5.5	–3.9	4.5	1.9	0.3	4.1	3.2	2.6	8.2	6	3.9	–3.7	5.1
RO-INS	11.1	–4.7	–3.3	5	2.4	0.6	4.5	3.7	3.5	8.8	6.6	4.3	–3.1	6.6
EU	0.6	–4.3	2.2	1.9	–0.7	–0.1	1.6	2.3	2	2.8	2.1	1.8	–5.7	5.4

Source: statistici.insse.ro, macrotrends.net (EU's GDP 1971–2023), data.worldbank.org.

In Tables 1–5, from the analysis of the GDP per capita growth rate compared to the EU average, Romania has generally recorded higher annual growth, except for the years 2009, 2010, and 2020, largely due to the economic crises during those periods. According to World Bank data, in 2024 Romania's GDP per capita was approximately 18,400 USD, remaining about 30% below the EU average, similar to the situation in 2023. In 2024, the global GDP growth rate was around 2.9%, with the highest regional growth observed in South Asia (around 5.5%) and the lowest in Europe and Central Asia (approximately 0.2%) [5], [6], [27].

Within Figures 1–5, Romania continues to face economic imbalances, as highlighted by the European Commission's Alert Mechanism Report [11], [22], positioning it within the average range among EU Member States. In terms of major macroeconomic imbalances, Greece, Cyprus, and Italy remain categorized as facing excessive imbalances, while Croatia and Ireland are among the few countries assessed as having no significant macroeconomic imbalances. The demographic indicator is

analyzed within the NUTS1 and NUTS2 framework, with a focus on the 2012–2021 period. This analysis considers components like resident population, birth and death rates, and internal migration patterns at the regional level. It also references previous periods to observe trends and demographic changes over time [23], [24].

The Regional Typology divides regions into NUTS1 macroregions, NUTS2 regions, and NUTS3 counties, with further subcategories based on characteristics such as coastal, border, mountain, and urban-rural distinctions. These subdivisions incorporate the degree of urbanization, categorized into predominantly urban, intermediate, and predominantly rural regions based on population density and administrative unit distribution [20], [21], [25].

The Local Typology, based on Local Administrative Units (LAU), further classifies areas into cities, communes or suburbs, and rural zones. Cities are defined as large urban areas with more than 50% of the population concentrated in high-density clusters, while communes and suburbs are intermediate urban areas with less than 50% of the population in dense networks. Rural areas are those where more than half of the population resides in low-density, rural networks [16]. The network typology provides a more detailed territorial zoning, dividing the area into urban centers, urban clusters, and rural grids for more accurate statistical analysis and practical solutions [17]. In the following, we aim to analyze the factors contributing to regional imbalances, specifically identifying the drivers of socio-economic discrepancies. We will first identify the relevant indicators and then conduct a brief analysis at the NUTS2 regional development level and NUTS3 counties [18], [19]. Additionally, we seek to observe the distinct profiles of each region and the complementary relationships that exist, focusing on the division by counties and examining both inter- and intra-regional economic power. This chapter sets the foundation for the subsequent one, where we will delve deeper into the existing discrepancies at the level of development regions.

Table 6. Resident population

Development Regions								
Year	**Northwest**	**Center**	**Northeast**	**Southeast**	**South-Muntenia**	**Bucharest-Ilfov**	**South-West Oltenia**	**West**
2012	2597160	2360297	3286812	2531465	3118827	2280797	2058288	1826536
2017	2565058	2329696	3231764	2435778	2985107	2294824	1961888	1788818
2021	2530879	2288700	3193246	2357248	2862638	2297816	1881337	1714438
Evolve	**–66,281**	**–71,597**	**–93566**	**–174,217**	**–256,189**	**17,019**	**–176951**	**–112098**
Average	2,568,117	2,332,454	3,236,346	2,445,064	2,995,581	2,297,286	1,971,745	1,789,484

Source: Tempo online site data, www.statistici.insse.ro.

Between 2012 and 2021, Romania experienced a negative population evolution, with an average annual decrease of 116,735 residents, according to the Evolution criterion. The only region registering a population increase was Bucharest-Ilfov, with a net gain of 17,019 people by 2021, although the growth trend was consistent between 2012 and 2020 [15], followed by a slight decrease in 2021. Population concentrations stimulate economic activity, leading to diversified supply and demand and higher labor value.

In 2021, the country had 19,126,302 residents, a decrease of over 933,000 compared to 2012. To better understand regional dynamics, I will analyze the urbanization percentage for each NUTS2 and NUTS3 County, correlating it with population share and the distribution of development poles. Additionally, I will compare the migration trends towards major cities for the years 1992, 2019, and 2021 to identify new regional attractors.

Table 7. Population, attractor cities – 2nd and 3rd places in population/region

Northwest	Center	Northeast	Southeast	South-Muntenia	Bucharest-Ilfov	South-West Oltenia	West
Economic Pole Cities/Attractors and Population 1992/2019/2021							
Cluj-Napoca	Braşov	IASI	Constant	Ploiesti	Bucharest	Craiova	Timisoara
Oradea	**Sibiu**	**Bacau**	**Galati**	**PITEŞTI**	–	**Ramnicu Valcea**	**Arad**
228318	170324	198158	311008	179887	–	112968	192310
221567	**168792**	**197736**	**304873**	**174076**	–	**117891**	**177006**
219971	167124	195687	304985	171110	–	116422	174244
Baia Mare	**Targu Mures**	**Suceava**	**Braila**	**Targoviste**	–	**Drobeta-Turnu Severin**	**Deva**
152953	161786	113554	233969	98155	–	115169	78697
145636	**147770**	**125021**	**202924**	**92004**	–	**106835**	**69231**
143272	145534	124166	196969	90674	–	104121	67786

Source: Tempo online site data, www.statistici.insse.ro, data for 2019.

The analysis of demographic data shows that the South-Muntenia region recorded the largest population decrease; however, this trend is less pronounced in its major cities, suggesting internal migration from rural areas to urban centers within the region, rather than significant outmigration to other regions. To deepen the understanding of these dynamics, the study proposes a county-level analysis of income contribution within the region, correlated with urbanization rates and population distribution, in order to better observe migration flows and the role of urban agglomerations in economic development.

Comparatively, European data highlight that cities like Bucharest and Naples have a lower concentration of the active population in their immediate periphery. For instance, only 12–15% of Ilfov County's population works in Bucharest, contrasting with functional urban areas such as Stuttgart, the Ruhrgebiet, or Amsterdam, where more than 50% of workers commute from outside the core cities. Moreover, Eurostat reports that Romanian cities tend to have a lower share of elderly population, with migration often favoring rural or peri-urban areas.

Despite being among the top contributors to Romania's GDP, South-Muntenia remains the least urbanized region, with a 40% urbanization rate. Cities like Ploiești, Pitești, and Târgoviște have a low population ranking relative to their economic role, reflecting a limited ability to retain and attract population through urban-driven economic diversification. This highlights a broader transition in the region's economy, shifting from traditional industrial sectors to services and creative industries.

In order to better understand the socioeconomic evolution of South-Muntenia and similar regions, the study aims to use a set of economic (GDP per capita, GDP growth rate, investment levels, company density, labor productivity, and income per capita), social and demographic, as well as innovation indicators. Additionally, the analysis will explore the relationship between economic growth and demographic trends, particularly birth rates and migration patterns, comparing data from national censuses conducted before and after Romania's EU accession. Cyber-Physical Systems in regional development

This study topic is adjacent to the analysis of regional convergence by identifying post-industrial cities, the type of industry currently dominant, the level and niche of specialization of human resources, and customization through a system-type planning and organization, with regional development poles or at the macro-regional level. Thus, we will have a solid foundation for studying the regions and cities with access to the Danube.

The 8 regions of Romania are classified as development regions. The goal of developing the country is to ensure the harmonious growth of all its regions,

analyzing their interconnections by conceptualizing them as a system of systems, with each region functioning as a dynamic system. We aim to define the region as a system, followed by a macro analysis of the 8 regions and an exploration of their interactions, represented through a state equation: $\dot{x} = ax + \sum b*U$, where we account for the internal state and external factors, such as interactions from other regions.

What does a formal representation of a region's evolution entail? What are the key factors determining the evolution of each region? In this analysis, we will focus on several factors—more or less significant—that play a role in the regulation of a system. These factors include economic indicators (GDP per capita, PPS), demographic indicators (age pyramid, generations M and Z), and social indicators (education). The system can be characterized by a global indicator, with varying weights for different parameters: p1, p2, ... pn, where each factor carries a specific weight, such as the level of human resource training, available natural resources, types of industries, cultural assets, and more.

The proposed model treats the country as a dynamic system composed of eight regions (NUTS2 level), each functioning with distinct parameters influencing their development. By using a linear indicator model with weighted variables, I aim to study the convergence of regions towards a uniform level of well-being, evaluating quality of life through an entropic model of economic processes. The analysis will consider inputs, outputs, and outcomes of the regions, treating them similarly to components of a business model, where surplus production ensures reinvestment and export capacity, aligned with EU [10] and UN objectives [39].

To operationalize this model, four key resource layers are defined: human resources (R_u), natural resources (R_n), financial resources (R_f), and capital resources (R_c), with the potential addition of information resources. Each resource will be assessed through specific indicators and weighted accordingly. These layers will be superimposed to map resource flows, regional interactions, and cross-border dynamics, setting the foundation for a broader study of Danube cities and the economic status of border regions in the next chapter [12]. The ultimate goal is to identify stagnation points and propose strategies for balanced regional and national development [14], [15].

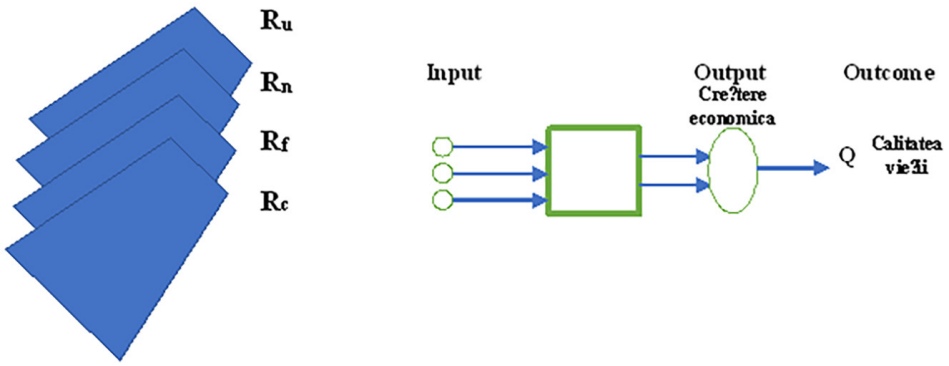

Fig. 3. System of systems for resources

Source: Author's own processing.

Now, each resource (R1-4) is characterized by a number of indicators ($I_{1..n}$), with α (alpha) weights, these resources are processed and adapted to the analysis of the eight development regions of the country in a mathematical model created, having as output GDP growth and outcome quality of life.

As part of the analysis conducted, a series of performance and evaluation indicators were defined and used to interpret the obtained results. Each indicator (I) represents a measurable unit derived from the extracted data, for example:

for R_u – human resources, we have I1-3: demography, active population, and education.

$$R_u = \alpha 1 * Id\ (demographics) + \alpha 2 * Ia\ (active) + \alpha 3 * Ie\ (educated) + \ldots$$

the sum of the coefficients must be 1 and α (alpha) is the weight, thus extract the indicators data into the table, I will need to determine the α (alpha) weights: parameters

$$\alpha 3 = (\text{Educated population})/(\text{Total population})$$

R1-4 are local indicators, and as an outcome we will have a global indicator: Q

Through Q we can see the sensitivity of the system and adjust the weights of the indicators.

Q can be GDP or quality of life,

$$\mathbf{Q} = \sum_{1}^{4} \boldsymbol{w_i} * \boldsymbol{i_i}$$

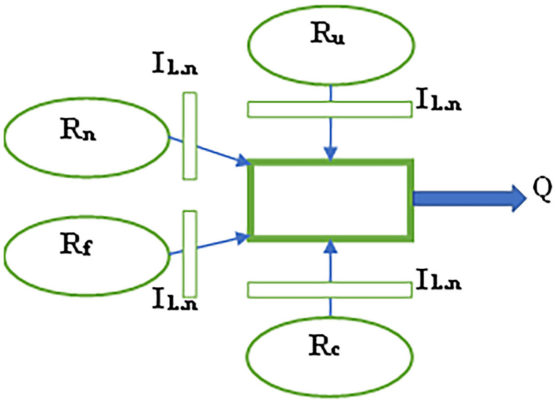

Fig. 4. Cyber physical system

Source: Author's own processing.

For export and discrepancy analysis, I will use the Herfindahl – Hirschmann Hirsch index HHI = $s_1^2 + s_2^2 + s_3^2 + \ldots . s_n^2$ (Goschin et al., 2009).

s_n = the percentage of the market, of a company n (market share), as an integer

$$H_j^C = \sum_{i=1}^{n} (g_{ij}^C)^2,\ H_i^S = \sum_{j=1}^{m} (g_{ij}^S)^2, \text{ where } g_{ij}^C = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} = \frac{X_{ij}}{X_j} \text{ and } g_{ij}^S = \frac{X_{ij}}{\sum_{j=1}^{m} X_{ij}} = \frac{X_{ij}}{X_i}$$

H_j^C – Herfindahl index for concentration, and H_i^S – Herfindahl index for specialization

i – region, j – field of specialization, X – Gross value added (GVA), employability

X_{ij} – GVA in specialization j, region i, X_j – GVA in specialization j, X_i – GVA in region i

g_{ij}^C – % of region i, in the value of specialization j (country), g_{ij}^S – % of specialization j, total V region i

Krugman specialization index for regional specializations–shows the comparative advantage of countries–compares the region with the overall economy (country, EU)

KSI – the higher the coefficient, the greater the regional specialization

$$K_j^C = \sum_{i=1}^{n} \left| g_{ij}^C - g_i \right| \text{ (measures concentration) – Krugman Dissimilarity Index}$$

$$K_i^S = \sum_{j=1}^{m} \left| g_{ij}^S - g_j \right| \text{ (measures specialization) – where } g_i = \frac{X_i}{X}, g_j = \frac{X_j}{X}$$

We analyze the first layer, human resources ($\mathbf{R_u}$). Within this layer, we will analyze a number of indicators ($\mathbf{I_{1..n}}$) to find out the number of inhabitants per region, how many are active to see a level of contribution to GDP, how much we produced, those who bring income and those who consume, and what education they have to see the level of training of the workforce and the degree of employment by fields of activity to see a regional specialization, similarly, higher education can develop other industries.

5 CONCLUSIONS, LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

In this analysis, we believe that the general recommendations regarding the strengthening of regional cooperation and the optimization of resource allocation [34] need to be transformed into concrete operational measures, tailored to the specific characteristics of each region. In this regard, to reduce economic disparities between regions in Romania, it is essential to implement well-targeted industrial policies and infrastructure projects that support the balanced development of less-developed regions. By making strategic investments in regions with high industrial potential, we can contribute to reducing development gaps, supporting initiatives that encourage the relocation and expansion of industry in regions that can benefit from these processes.

Additionally, we believe that the smart specialization strategy must be complemented with clear measures for industrial transformation and modernization [35]. Romania should leverage its specific industrial advantages, such as in the automotive, IT, and renewable energy sectors, by fostering technological innovation and improving industrial competencies. It is crucial to encourage partnerships between universities, research centers, and the private sector to boost investments in research and development, as well as support the transition to more sustainable and technologically advanced industries.

There is a region of knowledge where the eye receives information, which it focuses on a point, then connects it with another signal to form the image. In the DNA cell there are connecting bridges, also called sulfur bridges, formed by nucleic acids, at equal intervals of 10-5-6-5 [40]. These layers, as in the example with the four resources, form CPS systems with a command point.

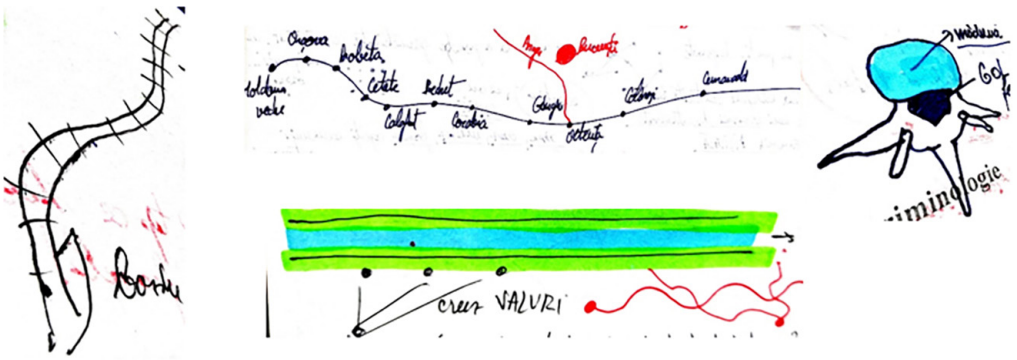

Fig. 5. The Danube as a human organism

Source: Author's own processing.

Finally, we consider that the use of digital technologies represents a major opportunity for optimizing regional economic structures. In this context, it is important to develop strategies for integrating digital infrastructure and improving connectivity between regions. Creating platforms and digital hubs that facilitate collaboration between industries and regions will help integrate local businesses into the digital economy, thereby stimulating regional economic development and enhancing their competitiveness. These measures will provide a clear and actionable framework for policymakers, supporting the sustainable development process of regions in Romania.

5.1 Study limitations

The study presents certain limitations related to the use of historical and statistical data, which do not always capture the current dynamics and unpredictable external influences on the regional economy [37]. The analysis focused on economic and demographic indicators, without taking into account in-depth political, climatic, or infrastructure factors, which can have a significant impact on economic convergence. Also, the methodology of data collection may vary between regions, which may introduce errors and difficulties in making accurate comparisons. Another limitation is related to the fact that, although the importance of using advanced technologies has been highlighted, concrete implementations of cyber-physical systems for monitoring and analyzing economic processes in real time have not yet been tested. These aspects require further in-depth study to support public policies based on reliable and up-to-date data.

5.2 Directions for future research

Further, future research should focus on developing predictive econometric models that allow estimating economic and demographic evolution at the regional level, thus providing a more precise tool for decision-making. Applying convergence formulas on updated databases and extending the analysis to the European level could contribute to identifying the most effective policies to reduce regional disparities. Mapping territorial evolution through cyber-physical systems and artificial intelligence would facilitate real-time monitoring of economic and social processes, providing essential support for targeted public policies. Also, integrating infrastructure and connectivity issues into regional development strategies could improve economic and social cohesion, especially in the Danube riparian areas. In the long term, an interdisciplinary approach, correlating the regional economy with elements of sustainability and technological innovation, could contribute to the formulation of effective applied public policies to increase competitiveness and reduce gaps between regions.

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