Regional Science Inquiry

Regional Science Inquiry

December 2025 Volume XVII Number 2

Regional Science Inquiry

THE JOURNAL OF THE
Hellenic Association of Regional Scientists

December 2025
Volume XVII
Number 2

The Journal is Indexed in

ECONLIT

RSAI

Scopus

RePEc

SJR

RSI J
FOUNDATION YEAR 2008

English Edition
ISSN: 1791-5961 Print
ISSN: 1791-7735 On line

RSI J

Website: http://www.rsijournal.eu, Email: info@rsijournal.eu, publisher@rsijournal.eu
Address: 19b Navarinou Street, 15232 Chalandri, Athens, Greece,Tel./Fax: +30 210 6833700.

The RSI is included in the following Reference Lists of: EconLit, Scopus, RSA I, EconPapers, RePec, IDEAS
The ICR, ZRW, ΚΠΕ and GGGR, are also included in the Reference Lists of: EconPapers, RePec, IDEAS

Electronic and hard copy editions are offered free of charge

Contents

The articles published in RSI Journal are in accordance with the approving dates by the anonymous reviewers.

Regional Science Inquiry, Vol. XVII, (2), 2025
Editorial Note

In the second semester of 2025, the Regional Science Inquiry Journal (RSI J), a scientific journal published under the aegis of the Hellenic Association of Regional Scientists, launches the second (2) issue of its seventeenth volume (Vol. XVII) since its first day of publication.

RSI J is an international, open-access, peer-reviewed journal publishing research across the broad and multidisciplinary field of Regional Science. The journal aims to foster global academic dialogue by supporting rigorous scientific inquiry and advancing high-quality empirical, methodological, and theoretical contributions. As a platform for scholars, researchers, policymakers, and practitioners, RSI J facilitates the exchange of insights on regional development and its various dimensions. According to the SCImago Journal Rank database[1], RSI J is currently being classified in the Q_2 quartile of the "Sociology and Political Science" category. Dedicated to upholding its high standards and core values, RSI J will continue striving for excellence and further improvement in the years ahead.

This issue (RSIJ, Vol. XVII, No. 2, 2025) presents 7 papers that were carefully selected to meet the journal's high standards. These papers cover contemporary topics in Regional Science, such as regional inequalities, regional economic resilience, regional business cycles, economic disasters and savings, sustainable transport, clustering and competitiveness, complexity, knowledge economies and sustainable development, and are described in brief as follows:

The *first* paper, titled "*ADVANCING A NEW ERA IN HIGHER EDUCATION MANAGEMENT: A STAKEHOLDER OVERVIEW ANALYSIS FROM EUROPEAN AND NON-EUROPEAN COUNTRIES*", authored by Ina SEJDINI, Imelda SEJDINI, Ardita TODRI, Petraq PAPAJORGJI, Christos Ap. LADIAS and Filip RUXHO, explores how higher education institutions' (HEI) academic and administrative staff evaluate the Albanian, Algerian, Polish, Turkish, and Spanish institutional openness toward the responsibility and sustainability approaches and analyzes how it can be improved, based on an online questionnaire-based research. The questionnaire builds on four pillars of Culture, Resources, and Infrastructure in higher education institutions; Research and Responsible Education; Solidarization for Sustainable Development; and Social Management and Knowledge, and shifts from a hypothesis-free to a hypothesis-based approach to show diversification in responsible and sustainable approaches engagement. The analysis suggests that improving Culture, Resources, and Infrastructure toward responsible and sustainable approaches is strongly correlated with the efficient management of Research and Responsible Education, Solidarization for Sustainable Development, and Social Management and Knowledge in these institutions, providing some practical implications for HEI stakeholders and line institutions.

The *second* paper, titled "*SAVINGS AND ECONOMIC DISASTERS: GLOBAL EVIDENCE*", authored by Vladimir ŠIMIĆ and Bruno ĆORIĆ, examines the impact of economic disasters on savings by providing new empirical evidence based on a new database on economic disasters from a global perspective. Using a sample of 169 – both developed and less developed – countries since 1980, the paper finds that economic disasters have a positive, statistically significant effect on saving, widening the current empirical knowledge that this relationship stands for high-income countries.

The *third* paper, titled "*REGIONAL BUSINESS CYCLES SYNCHRONIZATION AND REGIONAL INEQUALITIES IN THE EU*", authored by Dimitris KALLIORAS, Spyros NIAVIS, George PETRAKOS, and Maria TSIAPA, examines the impact of regional business cycles' synchronization on the evolution of regional inequalities in the EU, aiming to reveal whether (and to what extent) sectoral shocks are distributed evenly or unevenly within the integrated economic space. The empirical analysis applies to 242 EU NUTS II regions for the period 1990-2020 and provides clear-cut empirical evidence, shedding light on academic theory and providing valuable insight to policy making.

The *fourth* paper, titled "*THE TRANSPORT SYSTEM IN BUCHAREST-ILFOV REGION IN ROMANIA: THE PATH TOWARDS SUSTAINABILITY*", authored by Corina-Cristiana NASTACĂ and Claudiu-Emanuel SIMION, analyses the transport system in Bucharest-Ilfov, Romania, to identify the challenges in managing its development and solutions for improving urban mobility and promoting sustainable transportation. Aiming to investigate citizens' opinions in Bucharest-Ilfov region regarding the transport infrastructure in the area; analyse citizens' degree of satisfaction regarding public transport in Bucharest-Ilfov region; investigate the main problems and challenges of the public transport system and transport infrastructure in the region and propose solutions for improving urban mobility in a sustainable manner; the paper conducts an opinion survey in Bucharest-Ilfov, emphasizing the need for the strategic implementation of sustainable transport solutions that promote environmentally friendly mobility, reduce greenhouse gas emissions, ease traffic congestion, toward ensuring balanced, resilient and environmentally friendly urban growth.

[1] https://www.scimagojr.com/journalsearch.php?q=21100228533&tip=sid&clean=0

The *fifth* paper, titled "*MEASURING THE PERFORMANCE OF EXPORT ECONOMIC BRANCHES LOCATED INSIDE CLUSTERS: EVIDENCE FROM GREECE*", authored by Andreas GKOUZOS and Manolis CHRISTOFAKIS, investigates the impact of clusters on the performance of export economic branches in Greek NUTS-2 regions for the years 2008 and 2018. Employing clustering, statistical techniques, and Exploratory Spatial Data Analysis, the study unveils the intricate relationship between clusters and the competitiveness of export-driven economic branches. The findings highlight the pivotal role of clusters in shaping export outcomes, indicating that regions in both mainland and insular space host multiple clusters that significantly influence the export performance of economic branches. The analysis offers valuable insights into policy formulation, contributing to a deeper understanding of the complex dynamics between clusters and export performance.

The *sixth* paper, titled "*SUSTAINABLE REGIONAL DEVELOPMENT AND COMPLEX ADAPTIVE SYSTEMS: A METHODOLOGICAL PROPOSAL THROUGH SOCIAL NETWORK ANALYSIS*", authored by Diego Andrés CARREÑO DUEÑAS and Walter Lugo RUIZ CASTAÑEDA, studies the evolution of the main theories that have shaped the complexity of Sustainable Regional Development (SRD) with the progressive incorporation of economic, social, environmental, and institutional dimensions. The study links the analysis of SRD to the Complex Adaptive Systems (CAS) framework and to Social Network Analysis (SNA) as a tool for modelling interactions among regional stakeholders, introducing a correlation between the resulting regional network metrics and the Departmental Innovation Index (IDIC) indicators for Colombia's regions that offers an alternative perspective for analysing regional disparities.

Last but not least, the *seventh* paper, titled "*REGIONAL ECONOMIC RESILIENCE AND TOURISM DEMAND: THE CASE OF GREECE*", authored by Dimitrios TSIOTAS, Thomas KRABOKOUKIS, and Dimitrios KANTIANIS, assumes that an economic crisis can be interpreted as a 'disturbance' to the functional equilibrium of open economies, to examine the extent to which the 2008 economic crisis affected the resilience of Greece's regions in terms of their tourism demand. The study focuses on tourism, considered one of the country's key economic sectors, and analyzes tourism demand data (accommodation occupancy) and annual employment for the period January 2000 – December 2018, using a recently proposed three-dimensional (3D) economic resilience index, along with location quotients and statistical analysis techniques, to investigate the extent to which a region's sectoral specialization is related to aspects of its economic resilience in tourism demand. The analysis provides insights into the spatial asymmetry generally characterizing the relationship between a region's basic sector and the vulnerability of its economy due to its core specialization.

All these interesting works are available on the next pages of the RSI J, intending to promote the academic dialogue in Regional Science. Overall, the Editor in Chief, Prof. Christos Ap. Ladias, the Editorial Board, and the signatories of this Editorial Note welcome the reader to the multidisciplinary journey of Regional Science Inquiry that the current issue promises on its following pages.

On behalf of the Editor-in-Chief and the Editorial Board
Dimitrios Tsiotas, Ph.D.,
Assistant Professor – RSI J.

Articles

ADVANCING A NEW ERA IN HIGHER EDUCATION MANAGEMENT: A STAKEHOLDER OVERVIEW ANALYSIS FROM EUROPEAN AND NON COUNTRIES

Ina SEJDINI
Lecturer, Professor, University of Elbasan
ina.sejdini@uniel.edu.al

Imelda SEJDINI
Associate Professor, University of Elbasan
imelda.sejdini@uniel.edu.al

Ardita TODRI
Associate Professor, University of Elbasan
ardita.todri@uniel.edu.al

Petraq PAPAJORGJI
Professor, Proinfinit Consulting Tirana
petraq@gmail.com

Christos Ap. LADIAS
Professor, Regional Science Inquiry Journal, Greece
ladias@rsijournal.eu

Filip RUXHO
Associate Professor, University "Haxhi Zeka"
filipos.ruxho@unhz.eu
(Corresponding Author)

Abstract

This paper aims to explore how higher education institutions' (HEI) top managers, students, professors, assistant professors, education experts, and administrative staff evaluate the Albanian, Algerian, Polish, Turkish, and Spanish institutional openness toward the responsibility and sustainability approaches and analyze how it can be improved. In this research study participated 406 individuals out of 680 that were contacted. The study participants' data were collected using an online questionnaire. The questionnaire uses four pillars concerning institutions' responsible and sustainable approaches, each containing eight elements. These pillars are: Culture, Resources, and Infrastructure in higher education institutions; Research and Responsible Education; Solidarization for Sustainable Development and Social Management and Knowledge. We start the research with a hypothesis-free approach, and in the following, we handle a hypothesis-based approach. The study shows that the Spanish HEI exhibit higher engagement in terms of responsible and sustainable approaches followed by Turkish, Albanian, Algerian and Polish ones. Further, our analysis suggests that improving Culture, Resources, and Infrastructure toward responsible and sustainable approaches is strongly correlated with the efficient management of Research and Responsible Education, Solidarization for Sustainable Development and Social Management and Knowledge in these institutions. The study provides some practical implications for HEI stakeholders and line institutions.

Keywords: higher education institutions management, responsible management, sustainable management, countries mindsets

JEL classification: Q01, Q28, Q55

pp. 11-23

1. Introduction

Higher education institutions (HEI) assume the primary responsibilities in human capital formation, knowledge creation, and innovation, thus contributing to the economic, social, cultural, and environmental development of communities, regions, countries, and even supra-

national areas. Thus, HEI continuously compete with each other at the national and international levels. Correspondingly, since their first appearance in the early 2000s, the global HEI rankings have fostered competition by seriously impacting their working culture and the enhancement of national policies (Sarrico and Godonoga 2021). The IREG observatory inventory reports thirty-nine HEI rankings, from which fourteen are global HEI rankings, seven are regional rankings, sixteen are business school rankings, and the rest are specialized rankings by different institutional characteristics and fields of study (IREG 2019).

In the middle of the debate during September 2023 concerning the QS academic ranking of world higher education institutions for the year 2024, it was introduced for the first time the sustainability element (QS World University Rankings 2024). Furthermore, the 20th edition of the QS World University Rankings features 1,500 institutions across 104 locations that considers employability and sustainability. HEI ranking generally considers their Nobel Laureates, Fields Medalists, Highly Cited Researchers, or papers published in Nature or Science indexed by Science Citation Index-Expanded (SCIE) and Social Science Citation Index (SSCI). However, this year demonstrates the largest-ever methodological enhancement implementation, introducing three new metrics in the HEI's rankings: sustainability, employment outcomes, and international research network. In this new context, the worldwide top 10 HEI elected are Massachusetts Institute of Technology (MIT), University of Cambridge, University of Oxford, Harvard University, Stanford University, Imperial College London, ETH Zurich, National University of Singapore (NUS), United Kingdom (UCL) and University of California, Berkeley (UCB).

Meanwhile, considering environmental and social sustainability QS World Ranking, in its first edition, used a methodology that comprises indicators designed to measure an institution's ability to tackle the world's most significant environmental, social, and governance (ESG) challenges (QS Universities Sustainability Rankings 2023). The new methodology was applied to 700 HEI. These indicators are split into environmental sustainability measures – including sustainable institutions, sustainable education, and sustainable research – and social impact measures, which include equality, knowledge exchange, educational impact, employability and opportunities, and quality of life. The worldwide top 10 HEI ranked according to these environmental and social sustainability measures are the University of California, Berkeley (UCB) also part of the previous ranking metrics and in addition the University of Toronto, the University of British Columbia, the University of Edinburgh, the University of New South Wales (UNSW Sydney), the University of Sydney, the University of Tokyo, University of Pennsylvania, Yale University and the University of Auckland.

While referring to Greenmetric ranking in Europe (Greenmetric by Region 2022) that takes into account their setting and infrastructure, energy and climate change, waste and water, transportation, and education, the top 10 ranked HEI are Wageningen University & Research, Nottingham Trent University, University of Nottingham, University of Groningen, Umwelt-Campus Birkenfeld (Trier University of Applied Sciences), University College Cork, University of Bremen, University of Bologna, Leiden University and University of Southern Denmark. Despite their value and impact, the global HEI rankings often have been criticized regarding various aspects, such as the nature of indicators used, their weightings, and the limited reliability and quality of data (Hazelkorn 2013; van Vught and Ziegele 2013). However, in part of these rankings or not, HEI produce and promote values that correspondingly have essential impacts on society and the nation's economic, environmental, and social development. The latter is so true that referring to iconstylealbania account (Iconstyle_al 2023) the best countries to live in 2023 considering the well-developed higher education system are: 1. Sweden; 2. Denmark; 3. Canada; 4. Switzerland; 5. Norway; 6. Finland; 7. Germany; 8. Netherlands, and 9. Australia.

In this context, it is worth investigating how HEI act regarding sustainable development and social responsibility matters. HEI are socially responsible (SR) when they positively impact society through higher education, research, and the transfer of knowledge and technology, as well as education for sustainability (Sepetis 2024; Meseguer-Sánchez et al. 2020). From now on, for future leaders and policymakers, HEI need to integrate social responsibility principles in teaching and research activities into their management and community engagement activities (Ralph and Stubbs 2014; Garde Sánchez, Rodríguez

Bolívar, and López-Hernández 2013). Avant-garde HEI approaches are being developed on these two principles today. Moreover, this is turning into a challenge for them to absorb students and funds against a healthier competition that produces sustainable growth.

Several authors primarily deal with the HEI's responsibility and sustainability issues (i.e:

Godonoga and Sporn 2023; Kholiavko et al. 2021; Nardo, Codreanu, and Roberto 2021; O'Brien et al. 2021; Sarrico and Godonoga 2021; Compagnucci and Spigarelli 2020; Meseguer-Sánchez et al. 2020; Bokhari 2017; Ramos-Monge, Llinas-Audet, and Barrena-Martinez 2017) to name a few.

However, the overview analysis of HEI stakeholders on responsibility and sustainability

in various countries is still missing. Thus, in this study, we explore how HEI top managers, students, professors, assistant professors, education experts, and administrative staff evaluate the institutional openness toward the responsibility and sustainability approaches in Albania, Algeria, Poland, Turkey, and Spain and analyze how it can be improved. This study can help these institutions prepare to make further progress, reach the established goals, fill the literature gap, and provide recommendations for implications and future research in the field.

2. Literature review

The current challenges (financial and COVID-19 pandemic crisis, global warming, the

technological revolution, etc.) have re-conceptualized HEI's missions. HEI build human capital, strengthen research and innovation, and boost social, economic, cultural, and environmental development (Sarrico and Godonoga 2021; Farnell et al. 2020; Vasilescu et al. 2010).

According to Sarrico and Godonoga (2021) study, the HEI systems are increasingly diverse and include institutions providing short-cycle tertiary education, which is often occupationally oriented and with a significant component of work-based learning, typical of developing countries. In addition, doctoral-level educations, oversized comprehensive HEI with broad missions, and small specialized institutions with narrower missions; public and private institutions are mainly established in developed countries.

Various countries are also exploring public-private partnerships (PPP) to solve

educational development challenges (Sajida and Kusumasari 2023). In this context, HEI tend to adopt a self-evaluation process to improve their outputs. Thus, in recent years, they have shifted from traditional teaching and developing research considering a Third Mission (TM), entitled "a contribution to society" (Compagnucci and Spigarelli 2020; Urdari, Farcas, and Tiron-Tudor 2017; Hazelkorn 2016). The TM activities constitute the engines that contribute to the social, economic, and cultural development of the regions in which they operate by transferring knowledge and technologies to industry and society to a large extent (Agasisti, Barra, and Zotti 2019). In the value creation process, HEI must manage intangible assets and corporate values. Thereby, in the education sector, institutions need to link ethics and responsibility to quality and sustainability in their mission (Kouatli 2019; Fedyunin et al. 2018; Leal Filho et al. 2018; Largacha-Martínez, Pinzón, and Velásquez 2015).

The HEI responsibility, or "social responsibility" and their "sustainability approach"

constitute the skeletal in the globalized world (Larr_an Jorge and Andrades Peña 2017; Vasilescu et al. 2010). Thus, Bokhari's (2017) study states that the HEI definition of social responsibility encompasses economic, legal, ethical, and philanthropic responsibility. In addition, HEI coordinate educational, cognitive, labor, and environmental activities to promote sustainable human development (Lo et al. 2017). Vasilescu et al.'s (2010) research goes deeper into the context. It defines responsible HEI as those who "are engaged in volunteering and encouraging students and the academic staff to provide social services to their local community or to promote ecological, environmental commitment for local and global sustainable development". Moreover, the Giuffré and Ratto (2014) study considers those HEI responsible when producing educational services and transferring knowledge regarding environment and social engagement through management, teaching, research, and extension. All these initiatives together require engagement toward the establishment of a strategic plan. At the same time, strategic planning allows HEI to benefit from the

opportunities, strategically using resources and helping future plans (Nardo, Codreanu, and Roberto 2021; Hunt et al. 1997).

Thereby, academic authorities and public institutions must design a framework that orients HEI in the use of strategic plans to comply with responsibility and sustainability dimensions, considering that 1) within the educational activity, HEI train highly qualified personnel for the national economy; 2) within the extracurricular activities, they develop new green consciousness of the young generation that is crucial for further sustainable development of the national economy; 3) within the research activity, they develop innovative regenerative technologies and environmentally friendly technologies; 4) their cooperation with businesses (industries), government, public (civil society) can create a foundation for sustainable development of the national economy (Qin et al. 2023; Kholiavko et al. 2021). Thus, strategic plans can be developed by considering such pillars as infrastructure, research and education, sustainable development, social management, and knowledge.

The criteria for judging a socially and environmentally responsible infrastructure are inclusive and sustainable industrialization; modernization of study and research environments; improvement of HEI facilities; investments in research equipment; development of teaching; research, and service facilities; dynamic management of technological and IT infrastructures, etc. (Qin et al. 2023; Gupta, Mitra, and Garg 2021; Kholiavko et al. 2021; Nardo, Codreanu, and Roberto 2021).

A responsible research and education system, must include elements such as the right to students with disabilities; reward and merit-based policies; access to university training; qualitative and quantitative increase in scientific productivity; research spread; promotion and support of scientific research; protection and enhancement of intellectual property (Godonoga and Sporn 2023; Todri et al. 2020; Bastos et al. 2019).

Meanwhile, factors affecting the solidarity to sustainable development are gender balance, gender policies, equal remuneration for women and men, equal career opportunities, sustainability of the educational offer and sustainability of the training offer (Shah, Khuhro, and Bakari 2021; Mazon et al. 2020; Montenegro de Lima et al. 2020; Guthrie, Ball, and Farneti 2010; Marcuccio and Steccolini 2005).

Regarding the fourth pillar "Social Management and Knowledge" the following elements are considered: the use of innovative technologies in teaching; transfer of skills, knowledge and technology to the community; innovation of the training offer; social impact of training; social impact of research (Quarchioni, Paternostro, and Trovarelli 2022; Kholiavko et al. 2021; Archer-Kuhn et al. 2020; Morley and Clarke 2020; Spaapen and Sivertsen 2020; Terán-Bustamante and Torres-Vargas 2020; Ayala-Rodríguez et al. 2019; Clark et al. 2016; Taysum 2014; Ceulemans and De Prins 2010).

Several authors have dealt with the concept of HEI responsibility and sustainability (Godonoga and Sporn 2023; Kholiavko et al. 2021; Compagnucci and Spigarelli 2020; Meseguer-Sánchez et al. 2020; Nardo, Codreanu, and Roberto 2021; O'Brien et al. 2021; Sarrico and Godonoga 2021; Bokhari 2017; Ramos-Monge, Llinas-Audet, and Barrena-Martinez 2017), but however, there has yet to be any research considering the view of HEI stakeholders on responsibility and sustainability in Albania, Algeria, Poland, Turkey, and Spain.

Thus, in this research, we explore how HEI top managers, students, professors, assistant professors, education experts, and administrative staff evaluate the institutional openness toward the responsibility and sustainability approach. This study can help these institutions prepare to make further progress, reach the established goals, fill the literature gap, and provide recommendations for implications and future research in the field.

3. Methodology

3.1. The methodological research design

This research study uses an online questionnaire to collect data concerning responsible and sustainable approaches in HEI. The heart of the questionnaire is defining four pillars concerning HEI's responsible and sustainable approaches. Each of the pillars contains eight elements. These pillars are: 1. Culture, Resources, and Infrastructure (CRI) in HEI; 2.

Research and Responsible Education (RRE); 3. Solidarization for Sustainable Development (SSD) and 4. Social Management and Knowledge (SMK). We start the research with a hypothesis-free approach and use a hypothesis-based approach in the following.

Thus, we assess whether HEI Research and Responsible Education (RRE), Solidarization for Sustainable Development (SSD), and Social Management and Knowledge (SMK) approaches impact their Culture, Resources, and Infrastructure (CRI) toward responsibility and sustainability. Based on the explanations provided, the research study hypothesis is stated as follows:

$$\text{Ho: } CRI = \beta_0 + \beta_1 * RRE + \beta_2 * SSD + \beta_3 * SMK + \mu_t. \quad (1)$$

3.2. Participants and data

In this research study participated 406 individuals out of 680 were contacted. Participants' nationalities (in Table 1) in percentage are Algerian (16%), Spanish (21.18%), Turkish (19.95%), Polish (20.19%), and Albanian (22.66%). Most study participants are involved in public universities (51.5%), and the rest are in private (48.5%) universities. The participants of the study are university top managers (10.1%), education experts (7.9%), professors (25.4%), assistant professors (17%), administrative staff (17.7%) and university students (21.9%). All the participants in this study are involved in the university's daily life.

The university students mainly pertain to bachelor's (41.6%), professional (38.2%), and scientific (20.2%) master's programs. Meanwhile, most administrative staff in the study hold a scientific master's degree (71.02%), and the rest hold a bachelor's degree (28.98%). Also, the assistant professors involved in this study hold a scientific master's degree. Most education experts in this study instead hold a Ph.D degree (68.75%), and the rest are associate professors (31.25%).

While professors have a scientific master's degree (15.5%) or a Ph.D degree (29.13%), have the associate professor title (43.7%), and the rest of 21.67 % possess a full professor academic title.

Table 1. Questionnaire participant`s data

The demographic information of the participants	Total	HEI Environment		Age					
		Public	Private	18-25	26-34	35-44	45-54	55-64	65
Base size	406	209	197	79	97	83	54	49	44
Albanian	92	40	52	13	25	22	12	11	9
Polish	82	45	37	17	19	16	9	10	11
Spanish	86	47	39	19	21	17	10	8	11
Turkish	81	40	41	15	19	18	11	9	9
Algerian	65	33	32	15	13	10	12	11	4

Source: Online Questionnaire

3.3. Research method

The online questionnaire (in Table 2) to explore opinions of students, top managers, education experts, professors, assistant professors, academic staff, and administrative staff perceptions concerning responsible and sustainable approaches in HEI used their official e-mail addresses. The questionnaire evaluation uses the Likert scale from 1 (one) to 5 (five), meaning: 1= Strongly disagree (Sa); 2=Disagree (D); 3 = Undecided (U); 4=Agree (A) and 5= Strongly agree (Sa).

Then, considering the Likert scale data distribution, we implement a non-parametric estimation method to analyze whether Research and Responsible Education (RRE), Solidarization for Sustainable Development (SSD), and Social Management and Knowledge

(SMK) impact the HEI Culture, Resources and Infrastructure (CRI) toward responsible and sustainable approaches.

The SPSS 20 (Statistical Package for Social Sciences Inc., Chicago, IL) statistical program is used to analyze the data and further assess the Research and Responsible Education (RRE), Solidarization for Sustainable Development (SSD), and Social Management and Knowledge (SMK) impact on HEI Culture, Resources and Infrastructure (CRI).

The data collected per each pillar element (CRI/RRE/SSD and SMK from 1-8) are

evaluated using average ratings. Decimal values are rounded to the nearest value. This first transformation is advisable because most users of the information need help figuring out what to do with Likert Scales, such as the 5-point scale.

Table 2. Likert scale questionnaire structure

			Rating 1-5				
			Sd	**D**	**U**	**A**	**Sa**
			1	2	3	4	5
Culture, Resources and Infrastructure (CRI)	cri 1	Green engineering is finding more and more applications in the development of infrastructures of higher education establishment					
	cri 2	Energy planning resulted in a significant reduction in energy costs for higher education institution					
	cri 3	The waste management plan helped HEI to design an environmentally friendly strategy					
	cri 4	Water harvesting (rain, recycling of waste water) has reduced the institutional utility cost as well as that of construction in HEI					
	cri 5	Continuous investments in research, teaching and service equipment as well as efficient management of technological infrastructures make HEI an example in the community					
	cri 6	The HEI makes investments aimed at modernizing its study and research environments					
	cri 7	HEI creates infrastructure for students, academic staff, academic and administrative assistants with limited abilities					
	cri 8	HEI has invested in special infrastructure for community service activities					
Research and Responsible Education (RRE)	rre 1	HEI aims to increase the level of qualification in society					
	rre 2	HEI provides access to studies and research to disadvantaged social groups (involves the LGTBI community, Roma and Egyptian minorities as well as people with disabilities)					
	rre 3	HEI graduates students have high employment potential					
	rre 4	The number of foreign students in HEI has increased					
	rre 5	HEI offers courses and study programs for all ages					
	rre 6	The HEI is ready to reform to adapt to the environment in which operates, technological progress as well as market needs					
	rre 7	The HEI encourages critical thinking, dialogue, negotiation and cultural and religious tolerance in its study programs and research projects					
	rre 8	The HEI is committed to interdisciplinary education across the cultural, environmental and global spectrum					
Solidarization sustainable development (SSD)	ssd 1	The HEI develops activities that promote sustainability within the curriculum (spiritual development, equality and global ethics, environmental awareness, cooperation for the development of global environmental policies)					
	ssd 2	HEI invested in line with solidarity needs for sustainable development					
	ssd 3	The HEI develops extracurricular activities in support of the community for sustainable development					
	ssd 4	The HEI offers pilot financing projects for social enterprises					
	ssd 5	HEI implements policies based on gender equality and equal social opportunities (in terms of remuneration, research funding, etc.)					

	ssd 6	The HEI constantly conducts awareness training for teachers, administrative staff and students in the context of sustainable development
	ssd 7	The HEI provides community services, encourages students to assist students in their studies and research, and provides assistance to students with disabilities
	ssd 8	HEI promotes cooperation, conflict management and taking responsibility in a wide range of areas
Social management and knowledge (SMK)	smk 1	The HEI continuously trains students, teaching and administrative staff in innovations in digital systems in use (linked to educational and administrative logistics)
	smk 2	The HEI uses innovative and environmental friendly technologies in scientific research and not only
	smk 3	The HEI operates with a diverse portfolio of training, consultations and seminars with innovative themes on the development of community cooperation
	smk 4	HEI puts the necessary knowledge and technology at the service of the community
	smk 5	The HEI cooperates with businesses, government and civil society for the development of community projects
	smk 6	The HEI includes students and community groups in activities that take place based on interdisciplinary teaching, service and research programs addressing social and economic issues
	smk 7	The HEI publishes on its website the results of all researches (of individual and collective student staff financed by the establishment itself or by other private or public, national and international sources)
	smk 8	The HEI participates in public debates on the possibilities of developing studies for people with disabilities

4. Results and discussions

The research questionnaire was completed only by 59.7% of students, education experts, assistant professors, professors, top managers as well as administrative staff that were contacted by e-mail. Referring to these data, 60% of the elements evaluated in this questionnaire were rated with 4 (participants agree with HEI approaches) and the rest of 40% were rated with 3 (undecided related to HEI approaches).

These results show that the elements mostly rated with 4 pertain to Research and Responsible Education (RRE)-6 out of 8, Solidarization for Sustainable Development (SSD)-5 out of 8, Social Management and Knowledge (SMK)-5 out of 8, and finally Culture, Resources and Infrastructure (CRI) in HEI- 2 out of 8.

Referring to HEI Culture, Resources and Infrastructure (CRI) pillar, the only elements where the participants agree toward HEI responsible and sustainable approaches are:

CRI 5-The HEI continuous investments in research, teaching and service equipment, as well as efficient management of technological infrastructures, make them an example in the community; and CRI 6-The HEI make investments aimed at modernizing its study and research environments.

The CRI 5 is rated mainly by Spanish participants (with 5) followed by Polish participants (with 4), Turkish participants (with 3.7), Albanian participants (with 3.45) and Algerian participants (with 3).

Meanwhile, CRI 6 is mostly rated by Spanish participants (with 5), Algerian, Turkish and Albanian participants with (3.5) and Polish participants (with 1). In other words, these results mean that participants have different exigencies toward HEI Culture, Resources and Infrastructure engagement in responsible and sustainable approaches.

In this context, it is important to assess whether improving HEI Culture, Resources and Infrastructure is possible. Thus, we test whether Research and Responsible Education (RRE), Solidarization for Sustainable Development (SSD) and Social Management and Knowledge (SMK) impact the Culture, Resources and Infrastructure (CRI) in HEI at 95% confidence level:

$$CRI = \beta 0 + \beta 1 * RRE + \beta 2 * SSD + \beta 3 * SMK + \mu t. \quad (1)$$

The analysis demonstrates that RRE, SSD, SMK and CRI Likert scale data are not normally distributed as the Shapiro-Wilk and Kolmogorov-Smirnov tests (Oppong and Agbedra 2016) significance is lower than 0.05 referring to above ordinal regression variables at 95% confidence level (in Table 3).

Table 3. Ordinal regression variables tests of normality data

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
CRI	0.073	406	0.000	0.977	406	0.000
RRE	0.118	406	0.000	0.949	406	0.000
SSD	0.081	406	0.000	0.952	406	0.000
SMK	0.103	406	0.000	0.967	406	0.000

Source: Author`s calculations

In addition, through the test of parallel lines (Erkan and Yildiz 2014) the ordinal regression model significance is estimated 0.989 (higher than 0.05). It confirms that location parameters (slope coefficients) are not the same across response categories in CRI variable (in Table 4).

Table 4. Test of parallel lines

Model	2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	2138.283			
General		2073.729	64.555	93	0.989

Source: Author`s calculations

Thus, we proceed with the Generalized Linear Model (Dobson and Barnett 2018) to estimate the Research and Responsible Education (RRE), Solidarization for Sustainable Development (SSD), and Social Management and Knowledge (SMK) impact on the HEI Culture, Resources and Infrastructure (CRI) at 95% confidence level. The omnibus test (Pan and Lin 2005) demonstrates that the Generalized Linear Model used to test our hypothesis (in Table 5) fits well, as the Chi-square significance is 0.000 (lower than 0.05). Also, the test of model effects confirms the omnibus test results as the RRE, SSD, and SMK significance is 0.000 (lower than 0.05).

Table 5. Omnibus Test

Likelihood Ratio	Chi-Square	df	Sig.
491.152		3	0.000

Source: Author`s calculations

The Generalized Linear Model parameters presented in Table 6 confirm that each study pillar impacts the improvement of HEI Culture, Resources and Infrastructure (CRI) and is statistically significant at 95% confidence level.

Table 6. Generalized linear model parameters estimation

			95% Wald Confidence Interval		Hypothesis Test			
Parameter	**B**	**Std. Error**	**Lower**	**Upper**	**Wald Chi-Square**	**df**	**Sig.**	**Exp(B)**
RRE	0.883	0.1856	0.519	1.247	22.63	1	0.000	2.418
SSD	0.925	0.1848	0.563	1.287	25.048	1	0.000	2.522
SMK	1.267	0.2228	0.831	1.704	32.352	1	0.000	3.551
(Scale)	1							

Source: Author`s calculations

Further (in Table 7), Spearman`s correlations (Hauke and Kossowski 2011) confirm that RRE (0.765), SSD (0.782), and SMK (0.805) have a moderate and statistically significant correlation with CRI.

Table 7. Spearman`s correlations

		CRI	RRE	SSD	SMK
Spearman's rho	CRI Correlation Coefficient	1	0.765	0.782	0.805
	Sig. (2-tailed)		0	0	0
	N	406	406	406	406
	RRE Correlation Coefficient	0.765	1	0.791	0.834
	Sig. (2-tailed)		0	0	0
	N	406	406	406	406
	SSD Correlation Coefficient	0.782	0.791	1	0.86
	Sig. (2-tailed)		0	0	0
	N	406	406	406	406
	SMK Correlation Coefficient	0.805	0.834	0.834	1
	Sig. (2-tailed)		0	0	0
	N	406	406	406	406

Source: Author`s calculations

5. Conclusions

This research study considered HEI top managers, students, education experts, assistant professors, professors as well as administrative staff perceptions concerning responsible and sustainable approaches implemented in private and public HEI operating in Albania, Algeria, Spain, Poland, and Turkey.

Through the questionnaire above, 58% of study participants reveal that HEI does not have a strategic plan for sustainable development and social engagement where they are involved. Above 25.6% of them declare that they do not know if HEI, where they are involved, has a strategic plan for sustainable development and social engagement; the rest of 16.4% confirm the existence of this strategic plan.

Predominantly, Albanian, Turkish, Polish, and Algerian HEI results are the ones that do not have a strategic plan for sustainable development and social engagement. Spanish HEI, instead, are reported as the most avant-garde concerning sustainable development and social engagement strategic planning. In this way, the study shows that the Spanish HEI exhibit higher engagement in terms of responsible and sustainable approaches (rated on average at 4.8), followed by Turkish (rated on average at 3.6), Albanian (rated on average at 3.4), Algerian (rated on average at 2.7) and Polish ones (rated on average at 2.5).

Further, our analysis suggests that the improvement of HEI Culture, Resources and Infrastructure toward responsible and sustainable approaches is possible through significant engagement in Research and Responsible Education (RRE), Solidarization for Sustainable Development (SSD) and Social Management and Knowledge (SMK) pillars. Statistically based, the last pillar constitutes the most critical context concerning developing Culture, Resources and Infrastructure (CRI) to improve responsible and sustainable approaches in HEI.

The study analysis route-one results confirm that for every unit of improvement in:

- Research and Responsible Education (RRE), there is a predicted increase of 0.883 in the log odds of being at a higher level of HEI Culture, Resources and Infrastructure (CRI);
- Solidarization for Sustainable Development (SSD), there is a predicted increase of 0.925 in the log odds of being at a higher level of HEI Culture, Resources and Infrastructure (CRI);
- Social Management and Knowledge (SMK), there is a predicted increase of 1.267 in the log odds of being at a higher level of HEI Culture, Resources and Infrastructure (CRI).

The study analysis route-two results demonstrate that the odds ratio indicates that the odds of being in a higher level HEI Culture, Resources and Infrastructure (CRI) toward responsible and sustainable approaches increases by a factor of:

-2.418 for every one-unit increase on Research and Responsible Education (RRE);

-2.522 for every one-unit increase on Solidarization for Sustainable Development (SSD);

-3.551 for every one-unit increase on Social Management and Knowledge (SMK).

Thus, much more should be done to improve those elements which are especially low rated in Social Management and Knowledge (SMK) pillar such as:

a. The inclusion of students and community groups in activities that take place based on interdisciplinary teaching, service and research programs addressing social and economic issues (rated in average with 3.4). Polish (rated at 2), Algerian (rated at 3), Turkish (rated at 3.2) and Albanian (rated at 3.4) study participants have been sceptical of this HEI approach.

b. The publication of the results of all research on HEI websites (such as those of professors, research groups and the one where students are involved financed by the establishment itself or by other private or public, national and international sources-rated on average at 3.41). Polish and Algerian (rated at 2), Albanian (rated at 2.49) and Turkish (rated at 3) study participants think that HEI have not been enough transparent at this point.

c. The participation of HEI in public debates on the possibilities of developing studies for people with disabilities. This element is considered emergent, especially for Polish (rated at 2), Algerian (rated at 2.5), Albanian (rated at 2.28) and Turkish study participants (rated at 2.8).

In other words, HEI should act according to the practical needs of the community; this applies to the study programs offer, the orientation of scientific research, and the taking of initiatives for the inclusion of people with disabilities in the working environment. However, to manage these challenges, HEI need to be supported even by line ministries and other central or local authorities.

Additional elements that Albanian, Turkish, Polish, and Algerian study participants think might be improved pertaining to Solidarization for Sustainable Development (SSD) pillar are those concerning HEI offer of pilot financing projects for social enterprises (rated in average at 3.4), development of extracurricular activities in support of the community for sustainable development (rated at 3.5) as well as the promotion of cooperation, conflict management and taking responsibility in a wide range of areas (rated at 3.5). Obviously, these commitments require higher institutional budgets and human capital. Thus HEI should take action immediately, starting with short and medium-term strategic planning.

Comparatively, referring to the Research and Responsible Education (RRE) pillar it is argued above the need to establish further institutional agreements or programs in foreign languages to increase international students' mobility programs and international students' involvement in HEI programs (rated at 3.3). Study participants' point of view is essential to provide access to studies and research to disadvantaged social groups (including here the LGTBI community, Roma and Egyptian minorities, as well as people with disabilities rated at 3.4). Diversity management and inclusive education platforms enable more social cooperation and sustainable development opportunities. In this regard, all HEI initiatives can be handled more efficiently by expanding their synergies through partnerships with civil society, municipalities, and business environments.

Although this paper points out some essential perceptions of HEI stakeholders and practical insights on improving their Culture, Resources and Infrastructure toward responsible and sustainable approaches, it remains under the discretion of HEI, various institutions' actions, and societal needs to make advancements and produce concrete results.

Acknowledgments

We thank of all the Albanian, Spanish, Polish, Turkish and Algerian colleagues and friends who helped us in the survey process.

6. References

Agasisti, Tommaso., Cristian Barra., and Roberto Zotti. 2019. "Research, knowledge transfer, and innovation: The effect of Italian universities' efficiency on local economic development 2006−2012." Journal of Regional Science, 59(5): 819-849. https://doi.org/10.1111/jors.12427.

Alexiadis Stelios, Ladias Christos Ap., 2010. "Converging and diverging regions in the eu: implications for regional policy", Regional Science Inquiry Journal, Vol. II (2), 2010, pp 55-70

Antoneta Polo, 2010. "Globalism - the important factor of the life of the countries of the region in general and of Albania in particular", Regional Science Inquiry Journal, Issue II, (1), pp 33-40

Archer-Kuhn, Beth., Jessica Ayala., Jennifer Hewson., and Lorraine Letkemann. 2020. "Canadian reflections on the Covid-19 pandemic in social work education: From tsunami to innovation." Social Work Education, 39(8):1010-1018. https://doi.org/10.1080/02615479.2020.1826922.

Ayala-Rodríguez, Nelly., Idaly Barreto., German Rozas Ossandón., Alejandra Castro., and Sebastian Moreno. 2019. "Social transcultural representations about the concept of university social responsibility." Studies in higher education, 44(2): 245-259. https://doi.org/ 10.1080/03075079.2017.1359248.

Bastos, Fernando. Clemente. Cunha., Maria Jose Barbarosa de Souza., and Estela Maria Hoffmann. 2019. "University social responsibility: An analysis from the Carroll's model." Revista de Negócios, 24(3): 27-48.

Ceulemans, Kim., and Marijke De Prins. 2010." Teacher's manual and method for SD integration in curricula. "Journal of Cleaner Production, 18(7): 645-651. https://doi.org/ 10.1016/j.jclepro.2009.09.014.

Clark, C. William., Lorrae Van Kerkhoff., Louis Lebel., and Gilberto C. Gallopin, G. 2016. "Crafting usable knowledge for sustainable development." Proceedings of the National Academy of Sciences, 113(17): 4570-4578. https://doi.org/ 10.1073/pnas.1601266113.

Compagnucci, Lorenzo., and Francesca Spigarelli. 2020. "The Third Mission of the university: A systematic literature review on potentials and constraints." Technological Forecasting and Social Change, 161, 120284. https://doi.org/10.1016/j.techfore.2020.120284.

Dekanic A., Krstinic Nizic M., Ladias Christos Ap., 2025. "Efficiency of the waste management system as a precondition for the regional sustainability of the islands", Regional Science Inquiry, Vol. XVII, (1), pp. 73-94

Dionisio A., Rolim C., Rego C., 2025. "Determinants of demand for cities with higher education institutions: An approach based on fractional regression", Sustainable Regional Development Scientific Journal, Vol. II, (1), 2025, pp. 81- 93

Erkan, Ari., & Zeki Yildiz. 2014. "Parallel lines assumption in ordinal logistic regression and analysis approaches." International Interdisciplinary Journal of Scientific Research, 1(3): 8-23. Accessed April 12, 2025. https://www.researchgate.net/profile/Erkan-Ari-2/publication.

Fedyunin, V. Dmitriy., Sergey A. Lochan., Svetlana A. Avtonomova., Lyudmila V. Kutyrkina., and Igor E. Mintusov. 2018. "The scenario approach to establishing GR communications in higher education institutions." Journal of Advanced Research in Law and Economics, 9(2(32)): 472-480. https://doi.org/10.14505/jarle.v92(32).11.

Garde Sánchez, Raquel., Manuel P. Rodríguez Bolívar., and Antonio M. López-Hernández. 2013. "Online disclosure of university social responsibility: A comparative study of public and private US universities." Environmental Education Research, 19(6): 709-746. https://doi.org/10.1080/13504622.2012.749976.

Giuffré, Lidia., and Silvia E. Ratto. 2014. "A new paradigm in higher education: university social responsibility (USR)." Journal of Education & Human Development, 3(1): 231-238. Accessed April 12, 2025. http://jehdnet.com/journals/jehd/Vol_3_No_1_March_2014/15.pdf.

Godonoga, Ana., and Barbara Sporn. 2023. "The conceptualisation of socially responsible universities in higher education research: a systematic literature review." Studies in Higher Education, 48(3): 445-459. https://doi.org/10.1080/03075079.2022.2145462.

Gupta, Jaya., Baishali Mitra., and Kapil Garg. 2021. "Technological disruptions reshaping management education: a qualitative study of stakeholder perspectives." International Journal of Management in Education, 15(2): 179-198. https://doi.org/10.1504/IJMIE.2021.113526.

Guthrie, James., Amanda Ball., and Federica Farneti. 2010. "Advancing sustainable management of public and not for profit organizations." Public Management Review, 12(4): 449-459. https://doi.org/10.1080/14719037.2010.496254.

Hamiti A., 2025. "The relationship between forms of bullying and academic success of high school students in the region of Prishtina, Kosovo", Sustainable Regional Development Scientific Journal, Vol. II, (1), pp. 54-66

Khan A., Tripathi S., Chandiramani J., 2024. "Smart city initiatives and economic growth in india: an empirical analysis", Sustainable Regional Development Scientific Journal, Vol. I, (2): Special Issue, pp. 41-56

Kholiavko, Nataliia., Veronica Grosu., Yuriy Safonov., Artur Zhavoronok., and Cristina G. Cosmulese. 2021. "Quintuple helix model: investment aspects of higher education impact on sustainability." Management Theory and Studies for Rural Business and Infrastructure Development, 43(1): 111-128. https://doi.org/10.15544/mts.2021.10.

Kouatli, Issam. 2019. "The contemporary definition of university social responsibility with quantifiable sustainability." Social responsibility journal, 15(7): 888-909. https://doi.org/10.1108/SRJ-10-2017-0210.

Krupavicius, A., Šarkute, L., Krasniqi, A., Ladias, Christos Ap. 2024. “Perceived and desired images of society: how (un)equal is society?” Regional Science Inquiry, 16(1), pp. 55-70

Larrán Jorge, M., & Andrades Peña, F. J. (2017). "Analysing the literature on university social responsibility: A review of selected higher education journals." Higher Education Quarterly, 71(4): 302-319. https://doi.org/10.1111/hequ.12122.

Leka B., Bajrami E., Sharku G., 2023. “An empirical study on family business financing”, Regional Science Inquiry, Vol. XV,(2), pp.81-91

Lincaru C., Tudose G., Cosnita D., Pirciog S., Grigorescu A., Ciuca V., 2024. “Clusters as engines of sustainable employment growth in Romania1”, Sustainable Regional Development Scientific Journal, Vol. I, (3), pp. 10-27

Lo, W.H. Carlos., Rose. X. Pang., Carolyn P. Egri., and Pansy H.Y. Li. 2017. "University social responsibility: Conceptualization and an assessment framework" In University social responsibility and quality of life: a global survey of concepts and experiences, edited by Daniel T. Shek and Robert M. Hollister, 37-59. Springer Nature.

Marcuccio, Manila., and Ileana Steccolini. 2005. "Social and environmental reporting in local authorities: a new Italian fashion?." Public Management Review, 7(2): 155-176. https://doi.org/10.1080/14719030500090444.

Mazon, Gisele., Marcelo J. Pereira Ribeiro., Carlos R. Montenegro de Lima., Brenda C.G. Castro., and Jose B. S. O. D. A. Guerra. 2020. "The promotion of sustainable development in higher education institutions: top-down bottom-up or neither?." International Journal of Sustainability in Higher Education, 21(7): 1429-1450. https://doi.org/10.1108/IJSHE-02-2020-0061.

Meseguer-Sánchez, Victor., Emilio Abad-Segura., Luis J. Belmonte-Ureña., and Valentin Molina-Moreno. 2020. "Examining the research evolution on the socio-economic and environmental dimensions on university social responsibility." International Journal of Environmental Research and Public Health, 17(13): 4729. https://doi.org/10.3390/ijerph17134729.

Montenegro de Lima, R. Carlos., Thiago Coelho Soares., Mauricio Andrade de Lima., Manoela Oliveira Veras., and Jose B. S. O. D. A. Andrade Guerra. 2020. "Sustainability funding in higher education: a literature-based review." International journal of sustainability in higher education, 21(3): 441-464. https://doi.org/10.3390/ijerph17134729.

Morley, Christine., and Joanne Clarke. 2020. "From crisis to opportunity? Innovations in Australian social work field education during the COVID-19 global pandemic." Social Work Education, 39(8): 1048-1057. https://doi.org/10.1080/02615479.2020.1836145.

Nardo, T. Maria., Georgiana C. Codreanu., and Fabiana Roberto. 2021. "Universities’ social responsibility through the lens of strategic planning: a content analysis." Administrative Sciences, 11(4): 139. https://doi.org/10.3390/admsci11040139.

O’Brien, Emma., Bojana Ć Ilić., Anete Veidemane., Davide Dusi., Thomas Farnell ., and Ninoslav Š. Schmidt. 2021. "Towards a European framework for community engagement in higher education–a case study analysis of European universities." International journal of sustainability in higher education, 23(4): 815-830. https://doi.org/10.1108/IJSHE-03-2021-0120.

Pan, Zhiying., and DY Lin. 2005. "Goodness-of-fit methods for generalized linear mixed models." Biometrics, 61(4): 1000-1009. https://doi.org/10.1111/j.1541-0420.2005.00365.x.

Papajorgji P., Tordi A., 2024. “Using quantitative tools to understand political issues”, Sustainable Regional Development Scientific Journal, Vol. I, (3), pp. 28-35

Pescada S., Teixeira F., Pereira W., 2025. “Organisational culture at public hospital of Algarve: Internal medicine staff perception”, Sustainable Regional Development Scientific Journal, Vol. II, (1), pp. 11-21

Polo A., Caca E., Zyberi I., Ladias Christos A, Ruxho F., 2025. “Foreign direct investment in real estate in Albania and its impact on GDP”, Regional Science Inquiry, Vol. XVII, (1), 2025, pp. 135-142

Polo A., Nano D., 2015. “The role of university on student’s money management practices”, Regional Science Inquiry, Vol. VII, (2), pp. 87-96

Qin, Shengyang., Xingxing Duan., A.S. Khandan., and Somayeh Abdollahi. 2023. "An Introduction to Human Resources for Development and Innovation, Science Transformation into Industry Infrastructure by China’s New Universities: A Case Study of Green Materials." Sustainability, 15(2): 975. https://doi.org/10.3390/su15020975.

Ralph, Meredith., & Wendy Stubbs. 2014. "Integrating environmental sustainability into universities." Higher Education, 67: 71-90. https://doi.org/10.1007/s10734-013-9641-9.

Ramos-Monge, L. Elva., Xavier Llinas-Audet., and Jesus Barrena-Martinez. 2017. "Universities as corporate entities: The role of social responsibility in their strategic management." Corporate governance and strategic decision making, 199-215. https://doi.org/10.5772/intechopen.69931.

Ruxho F., 2024. “Kosovo employee’s perception of economic growth and decent work according to sustainability”, Sustainable Regional Development Scientific Journal, Vol. I, (3), pp. 53-66

Ruxho F., Ladias C.A, Tafarshiku A., Abazi E., 2023. “Regional employee’s perceptions on decent work and economic growth: labour market of Albania and Kosovo”, Regional Science Inquiry, Vol. XV, (2), pp.13-23.

Sajida, and Bevaola Kusumasari. 2023." Public private partnership implementation in education sector: a systematic literature review." International Journal of Management in Education, 17(5): 520-539. https://doi.org/10.1504/IJMIE.2023.133217.

Sarrico, S. Claudia., and Ana Godonoga. 2021. "15. Higher education system rankings and benchmarking." Research Handbook on University Rankings: Theory, Methodology, Influence and Impact, 197. https://doi.org/10.4337/9781788974981.00025.

Sepetis, Anastasios. 2024. "The Implementation of Social Protection Policies At Local Level According To Inclusive And Sustainable Development." Regional Science Inquiry Journal, 111-130.

Shah, A. Imran., Rashid A. Khuhro., and Haroon Bakari. 2021. "A study of organisational determinants influencing employees' behaviour in the educational sector: a scoping review." International Journal of Management in Education, 15(6): 523-543. https://doi.org/10.1504/IJMIE.2021.119346.

Spaapen, Jack., and Gunnar Sivertsen. 2020. "Assessing societal impact of SSH in an engaging world: focus on productive interaction, creative pathways and enhanced visibility of SSH research." Research Evaluation, 29(1), 1-3. https://doi.org/10.1093/reseval/rvz035.

Taysum, Alison. 2014. "Learning from international education policies to move towards education systems that facilitate sustainable full economic, cultural and political participation." Italian Journal of Sociology of Education, 6: 1-7. Accessed April 15, 2025. http://www.ijse.eu/wp-content/uploads/2014/06/2014_2_1.pdf.

Terán-Bustamante, Antonia., and Arturo Torres-Vargas. 2020. "University Social Responsibility (USR) and its mission: The case of the Universidad Panamericana in Mexico. In Strategy, power and CSR: Practices and challenges in organizational management, 235-257. Emerald Publishing Limited.

Todri A., Sejdini I., Sejdini I. Balukja I., 2025. “Stakeholders` perceptions on corporate engagement in social responsibility and sustainable development: Insights from domestic and foreign-owned corporations in Albania“, Sustainable Regional Development Scientific Journal, Vol. II, (1), 2025, pp. 22-31

Todri, Ardita., Petraq Papajorgji., Howard Moskowitz., and Francesco Scalera. 2020. "Perceptions regarding distance learning in higher education, smoothing the transition." Contemporary Educational Technology, 13(1), ep287.

Todri A., Sejdini I., Papajorgji P., Ladias Christos A., 2024. “Mapping the psychological landscape of social preferences and attitudes towards voluntary insurance products in the Western Balkan region” , Regional Science Inquiry, Vol. XVI, (2), 2024, pp. 131-142

Tsiotas D., Giannakis E., Papadas C., 2025. “A modularity decomposition model of evolving input-output sectorial structure, Regional Science Inquiry, Vol. XVII, (1), pp. 107-133

Tsiotas D., Polyzos S., 2024. “Analyzing the spatial interactions in the nationwide regional capitals network of Greece”, Sustainable Regional Development Scientific Journal, Vol. I, (3), pp. 36-52

Urdari, Claudia., Teodora V. Farcas., and Adriana Tiron-Tudor. 2017. "Assessing the legitimacy of HEIs’ contributions to society: the perspective of international rankings." Sustainability Accounting, Management and Policy Journal, 8(2): 191-215. https://doi.org/10.1108/SAMPJ-12-2015-0108.

Vasilescu, Ruxandra., Cristina Barna., Manuela Epure., and Claudia Baicu. 2010. "Developing university social responsibility: A model for the challenges of the new civil society." Procedia-Social and Behavioral Sciences, 2(2): 4177-4182. https://doi.org/10.1016/j.sbspro.2010.03.660.

SAVINGS AND ECONOMIC DISASTERS: GLOBAL EVIDENCE

Vladimir ŠIMIĆ
Faculty of Economics, Business and Tourism Split, University of Split; Croatia, Full professor
vsimic@efst.hr

Bruno ĆORIĆ
Faculty of Economics, Business and Tourism Split, University of Split; Croatia, Full professor
bcoric@efst.hr

Abstract

In recent literature, economic disasters have shown promising potential to fill some important gaps in empirical research. The term economic disaster is used in the literature to identify particularly large economic crises, and Barro and Ursúa (2008, 2012) define it as a cumulative decline in output or consumption over one or more years of at least 10 percent. The contribution of economic disasters has been recognized in a number of phenomena ranging from those of finance to those of traditional macroeconomic analysis related to investment and output. Using the recently updated and expanded Ćorić (2021) database on economic disasters, this paper re-examines the impact of economic disasters on saving. Early studies suggest that theoretically negative effects are to be expected. However, more recent empirical research by Aizenman and Noy (2015) shows that economic disasters increase the savings rate. This result implies that the predominant effect of uncertainty related to economic disasters is to increase precautionary saving, which is in contrast to previous findings in the literature. The present study therefore aims to investigate this discrepancy in the results by providing new empirical evidence based on the new database on economic disasters. This database covers a much larger number of countries and thus provides new insights into the relationship between economic disasters and saving from a global perspective. Using a sample of 169 countries, both developed and less developed, since 1980, this study finds that economic disasters have a positive effect on saving and that the effect is statistically significant.

Keywords: Saving, Economic disasters, Global evidence
JEL classification: C5, E2, O4

Acknowledgment: This article was supported by the Croatian Science Foundation under the project IP-2020-02-9710.
pp. 25-35

1. Introduction

In recent literature, economic disasters have shown promising potential to fill some important gaps in empirical research. The contribution of economic disasters has been recognized in a number of phenomena ranging from those of finance to those of traditional macroeconomic analysis related to investment and output. Despite this prominance of economic disasters in the recent literature, the relevance of this phenomenon to saving remains relatively under-researched. Using the recently updated and expanded Ćorić (2021) database on economic disasters, this paper re-examines the impact of economic disasters on saving, making an important contribution to the empirical literature. The early literature on economic disasters suggests that, theoretically, economic disasters are expected to have a negative impact on saving. However, more recent empirical studies show that economic disasters increase the savings rate. This finding implies that the predominant effect of uncertainty associated with economic disasters is to increase precautionary saving, which is in contrast to previous findings in the literature. The present study therefore aims to investigate this discrepancy in the results by providing new empirical evidence based on the new database on economic disasters. This database covers a much larger number of countries and thus offers new insights into the relationship between economic disasters and saving from a global perspective. This global perspective is particularly important as the incidence of economic disasters, which is much higher in less developed countries than in developed

countries after the Second World War, could provide a better understanding of the importance of economic disasters for saving.

This article is structured as follows. Section 2 explains the theoretical background for the link between economic disasters and saving and provides an overview of previous empirical studies. The modelling strategy, data and results of our empirical study are presented in Section 3. Section 4 contains the conclusions.

2. Previous literature and theoretical background

Economic disasters have recently found various applications to explain a range of economic phenomena showing a strong potential to fill gaps in the theoretical and empirical literature. These rare but extremely large economic crises have attracted the interest of researchers from all over the world. The term economic disaster is used in the literature to distinguish particularly large economic crises, defined in Barro and Ursúa (2008, 2012) as a cumulative decline in output or aggregate consumption over one or more years of at least 10 percent. The application of the concept of economic disasters has a long history. One of the first applications dates back to Rietz (1988), who explained the equity premium puzzle by including economic disasters in the analysis. Barro (2006) returned to this theme and showed that by calibrating the probability of economic disasters with 20th century GDP data, the puzzle can indeed be explained empirically. After the 2007/2008 global financial crisis, a number of researchers have built on the findings of Rietz (1988) and Barro (2006) to construct models of asset pricing and macroeconomic dynamics that take into account economic disasters.

The inclusion of economic disasters in the modelling strategy to explain additional phenomena in finance has proven valuable in the recent finance literature (see, e.g., Gabaix, 2012; Watcher, 2013; Barro and Jin, 2018; Gourio, 2013; Farhi and Gabaix, 2016; Barro and Liao, 2016; Seo and Wachter 2019). In addition to these studies focusing on financial phenomena, a growing number of publications indicate that economic disasters can also have a significant impact on the real economy. For example, the effects of economic disasters on business cycles are examined by Gourio (2012) and their significance for explaining debt intolerance by Rebelo et. al. (2022). Barro (2009) shows that economic disasters can have a negative impact on long-term output growth within the framework of the standard AK model of growth. Indeed, Ćorić (2017) confirms this relationship empirically and finds strong negative effects of economic disasters on long-run growth. The effects of economic disasters on savings and investment are examined by Aizenman and Noy (2015) and Ćorić and Šimić (2021). Since the present study focuses on the relationship between saving and economic disasters, we additionally refer to Barro (2009), Aizenman and Noy (2015) and Ćorić and Šimić (2021) to provide a deeper context for our own empirical analysis of the impact of economic disasters on saving.

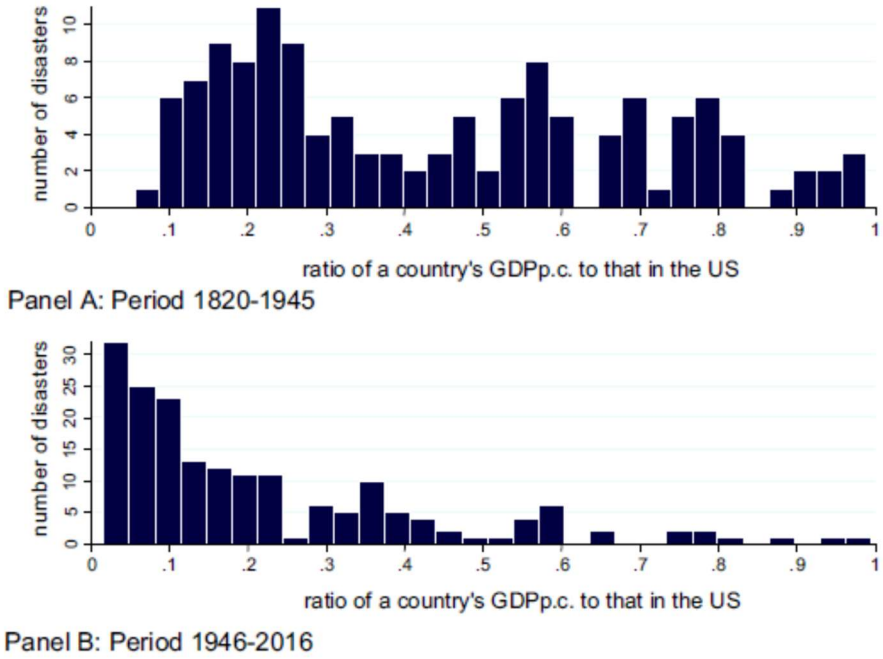
The empirical study by Ćorić and Šimić (2021) shows a significantly negative and economically important long-term effect of economic disasters on aggregate investment after the Second World War. The channel through which this identified relationship could operate is savings and the impact of economic disasters on them. These results (considerations) are consistent with the theoretical macroeconomic model of Barro (2009). Building on the AK type of growth model and focusing on an economic subject trying to maximize expected lifetime utility (by miximizing the intertemporal consumption function), Barro (2009) argues that the effect of uncertainty associated with output volatility (economic disasters) on saving and investment depends on the size of the subject's intertemporal elasticity of substitution for consumption. This leaves open the theoretical possibility that economic disasters have both negative and positive effects on saving and investment. If the intertemporal elasticity of substitution is greater than 1, the uncertainty associated with output volatility primarily has the effect of reducing the risk-adjusted return on capital, which leads to a reduction in savings and therefore investment. If the IES is less than 1, then output volatility increases investment, as the uncertainty in this case primarily causes an increase in precautionary savings and therefore investment. Without going into the very complex details, the standard additive utility function and the widely accepted values of the parameters used (see e.g. Gandelman and Hernandez-Murillo, 2015) would (implicitly) result in a positive influence of output volatility on saving (and investment). However, Barro (2009) argues that a less restricted

version of a utility function can be used instead, and if the recursive version of a utility function is assumed, the impact of output volatility on saving and investment is likely to be negative.

A recent empirical study by Aizenman and Noy (2015) shows that economic disasters increase the savings rate. This result implies that the predominant effect of uncertainty associated with economic disasters is to increase precautionary saving. Consequently, according to the results of Aizenman and Noy (2015), economic disasters should increase rather than decrease saving and investment, as suggested by Barro (2009) and Ćorić and Šimić (2021). Gourio (2012) also comes to the conclusion that an increase in disaster risk leads to more precautionary saving. Nakamura et al. (2013) also find that the persistence of the income shock causes households to increase their savings over a longer period of time. Given these results, the possibility that painful past experiences increase the demand for precautionary saving should be considered.

The alternative theoretical considerations discussed above and the discrepancy found in the empirical results should be further investigated. This paper therefore re-examines the results of Aizenman and Noy (2015) using the new Ćorić (2021) economic disasters dataset. The reason for this is that the study by Aizenman and Noy (2015) is based on a limited sample of 23 high-income countries with a relatively low number of economic disasters. Using the new Ćorić (2021) dataset on economic disasters should allow us to examine the relationship between economic disasters and saving from a global perspective that includes both developed and less developed countries. This is important in view of the fact that the incidence of economic disasters is much higher in less developed countries in the post-World War II period. The importance of this fact can be seen in Figure 1 below, which is taken from Ćorić (2021, p. 5)

Figure 1. Distribution of economic disasters by the level of development



Source: Ćorić (2021), p. 5

Figure 1 (taken from Ćorić, 2021, p. 5) shows a large discrepancy in distribution of economic disasters between countries according to their level of development in the period before and after the Second World War. Panel A is based on the data on economic disasters from Barro and Ursúa (2012) and Panel B is based on the data on economic disasters from Ćorić (2021). Panel A shows that economic disasters were relatively evenly distributed between developed and less developed countries (the level of development is measured in this figure by the ratio of a country's GDP per capita to that of the US), while in Panel B we see that economic disasters are found in less developed countries. Although not shown here, it is also worth noting that Ćorić (2021) additionally reports that almost all economic disasters in the post-World War II period (182) are recorded in non-OECD countries. This suggests that

the impact of economic disasters can best be studied when the less developed countries are considered together with the developed countries. In light of the above considerations, it becomes clearer why the findings of Aizenman and Noy (2015), which focused on the 23 high-income countries, should be reconsidered to include all countries in the world. Focusing only on the developed countries is not very promising, as it has been shown that economic disasters were not frequent there in the post-World War II period. Therefore, this study uses the updated and expanded Ćorić (2021) dataset on economic disasters and focuses on a sample of 169 countries, both developed and less developed, in the empirical analysis below.

3. Empirical investigation - modelling strategy, data and results

3.1. Modelling strategy and data

In light of the literature review in the previous section, we employ the following general panel model to test the relationship between savings and economic disasters.

$$\text{Saving}_{i,t} = \beta\ \text{Economic disasters}_{i,t} + X_{i,t}\theta + \eta_i + \mu_t + \varepsilon_{i,t} \quad (1)$$

where the superscripts i and t stand for country and time period, and Xit is a vector of control variables. η and μ denote unobserved country- and time-specific effects, and ε is the error term. In this model, our main variable of interest is the economic disasters, but in addition, following previous studies, we add a number of control variables to ensure that our savings function is correctly specified.

Our dependent variable, saving, is the share of savings in GDP, and we have taken the data for this variable from the IMF's World Economic Outlook (WEO) database. A number of control variables are included in the analysis. In short, we use the explanatory variables suggested by standard models of the intertemporal allocation of consumption and saving (see, for example, Attanasio and Weber, 2010) and empirical studies on the determinants of saving (examples include: Loayza et al., 2000a; Loayza et al., 2000b; Mason and Kinugasa, 2007; Hufner and Koske, 2010; Horioka and Terada-Hagiwara, A., 2012; Aizenman and Noy, 2015; Bebczuk and Cavallo, 2015; Becerra et al., 2015; Grigolli et al., 2018). Bussollo et al. (2017) point out, in line with the standard life-cycle approach, saving behaviour depends on demography and per capita income growth as well as on additional determinants. These additional determinants in the previous literature include: population under 15 or over 65 (young and old dependency ratios), urbanisation rate, real interest rate, level of real per capita income, government stability index, law-and-order index, corruption index, years of schooling, unemployment rate, income inequality, uncertainty (uncertainty related to output volatility), etc. We also add the lagged dependent variable to allow for partial adjustment of the saving rate and estimate the dynamic version of the model shown in equation 1. The data for included variables are detailed in Table 1 below.

Our econometric estimates of the model shown in equation (1) are performed using different estimators. The linear version of the model is estimated using the standard fixed-effects OLS estimator. To address the potential problem of endogeneity, we will use two GMM estimators, the Arellano-Bond estimator (Arellano and Bond, 1991) and the Blundell-Bond estimator (Blundell and Bond, 1998). These additional estimators are also used to check the robustness of our results.

In terms of data, we used a variety of sources to collect our variables. Some of the sources have already been mentioned above, but in order to systematize them in one place, we give the details in Table 1.

Table 1. Variable description and sources

Variable	Description	Source
Savings	Gross national savings	IMF World Economic Outlook (WEO)
logGDPpc	GDP per capita (current US$), logarithm	World Bank WDI
GDPpcgrowth	GDP per capita growth (annual %)	World Bank WDI
Young dependency ratio	Age dependency ratio, young (% of working-age population), people younger than 15	World Bank WDI
Old dependency ratio	Age dependency ratio, old (% of working-	World Bank WDI

Variable	Description	Source
	age population), people older than 64	
Economic disasters	Economic disasters (1 in year when an economic disaster is identified; 0 otherwise)	Ćorić (2021)
Real interest rate	Real interest rate (%)	World Bank WDI
Inflation rate	Inflation, consumer prices (annual %)	World Bank WDI
Urbanization	Urban population (% of total population)	World Bank WDI
Domestic credit	Domestic credit to private sector (% of GDP)	World Bank WDI
Financial openness	Sum of total financial claims and total financial liabilities to nonresidents (% of GDP)	Lane and Milesi-Ferretti (2018)
Terms of trade (log)	Net barter terms of trade index (2000 = 100), logarithm	World Bank WDI

Our data presented in Table 1 include annual observations for most of the world's economies. We had originally planned to include all countries in the world, but given the typical missing observations and the fact that some countries do not report all the usual statistics, we were able to include as many as 169 countries in our econometric estimates. Considering that our data starts in 1980 and we use panel data estimation techniques, this provides a sizeable number of observations for our estimates.

After presenting our modelling strategy and the data, in the remainder of this paper we conduct our econometric estimations and present the results of our analysis.

3.2. Results

In this subsection we present the most important results of our empirical analysis. The results are presented in three tables that take into account three different estimators used in our panel models: OLS fixed effects model (Table 2), GMM Arellano-Bond estimator (Table 3) and GMM Blundell-Bond estimator (Table 4). We start with the fixed effects OLS model but later also present our results based on the GMM estimators to check robustness and account for possible endogeneity between the variables we use.

Table 2. Savings and economic disasters - OLS

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Savings (t-1)	0.622***	0.629***	0.630***	0.622***	0.543***	0.616***	0.557***	0.533***
	(0.010)	(0.013)	(0.011)	(0.010)	(0.012)	(0.010)	(0.012)	(0.018)
logGDPpc	0.933**	1.482**	1.206***	1.145**	1.018*	0.966**	0.446	1.758*
	(0.466)	(0.643)	(0.482)	(0.491)	(0.581)	(0.474)	(0.594)	(0.958)
GDPpc growth	0.184***	0.245***	0.202***	0.184***	0.156***	0.176***	0.192***	0.256***
	(0.017)	(0.024)	(0.018)	(0.017)	(0.019)	(0.017)	(0.020)	(0.033)
Young dependency ratio	-0.046***	-0.017	-0.038***	-0.053***	-0.082***	-0.047***	-0.042***	0.019
	(0.013)	(0.018)	(0.014)	(0.014)	(0.016)	(0.013)	(0.017)	(0.027)
Old dependency ratio	-0.064	-0.041	-0.049	-0.064	0.047	-0.031	0.044	0.154
	(0.048)	(0.065)	(0.047)	(0.048)	(0.062)	(0.049)	(0.070)	(0.097)
Economic disasters	0.960*	1.851***	1.220**	0.930*	1.624***	0.910	1.240**	2.459***
	(0.570)	(0.722)	(0.592)	(0.570)	(0.616)	(0.572)	(0.636)	(0.864)
Real interest rate		-0.045***						-0.068***
		(0.006)						(0.014)
Inflation			0.000					-0.000
			(0.000)					(0.001)
Urbanization				-0.033				0.002
				(0.024)				(0.041)
Domestic credit					-0.017***			-0.017*

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					(0.006)			(0.009)
Financial openness						-0.024***		-0.015
						(0.010)		(0.025)
Terms of trade (log)							3.116***	4.419***
							(0.958)	(1.437)
No of countries	169	130	167	169	169	169	168	127
No of observations	5478	3187	5008	5478	4217	5399	4361	2243

Standard errors in parentheses; *** P<0.01, ** P<0.05, * P<0.10 - Source: Authors' calculations

Table 2 contains our empirical results based on the OLS model with fixed effects. A total of 8 models are listed in this table. Common to all models is that they include the typical savings determinants - the income variables and the demographic variables - and we add the economic disasters to arrive at the benchmark model shown in column 1. The lagged dependent variable is also included to account for the strong persistence of saving. Then, in columns 2 to 7, we gradually add other variables that have been shown to be important determinants of saving in previous studies. In column 8, we include all variables together to additionally test whether the effect of economic disasters remains consistent. At the bottom of each column, we report the number of countries and the number of observations included in our estimates. Since Table 2 contains a lot of information about our models and variables, we will try to simplify the interpretation of our results by focusing on the benchmark model in column 1 and later provide a general comment on the estimated signs and statistical significance of the variables in all models (columns). In particular, we will consider the economic disasters variable and check its consistency in the different models.

In our benchmark model in column 1, we see that the lagged dependent variable, savings, is estimated to be positive and statistically significant, indicating strong persistence in our dependent variable. The income variables, both logGDPpc and GDPpc growth, are positive and statistically significant, and these variables appear to positively influence saving, which is consistent with previous studies. The demographic variables, the young and old dependency ratios, are both estimated to be negative, but only the coefficient of the young dependency ratio is statistically significant. Typically, both ratios are estimated to have a negative and statistically significant impact, but in our case this is only the case for the young dependency ratio. This brings us to our main variable, namely economic disasters. As we can see, the coefficient for economic disasters in our benchmark model is positive and statistically significant at the 10 percent level of statistical significance. We do not make much of this first result, but simply note that economic disasters appear to have the potential to explain savings and that the effect is positive albeit only marginally significant. Perhaps, as noted by Aizenman and Noy (2015), economic disasters do indeed lead to an increase in precautionary saving.

As indicated above, we add additional determinants to the savings function in models 2 to 7, where the real interest rate, domestic credit, financial openness and the terms of trade are statistically significant, while inflation and urbanization are not. The signs and statistical significance of the variables included in the benchmark model (column 1) remain virtually unchanged. Of the particular interest is the variable economic disasters, which is positively estimated and statistically significant in all but one model (column 6). If we include all variables simultaneously and not individually (column 8), we can see that economic disasters are still positive and strongly statistically significant. Since economic disasters are statistically significant in 7 out of 8 models in Table 2, we can conclude that economic disasters have a consistently positive effect on saving, which supports the studies that argue that the effect of economic disasters is to increase saving.

This initial finding is further investigated with two additional estimators. Table 3 presents the results based on the Arellano-Bond GMM estimator.

Table 3. Savings and economic disasters - GMM Arellano Bond

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

Savings (t-1)	0. 561***	0. 430***	0.525***	0.560***	0.432***	0.543***	0.465***	0.377***
	(0. 066)	(0. 077)	(0.088)	(0.067)	(0.063)	(0.069)	(0.075)	(0.097)
logGDPpc	1.039	0.359	2.351*	2.121	-0.042	1.553	-0.315	0.627
	(1.359)	(1.977)	(1.348)	(1.847)	(1.382)	(1.397)	(1.680)	(2.544)
GDPpc growth	0. 159***	0.245***	0.186***	0.155***	0.133***	0.150***	0.165***	0.250***
	(0. 033)	(0.065)	(0.041)	(0.033)	(0.035)	(0.031)	(0.041)	(0.070)
Young dependency ratio	-0. 032	-0. 003	0.051	-0.087*	-0.167***	-0.026	0.004	-0.001
	(0. 045)	(0.061)	(0.048)	(0.046)	(0.043)	(0.047)	(0.059)	(0.102)
Old dependency ratio	0. 022	0.114	0.097	-0.002	0.083	0.158	0.129	0.171
	(0. 125)	(0.141)	(0.124)	(0.128)	(0.104)	(0.136)	(0.130)	(0.183)
Economic disasters	1.905*	2.332***	2.062*	1.813*	2.442**	1.668	1.882	2.210***
	(1.044)	(0.820)	(1.227)	(1.022)	(1.262)	(1.061)	(0.122)	(0.863)
Real interest rate		-0.059**						-0.090***
		(0.027)						(0.030)
Inflation			0.000					-0.001
			(0.000)					(0.001)
Urbanization				-0.163				-0.077
				(0.112)				(0.144)
Domestic credit					-0.072***			-0.012
					(0.022)			(0.028)
Financial openness						-0.120		0.026
						(0.084)		(0.069)
Terms of trade (log)							8.081**	7.613***
							(3.663)	(3.255)
No of countries	169	130	167	169	169	169	168	127
No of observations	5309	3049	4837	5309	4037	5230	4190	2107

Standard errors in parentheses; *** P<0.01, ** P<0.05, * P<0.10 - Source: Authors' calculations

Table 3 contains the econometric estimates using the Arellano-Bond GMM system estimator. We estimate the same models as in Table 2, but instead of the OLS estimates in Table 3, we perform our estimates using the aforementioned Arellano-Bond system estimator. The use of this estimator is important for two reasons. First, it reduces the problem of potential endogeneity in our model, and second, it allows us to check the robustness of our results. As in Table 2, we are primarily interested in our main variable, economic disasters, but we will also examine other variables. Again, a total of 8 models were estimated. In all models, the coefficients for economic disasters are estimated as positive and are statistically significant in 6 out of 8 models. Economic disasters are not statistically significant in models (columns) 6 and 7, in which financial openness and the terms of trade were included as additional control variables. The fact that economic disasters remain positive and statistically significant in a large majority of the models suggests that economic disasters are an important determinant of saving, which further supports the studies showing a positive impact of economic disasters on saving. Our analysis so far suggests that this positive influence is robust and consistent. As for the other variables, the lagged dependent variable is positive and statistically significant in all models, again indicating a strong persistence of saving. GDP growth is also statistically significant and positive in all models, while GDP per capita (logarithm) loses significance in most models. As in Table 2, the old dependency ratio remains statistically insignificant, while the young dependency ratio is estimated to be negative in most models, but is statistically significant in only two models. As for the

remaining variables, the real interest rate, domestic credit and the terms of trade are statistically significant as in Table 2, while inflation, urbanization and financial openness are not significant. Overall, the results in Table 3 are largely consistent with those in Table 2 and suggest that we can draw stronger conclusions about the consistency of our results. This is particularly true for economic disasters, which turn out to be consistently positive and statistically significant. The final check on the robustness of our empirical results is in Table 4, which uses an alternative GMM estimator: the Blundell-Bond estimator.

Table 4. Savings and economic disasters - GMM Blundell Bond

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Savings (t-1)	0. 551***	0. 434***	0.507***	0.554***	0.424***	0.542***	0.466***	0.376***
	(0. 075)	(0. 097)	(0.098)	(0.074)	(0.074)	(0.077)	(0.083)	(0.118)
logGDPpc	2.341	0.883	3.591*	2.596	1.524	3.046*	0.204	0.093
	(1.762)	(1.928)	(1.946)	(2.116)	(1.717)	(1.730)	(2.024)	(2.561)
GDPpc growth	0. 167***	0.265***	0.184***	0.166***	0.140***	0.161***	0.184***	0.260***
	(0. 042)	(0.066)	(0.050)	(0.042)	(0.045)	(0.041)	(0.051)	(0.068)
Young dependency ratio	-0. 005	-0. 029	0.079	-0.017	-0.105*	0.007	0.003	0.021
	(0. 059)	(0.076)	(0.074)	(0.051)	(0.063)	(0.059)	(0.072)	(0.138)
Old dependency ratio	-0. 104	-0.093	-0.067	-0.127	-0.147	-0.038	-0.011	-0.028
	(0. 122)	(0.196)	(0.139)	(0.122)	(0.161)	(0.131)	(0.165)	(0.185)
Economic disasters	2.615*	2.453***	2.505	2.590*	3.262*	2.459	3.213	2.197**
	(1.591)	(0.859)	(1.787)	(1.572)	(1.960)	(1.661)	(2.239)	(0.923)
Real interest rate		-0.062**						-0.094***
		(0.029)						(0.028)
Inflation			-0.000					-0.001
			(0.000)					(0.001)
Urbanization				-0.027				0.070
				(0.057)				(0.057)
Domestic credit					-0.067***			-0.021
					(0.026)			(0.037)
Financial openness						-0.091		0.064
						(0.063)		(0.072)
Terms of trade (log)							8.130**	9.575*
							(4.216)	(5.154)
No of countries	169	130	167	169	169	169	168	127
No of observations	5478	3187	5008	5478	4217	5399	4361	2243

Standard errors in parentheses; *** P<0.01, ** P<0.05, * P<0.10 - Source: Authors' calculations

Table 4 contains our final results and provides a valuable additional test of robustness. In this table, the Blundell-Bond GMM system estimator is used to provide econometric estimates for the same models as reported in Table 2 and Table 3. To simplify interpretation and avoid repetition, only the main variable is discussed: economic disasters, while the other variables are only commented on in passing. Table 4 again shows that the estimated coefficients for economic disasters are consistently positive and statistically significant in 5 out of 8 models. This is slightly less than for the Arellano-Bond estimator in Table 3, but still strongly suggests that economic disasters are an important determinant of saving. The

estimated effect is statistically significant and positive. Together with the results in Tables 2 and 3, these results in Table 4 indicate that economic disasters do indeed increase saving. As for the other variables, the results are similar to those in Tables 2 and 3, with one important exception. The young dependency ratio is only rarely statistically significant, namely in only one of the 8 models estimated in Table 4.

Summarizing the results of our empirical analysis in Tables 2, 3 and 4, we find that economic disasters are statistically significant and positive in most models. These results confirm the findings of Aizenman and Noy (2015) on the positive impact of economic disasters on saving. However, compared to Aizenaman and Noy (2015), our study goes further as it covers most of the world's economies and not only high-income countries. Therefore, our study makes an important and consistent contribution to the empirical literature on the impact of economic disasters on saving. When we compare our results on the additional determinants of saving, they are broadly consistent with the previous literature on the determinants of saving. As a good representative of this literature, we take the recent study by Grigoli et al. (2018), which empirically investigated the determinants of saving in the world, but without considering economic disasters. The comparison with their results shows that our study is consistent with the typical findings on the importance of income variables, especially income growth, and additionally with the availability of credit, and the terms of trade. As for the dependency ratio, we partially confirm the negative impact of the young dependency ratio, but not for the old dependency ratio, which is not statistically significant in our case. Our results also do not seem to confirm the importance of inflation, urbanization and financial openness, as they are mostly not statistically significant. Notwithstanding these differences, our study makes an important contribution to the empirical literature as it provides new insights into the importance of economic disasters for saving.

4. Conclusions

This paper investigated the effects of economic disasters on saving. With a comprehensive empirical investigation using the new database on economic disasters and linking it to the savings function, the paper makes a valuable contribution to the empirical literature.

In this study, we used the new and expanded database on economic disasters, which covers a much larger number of countries compared to previous studies. This allowed us to empirically assess the impact of economic disasters from a global perspective, including both developed and less developed countries. In the empirical analysis, we used a broad panel data model and the results were obtained using three different estimators. As a starting point, we estimated the OLS model with fixed effects, but also ran our estimates with two GMM system estimators: the Arellano-Bond and Blundell-Bond estimators. The use of GMM estimators helps to reduce the potential endogeneity issues that can arise in models as large as ours. It also increases the reliability of our results and provides a good robustness check.

The results of our empirical analysis generally support the previous literature on the standard determinants of saving. Regarding the main variable of interest, we find that economic disasters are statistically significant and positive. These results confirm the findings of Aizenman and Noy (2015) on the positive impact of economic disasters on saving, but with the important difference that our study includes most of the world's economies and not only high-income countries, as was the case in Aizenman and Noy's (2015) study. Therefore, by including a broader sample of countries and applying the new dataset on economic disasters, our study makes an important and consistent contribution to the empirical literature on the impact of economic disasters on saving.

Although the present study provides new and important insights, it could be extended in future research by including additional determinants of saving, such as institutional variables. Another promising avenue for future research could include alternative aspects of economic disasters, such as examining how the magnitude of economic disasters affects saving.

5. References

Aizenman, J. and Noy, I. 2015. "Saving and the long shadow of macroeconomic shocks." Journal of Macroeconomics, 46: 147-159.

Arellano, M. and Bond, S. 1991. "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." Review of Economic Studies, 58 (2): 277-297.
Attanasio, O. P. and Weber, G. 2010. “Consumption and Saving: Models of Intertemporal Allocation and Their Implications for Public Policy.” Journal of Economic Literature, 48: 693-751.
Barro, R. J. 2006. “Rare Disasters and Assets Markets in the Twentieth Century.” Quarterly Journal of Economics 121: 823-866.
Barro, R. J. 2009. “Rare Disasters, Asset Prices, and Welfare Costs.” American Economic Review, 99: 243-264.
Barro, R. J. and Jin, T. 2018. “Rare Events and Long-run Risks.” NBER Working Paper No. 21871.
Barro, R. J. and Liao, G. Y. 2016. “Option-pricing Formula with Disaster Risk.” NBER Working Paper No. 21888.
Barro, R. J. and Ursúa, J. F. 2008. “Macroeconomic Crises since 1870.” Brooking Papers on Economic Activity, 1: 255-335.
Barro, R. J. and Ursúa, J. F. 2012. “Rare Macroeconomic Disasters.” Annual Review of Economics, 4: 83-109.
Bebczuk, R. N. and Cavallo, E. A. 2015. “Is business saving really none of our business?” Applied Economics, 48: 2266-2284.
Becerra, O., Cavallo, E. and Noy, I. 2015. “The Mystery of Saving in Latin America.” IDB Working Paper IDB-WP-615, Inter-American Development Bank.
Blundell, R. and Bond, S. 1998. “Initial conditions and moment restrictions in dynamic panel data models.” Journal of Econometrics, 87: 115-43.
Bussolo, M., Schotte, S. and Matytsin, M. 2017. “Accounting For the Bias Against the Life-Cycle Hypothesis in Survey Data: An Example for Russia.” The Journal of the Economics of Ageing, 9: 185–207.
Ćorić, B. 2017. “The long-run effect of economic disasters.” Applied Economics Letters, 25: 296-299.
Ćorić, B. 2021. “Economic Disasters: A New Dataset.” Finance Research Letters, 39: 1-7.
Ćorić, B. and Šimić, V. 2021. “Economic Disasters and Aggregate Investment.” Empirical Economics, 61: 3087-3124.
Farhi, E. and Gabaix, X. 2016. “Rare Disasters and Exchange Rates.” Quarterly Journal of Economics, 131: 1-52.
Gabaix, X. 2012. “Variable Rare Disasters: An Exactly Solved Framework for Ten Puzzles in Macro-Finance.” Quarterly Journal of Economics, 127: 645–700.
Gandelman N. and Hernandez-Murillo, R. 2015. “Risk aversion at the country level.” Federal Reserve Bank of Saint Louis, 97: 53-66.
Gourio, F. 2012. “Disaster Risk and Business Cycles.” American Economic Review, 102: 2734-2766.
Gourio, F. 2013. “Credit Risk and Disaster Risk.” American Economic Journal: Macroeconomics, 5 (3): 1–34.
Grigoli, F., Herman A. and Schmidt-Hebbel, K. 2018. “Saving in the World.” World Development, 104: 257-270.
Horioka, C.J. and Terada-Hagiwara, A. 2012. “The determinants and long-term projections of saving rates in Developing Asia.” Japan and the World Economy, 24: 128-137.
Hufner, F. and Koske, I. 2010. “Explaining Households Saving Rates in G7 Countries: Implications for Germany.” OECD Economics Department Working Papers No. 754
IMF World Economic Outlook. Available at: https://www.imf.org/en/Publications/WEO/weo-database/2024/October
Lane, P. R. and Milesi-Ferretti, G. M. 2018. “The External Wealth of Nations Revisited: International Financial Integration in the Aftermath of the Global Financial Crisis.” IMF Economic Review, 66: 189-222.
Loayza, N., Schmidt-Hebbel, K. and Servén, L. 2000a. “What drives private saving across the world?” Review of Economic Statistics, 82: 165–181.
Loayza, N., Schmidt-Hebbel, K. and Servén, L. 2000b. “Saving in Developing Countries: An Overview.” World Bank Economic Review, 14(3): 165–181.
Mason, A. and Kinugasa, T. 2007. “Why countries become wealthy: the effects of adult longevity on saving.” World Development, 35: 1–23.
Nakamura, E., Steinsson, J., Barro, R. and Ursua, J.F. 2013. “Crises and recoveries in an empirical model of consumption disasters.” American Economic Journal of Macroeconomics, 5(3): 35-74.
Rebelo, S., Wang, N. and Yang, J. 2022. “Rare Disaster, Financial Development and Sovereign Debt.” Journal of Finance, 77(5): 2719-2764.
Rietz, T. A. 1988. “The equity risk premium: A solution.” Journal of Monetary Economics, 22: 117-131.
Seo, S. B. and Wachter, J. A. 2019. “Option Prices in a Model with Stochastic Disaster Risk.” Management Science, 65: 3449-3469.

Wachter, J. A. 2013. “Can Time-Varying Risk of Rare Disasters Explain Aggregate Stock Market Volatility.” The Journal of Finance, 68: 987-1035.
World Bank World Development Indicators. Available at: https://databank.worldbank.org/data/source/world-development-indicators

REGIONAL BUSINESS CYCLES SYNCHRONIZATION AND REGIONAL INEQUALITIES IN THE EU

Dimitris KALLIORAS
Professor, University of Thessaly
dkallior@uth.gr
ORCID: 0000-0003-3060-3745

Spyros NIAVIS
Assistant Professor, University of Thessaly
spniavis@uth.gr
ORCID: 0000-0001-9210-9190

George PETRAKOS
Professor, University of Thessaly
petrakos@uth.gr
ORCID: 0000-0001-6542-6799

Maria TSIAPA
Assistant Professor, University of Thessaly
mtsiapa@uth.gr
ORCID: 0000-0001-5852-8156

Abstract

The paper examines the impact of the synchronization of regional business cycles on the evolution of regional inequalities in the EU. The topic is crucially important given that the relation between the synchronization of regional business cycles and the evolution of regional inequalities reveals whether (and to what extent) sectoral shocks are distributed evenly or unevenly within the integrated economic space. The analysis of the paper refers to 242 EU NUTS II regions and covers the period 1990-2020. Using sound and rigorous methods of empirical analysis, the paper presents clear-cut empirical evidence that shed light on academic theory and provide valuable insight to policy making.

Keywords: EU regions, business cycles synchronization, inequalities
JEL classification: E32, R11, R15

Funding

The authors gratefully acknowledge the funding from the EU Horizon Program, project number 101061104 - ESSPIN "ECONOMIC, SOCIAL AND SPATIAL INEQUALITIES IN EUROPE IN THE ERA OF GLOBAL MEGA-TRENDS". The opinions expressed in this document are the sole responsibility of the authors and do not necessarily represent the official position of the EU.

pp. 37-51

1. Introduction

Within the EU framework, the gradual emaciation of the (artificial) border impediments, concerning the movement of people, products, production factors and money, constitutes the structural element – and the pure essence – of the EU (economic) integration process. The EU is, gradually, moving from a "space of places" to a "space of flows" (Castells, 1996, p. 29) and from a "space to States" to a "State of spaces" (Karanika & Kallioras, 2018, p. 68); especially so after the completion of the SEM and the formation of the EMU. The EU experience has shown that deeper integration – and disintegration – may coincide with increasing imbalances in competitiveness, trade relations, and development levels (Petrakos, 2008; Tsiapa et al., 2025). Especially at the regional level, the evidence in the literature seems to shift progressively from the widespread euphoria of the prior-to-the-crisis (i.e., year 2008) convergence models to the uncomfortably repeated divergence (or very slow convergence) findings afterwards (Iammarino et al., 2017; Rodriguez-Pose, 2018; Pina & Sicari, 2021;

Capello & Cerisola, 2023). These findings come to add their weight to old and new debates concerning the relationship between growth, integration, and regional inequalities. Particularly, given that growth is, often, cumulative in nature, a question arises as regards the impact of economic integration on regional inequalities. Does economic integration among more advanced and less advanced regional counterparts has a spatially (un)balancing effect?

Against the backdrop of the EU economic integration process, the paper focuses on regional business cycles. Particularly, the paper examines the impact of the synchronization of regional business cycles on the evolution of regional inequalities in the EU. The topic is crucially important (Mullineux, 1990; Geiger et al., 2020) given that the relation between the synchronization of regional business cycles and regional inequalities is going to reveal whether (and to what extent) sectoral shocks are distributed evenly or unevenly within the integrated economic space. An even distribution indicates the smooth functioning of the economic union. Apparently, the notion of business cycles is not compatible with the neoclassical understanding of the (spatial) economy, which operates always in equilibrium and the only variations from a steady-state growth path may be arising from random or external shocks (Trotta Vianna, 2023).

The analysis of the paper refers to 242 EU NUTS II regions (the UK regions are included) and covers the period 1990-2020. Using sound and rigorous methods of empirical analysis, the paper presents clear-cut empirical evidence that shed light on academic theory and provide valuable insight to policy making. The current section of the paper is introductory. The next section provides the review of the literature. The third section refers to data and methodology. The fourth section conducts the empirical analysis and discusses the results. The last section of the paper offers the conclusion.

2. Literature Review

2.1. Economic Integration and Regional Inequalities

The process of (economic) integration has, progressively, transformed regional economies into integral parts of the emerging EU (economic) space (Petrakos et al., 2016). The latter, instead of getting "flat", is getting more "curved", as it appears to be simultaneously characterized both by EU-wide "flattening" and by local "steepening", and thus more "sticky" (McCann, 2008, p. 361). Such "stickiness" may even reinforce spatial externalities (Kemeny, 2011) as the process of economic integration has "neither implied the ubiquity of economic activity nor undermined the need for urban concentration" (Scott et al., 2001, p. 15). In contrast, technological progress and human resources – the main forces "behind perpetually rising standards of living" (Grossman & Helpman, 1994, p. 24) – continue to "change differently in different territories" (Rodríguez-Pose & Crescenzi, 2008, p. 378). Such a reality is significantly far from *clichés*, such as the "end of geography" (O'Brien, 1992) and the "death of distance" (Cairncross, 1997), and the notions of "slipperiness" (Markusen, 1996; Friedman, 2005) or "flatness" (Friedman, 2007), which is combined to suggest "tendencies towards an equalization of chances of economic development" (Cox, 2008, p. 389), in general.

Geography still matters (Gertler, 2003) and, apparently, in the (old) theoretical debate about the operation of the spatial economy, such a reality challenges the neoclassical-type assumptions that the market forces generated (released) in the process of economic integration involve a spreading-out of economic activity or the "transformation of the economic order into a liquefied space of flows" (Scott & Storper, 2003, p. 581). In fact, the market-based process of economic integration, although it is perceived to generate higher levels of aggregate efficiency, can possibly be associated with higher levels of inequality. In spatial terms, this is believed to lead to regional imbalances with less advanced regions possibly experiencing, in the integration process, weaker gains, or, even, net losses, by comparison with their more advanced counterparts (Kallioras, 2010; Kallioras & Petrakos, 2010; Lincaru et al., 2025; Polyzos & Tsiotas, 2025).

There is widespread skepticism in the less advanced EU regions regarding their ability to adjust to the requirements of the emerging European space. Imperfect competition is deemed to result in an uneven distribution of the benefits of economic integration, due to the inability of the market to create conditions of optimum economic space. Such skepticism questions,

indeed, the neoclassical understanding for the operation of the (spatial) economy. The EU experience highlights that regional inequalities have been consistently high, following a mixed core-periphery, west-east, and north-south pattern, with metropolitan, western, and northern EU regions to be, on average, more advanced compared to peripheral, eastern and southern EU regions (Amin & Tomaney, 1995; Barrios & Strobl, 2005; Petrakos et al., 2020; Constantin & Volintiru, 2024; Kallioras & Niavis, 2025).

It comes that the impact of economic integration on regional growth, and consequently on regional inequalities, depends on the development level and the ability of regions to compete successfully in order to capitalize on the opening up of markets (Camagni, 1992; Cox & Wood, 1997). Engaged in an integration process with distant and more advanced counterparts, less advanced EU regions tend, typically, to specialize in (unskilled-)labor-intensive or resource-intensive sectors. Such a specialization is the outcome of the inability to compete in the markets for capital-intensive and knowledge-intensive sectors (Alexiadis et al., 2010; Kallioras et al., 2021; Uzsaylir & Baycan, 2024). Even though it provides an alternative - and perhaps the only feasible - route for the exploitation of the locally available skills, it is extremely doubtful whether such a structural differentiation can "produce" long-term income convergence (Brülhart & Elliott, 1998). Even though economic integration allows for greater specialization, enhancing inherent and acquired comparative advantages to be exploited more intensively (Weinhold & Rauch, 1999), the fact is that the positive impact of specialization on growth might be weaker in regions that are not specialized in sectors associated with IRS (Paci & Usai, 2000; Martin & Ottaviano, 2001; Ciccone, 2002; Tsiapa et al., 2018).

2.2. Business Cycles Synchronization and Regional Inequalities

The degree of synchronization of business cycles across economies has been a core issue in the debate of the economic integration literature as the synchronization of macroeconomic fluctuations is crucial for the smooth functioning of an economic union. This is especially so in the EU (Geyer, 2007; Matesanz & Ortega, 2016; Jokubaitis & Celov, 2023) as the deepening and the enlargement of European economic integration process raises questions with respect to the pattern of European economic integration *per se*. Considering that national economies are composed of regions with diverse economic profile, the process of economic integration is, most probably, going to exert a stronger effect at the regional level than at the national one (Panteladis & Tsiapa, 2014; Anagnostou et al., 2015). The dynamics of regional business cycles may thus condition the adjustment of national economies to the economically integrated environment (Barrios & de Lucio, 2003). Economic barriers are *de facto* lean(er) at the regional level, and thus the stronger effect at the regional level can be expected because, at the regional level, trade activity is more intense and specialization is higher (Fatás, 1997; Siedschlag & Tondl, 2011). Yet, there is still no concrete body of literature that examines directly the relation between regional business cycles synchronization and regional inequalities.

There is a couple of streams of thought as regards the synchronization of business cycles in an economically integrated environment. The first one supports the idea that economic integration leads, through facilitating the coordination of economic policies, to more symmetric fluctuations, which in turn leads to more synchronized business cycles. The more synchronized the national business cycles are, the less costly it should be for countries to abandon their independent monetary policy (Mundell, 1961; McKinnon, 1963). The second one argues that increasing economic integration leads to regional concentration of economic activities, which may, in turn, convert sector-specific shocks into regional-specific shocks, thus increasing the likelihood of diverging business cycles (Amiti, 1999; Melachroinos, 2002; Belke & Heine, 2006; Camacho et al., 2008). Even though empirical literature utilizes different datasets, employs different methods, and focuses on different spatial levels and time intervals, the findings, mostly, suggest that business cycles in the EU are becoming more synchronized (Artis & Zhang, 1997; Beine et al, 2003; Darvas & Szapáry, 2008; Michaelides et al., 2013). This holds mostly for the core EU countries (in particular, the core EMU countries). Notable is the finding that regional business cycles synchronization has increased between EU countries (i.e., across national economies) and has decreased within EU countries (i.e., within national economies).

3. Data and Methodology

3.1. Data: Stylized Facts

The variable under consideration is real (i.e., inflation-adjusted) GDP per capita. The paper utilizes ARDECO data (ARDECO, 2024) that refer to the 242 EU regions (NUTS II level) and cover the period 1990-2020. GDP per capita data are expressed in constant, year 2015, prices.

Table 1 presents some stylized facts for selected years within the period under consideration. Luxembourg is diachronically the richest EU region, whereas Swietokrzyskie, Yuzhen tsentralen, Severozapaden, and Nord-Est are (depending on the year) the poorest EU regions. Evidently, the (EU) average GDP per capita figure is increasing over time. However, the corresponding standard deviation is increasing as well. More (less) developed EU regions are considered to be the EU regions that on average (i.e., during the entire period 1990-2020) exhibit a GDP per capita figure that is above (below) the corresponding EU average figure. Overall, 116 EU regions belong to the group of more developed regions and 126 belong to the group of less developed regions. The GDP per capita gap between the richest EU region (i.e., Luxembourg) and each of the EU regions considered is estimated as the corresponding GDP per capita ratio.

Table 1. GDP per capita in the EU regions (€/inh.; constant, 2015, prices), 1990-2020 (selected years)

GDP per capita	1990	1995	2000	2005	2010	2015	2020
richest region*	55,941	68,502	83,391	91,254	96,013	95,053	93,870
poorest region**	2,693	2,640	2,597	3,587	3,722	3,954	4,863
EU	19,693	20,574	23,736	25,508	26,450	27,583	28,109
standard deviation	10,398	11,139	12,916	13,292	13,524	14,068	14,346

* LU: Luxembourg; ** PL72: Swietokrzyskie (1990), BG42: Yuzhen tsentralen (1995, 2000, 2005), BG31: Severozapaden (2010, 2015), RO21: Nord-Est (2020)
Sources: ARDECO (2024) / Authors' Elaboration

3.2. Methodology: Business Cycles De-trending

The paper studies the synchronization of regional business cycles and the cyclical behavior of regional inequalities in the EU on the basis of the concept of deviation business cycle (Lucas, 1977; Kydland & Prescott, 1990). Deviation business cycles refer to fluctuations of an economy around its deterministic trend. Particularly, the analysis of deviation business cycles is based on the decomposition of a time series into a cyclical component and a permanent component. The cyclical component is regarded as a measurement of the business cycle, whereas the permanent component (i.e., the deterministic trend) is interpreted as a measure of potential output. Thus, the concept of deviation business cycles is opposed to the classical business cycle that refers to the (mere) sequence of expansions and contractions of the level variables (Dimelis & Livada, 1999). Deviation business cycles are considered to be more useful than classical business cycles. This is so as deviation business cycles include more fluctuations with adequate duration and amplitude (Zarnowitz & Ozyildirim, 2006).

Towards isolating the cyclical component from the trend component, it is necessary to apply a specific de-trending technique that transforms the non-stationary variable of regional per capita GDP into a stationary variable. The paper uses the HP filter (Hodrick & Prescott, 1980 & 1997), which estimates the trend component by minimizing deviations from the trend, subject to a pre-determined smoothness of the resulting trend. The HP filter is a special case of a smoothing spline (i.e., a function estimate observed from a set of "noisy" observations) and it is used to obtain a smoothed-curve representation of a time series, one that is more sensitive to long-term than to short-term fluctuations. It is a high-pass filter that removes fluctuations with a frequency of 8+ years and puts those fluctuations in the trend. The use of the HP filter has been subject to heavy criticism (King & Rebelo, 1993; Canova, 1994 & 1998; Cogley & Nason, 1995). However, it has "withstood the test of time and the fire of discussion remarkably well" (Ravn & Uhlig, 2002, p. 371) even though new band-pass filters - such as the CF filter (Christiano & Fitzgerald, 1999 & 2003) - are being developed.

The economic series under consideration are decomposed into the sum of a slowly evolving secular trend and a transitory deviation from the trend, as it is presented in Equation (1).

$$\boldsymbol{X_t = T_t + Z_t + \varepsilon_t}$$
$$X_t = actual\ series, T_t = permanent\ trend, Z_t = cycle, \varepsilon_t = error\ term \quad \textbf{(1)}$$

The HP filter extracts the trend from the observed series by minimizing a function that considers the cyclical component and the growth rate of the trend component, given an adequately chosen smoothing parameter. The reasoning behind the minimization of the function is the penalization of both the cyclical component and the variations of the growth rate of the trend component. The larger the value of the smoothing parameter the higher the penalty, as it is presented in Equation (2).

$$\boldsymbol{min_T(\sum_{t=1}^{T}(X_t - T_t)^2 + \lambda \sum_{t=2}^{T-1}[(T_{t+1} - T_t) - (T_t - T_{t-1})]^2}$$
$$X_t = actual\ series, T_t = permanent\ trend, \lambda = smoothing\ parameter$$
$$\sum_{t=1}^{T}(X_t - T_t)^2 = cyclical\ component$$
$$\sum_{t=2}^{T-1}[(T_{t+1} - T_t) - (T_t - T_{t-1})]^2 = trend\ component\ growth\ rate \quad \textbf{(2)}$$
$$\lambda > 0$$

The paper sets the value of the smoothing parameter at the level of 6.25 (Marcet & Ravn, 2004) and calculates an 8-year rolling window (Massmann & Mitchel, 2004; Montoya & de Haan, 2008) Pearson correlation coefficient (Pearson, 1895) in order to estimate the degree of linear co-movement of the EU regions (i.e., of the cyclical part of EU regions GDP) in different time series. If the business cycle correlation coefficient has values of approximately 1, it denotes full business cycle convergence, while if it has values of approximately -1, it suggests full business cycle divergence.

The paper estimates the synchronization, in real GDP per capita terms, of each regional business cycle with the business cycle of the richest EU region (i.e., Luxembourg).

3.3. Methodology: Compilation of Econometric Model

In order to assess the impact of regional business cycles synchronization on the evolution of regional inequalities in the EU, the paper compiles and estimates a panel data GLS model, as it is presented in Equation (3). The GLS estimator of a linear regression is a generalization of the OLS estimator (Aitken, 1935), and it is used to deal with situations in which the OLS estimator is not the BLUE (i.e., the estimator that has the smallest variance among those that are unbiased and linear in the observed output variables). Particularly, the paper compares a baseline model (i.e., model 1) and a couple of augmented versions (i.e., model 2 and model 3).

The dependent variable in all models is the per capita GDP gap change. The independent variables are the lagged value of the dependent variable (in all models), the lagged value of the regional business cycles (i.e., of Luxembourg and each of the other regions considered) synchronization change (in all models), the spatial lag (in all models), a dummy for the less advanced regions (in models 2 and 3), the lagged value of the WID ratio (in models 2 and 3), the interaction between the lagged value of structural funds as a share of GDP change with the lagged value of the gravity index (in model 2), the lagged value of unemployment change (in model 2), the lagged value of diversification (in model 2), and the lagged value of GFCF (in model 3). All models include country FE.

$$\boldsymbol{Y_t = c + \beta Y_{t-1} + \gamma C_{t-1} + \delta_\kappa \sum_{t=1}^{\kappa} X_{\kappa_{t-1}} + \varepsilon_{t-1}}$$
$$Y_t = dependent\ variable, c = constant, \quad \textbf{(3)}$$

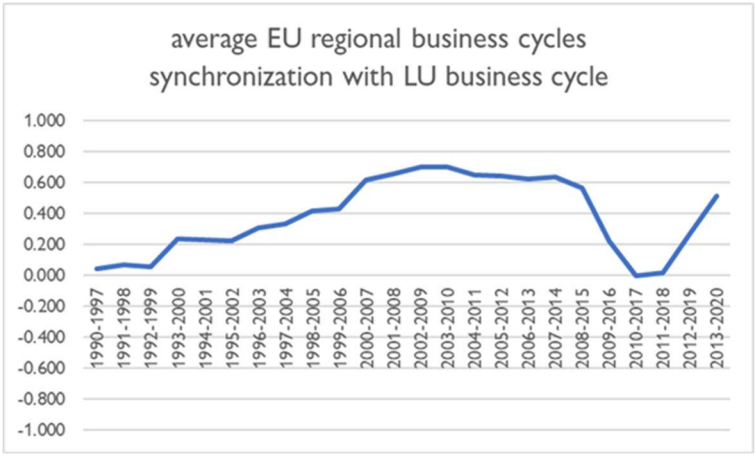
$$Y_{t-1} = independent\ variable\ (lagged\ value\ of\ the\ dependent\ variable),\ C_{t-1} = cycles\ variable\ (lagged\ value\ of\ synchronization),\quad X_{\kappa_{t-1}} = control\ variables\ (lagged\ values),\ \varepsilon_{t-1} = error\ term$$

4. Empirical Analysis

4.1. Regional Business Cycles Synchronization in the EU

Figure 1 presents the average (i.e., for all regions under consideration) regional business cycle synchronization with the business cycle of Luxembourg (i.e., the richest EU region). Towards estimating business cycle synchronization, the paper utilizes the HP filter (smoothing parameter 6.25 and 8-year rolling-window). Evidently, in only 1 out of the 24 8-year periods under consideration there is a (marginally) negative correlation (period 2010-2017; -0.001). Correspondingly, in 10 periods there is a strong positive correlation (i.e., ≥ 0.500). These periods are the periods from 2000-2007 to 2008-2015 and the period 2013-2020. The highest correlation is recorded in the period 2002-2009 (0.702), the lowest correlation is recorded in the period 2010-2017 (-0.001), and the average (i.e., for all the 8-year periods under consideration) correlation is 0.382. The average business cycle synchronization exhibits decreasing trend in 10 pairs of consecutive periods (i.e., from 1991-1998 to 1992-1999, from 1993-2000 to 1995-2002, from 2002-2009 to 2006-2013, and from 2007-2014 to 2010-2017). The highest negative change is recorded from 2008-2015 to 2009-2016 (-0.338), and the highest positive change is recorded from 2011-2018 to 2012-2019 (0.250).

Figure 1. Average EU regional business cycles synchronization with the business cycle of Luxembourg, 8-year rolling window, period 1990-2020



Sources: ARDECO (2024) / Authors' Elaboration

4.2. The Impact of the Synchronization of Regional Business Cycles on the Evolution of Regional Inequalities in the EU

The dependent variable in all models is the per capita GDP gap change. This variable indicates the evolution of inequalities, in per capita GDP terms, between the region of Luxembourg (i.e., the richest EU region) and each of the other EU regions considered between two consecutive 8-year periods. The inequalities between the region of Luxembourg and each of the other EU regions considered are expressed as the ratio of the corresponding average (i.e., for the 8-year period) per capita GDPs. The evolution of inequalities is expressed as the change exhibited in the aforementioned ratio between two consecutive 8-year periods.

The lagged value of the dependent variable is included in the independent variables of all three models. A positive value of the coefficient indicates that, *ceteris paribus*, the evolution of regional inequalities is a self-sustained process in the sense that higher initial changes of regional inequalities cause even higher consequent corresponding changes.

The lagged value of the regional business cycles synchronization change is included in the independent variables of all three models. The level of regional business cycles synchronization has been estimated with the use of the HP filter. A negative value of the

coefficient indicates that, *ceteris paribus*, the deepening of the process of economic integration exerts negative impact on the evolution of regional inequalities. Overall, this indicates the smooth functioning of the EU in the sense that sectoral shocks are distributed evenly within the integrated EU economic space.

The paper utilizes WID data (WID, 2024) and includes the lagged value of the WID ratio change in the independent variables of the augmented models (i.e., model 2 and model 3). The WID ratio is provided at the country level. Towards obtaining the ratio, WID (2024) utilizes data obtained from tax departments. Wealth inequality is measured using the distribution of net household wealth among individuals. The latter is the sum of financial assets (e.g., equity or bonds) and non-financial assets (e.g., housing or land) owned by individuals, net of their debts. Income inequality is measured using the distribution of pre-tax national income among individuals. Pre-tax national income is the sum of all pre-tax personal income flows accruing to the owners of the production factors. High(er) values of the WID ratio indicates high(er) concentration of accumulated wealth. A positive sign of the coefficient indicates that, *ceteris paribus*, the increase of inequality of wealth compared to the inequality of income increases regional inequalities.

The lagged value of structural funds (as a share of GDP) change is included in the independent variables of the first augmented model (i.e., model 2). Given that structural funds aim at assisting the less developed EU regions, a negative sign of the coefficient is expected. Such a sign is going to be an indication of the ability of regions (i.e., the recipients of structural funds) to convert financial aid into growth, *ceteris paribus*.

The lagged value of the gravity index is included in the independent variables of the first augmented model (i.e., model 2). For each EU region, the gravity index is estimated as the sum of the regional GDP and the ratios of the GDP of each of the other EU regions considered to the corresponding (Euclidean) distances (Petrakos, 2000), as it is presented in Equation (4). The gravity index indicates the centrality (peripherality) of a region within the EU context. Particularly, higher values of the gravity index indicate a more central place in the EU space, better accessibility, and greater market potential. A positive sign of the coefficient indicates that, *ceteris paribus*, gravity impacts positively on inequality because regions with a more central place and larger markets have a better growth performance.

$$\boldsymbol{GRAV_{i,t} = GDP_{i,t} + \sum_{j=1}^{n} \frac{GDP_{j,t}}{d_{i,j}}} \quad (4)$$

$$GRAV_{i,t} = gravity,\ GDP_{i,t} = GDP\ of\ the\ region\ under\ consideration,\ GDP_{j,t} = GDP\ of\ each\ of\ the\ other\ region\ considered,\ d_{i,t} = Euclidean\ distance\ with\ each\ of\ the\ other\ regions\ considered$$

The interaction between the lagged value of structural funds (as a share of GDP) change and the lagged value of the gravity index is also included in the independent variables of the first augmented model (i.e., model 2). The interaction is going to reveal whether the impact of structural funds is conditional on the level of gravity. An inverted-U-type relationship between the two variables is going to indicate that, *ceteris paribus*, structural funds exert a negative impact on the evolution of regional inequalities only after a certain threshold of gravity, as it is presented in Equation (5).

$$\boldsymbol{Y_{i,t} = \cdots + \gamma_1 * SF_{i,t} + \gamma_2 * GRAV_{i,t} + \gamma_3 * SF_{i,t} * GRAV_{i,t}}$$

$$\boldsymbol{\frac{\partial Y_{i,t}}{\partial SF_{i,t}} = \gamma_1 + \gamma_3 * GRAV_{i,t}}$$

$$\boldsymbol{\frac{\partial Y_{i,t}}{\partial SF_{i,t}} > 0 \Rightarrow \gamma_1 + \gamma_3 * GRAV_{i,t} > 0 \Rightarrow} \quad (5)$$

$$\boldsymbol{GRAV_{i,t} < \frac{\gamma_1}{\gamma_3}\ \forall\ \gamma_3 < 0}$$

$$Y_{i,t} = dependent\ variable,\ SF_{i,t} = structural\ funds,\ GRAV_{i,t} = gravity$$

The lagged value of unemployment change is included in the independent variables of the first augmented model (i.e., model 2). Unemployment highlights the under-utilization of the labor force (and especially of the human capital) capabilities. A positive sign of the

coefficient indicates that, *ceteris paribus*, unemployment change (i.e., increase of unemployment) exerts a positive impact on regional inequalities.

The lagged value of diversification change is included in the independent variables of the first augmented model (i.e., model 2). Diversification is estimated with the HK index (OECD, 2013), as it is presented in Equation (6). The HK index captures the sectoral composition of a region and shows the influence of large sectors. The higher the values of the HK index, the more diversified (or the less specialized) the regional economy (i.e., the broader the range of sectoral activities a regional economy relies upon). A negative sign of the coefficient indicates that, *ceteris paribus*, diversification exerts a negative impact on regional inequalities.

$$HK(\theta) = (\sum_{i=1}^{n} s_i^{\theta})^{\frac{1}{1-\theta}}$$
$$\theta = 2 \quad (6)$$
$$s_i = the\ relative\ output\ of\ the\ ith\ sector,\ n = number\ of\ sectors,\ \theta = the\ influence\ of\ large\ sectors$$

The lagged value of GFCF (as a share of GDP) (in both the first and the second power) is included in the independent variables of the second augmented model (i.e., model 3). GFCF is a component of the expenditure on GDP that indicates how much of the new value added in an economy is invested rather than consumed. In other words, GFCF measures the value of acquisitions of new or existing fixed assets minus disposals of fixed assets. An inverted U-type impact is going to indicate that, *ceteris paribus*, GFCF exerts a negative impact on regional inequalities after a threshold, as it is presented in Equation (7).

$$Y_{i,t} = \cdots + \gamma_1 * GFCF_{i,t} + \gamma_2 * GFCF_{i,t}^2$$
$$\frac{\partial Y_{i,t}}{\partial GFCF_{i,t}} = \gamma_1 + 2 * \gamma_2 * GFCF_{i,t}$$
$$\frac{\partial Y_{i,t}}{\partial GFCF_{i,t}} > 0 \Rightarrow \gamma_1 + 2 * \gamma_2 * GFCF_{i,t} > 0 \Rightarrow \quad (7)$$
$$GFCF_{i,t} < -\frac{\gamma_1}{2 * \gamma_2}\ \forall\ \gamma_2 < 0$$
$$GFCF_{i,t} = gross\ fixed\ capital\ formation$$

The spatial lag of the dependent variable is included in the independent variables of all three models in order to detect for the presence of spatial autocorrelation. For the "designation" of the neighbours, a spatial weights matrix based on geographical distance is used. A positive sign of the coefficient is going to indicate the presence of positive spatial autocorrelation.

A dummy variable for the less advanced regions is included in all three augmented models. Less advanced regions are the regions that on average (i.e., average figure for the entire period under consideration) exhibit per capita GDP figure below the corresponding EU average figure. A positive sign of the coefficient is going to indicate that, *ceteris paribus*, less advanced regions have been diverging from the richest EU region (i.e., Luxembourg).

Table 2 presents the results of the econometric investigation of the impact of the synchronization of regional business cycles on the evolution of regional inequalities in the EU, during the period 1990-2020.

Table 2. Impact of the synchronization of regional business cycles on the evolution of regional inequalities in the EU: econometric investigation, period 1990-2020

dependent variable: per capita GDP gap change			
	baseline (model 1)	**augmented (model 2)**	**augmented (model 3)**
per capita GDP gap change (lagged)	0.81***	0.81***	0.82***
synchronization change (lagged)	-1.49***	-1.51***	-1.55***
less developed regions (dummy)		0.36**	0.24
wealth-to-income ratio change (country level) (lagged)		6.79***	6.20***
structural funds (% GDP) change (lagged)		3^10^{-4}**	
gravity level (lagged)		-4^10^{-7}	
structural funds (% GDP) change (lagged) X gravity (lagged)		-1^10^{-8}***	
unemployment change (lagged)		0.01***	

dependent variable: per capita GDP gap change			
diversification level (lagged)		-0.34**	
gross fixed capital formation level (% GDP) (lagged)			0.15
gross fixed capital formation level (% GDP) (lagged) ^ 2			-4^10^{-3}*
per capita GDP gap change of neighboring regions (spatial lag)	1^10^{-3}***	2^10^{-3}***	2^10^{-3}***
constant	-2.57***	-0.57	-2.91**
country FE	yes	yes	yes
Adj. R^2	0.85	0.85	0.85
N	5,566	4,946	5,324

* statistically significant at 10%, ** statistically significant at 5%, *** statistically significant at 1%
Sources: ARDECO (2024) / WID (2024) / Authors' Elaboration

All three econometric models indicate that the evolution of regional inequalities in the EU is a self-sustained process. This is because the per capita GDP gap of each EU region with the richest EU region (i.e., Luxembourg) impacts positively on the consequent corresponding gap, *ceteris paribus*. In other words, all three econometric models indicate that past performance affects current performance in a positive way, ceteris paribus. The finding is statistically significant at 1% level.

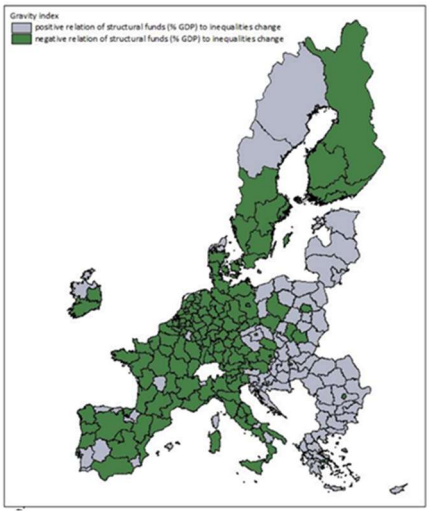
In all three models, the lag of the regional business cycles synchronization change impacts negatively on the evolution of regional inequalities, *ceteris paribus*. This indicates that the deepening of the process of economic integration exerts a negative impact on the evolution of regional inequalities since sectoral shocks are distributed more evenly within the integrated EU economic space. Increasing regional business cycles synchronization indicates that the regions under consideration are becoming more similar as regards their production structures. This can be attributed both to the similarity of economic policies implemented within the EU (and especially within the EMU) and to the increasing structural similarity between the EU regions. The finding is statistically significant at 1% level.

The dummy for the less advanced (i.e., with per capita GDP below the EU average) regions has a positive coefficient. This indicates that, *ceteris paribus*, the tendency for inequalities with the region of Luxembourg to increase is greater in the less developed regions. The finding is statistically significant at 5% level (model 2).

The lag of the WID ratio change exerts a positive impact on the evolution of regional inequalities, *ceteris paribus* (models 2 and 3). This is so as the concentration of accumulated wealth contributes to the idleness of part of the wealth (i.e., excess wealth) and to the increase of poverty rates. Thus, the concentration of wealth has a deterrent effect on growth (thus increasing regional inequality). The finding is statistically significant at 1% level.

The lag of structural funds (as a share of GDP) change has a positive impact on regional inequality, *ceteris paribus* (model 2). The finding is statistically significant at 5% level. Apparently, the sign of the coefficient is not the expected one. The lag of the gravity index has a statistically non-significant impact on regional inequality, *ceteris paribus* (model 2). The interaction of the two variables, however, reveals that there is an inverted-U-type relationship, *ceteris paribus* (model 2). This indicates that structural funds exert a negative impact on the evolution of regional inequalities only after a certain threshold of gravity. The finding is statistically significant at 1% level. Map 1 presents cartographically the conditional-on-gravity impact of structural funds (as a share of GDP) on regional inequality and indicates the regions that experience positive and negative impact.

Map 1. The conditional-on-gravity impact of structural funds (as a share of GDP) on the evolution of regional inequality, period 1990-2020

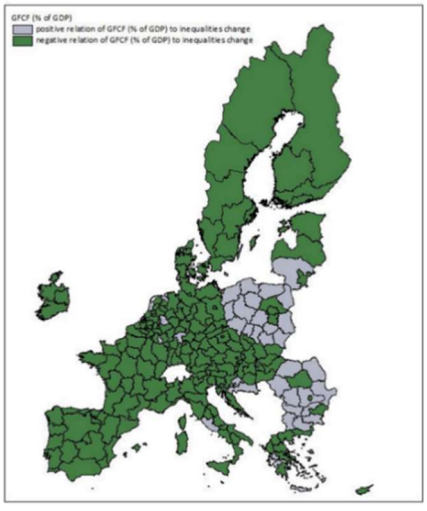


Sources: ARDECO (2024) / Authors' Elaboration

The lag of diversification change impacts negatively on regional inequalities, *ceteris paribus* (model 2). This is so as regions with a diversified regional profile are protected from sector-specific shocks and also have the opportunity to divert resources from one sector to another when economic conditions require it. The finding is statistically significant at 5% level.

The lag of GFCF level (as a share of GDP) exerts a non-linear impact on regional inequalities, *ceteris paribus* (model 3). It comes that there is an inverted U-type impact, indicating that GFCF exerts a negative impact on regional inequalities after a threshold. The finding is statistically non-significant in the first power of the variable, and it is statistically significant at 10% level in the second power of the variable. Map 2 presents cartographically the non-linear impact of GFCF on regional inequality and indicates the regions that experience positive and negative impact.

Map 2. The non-linear impact of GFCF (as a share of GDP) on the evolution of regional inequality, period 1990-2020



Sources: ARDECO (2024) / Authors' Elaboration

All three models indicate that there is a positive spatial autocorrelation, *ceteris paribus*. The finding is statistically significant at 1%. This means that the per capita GDP ratio change of the neighbors affects positively the evolution of regional inequalities between Luxembourg and the region under consideration.

5. Conclusion

The paper examines the impact of the synchronization of regional business cycles on the evolution of regional inequalities in the EU. The topic is crucially important given that the relation between the synchronization of regional business cycles and the evolution of regional inequalities reveals whether (and to what extent) sectoral shocks are distributed evenly or unevenly within the integrated economic space. The main variable under consideration is real (i.e., inflation-adjusted) GDP per capita. The paper utilizes ARDECO data that refer to the 242 EU regions (NUTS II level) and cover the period 1990-2020. GDP per capita data are expressed in constant, year 2015, prices.

The paper estimates the synchronization of the business cycle of Luxembourg (i.e., the richest EU region) with the business cycle of each of the EU regions under consideration. To this end, the paper utilizes the HP filter. The findings of the paper indicate that in only 1 out of the 24 8-year periods under consideration there is a (marginally) negative correlation, and, correspondingly, in 10 out the 24 periods there is a strong positive correlation. The average business cycle synchronization exhibits decreasing trend in 10 pairs of consecutive periods.

In order to assess the impact of the synchronization of regional business cycles on the evolution of regional inequalities in the EU, the paper compiles and estimates a panel data GLS model. In total, three different models are presented. The models indicate that past performance affects current performance in a positive way. This means that the evolution of regional inequalities in the EU is a self-sustained process. The models detect that regional business cycles synchronization change impacts negatively on the evolution of regional inequalities. This indicates that the deepening of the process of economic integration exerts a negative impact on the evolution of regional inequalities since sectoral shocks are distributed more evenly within the integrated EU economic space. The models also detect the role of a series of control variables as regards the evolution of regional inequalities. Particularly, the models indicate the positive impact of WID ratio change, the positive impact of unemployment change and the positive impact of spatial lag. The models also indicate the negative impact of diversification, the non-linear impact of GFCF and the conditional-on-gravity impact of structural funds change.

Evidently, the synchronization of regional business cycles may act as a catalyst for the reduction of regional inequalities in the EU. This is because sector-specific shocks are going to be spread throughout the EU economy instead of being region-specific. To the end of increasing regional business cycles synchronization, the EU needs to further develop adequate macroeconomic policies in order to address the structural deficiencies of the EU regions, and especially of the less developed ones. This seems to be the only way for these regions in order to cope successfully with the competitive pressures that are generated in the EU economically integrated environment. Regional policy, in particular, needs to become counter-cyclical. This means that regional policy must be more intense in periods of recession, when regional aid is needed the most. Attention needs to be paid to the fact that structural funds have a negative impact on the evolution of regional inequalities only after a certain threshold of gravity as the model indicates. This means that in order for regions to fully utilize the financial aid provided, a minimum economic size (i.e., GDP) is needed. Towards reducing regional inequalities, policies that de-concentrate wealth, diversify the production structure, strengthen GFCF and combat unemployment are thus necessary.

6. References

Aitken, A. C. (1935), 'On Least Squares and linear combinations of observations', Proceedings of the Royal Society of Edinburgh, 55, pp. 42-48. https://doi.org/10.1017/S0370164600014346

Alexiadis, Stelios, Ladias, Christos, Ap & Polo, Antoneta. (2010), 'Converging and diverging regions in the EU: Implications for regional policy', Regional Science Inquiry, 2(2), pp. 55-70. https://rsijournal.eu/?p=1182

Amin, A. & Tomaney, J. (1995), 'The regional dilemma in a neo-liberal Europe', European Urban and Regional Studies, 2 (2), pp. 171-188. https://doi.org/10.1177/096977649500200205

Amiti, M. (1999), 'Specialization patterns in Europe', Weltwirtschaftliches Archiv, 135, pp. 573-593. https://doi.org/10.1007/BF02707385

Anagnostou, A., Panteladis, I. & Tsiapa, M. (2015), 'Disentangling different patterns of business cycle synchronicity in the EU regions', Empirica, 42, pp. 615-641. https://doi.org/10.1007/s10663-014-9268-9
ARDECO (2024), Annual Regional Database of the EC DG for Regional and Urban Policy, https://knowledge4policy.ec.europa.eu/territorial/ardeco-database_en [accessed on: 30.06.2024].
Artis, M. & Zhang, W. (1997), 'International business cycles and the ERM: Is there a European business cycle?', International Journal of Finance and Economics, 2 (1), pp. 1-16. https://doi.org/10.1002/(SICI)1099-1158(199701)2:1<1::AID-IJFE31>3.0.CO;2-7
Barrios, S. & de Lucio, J. J. (2003), 'Economic integration and regional business cycles: Evidence from the Iberian regions', Oxford Bulletin of Economics and Statistics, 65 (4), pp. 497-515. https://doi.org/10.1111/1468-0084.t01-2-00059
Barrios, S. & Strobl, E. (2005), The dynamics of regional inequalities, European Commission Economic Paper no. 229.
Beine, M., Candelon, B. & Sekkat, K. (2003), 'EMU membership and business cycle phases in Europe: Markov-switching VAR analysis', Journal of Economic Integration, 18 (1), pp. 214-242. https://doi.org/10.11130/jei.2003.18.1.214
Belke, A. & Heine, J. (2006), 'Specialisation patterns and the synchronicity of regional employment cycles in Europe', International Economics and Economic Policy, 3 (2), pp. 91-104. https://doi.org/10.1007/s10368-006-0049-1
Brülhart, M. & Elliott, R. (1998), 'Adjustment to the European Single Market: Inferences from intra-industry trade patterns', Journal of Economic Studies, 25, pp. 225-247. https://doi.org/10.1108/01443589810215360
Cairncross, F. (1997), The death of distance: How communications revolution will change our lives, London: Orion Business Books.
Camacho, M., Perez-Quiros, G. & Saiz, L. (2008), 'Do European business cycles look like one?', Journal of Economic Dynamics and Control, 32 (7), pp. 2165-2190. https://doi.org/10.1016/j.jedc.2007.09.018
Camagni, R. (1992), 'Development scenarios and policy guidelines for the lagging regions in the 90s', Regional Studies, 26 (4), pp. 361-374. https://doi.org/10.1080/00343409212331347051
Canova, F. (1994), 'Detrending and turning-points', European Economic Review, 38 (3/4), pp. 614-623. https://doi.org/10.1016/0014-2921(94)90097-3
Canova, F. (1998), 'Detrending and business cycle facts', Journal of Monetary Economics, 41 (3), pp. 475-512. https://doi.org/10.1016/S0304-3932(98)00006-3
Capello, R. & Cerisola, S. (2023), 'Industrial transformations and regional inequalities in Europe', Annals of Regional Science, 70, pp. 15-28. https://doi.org/10.1007/s00168-021-01097-4
Castells, M. (1996), The rise of the network society, Oxford: Blackwell.
Christiano, L. J. & Fitzgerald, T. J. (1999), The band-pass filter, NBER Working Paper no. 257.
Christiano, L. J. & Fitzgerald, T. J. (2003), 'The band-pass filter', International Economic Review, 44 (2), pp. 435-465. https://doi.org/10.1111/1468-2354.t01-1-00076
Ciccone, A. (2002), 'Agglomeration effects in Europe', European Economic Review, 46, pp. 213-227. https://doi.org/10.1016/S0014-2921(00)00099-4
Cogley, T. & Nason, J. M. (1995), 'Effects of the Hodrick-Prescott filter on trend and difference stationary time series: Implications for business cycle research', Journal of Economic Dynamics and Control, 19 (1), pp. 253-278. https://doi.org/10.1016/0165-1889(93)00781-X
Constantin, D.-L. & Volintiru, C.-A. (2024), 'Place-based policy responses to spatial inequalities', Regional Science Inquiry, 16(2), pp. 43-62. https://rsijournal.eu/?p=4515
Cox, K. R. (2008), 'Globalization, uneven development and capital: Reflections on reading Thomas Friedman's The World Is Flat', Cambridge Journal of Regions, Economy and Society, 1, pp. 389-410. https://doi.org/10.1093/cjres/rsn017
Cox, A. & Wood, K. (1997), 'Competition and cooperation in mediating the global: The case of local economic development', Competition and Change, 2, pp. 65-94. https://doi.org/10.1177/1024529497002001
Darvas, Z. & Szapáry, G. (2008), 'Business cycle synchronization in the enlarged EU', Open Economies Review, 19 (1), pp. 1-19. https://doi.org/10.1007/s11079-007-9027-7
Dimelis S. & Livada A. (1999), 'Inequality and business cycles in the US and European Union countries', International Advances in Economic Research, 5, pp. 321-338. https://doi.org/10.1007/BF02296415
Fatás, A. (1997), 'EMU: countries or regions? Lessons from the EMS experience', European Economic Review, 41 (3–5), pp. 743-751. https://doi.org/10.1016/S0014-2921(97)00033-0
Friedman, T. (2005), The world is flat: A brief history of the twenty-first century, New York: Farrar, Strauss and Giroux.
Friedman, T. (2007), The world is flat, New York: Picador.

Gayer, C. (2007), A fresh look at business cycle synchronisation in the euro area, European Economy Economic Paper no. 287.
Geiger, M., Mayer, E. & Scharler, J. (2020), 'Inequality and the business cycle: Evidence from U.S. survey data', Applied Economics, 52 (31), pp. 3418-3435. https://doi.org/10.1080/00036846.2020.1711508
Gertler, M. S. (2003), 'Tacit knowledge and the economic geography of context, or The undefinable tacitness of being (there)', Journal of Economic Geography, 3 (1), pp. 75-99. https://doi.org/10.1093/JEG/3.1.75
Grossman, G. M. & Helpman, E. (1994), 'Endogenous innovation in the theory of growth', Journal of Economic Perspectives, 8, pp. 23-44. DOI: 10.1257/jep.8.1.23
Hodrick, R. J. & Prescott, E. C. (1980), Postwar U.S. business cycles: An empirical investigation, Carnegie-Mellon University Discussion Paper no. 451.
Hodrick, R. & Prescott, E. C. (1997), 'Postwar U.S. business cycles: An empirical investigation', Journal of Money, Credit, and Banking, 29 (1), pp. 1-16. https://doi.org/10.2307/2953682
Iammarino, S., Rodriguez-Pose, A. & Storper, M. (2017), Why regional development matters for Europe's economic future, European Commission Working Paper no. 7.
Jokubaitis, S. & Celov, D. (2023), 'Business cycle synchronization in the EU: A regional-sectoral look through soft-clustering and wavelet decomposition', Journal of Business Cycles Research, 19, pp. 311-371. https://doi.org/10.1007/s41549-023-00090-4
Kallioras, D. (2010), 'Regional inequalities in the new European Union Member-States: Is there a "population size" effect?', European Spatial Research and Policy, 17 (2), pp. 107-116. https://doi.org/10.2478/s10105-010-0013-5
Kallioras, D. & Niavis, S. (2025), 'Regional inequalities: Knowledge frontiers and debates', Sustainable Regional Development Scientific Journal, 2(1), pp. 67-80. https://srdsjournal.eu/articles/files/2025-1-6.pdf
Kallioras, D. & Petrakos, G. (2010), 'Industrial growth, economic integration and structural change: Evidence from the EU new member-states regions', Annals of Regional Science, 45, pp. 667-680. https://doi.org/10.1007/s00168-009-0296-5
Kallioras, D., Tzeremes, N., Tzeremes, P. & Adamakou, M. (2021), 'Technological change, technological catch-up and market potential: Evidence from the EU regions', Regional Science Inquiry, 13(1), pp. 135-151. https://rsijournal.eu/?p=4167
Karanika, M. & Kallioras, D. (2018), 'EU spatiality under question-Territorial cohesion in danger', Territories, 1 (1), pp. 60-72. https://doi.org/10.5070/T21141511
Kemeny, T. (2011), 'Are international technology gaps growing or shrinking in the age of globalization?', Journal of Economic Geography, 11 (1), pp. 1-35. https://doi.org/10.1093/jeg/lbp062
King, R. G. & Rebelo, S. T. (1993), 'Low frequency filtering and real business cycles', Journal of Economic Dynamics and Control, 17 (1/2), pp. 207-231. https://doi.org/10.1016/S0165-1889(06)80010-2
Kydland, F. E. & Prescott, E. C. (1990), 'Business cycles: Real facts and a monetary myth', Federal Reserve Bank of Minneapolis Quarterly Review, 14 (2), pp. 3-18. https://doi.org/10.21034/qr.1421
Lincaru, C., Tudose, G., Grigorescu, A. Pîrgioc, S. & Stroe, C. (2025), 'Marginalized zones as statistical instrucments to navigate permacrisis impacts in European regions', Regional Science Inquiry, 17(1), pp. 155-165. https://rsijournal.eu/?p=4581
Lucas, R. (1977), 'Understanding business cycles', Carnegie-Rochester Conference Series on Public Policy, 5, pp. 7-29. https://doi.org/10.1016/0167-2231(77)90002-1
Markusen, A. (1996), 'Sticky places in slippery places: A typology of industrial districts', Economic Geography, 72, pp. 293-313. https://doi.org/10.2307/144402
Marcet, A. & Ravn, M. (2004), The HP-filter in cross-country comparisons, CEPR Discussion Paper no. 4244.
Martin, P. & Ottaviano, G. I. P. (2001), 'Growth and agglomeration', International Economic Review, 42 (4), pp. 947-968. https://doi.org/10.1111/1468-2354.00141
Massmann, M. & Mitchell L, J. (2004), 'Reconsidering the evidence: Are Eurozone business cycles converging?', Journal of Business Cycle Measurement and Analysis, 1 (3), pp. 275-308. https://doi.org/10.1787/jbcma-v2004-3-en
Matesanz, D. & Ortega, G. J. (2016), 'On business cycles synchronization in Europe: A note on network analysis', Physica A: Statistical Mechanics and its Applications, 462, pp. 287-296. https://doi.org/10.1016/j.physa.2016.06.097
McCann, P. (2008), 'Globalization and economic geography: The world is curved, not flat', Cambridge Journal of Regions, Economy and Society, 1 (3), pp. 351-370. https://doi.org/10.1093/cjres/rsn002
McKinnon, R. I. (1963), 'Optimum currency areas', American Economic Review, 52, pp. 717-725. https://www.jstor.org/stable/1811021

Melachroinos, K. A. (2002), 'European integration and the spatial dynamics of manufacturing employment change', Environment and Planning A, 34 (11), pp. 2017-2036. https://doi.org/10.1068/a3543
Michaelides, P. G., Papageorgiou, T. & Vouldis, A. T. (2013), 'Business cycles and economic crisis in Greece (1960–2011): A long run equilibrium analysis in the eurozone', Economic Modelling, 31, pp. 804-816. https://doi.org/10.1016/j.econmod.2013.01.013
Montoya, L. A. & de Haan, J. (2008), 'Regional business cycle synchronization in Europe?', International Economics and Economic Policy, 5, pp. 123-137. https://doi.org/10.1007/s10368-008-0106-z
Mundell, R. A. (1961), 'A theory of optimum currency areas', American Economic Review, 51, pp. 657-665. https://www.jstor.org/stable/1812792
Mullineux, A. W. (1990), Business cycles and financial crises, Ann Arbor: The University of Michigan Press.
O'Brien, R. (1992), Global financial integration: The end of geography, New York: Council on Foreign Relations Press.
OECD (2013), OECD Science, Technology and Industry Scoreboard 2013, Paris: OECD.
Paci, R. & Usai, S. (2000), 'Technological enclaves and industrial districts: An analysis of the regional distribution of innovative activity in Europe', Regional Studies, 34 (2), pp. 97-114. https://doi.org/10.1080/00343400050006032
Panteladis, I. & Tsiapa, M. (2014), 'Fragmented integration and business cycle synchronization in the Greek regions', European Planning Studies, 22 (5), pp. 909-928. https://doi.org/10.1080/09654313.2012.744381
Pearson, K. (1895), 'Notes on regression and inheritance in the case of two parents', Proceedings of the Royal Society of London, 58, pp. 240-242. https://doi.org/10.1098/rspl.1895.0041
Petrakos, G. (2000), 'The new geography of development in Europe and the position of Balkans', [in:] Petrakos, G. (ed.), The development of the Balkans, Volos: University of Thessaly Press, pp. 13-35.
Petrakos, G. (2008), 'Regional inequalities in Europe: Reflections on evidence, theory and policy', Town Planning Review, 79 (5), pp. 7-13. https://doi.org/10.1093/jeg/lby021
Petrakos, G., Artelaris, P. & Kallioras, D. (2020), 'Convergence and public debt in the European Union: An overlooked trade-off?', Regional and Federal Studies, 31 (5), pp. 671-688. https://doi.org/10.1080/13597566.2020.1809382
Petrakos, G., Tsiapa, M. & Kallioras, D. (2016), 'Regional inequalities in the European Neighborhood Policy countries: The effects of growth and integration', Environment and Planning C: Government and Policy, 34 (4), pp. 698-716. doi: 10.1177/0263774X15614730
Pina, Á. & Sicari, P. (2021), Enhancing regional convergence in the European Union, OECD Working Paper no. 1696.
Polyzos, S. & Tsiotas, D. (2025), 'Spatial disparities in the European Union: A macroscopic review', Regional Science Inquiry, 17(1), pp. 13-36. https://rsijournal.eu/?p=4553
Ravn, M. O. & Uhlig, H. (2002), 'Notes on adjusting the Hodrick-Prescott filter for the frequency of observations', Review of Economics and Statistics, 84 (2), pp. 371-380. https://doi.org/10.1162/003465302317411604
Rodriguez-Pose, A. (2018), 'The revenge of places that don't matter (and what to do about it)', Cambridge Journal of Regions, Economy and Society, 11 (1), pp. 189-209.
Rodriguez-Pose, A. & Crescenzi, R. (2008), 'Mountains in a flat world: Why proximity still matters for the location of economic activity', Cambridge Journal of Regions, Economy and Society, 1 (3), pp. 371-388. https://doi.org/10.1093/cjres/rsx024
Scott, A., Agnew, J., Soja, E. & Storper, M. (2001), 'Global city-regions', [in:] Scott, A. (ed.), Global city-regions: Trends, theory, policy, Oxford: Oxford University Press, pp. 11-32.
Scott, A. J. & Storper, M. (2003), 'Regions, globalization, development', Regional Studies, 37 (6-7), pp. 579-593. https://doi.org/10.1080/0034340032000108697a
Siedschag, I. & Tondl, G. (2011), 'Regional output growth synchronisation with the Euro Area', Empirica, 38, pp. 203-221. https://doi.org/10.1007/s10663-010-9130-7
Trotta Vianna, M. (2023), 'Business cycle theories after Keynes: A brief review considering the notions of equilibrium and instability', Structural Changes and Economic Dynamics, 64, pp. 134-143. https://doi.org/10.1016/j.strueco.2022.12.004
Tsiapa, M., Kallioras, D., Manetos, P. & Pérez-Balsalobre, S. (2025), 'Brexit's ripple effect: transformations in European interregional trade', Regional Studies, 59 (1). https://doi.org/10.1080/00343404.2025.2518279
Tsiapa, M., Kallioras, D. & Tzeremes, N. G. (2018), 'The role of path-dependence in the resilience of EU regions', European Planning Studies, 26 (6), pp. 1099-1120. https://doi.org/10.1080/09654313.2018.1458284
Uzsaylir, A. & Baycan, T. (2024), 'Regional specialization in the context of deindustrialization: The case of Türkiye', Regional Science Inquiry, 16(2), pp. 33-42. https://rsijournal.eu/?p=4513

Weinhold, D. & Rauch, J. E. (1999), 'Openness, specialization and productivity growth in less developed countries', Canadian Journal of Economics, 32 (4), pp. 1009-1027. https://www.jstor.org/stable/136415

WID (2024), Database on world inequality of the World Inequality Laboratory, https://wid.world/wid-world/ [accessed on: 30.06.2024].

Zarnowitz, V. & Ozyildirm, A. (2006), 'Time series decomposition and measurement of business cycles, trends and growth cycles', Journal of Monetary Economics, 53, pp. 1717-1739. https://doi.org/10.1016/j.jmoneco.2005.03.015

7. Abbreviations

ARDECO	**Annual Regional Database of the European Commission's Directorate General for Regional and Urban Policy**
BLUE	best linear unbiased estimator
CF	Christiano - Fitzgerald
EMU	Economic and Monetary Union
EU	European Union
FE	fixed effects
GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
GLS	Generalized Least Squares
HK	Hannah-Kay
HP	Hodrick - Prescott
IRS	increasing returns-to-scale
NUTS II	Nomenclature of Territorial Units for Statistics (level 2)
OLS	Ordinary Least Squares
SEM	Single European Market
UK	the United Kingdom
WID	wealth-to-income
€/inh.	euros per inhabitant

THE TRANSPORT SYSTEM IN BUCHAREST-ILFOV REGION IN ROMANIA: THE PATH TOWARDS SUSTAINABILITY

Corina-Cristiana NASTACĂ
PhD, Bucharest University of Economic Studies, Department of Administration and Public Management, Bucharest, Romania
corina.nastaca@amp.ase.ro
(Corresponding Author)

Claudiu-Emanuel SIMION
Bucharest University of Economic Studies, Management Doctoral School, Bucharest, Romania
simionclaudiuemanuel@gmail.com

Abstract
The study analyses the transport system in Bucharest-Ilfov, the most developed region in Romania in order to identify the challenges in managing its development and solutions for improving urban mobility and promote a more sustainable transport system infrastructure in the area. The objectives of the research are: (1) To investigate citizens' opinions in Bucharest-Ilfov region regarding the transport infrastructure in the area; (2) To analyse citizens' degree of satisfaction regarding public transport in Bucharest-Ilfov region; (3) To investigate the main problems and challenges of the public transport system and transport infrastructure in the region and propose solutions for improving urban mobility in a sustainable manner. The methodology of the study consists of an opinion survey conducted by the authors within the citizens of Bucharest-Ilfov region in Romania, in order to find out their opinions regarding the transport infrastructure and the local transport system in the region. The research emphasizes the need for the strategic implementation of sustainable transport solutions that promote environmentally friendly mobility, reduce greenhouse gas emissions, and ease traffic congestion. Furthermore, in the context of the accelerated urbanization of the Bucharest-Ilfov region, the development of a sustainable transport system is becoming a key factor in ensuring balanced, resilient and environmentally friendly urban growth.

Keywords: urban mobility, sustainability, Bucharest-Ilfov region, local public transport system
JEL classification: R0, R1, R4
pp. 53-70

1. Introduction

Sustainable transport represents a key pillar of sustainable development, as it is directly referenced in several Sustainable Development Goals (SDGs) and significantly influences their achievement. Sustainable mobility systems aim to reduce greenhouse gas emissions and environmental impacts while ensuring safety, accessibility, and improved energy efficiency. At the same time, they seek to guarantee equitable access to mobility for all population groups (UNDP, 2025).

Sustainable transport systems contribute to enhancing social cohesion, mitigating environmental challenges, and promoting economic efficiency (Clitan, 2014). This holistic vision applies across all transport modes and geographical areas, positioning transport as a critical enabler of sustainable development in general and climate action in particular.

Sustainable transport is a complex system designed to meet people's mobility needs and the movement of goods and materials under optimal conditions, while significantly minimizing adverse environmental impacts. Globally, the transition to sustainable transport systems has become imperative. Significant investments are being directed toward policies that promote the adoption of non-polluting vehicles, the rehabilitation of infrastructure, and the optimization of logistics and transport routes (UNDP, 2025).

At the European level, the introduction of sustainable and innovative transport solutions is essential for meeting EU's energy and climate objectives. According to analyses conducted at EU level, the transport sector remains heavily dependent on oil and oil-derived products—a situation that is unsustainable both environmentally and economically (EU, 2025). By 2050,

the EU aims to reduce transport-related greenhouse gas emissions by 60% compared to 1990 levels and to significantly curb pollution generated by vehicles. Despite these ambitions, disparities in transport infrastructure persist across EU member states, and the region faces increasing competition from rapidly developing transport markets in other parts of the world.

Consequently, sustainable transport has become a matter of strategic importance, and its development depends on a range of interrelated factors, including the design and monitoring of strategies aligned with sustainable development objectives, allocation of public funds, access to non-reimbursable financing, provision of incentives, and the awareness and engagement of both individuals and organizations in shifting towards sustainable transport solutions.

In this respect, the present research analyses the transport system in Bucharest-Ilfov, the most developed region in Romania in order to identify the challenges in managing its development and solutions for improving urban mobility and promote a more sustainable transport system.

The study started from the following hypothesis:

H1: The transport infrastructure in the Bucharest-Ilfov region does not meet citizens' needs.

H2: Citizens' general level of satisfaction with public transport system in the region is low.

H3: The main problems of the public transport system are traffic jams and overcrowding.

The paper is structured as it follows: the first section comprises the literature review on sustainable transport, followed by main consideration about transport system and Romania and relevant information on Bucharest-Ilfov region. After the theoretical background, the research objectives and methodology are presented. The next part of the study focuses on the presentation of the main results followed by the discussions and conclusions section.

2. Literature review

2.1. Theoretical background regarding sustainable transport

Transport sector is one of the main sources of greenhouse gas emissions, representing a major challenge for global environmental protection strategies (Ferro, Ramos & Ferrero, 2025). In the European Union, this sector generates approximately one-quarter of CO_2 emissions, emphasizing the need for policies focused on reducing negative environmental impact (European Commission, 2019).

Current policies promote the transition to green mobility through measures such as encouraging electric vehicle use, developing public transport infrastructure, and traffic optimization via smart technologies. These initiatives contribute to reducing pollution and improving urban quality of life (Banister, 2008a; Bakogiannis, 2018).

Additionally, transport's impact on natural resource use requires a reevaluation of infrastructure project priorities. A sustainable approach includes integrating renewable energy, reducing dependence on fossil fuels, and promoting active transport modes such as walking and cycling (Amheka, 2018; Rodrigue, 2020; Ferro, Ramos & Ferrero, 2025).

For example, a study conducted in the Nordic countries (Banister, 2008b) showed that European cities that implemented integrated transport policies (public transport, cycling networks, walking solutions) reported significant greenhouse gas reductions and improved air quality. Also, cities with efficient public transport and cycling infrastructure reduced the usage of private vehicles by up to 30%. In Copenhagen, considered a leader in sustainable mobility, 40% of citizens cycle daily which led to a decrease in car use by 15% (Pucher & Buehler, 2017). Another research (Givoni, 2012) that also focused on integrated approach of the transport policy showed similar results, meaning that cities combining public transport with active mobility measures such as walking and cycling reduced private cars use by up to 25% and CO_2 emissions by 18%, leading to better air quality and lower noise pollution. In another study on the same subject, the author (Vuchic, 2017) concluded that cities investing in electric transport (buses, trams) achieved operational cost savings, pollution reduction, and 30% increased public transport use. In Amsterdam for example, electric transport reduced city CO_2 emissions by 20%, with electric buses representing around 25% of the fleet.

Recent advancements in the field of sustainable transportation further highlight emerging trends and best practices aimed at mitigating environmental impacts and enhancing urban

mobility. A study conducted by Litman (2017) emphasizes the role of electric vehicles and carpooling as effective strategies for reducing CO_2 emissions. In many European urban centers, the adoption rate of electric vehicles has increased by up to 50% in recent years, yielding substantial environmental benefits. For instance, in Berlin, the demand for EVs has risen by 40% over the past four years, with local authorities reporting significant improvements in air quality and a measurable decline in pollution levels.

These research indicate that urban areas which have implemented dedicated infrastructure for these sustainable modes have achieved substantial reductions in private car usage, along with measurable improvements in urban mobility.

Nevertheless, the development and implementation of sustainable transport policies remain a complex and multifaceted processes (Casas et al., 2012, Bakogiannis et al., 2018). These efforts are often impeded by a range of economic, political, cultural, and infrastructural barriers. The effectiveness of sustainable mobility initiatives is therefore closely linked to the ability of policymakers, institutions, and local communities to address and mitigate these challenges (Holden et al., 2019). Existing literature identifies several critical factors that influence the successful adoption and long-term impact of sustainable transport strategies (Holden, Giplin & Banister, 2019; Jeyaseelan et al., 2022), one of them being digitalization, a key enabler in the structural evolution of urban mobility systems (Creutzig et al., 2019; Schippl & Arnold, 2020; Havryliuk et al., 2021).

In numerous metropolitan areas, the adoption of mobile transport applications, offering real-time data, route optimization, and multimodal trip planning, has significantly contributed to reducing traffic congestion and enhancing the efficiency of public transport networks (Siuhi, & Mwakalonge, 2016; Seliverstov et al., 2020). For example, evidence from cities such as London and Paris indicates that the implementation of integrated mobility platforms has resulted in a 15% reduction in travel time and a 10% decrease in private car usage. Furthermore, users of these applications have reported notable improvements in travel satisfaction and reductions in stress associated with traffic conditions (Psaraki & Pagoni, 2012; Kamargianni et al., 2015; Fontes et al., 2017).

Furthermore, infrastructure challenges arise due to the limited spatial capacity of urban areas and the difficulties associated with embedding new transportation systems into pre-established urban environments (Vuchic, 2017). Notably, cities such as Paris and New York have made significant strides in upgrading their infrastructure to facilitate electric public transit and promote active mobility. However, these advancements have necessitated substantial financial investment and long-term strategic planning. In contrast, smaller or less developed urban centers face compounded difficulties due to the lack of essential infrastructure needed to sustain efficient public transport systems, as well as car-sharing and cycling networks.

A major obstacle to implementing sustainable transport policies remains the issue of financing. Infrastructure investments, such as expanding public transit systems, constructing dedicated cycling infrastructure, and supporting the transition to electric mobility, require substantial financial resources. However, many local governments operate under constrained budgets and lack sufficient funding to support large-scale sustainable transport initiatives. As a result, the long-term success of such policies often depends on securing diverse and stable funding sources, including public-private partnerships and targeted government subsidies (Pedrana, 2013; Kadyraliev et al., 2022; Zhang & Cheng, 2023). A relevant example is London, where the expansion of the public transport system, particularly through the development of new underground lines, has faced significant funding challenges due to high capital costs, resulting in implementation delays (Litman, 2017). Another challenge is political opposition to the enforcement of sustainable mobility strategies, particularly those targeting a decrease in private car usage (Bannister, 2008a). For instance, in several cities across the United States, local governments have faced opposition from both transport sector stakeholders and members of the public, who perceive investments in public transit and cycling infrastructure as limiting individual freedom of mobility.

Also, an important aspect in achieving sustainable transport is related to profound cultural shifts. In German cities, where cycling and public transportation are widely adopted, this transition was underpinned by long-term educational initiatives and awareness-raising efforts aimed at reshaping mobility habits. A significant portion of this success is attributed to

comprehensive public campaigns and the systematic development of infrastructure tailored to the needs of cyclists and pedestrians (Pucher & Buehler, 2017). Conversely, the promotion of public transportation in contexts such as the United States and Brazil has been impeded by a deeply ingrained automobile-centric culture. Addressing this issue necessitates the design and implementation of strategic interventions focused on altering public perceptions of transit, particularly through improvements in service quality and passenger comfort (Fang at al., 2022; Mohammed et al., 2023).

2.2. Main considerations on public transport in Romania

Public transportation constitutes a fundamental component in advancing sustainable urban mobility and in reducing the environmental footprint associated with urbanization. In alignment with the European Union's environmental policy framework, Romania is currently undergoing a progressive transformation towards a more sustainable and ecologically responsible public transport system. Traditionally, the public transport sector in Romania has been a notable contributor to greenhouse gas (GHG) emissions. Nonetheless, in recent years, local and national authorities have initiated a series of measures aimed at decarbonizing the sector. These include the integration of electric buses, the modernization of transport infrastructure, and the expansion of low-emission transit networks. Such efforts signify a strategic shift towards compliance with EU climate objectives and the enhancement of environmental quality in urban areas.

Public transport represents a major source of carbon dioxide (CO_2) emissions and other air pollutants. In the majority of Romanian cities, buses, trams, and trolleybuses have historically relied on fossil fuels, thereby contributing significantly to urban air pollution and elevated greenhouse gas (GHG) emissions. According to data published by the Ministry of Environment, Waters and Forests (2022), road transport is responsible for approximately 30% of the country's total CO_2 emissions. Furthermore, the emissions of nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$) are considerably higher in densely populated urban areas, where public transport constitutes a substantial proportion of overall mobility. These findings underscore the environmental challenges associated with conventional public transport systems in Romania and emphasize the need for cleaner, more sustainable alternatives (Ministry of Environment, Waters and Forests, 2022).

Between 2019 and 2020, carbon dioxide (CO_2) emissions generated by public transport in Romania's major urban centers were estimated at approximately 0.45 million tons per year (Ministry of Environment, Waters and Forests, 2022). These emissions primarily originated from conventional buses and trams powered by diesel and gasoline. In addition to greenhouse gas emissions, noise pollution and the release of fine particulate matter (PM) were identified as significant public health concerns.

To mitigate the environmental impact of public transport, Romanian authorities have implemented a range of measures aimed at enhancing sustainability and energy efficiency across the sector. Key initiatives include (Ministry of Transport, 2025):

- deployment of electric and hybrid buses: Beginning in 2020, several Romanian cities, including Bucharest and Cluj-Napoca - introduced electric buses on major public transport routes. According to the Ministry of Transport (2022), these initiatives have resulted in a notable decrease in CO_2 emissions, with reductions of up to 20% reported in areas where electric buses have been deployed.
- modernization of tram and trolleybus networks: in numerous large cities, tram and trolleybus systems have been expanded and upgraded to operate on cleaner electricity sources.
- development of green infrastructure: complementary to the adoption of low-emission vehicles, the expansion of charging infrastructure for electric buses and the installation of electric bicycle docking stations have facilitated the transition to sustainable urban mobility. These infrastructure projects, supported by European Union funding, have been implemented across several major cities in Romania (Ministry of Transport, 2025).

Collectively, these efforts reflect Romania's alignment with broader European environmental objectives and demonstrate a strategic commitment to decarbonizing the urban transport sector. Romania has undertaken a series of strategic actions aimed at advancing the

development of environmentally sustainable public transport systems. Key among these initiatives are the following:

- The National Strategy for Sustainable Urban Mobility adopted by the Romanian Government, this strategic framework aims to reduce CO_2 emissions and enhance the efficiency, accessibility, and environmental performance of public transport services. As reported by the Ministry of Transport (2022), the strategy envisions substantial public investments in low-emission and zero-emission transport infrastructure by 2030.
- utilization of European Union Funding. Romanian municipalities have actively accessed European structural funds to implement sustainable transport projects. Through the Regional Operational Programme (ROP), major urban areas have secured funding for the acquisition of electric buses and the modernization of public transport infrastructure, aligning local development efforts with broader EU climate and mobility goals (Ministry of Investments and European Projects, 2025).
- Local Sustainable Urban Mobility Plans (SUMPs). Many cities have adopted SUMPs that set out specific objectives and measurable targets to increase the proportion of environmentally friendly transport within the urban mobility mix. These plans are essential tools for guiding the long-term transition towards sustainable urban mobility at the local level.

Notable progress has been recorded in cities such as Bucharest and Cluj-Napoca. In Bucharest, a large-scale bus fleet modernization project was launched in 2020, replacing aging diesel vehicles with electric buses. According to data from Bucharest Municipality (2024), by 2023, approximately 30% of the city's bus fleet had been electrified, resulting in a significant reduction in CO_2 emissions and a marked improvement in urban air quality.

Cluj-Napoca has also implemented a similar program, initiating the introduction of hybrid and electric buses in 2021. According to reports published by Cluj-Napoca City Hall (2021), CO_2 emissions from public transport declined by approximately 15% within the first two years of the project, demonstrating the effectiveness of clean vehicle adoption in reducing the environmental footprint of urban mobility.

As part of the National Recovery and Resilience Plan (PNRR) adopted by the European Commission on September 21, 2021, Component 4 – Transport has been allocated a budget of €7.6 billion. The primary objective of this component is to enhance the sustainability of Romania's public transport system by supporting the green and digital transition through the development of durable, environmentally friendly infrastructure that meets appropriate safety standards. The component also aims to stimulate the transition toward a nationally sustainable transport model, emphasizing the implementation of environmentally friendly solutions (Ministry of Investments and European Projects, 2023).

To achieve this overarching objective, two major reforms have been outlined:

1. Sustainable Transport, Decarbonization and Road Safety,
2. Efficient Transport Management – aimed at improving institutional capacity for governance and corporate management.

In addition, four major investment priorities are being pursued:

- Modernization and renewal of railway infrastructure,
- Acquisition of new railway rolling stock,
- Development of sustainable road infrastructure on the TEN-T network,
- Expansion of the metro transport network in Bucharest and Cluj-Napoca.

Complementarily, under the Transport Programme 2021–2027, several state aid schemes have been launched to support energy efficiency in transport (Ministry of Transport, 2025), including:

- "e-Mobility RO" Programme – targeting the development of electric vehicle charging infrastructure along the national network of highways, expressways, and national roads. The programme has a total budget of €299 million, with projects to be completed by December 31, 2030.
- "e-MOVE RO" Programme – aimed at promoting zero-emission mobility infrastructure to support businesses and local communities. It has a budget of €250 million and an implementation deadline of December 31, 2028. Eligible beneficiaries include enterprises (micro, small, medium, and large), as well as state-owned companies and legally established public entities.

- Amendment and expansion of the State Aid Scheme for investments in inland waterway transport infrastructure, with a total budget of €150 million, and a final implementation deadline of June 30, 2030. The programme targets the acquisition of container-type modular battery charging stations, on-site renewable energy generation systems, and associated energy storage solutions.

Investments in Romania's transport sector are expected to contribute significantly to economic development, reduction of regional disparities, and overall improvement of mobility, particularly urban mobility.

In recent years, in the context of ongoing urban development, the concept of sustainable urban mobility has gained increasing importance in Romania. It reflects a growing concern for sustainability and efficiency in urban transport systems. In this regard, Law no. 155/2023 provides the legal framework necessary to promote and manage sustainable urban mobility at the national level.

According to Article 3 of the Law, sustainable urban mobility is defined as:

"the field that provides the strategic and operational framework for aligning urban planning and development with the transport of people and goods at the neighborhood, city, and metropolitan levels." (Romanian Parliament, 2023).

This approach contributes to reducing both traffic congestion and pollution, two of the most pressing issues facing urban areas in Romania. It promotes the use of efficient public transport and alternative modes of travel, such as walking and cycling. Consequently, in major urban centers, the implementation of effective sustainable mobility strategies is a sine qua non condition for achieving efficient and resilient sustainable development (Romanian Parliament, 2023).

2.3. Bucharest-Ilfov region- main aspects

The Bucharest-Ilfov region represents one of the most economically developed areas in Romania. Bucharest functions as the central economic hub and exerts a polarizing influence on Ilfov County, attracting and concentrating a significant share of the region's economic activities. With a population exceeding 2 million inhabitants and contributing approximately 10.5% to the national Gross Domestic Product (GDP), Bucharest is the most important economic center in the country (Bucharest Municipality, 2024).

Despite being the smallest administrative region by area, the Bucharest-Ilfov region is the most densely populated in Romania, comprising approximately 2,655,573 residents (National Institute of Statistics, 2021). Of this total, 81% reside in Bucharest and 19% in Ilfov County (Bucharest Municipality, 2024). The region's population has shown a consistent upward trend. A notable demographic shift involves residents relocating from Bucharest to Ilfov County while continuing to commute to the capital for employment. Furthermore, the official population figures may underestimate the actual number of inhabitants, as a substantial number of individuals reside in the region without having formally registered their residence, thus contributing to an unofficial but significantly higher population count.

In Bucharest, areas with the highest population densities are primarily located along major European and national road corridors, such as the E81 (including neighborhoods like Cotroceni, Militari, Preciziei, Dristor, and Trapezului) and in proximity to national roads DN4, DN5, and E85 (including Progresul, Industriilor, and Apărătorii Patriei). These densely populated zones frequently overlap with areas of recent urban expansion, particularly those governed by Zonal Urban Plans (PUZs) approved at the municipal level. Such areas are predominantly situated on the outskirts of the city, where land availability facilitates new residential development.

A clear spatial trend can be observed, wherein residents exhibit a preference for neighborhoods situated near major road infrastructure. The urbanized zones contributing to this expansion are largely residential in nature and are typically concentrated around high-capacity public transport nodes, such as Nicolae Teclu, Anghel Saligny, Valea Ialomiței, and Militari. Additionally, other expansion areas have emerged with specific functional profiles: industrial (e.g., along Splaiul Unirii) or recreational (e.g., around Lake Herăstrău). Conversely, the lowest population densities - fewer than 1,000 inhabitants - are found in peripheral natural areas, such as those surrounding the Zoo and Băneasa Forest, as well as Chitila Dendrological Park. Low-density zones are also observed near industrial zones (e.g.,

Berceni Industrial Area, Pantelimon Depot) and commercial peripheries adjacent to the Ilfov County border (e.g., West Park).

The most prevalent population size across Bucharest's traffic analysis zones ranges between 10,000 and 30,000 inhabitants. This distribution is relatively balanced between central and peripheral areas, reflecting both historical urban cores and newly developed residential districts (Bucharest Municipality, 2024).

Despite the rapid population growth observed in Ilfov County, the municipality of Bucharest continues to exhibit a negative demographic trend. Data from the most recent national censuses (2011 and 2021) indicate a steady depopulation of the capital city in favor of surrounding localities within Ilfov County, which are experiencing consistent population gains. This demographic shift is driven by multiple factors, including improved environmental quality in peri-urban areas and the availability of construction land at comparatively lower prices.

While Bucharest retains its role as the dominant economic and administrative center in the region, Ilfov County has increasingly assumed the residential function, giving rise to a widespread phenomenon of suburbanization and daily commuting. This pattern of metropolitan development introduces a series of challenges related to urban mobility, such as increased commuting flows, reduced accessibility to essential services, heightened environmental pollution, and escalating traffic congestion. These pressures have direct implications for the overall quality of life and sustainability of the Bucharest-Ilfov metropolitan area (Bucharest Municipality, 2024).

The Bucharest-Ilfov region exhibits a comparatively low incidence of population residing in disadvantaged areas. Data from the World Bank (2016) indicate that 78.87% of the region's stable population lives in non-disadvantaged areas, whereas 7.81% experience housing-related deprivation. Moreover, the region registers the lowest proportion of population living in marginalized rural areas in Romania, accounting for only 0.6%. Notably, rural marginalization within the region is predominantly concentrated in communities with a higher presence of Roma populations, underscoring persistent issues of social exclusion and limited access to essential public services.

The Bucharest-Ilfov region constitutes the most significant road transportation hub in Romania. It serves as a convergence point for three motorways that are part of the Trans-European Transport Network (TEN-T) corridors, alongside eight national roads and eleven county roads arranged in a radial pattern. These are interconnected through the Bucharest Ring Road and the A0 motorway, the latter currently under construction. Within Ilfov County, the overall quality of road infrastructure is relatively high. All national roads have been fully modernized; however, only 40% of county roads have undergone modernization, while 55% feature light road surfacing. As a result, inter-locality connectivity is generally adequate, with only 5% of county roads in substandard condition - comprising 2% paved but degraded roads and 3% unpaved (dirt) roads.

In contrast, the condition of communal roads is notably poorer. Approximately 14% are classified as being in unsatisfactory condition, including 11% gravel roads and 3% dirt roads. Moreover, communal roads have not benefited from modernization efforts, with 86% featuring only light road surfacing, indicating significant infrastructure deficits at the local level.

Employment in the Bucharest-Ilfov region is heavily concentrated in two primary areas: the central ring (also referred to as the central quadrangle), which exhibits a job density of approximately 20,000 jobs per square kilometer, and the northern part of the capital, particularly the emerging Aurel Vlaicu–Pipera business center, which hosts over 65,000 jobs. The road network experiences significant congestion in the northern sectors of the municipality, where transit traffic from Sectors 3, 4, and 5, as well as from adjacent localities, converges toward central, northern, and western districts of the city.

These employment hubs function as major attractors of commuter flows from the wider metropolitan area, including Ilfov County and beyond, thereby generating increased transport demand on both national and county-level radial road infrastructure. Under typical traffic conditions, the Pipera hub has the potential to draw commuters from a catchment area encompassing up to 3 million residents, reachable within a 60-minute travel time. This area

includes, for example, the city of Ploiești - located approximately 50 kilometers from Pipera - owing to its direct motorway connectivity (Bucharest Municipality, 2024; IHS, 2016).

Traffic analysis indicates a substantial increase in vehicular volumes since 2015, primarily driven by population growth in Ilfov County - the fastest-growing county in Romania, as reported in comparison to the 2011 census. On average, traffic volumes across all monitored routes have increased by 65.5% compared to 2015 levels. Congestion is particularly acute along the Bucharest Ring Road, where capacity constraints persist despite the construction of new overpasses. Inadequate infrastructure profiles - such as the southern segment of the ring road, which provides only one lane per direction - exacerbate these issues.

The significant transport demand originating from Ilfov County, largely directed toward Bucharest, leads to severe bottlenecks at nearly all intersections with the ring road during peak hours. Furthermore, congestion persists beyond the ring road, as Bucharest's internal road infrastructure lacks the capacity to accommodate the incoming flows from Ilfov and adjacent counties. Given the limited potential for road widening in the capital due to spatial constraints, managing demand becomes essential. This includes encouraging a modal shift toward more efficient and sustainable transport options, such as public transit and non-motorized travel.

Within Bucharest itself, all arterial roads leading to the central areas are characterized by high or very high congestion levels, not only during peak hours but often throughout the entire day. The concentration of employment in the northern part of the city - particularly in zones such as Piața Presei Libere, Pipera, Aurel Vlaicu, and Piața Victoriei - further intensifies congestion, resulting in persistent traffic delays across all access routes, irrespective of origin or direction of travel (Bucharest Municipality, 2024).

Bucharest functions as Romania's principal railway hub, strategically integrated into the Trans-European Transport Network (TEN-T). The city is traversed by the TEN-T Rhine - Danube Corridor via railway lines 300 (towards Ploiești–Brașov), 900 (towards Craiova), and 800 (towards Constanța), ensuring connectivity with major European destinations such as Strasbourg (France), and key ports on the Baltic Sea (e.g., Rostock) and the North Sea (e.g., Wilhelmshaven or Bremerhaven). Additionally, Bucharest is intersected by the TEN-T Baltic Sea–Black Sea–Aegean Corridor through line 300 and line 902 (towards Giurgiu–Ruse), enabling rail access to major maritime nodes including Gdańsk (Poland) on the Baltic Sea and Athens (Greece) on the Aegean Sea.

The total length of the railway network within the Bucharest–Ilfov region is 605.70 kilometers, with approximately 31% located within the municipality of Bucharest and 69% in Ilfov County. The region also records the highest railway network density in Romania, at 165.30 km per 1,000 km² - nearly four times the national average of 45 km per 1,000 km².

Despite this extensive network, approximately 30% of the railway lines in Ilfov County are currently non-operational, including the Bucharest Railway Belt, which remains unused. Of the entire network, only railway lines 300 and 800 have undergone modernization, permitting speeds of up to 140–160 km/h on certain sections. These upgraded lines offer competitive travel times, positioning rail transport as a viable alternative to road-based mobility within and beyond the region (Bucharest Municipality, 2024).

Despite the region's extensive rail infrastructure, train usage for daily commuting in the Bucharest–Ilfov area remains limited due to a combination of systemic and infrastructural shortcomings. One of the primary issues is the low frequency of regional trains, which typically operate as all-stop services and follow schedules that are insufficiently aligned with current commuting patterns and peak demand. The system remains largely oriented towards intercity connections rather than metropolitan mobility needs.

Furthermore, the existing rolling stock is outdated and provides a low level of comfort, which further discourages usage. Crucially, there is a lack of stations in key economic and development zones that serve as major employment hubs, such as Pipera or Institutul Fundeni, as well as in locations with potential for intermodal integration. The network itself is degraded in many areas, often consisting of single-track lines that limit capacity and reliability.

Railway stations are generally in poor condition, frequently lacking accessibility features, particularly with regard to platform access, and fail to provide basic amenities expected of modern intermodal nodes, such as parking facilities, waiting areas, or commercial services. In

addition, the railway network is not functionally integrated with the metropolitan public transport system, limiting multimodal connectivity. Several high-growth development areas, including Pantelimon and Dobroești, are spatially disconnected from the rail network, further reducing its relevance for local commuting.

Lastly, the absence of an integrated fare system with Bucharest's public transport network, except for the airport rail line, creates additional barriers to seamless travel across transport modes, disincentivizing potential users from adopting rail for daily commuting.

3. Methodology of research

The present research is an exploratory study conducted with the main purpose of analysing the transport system in Bucharest-Ilfov, the most developed region in Romania in order to identify the challenges in managing its development and solutions for improving urban mobility and promote a more sustainable transport system.

The main objectives of the study are:

Ob1. To investigate citizens' opinions in Bucharest-Ilfov region regarding the transport infrastructure in the area.

Ob2. To analyse citizens' degree of satisfaction regarding public transport in Bucharest-Ilfov region.

Ob3. To investigate the main problems and challenges of the public transport system and transport infrastructure in the region and propose solutions for improving urban mobility in a sustainable manner.

The research methodology consists of an opinion survey conducted by the authors within the citizens of Bucharest-Ilfov region in Romania, in order to find out their opinions regarding the transport infrastructure and the local transport system in the region. The survey was based on a quesstionaire designed by the authors that comprised closed questions measured on Likert scale or with several answer choices. The questionnaire was structured in four parts: the main characteristics of the sample, the opinion regarding the transport infrastructure in the region, the perception about the public transport system and problems and solutions for improving the urban mobility in the region. The questions used were created based on other studies conducted in different countries regarding citizens opinions on the transport system and infrastructure (e.g. Fiorio et al., 2013; Cusatellia et al., 2016; Romero-Subia et al., 2022)

The sample of the study was formed by 250 respondents, residents from Bucharest and other administrative territorial units from Ilfov county. The sampling method was the convenience one, a nonprobabilistic method where the respondents were chosen based on the accesibility criterion. The accesibility to the sample is a limitation of the study as it is very hard to have access to persons willing to respond to questionnaires. Being an exploratory study aiming to investigat perceptions, the sample is not representative for the whole country, but is pretty important for forming an objective opinion about the local transport system and the infrastructure in the region and what improvements does it need for a more sustainable future. In addition, the sample could not be representative for all the Romanian regions because Bucharest-Ilfov is a region with many particularities. First of all, it is the most developed region in the country, ranking on the first place on many economic indicators such as GDP/capita, employment, number of companies, number of graduates or research, development and innovation. The disparities between this region and the other ones are very high and did not succed in lowering during years. The region has the characteristics of a region experiencing rapid growth confronting with overpopulation and high level of pollution. Also, it cannot be compared with the other regions in the country regarding the size, being the smallest of the eighth regions in Romania. In order to research sustainability issues, this region is the first that should be analysed due to its major problems regarding pollution, transport and the increasing number of residents which lead to a decrease in the quality of life.

Table 1: The main characteristics of the sample

Item	Categories	Percent
Age	Under 25 years old	7.25%
	25-34 years old	18.36%
	35-44 years old	27.54%
	45-54 years old	22.71%

Item	Categories	Percent
	55-64 years old	15.94%
	Over 65 years old	8.2%
Gender	Men	36.71%
	Women	63.29%
Education	Highschool	26.57%
	Bachelor degree	41.06%
	Master degree and PhD	32.37%
Occupation	Full-time employee	59.9%
	Part-time employee	5.31%
	Freelancer	3.38%
	Student	13.52%
	Retired	9.18%
	Unemployed	6.76%
	Other	1.95%
Residence	Bucharest	65.7%
	Ilfov	34.3%

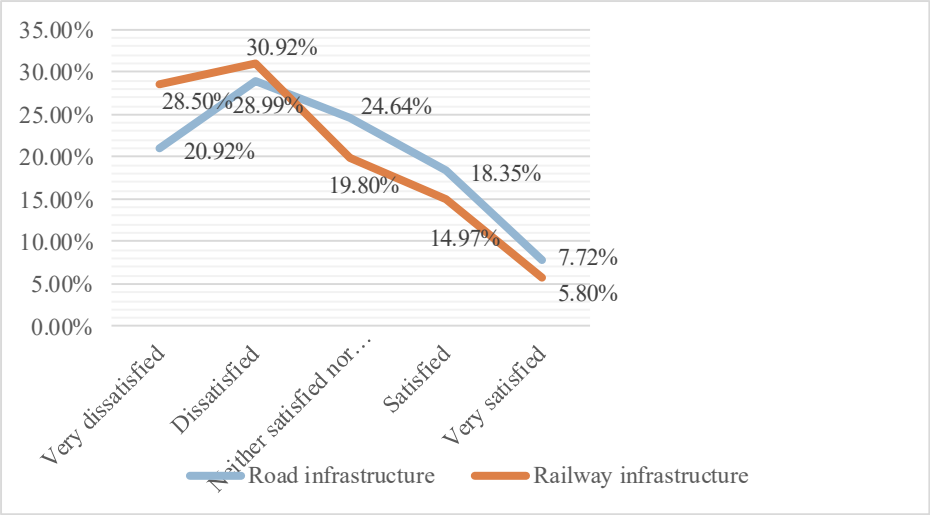
Source: authors, own interpretation

Table 1 presents the main characteristics of the sample involved in the study. There were taken into consideration aspects such as age, gender, education, occupation and residence. Most of the respondents were residents of the capital city, Bucharest and one third of them were from other territorial administrative units from Ilfov county. As Bucharest hosts the most of the population in the region the distribution of the sample based on residence is a normal one. Regarding age, most of the respondents were between 35 and 54 years old. Concerning gender, two thirds of the sample was comprised by women and one third by men. Regarding the occupation of the respondents, there were covered all types of situations. Most of the respondents were employees, full-time and part-time, the category of persons most prone of using the transport system daily.

4. The main results of the study

4.1. The transport infrastructure

Figure 1: The perception regarding road and railway infrastructure in the region



Source: authors, own interpretation

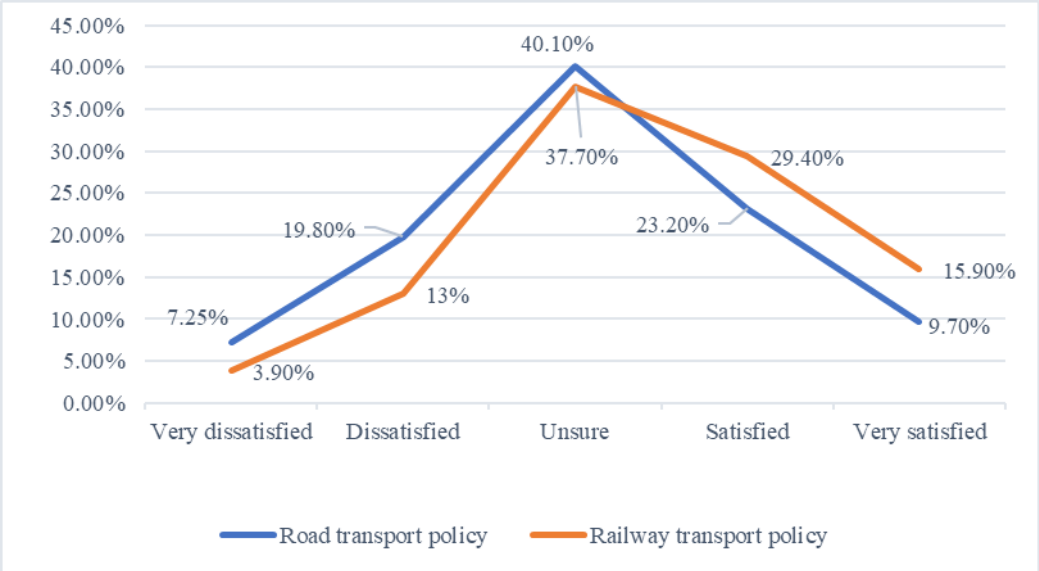
Regarding the level of satisfaction of the transport infrastructure in the region (measured on 5 point Liker scale), it can be observed that the citizens of the region are more satisfied with the road infrastructure compared with the railway infrastructure. Despite being the most developed region of the country, it seems that half of the respondents are dissatisfied with the transport infrastructure and around 20% have a neutral opinion. A critical view of the railway transport system is supported by several interrelated factors that significantly affect user satisfaction. Among the most pressing issues are the deteriorated state of railway

infrastructure and train stations, the use of outdated trains, and frequent - often substantial - delays, which undermine the system's reliability and efficiency.

Similarly, negative perceptions of road infrastructure, particularly in the capital, stem from multiple systemic shortcomings. These include an underperforming public transport network, exacerbated by the absence of dedicated lanes, an aging vehicle fleet, limited implementation of digital technologies at transport stations, and road infrastructure that is inadequate in relation to the growing volume of traffic. Moreover, the continued lack of a fully completed ring road around the capital further aggravates congestion, making travel within the metropolitan area increasingly difficult and inefficient.

Also, another problem is the subway system which is not extended in all the neighbourhoods of the capital and is not connected well with the railway system. The capital does not have a good infrastructure which connects the subway, busses, trains and trams and this could also be a major cause of this negative perception.

Figure 2: The perception regarding the implementation of the road and railway transport policies in the region



Source: authors, own interpretation

Concerning citizens' opinions regarding the implementation of the transport policy in the region once again the respondents have a better perception regarding the projects and measures related to the development of the road infrastructure compared with the ones related to the railway infrastructure. The results reveal uncertainty rather than a strong opinion. More citizens are satisfied with the measures implemented for improving the transport infrastructure rather than the disatisfied ones, but most of them do not have a clear opinion. The region has a ***Sustainable urban mobility plan*** based on the 2030 Agenda and the Green Deal (Bucharest Municipality, 2024). The plan comprises projects proposels that will contribute to the fulfilling of objectives such as: ***Development of local connectivity; Development of joint projects within territorial cooperation areas (peri-urban); Expansion and rehabilitation of utilities in peri-urban areas; Connecting the Bucharest green system with peri-urban areas; Increasing the accessibility of extra-urban cultural and recreational areas; Highlighting the capital's location in relation to major transcontinental corridors*** (Bucharest Municipality, 2024). There are ongoing projects that show that the transport policy in the region is implemented at a rapid pace even if the results are not perceived by citizens as they should be.

Figure 3: The perception regarding the adaptation of the transport infrastructure to the current needs of Bucharest-Ilfov residents

Source: authors, own interpretation

Then, respondents were asked if they consider that the transport infrastructure in the region (road, railway, subway, local transport) responds to citizens needs. Once again, the opinion is not positive but is better compared to the first questions. The participants in the study mostly consider that the infrastructure is only partially adapted to their needs and one third of them believe the infrastructure is not adapted at all. This perception could be due to the fact that the infrastructure does not respond to citizens' commute needs caused by frequent traffic jams, long periods spend in traffic, delays in the trains schedules or the overcrowding in the metro stations and trams.

Figure 4: Main problems of the transport infrastructure in Bucharest-Ilfov region

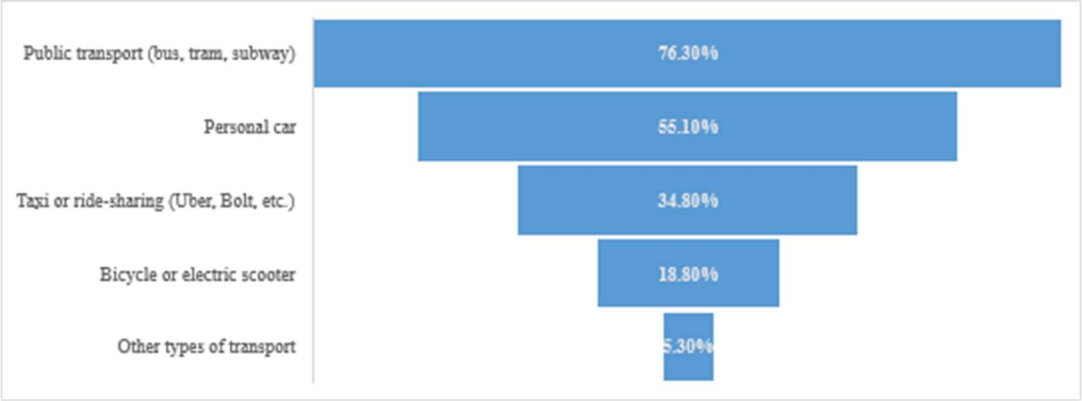
Source: authors, own interpretation

In order to understand the negative perception and to propose suited solutions for improving the transport infrastructure in a sustainable manner, the respondents were asked what are the main problems regarding transport in the region. On first place was the lack of highways and expressways followed by the poor state of the national and county roads crossing the region. Because the regions hosts the capital city there are three highways starting from Bucharest but it seems that the residents of the area consider that they need more highways. Also, the main problems is that the highways in these area are always crowded, especially the Sun Highway (A2) which leads to Constanța County, to the seaside. The response also is related to the state of the ring road which surrounds the capital and should help at decongesting the traffic. Another important problems are considered the delays and deficiencies of the rail transport which is problematic in the whole country and the insufficient conditions for means of transportation more fiendly with the environment such as bycicles.

Observing the results, it can be stated that the first hypothsis of the study validated: the transport infrastructure in the Bucharest-Ilfov region does not meet citizens' needs.

4.2. The local transport system in Bucharest-Ilfov region

Figure 5: The most used transportation means in Bucharest-Ilfov region



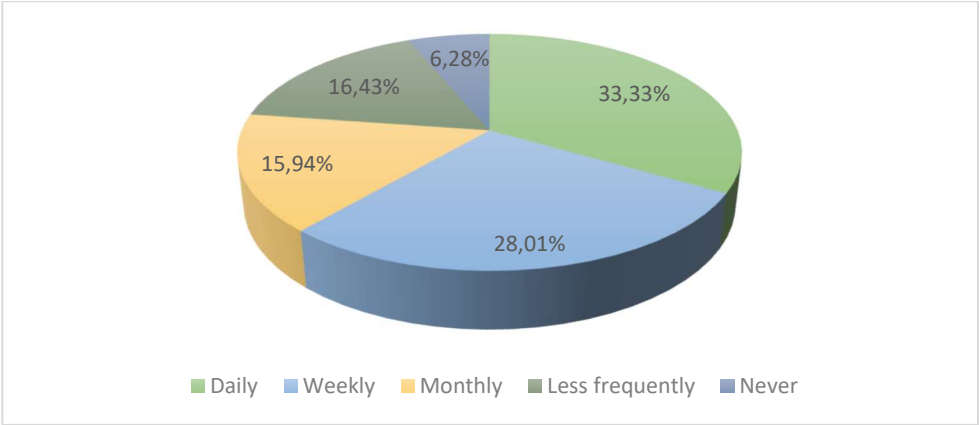
Source: authors, own interpretation

This part of the study is dedicated to different aspects regarding the public transport system. First, a hierarchy with the most used transportation means in the region was made. It is observed that on the first place is the public transport, followed by the personal car.

In Bucharest and its metropolitan area, transportation has become a strategic point of vulnerability within the broader framework of urban and regional development. Over the past years, the metropolitan region has experienced a notable increase in population density, primarily as a result of internal migration from the capital city to adjacent peri-urban zones. This demographic trend has generated a significant rise in demand for public transportation, particularly in suburban areas that often lack adequate infrastructure and service coverage. At the same time, private car usage continues to represent the second most prevalent mode of transport, contributing further to congestion, environmental degradation, and the overloading of an already insufficient road network.

The personal car is very used as a mean of communting, and even if the authorities promote the public transport, the reality shows its limitations and the fact that trams, buses and metros are overcrowded. It can be statead that especially in the capital, the public transport and the roads are used at their full pace. The authorities should find new solutions for reducing the time spent in trafic and to expand the public transport system.

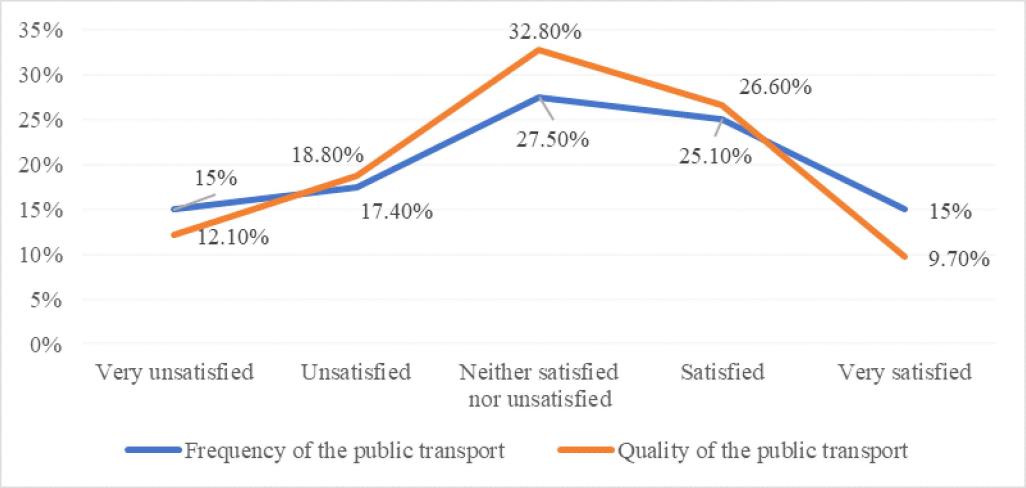
Figure 6: The frequency of usage of public transportation



Source: authors, own interpretation

The figure shows the frequency of using public transport by the respondents. One third of them use it daily and another third use it weekly. Only a small proportion use exclusively other means of transportation beside the public one.

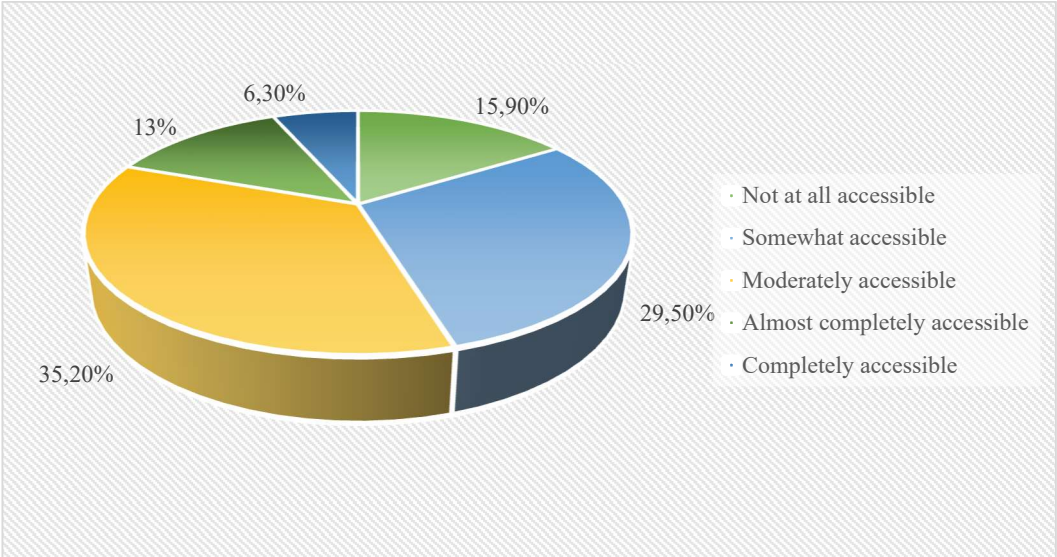
Figure 7: The satisfasfaction regarding the frequency and quality of the public transportation



Source: authors, own interpretation

Regarding the frequency and the quality of the public transport in the region, the responses are similar. Around one 30% of the respondents have a neutral opinion. Almost 40% declare themselves to be satisfied and very satisfied with these aspects, but still a pretty high proportion, around one third express a feeling of disatissfaction. The perception is better than the one related to the public infrastructure, but it shows again the need for appropriate measures in order to develop the public transport.

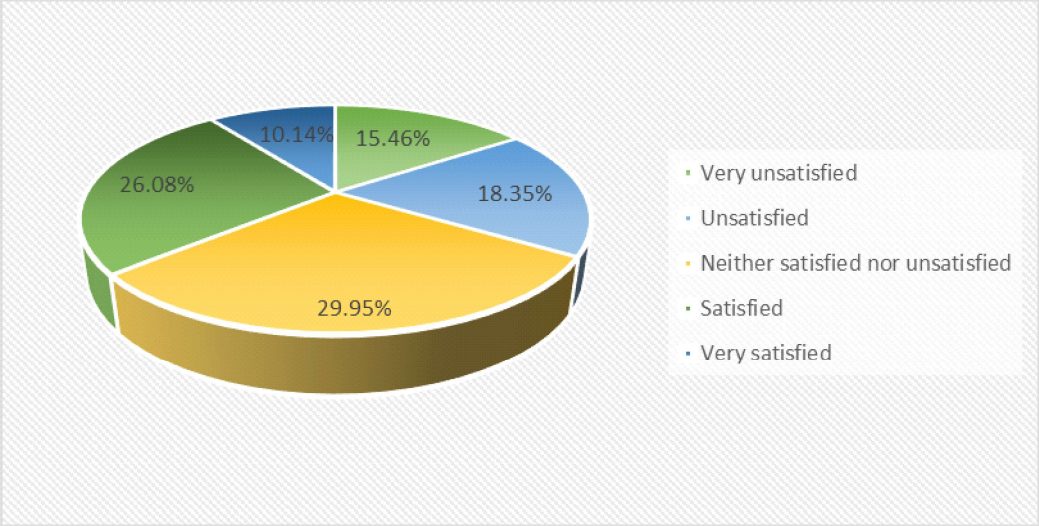
Figure 8: Assessment regarding the accesibility of public transport to disabled persons (cleanliness, comfort, safety)



Source: authors, own interpretation

A main problem in Romania is the access of disabled persons to the public transportation. In Bucharest most of the trams are old and inaccesible to disable persons. Most of the metro stations are accesible for people with disabilities, similarly, buses are equipped with ramps for people with disabilities. On a whole is quite difficult for a disabled person to use the public transport without help or even with the necessary help. The opinions of the respondents are divided between somewhat and moderately accesible.

Figure 9: The satisfaction regarding public transportation in Bucharest-Ilfov region



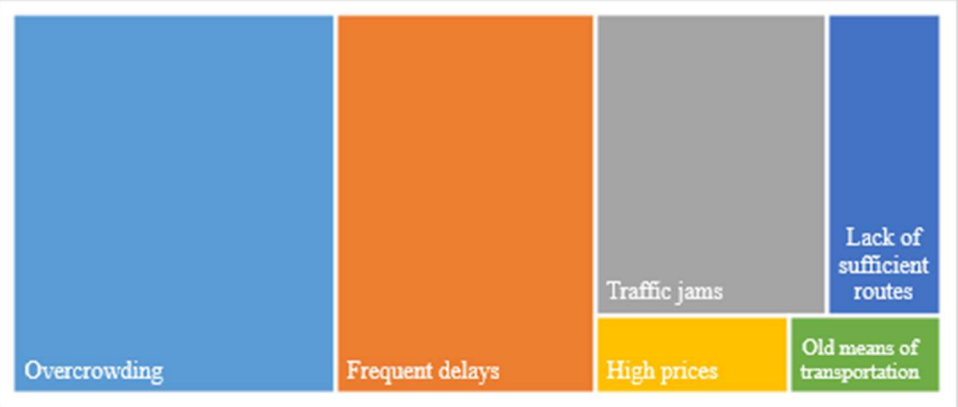
Source: authors, own interpretation

Concerning the general level of satisfaction with the public transport system in the region it is observed that the sample is divided clearly in three, as one third consider themselves to be satisfied, another third disatisfied and one third have a neutral opinion. The data on the question regarding the local transport in the region validate the second hypothesis: citizens' general level of satisfaction with public transport system in the region is low.

It is essential that both local and national authorities implement urgent and coordinated measures aimed at improving transport conditions, with a particular focus on infrastructure development and the modernization of the vehicle fleet. Such interventions are critical to enhancing the overall quality of mobility services and increasing citizen satisfaction.

4.3. Problems and solutions

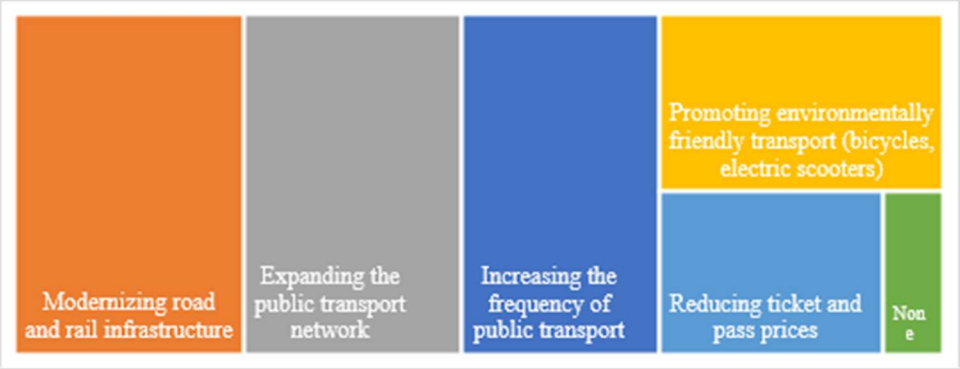
Figure 10: Main problems of the public transportation in Bucharest-Ilfov region



Source: authors, own interpretation

The last part of the research focused on identifying the main problems and proposing viable solutions that would lead to the development of urban mobility. The opinion of the respondents is that the most important problems in the area are the overcrowding, the frequent delays of the public transport and the traffic jams. Once again, the results show that the public transport infrastructure is insufficiently developed as to meet citizens' standards and needs. The results validate the last hypothesis of the study (H3: The main problems of the public transport system are traffic jams and overcrowding).

Figure 11: Proposed solutions for improving mobility in the Bucharest-Ilfov region in a sustainable manner



Source: authors, own interpretation

Regarding potential solutions for the development of a sustainable transport system, the results of the analysis reflect citizens' views that the top priorities should focus on improving both road and rail infrastructure. In the current context, the railway system is not widely used for daily commuting due to frequent delays, low travel speeds, and poor comfort conditions onboard trains. Consequently, investments in railway infrastructure are considered essential for enhancing the sustainability of the transport system.

A second proposed measure involves the expansion of the public transport network. Compared to other European capitals, Bucharest faces significant challenges due to the lack of well-integrated transport hubs that connect trains, trams, buses, and the metro. Furthermore, the need to increase the frequency of public transport services is highlighted, particularly for trams and the metro, where during peak hours the number of available vehicles remains insufficient relative to population demand.

Other advanced solutions include promoting the use of alternative modes of transport, such as bicycles. However, this approach remains debatable given the city's large size and the long distances typically traveled by commuters. Additionally, reducing ticket fares is perceived as a beneficial measure. Nonetheless, over the past two years, the trend has moved in the opposite direction, with rising prices for train, bus, tram, and metro services, which further complicates efforts to make public transportation more affordable and accessible.

5. Discussions and recommandations for improving urban mobility and promote a more sustainable transport system

Transport is a strategic issue with multiple connections and interactions in various fields. High-quality transport means a developed economy, high mobility, a protected environment, and satisfied citizens. In the past few years, european governments have put a lot of money into recovery and resilience plans for 2021-2027 and into transport programs to make big investments in all types of transport. As an EU member state, Romania needs massive investments in transport infrastructure and the acquisition of means of transport that meet both comfort and environmental requirements. In recent years, the Romanian government has often referred to transport as a priority 0.

The Bucharest-Ilfov area is the most important economic center and the largest population center in Romania, and in terms of transport, it is the most important rail and road hub.

The analysis highlights the need for the strategic implementation of sustainable transport solutions that promote environmentally friendly mobility, reduce greenhouse gas emissions, and ease traffic congestion. Furthermore, in the context of the accelerated urbanisation of the Bucharest-Ilfov region, the development of a sustainable transport system is becoming a key factor in ensuring balanced, resilient and environmentally friendly urban growth. An important aspect is the lack of effective coordination between all the authorities involved and overcoming these obstacles, which constitute major barriers to successful implementation. The promotion of sustainable transport in the Bucharest-Ilfov region is a pressing necessity, and it is imperative to adopt concerted and sustainable measures at local and regional level.

6. Acknowledgement

This work was funded by the EU's NextGenerationEU instrument through the National Recovery and Resilience Plan of Romania – Pillar III-C9-I8, managed by the Ministry of Research, Innovation and Digitization, within the project entitled „Place-based Economic Policy in EU's Periphery - fundamental research in collaborative development and local resilience. Projections for Romania and Moldova (PEPER)", contract no. 760045/23.05.2023, code CF 275/30.11.2022.

7. References

Amheka, A. (2018). Evaluation of economic structure development of kupang city, NTT province, indonesia to meet national GHG emission target. Regional Science Inquiry, 10 (1), 11-17.

Bakogiannis, E., Vassi, A., Christodoulopoulou, G., & Siti, M. (2018). Bike sharing systems as a tool to increase sustainable coastal and maritime tourism. the case of Piraeus. Regional Science Inquiry, 10 (3), 57-71.

Banister, D. (2008a). The sustainable mobility paradigm. Transport Policy, 15(2), 73-80.

Banister, D. (2008b). The sustainable transport revolution. Transport Policy, 15(2), 89-98.

Bucharest Municipality. (2024). Planul de mobilitate urbană durabilă pentru regiunea București – Ilfov. Accessed on: https://tpbi.ro/file/2024/08/R11-Raport-PMUD-Bucuresti-Ilfov-Final-1.pdf

Casas, I., Borzacchiello, M. T., Ciuffo, B., & Nijkamp, P. (2012). Short and long term effects of sustainable mobility policy: an exploratory case study. Regional Science Inquiry, 4(1).

Clitan, A.F. (2014). Sustainable transport in Romania vs. European Union. analysis of road transport system from the sustainable transport perspective. Romanian Journal of Transport Infrastructure, 3 (2), 37-45.

Cluj-Napoca City-Hall. (2021). Proiectul de implementare a transportului public ecologic în Cluj-Napoca. Accessed on: www.primariaclujnapoca.ro

Creutzig, F., Franzen, M., Moeckel, R., Heinrichs, D., Nagel, K., Nieland, S., & Weisz, H. (2019). Leveraging digitalization for sustainability in urban transport. Global Sustainability, 2, e14.

Cusatellia, C., Giacaloneb, M., & Troisic, A. (2016). The citizen satisfaction survey on the local public transport in Bologna. Electronic Journal of Applied Statistical Analyses, 9(4), 623-636.

European Commission. (2019). The European Green Deal. Accessed at: https://ec.europa.eu.

European Union. (2025). Transport. Accessed at: https://european-union.europa.eu/priorities-and-actions/actions-topic/transport_ro.

Fang, W., Ma, C. & Lei, Z. (2022). Research on Sustainable Development of Transport Infrastructure Based on Corporate Culture and Low-Carbon Perspective. Journal of Environmental and Public Health, 2022(1), 4629422.

Ferro, G., Ramos, M. P., & Romero, C. A. (2025). Net Jobs Generation And Net Ghg Emissions Reduction From Partial Replacement Of Fossil Fuels With Renewable Energy Sources In Southern Brazil. Regional Science Inquiry, 17 (1), 141-151.

Fiorio, C. V., Florio, M., & Perucca, G. (2013). User satisfaction and the organization of local public transport: Evidence from European cities. Transport Policy, 29, 209-218.

Fontes, T., Correia, J., de Sousa, J. P., de Sousa, J. F., & Galvão, T. (2017). A multi-user integrated platform for supporting the design and management of urban mobility systems. Transportation Research Procedia, 27, 35-42.

Givoni, M. (2012). Sustainable transport policies and the development of green transport. Environmental Policy and Governance, 22(6), 428-438.

Havryliuk, V., Hromyk, A., Semenets, I., Pylypiuk, T., Motsyk, R., & Kostyakova, A. (2021). Digitalization of territorial and economic systems at the regional level. Regional Science Inquiry, 13(2), 209-226.

Holden, E., Gilpin, G., & Banister, D. (2019). Sustainable mobility at thirty. Sustainability, 11(7), 1965.

IHS, (2016). Smart Interventions for Branding Pipera. Final Report on the 2nd Business Neighborhood Initiative in Pipera Business District.

Jeyaseelan, T., Ekambaram, P., Subramanian, J., & Shamim, T. (2022). A comprehensive review on the current trends, challenges and future prospects for sustainable mobility. Renewable and Sustainable Energy Reviews, 157, 112073.

Kadyraliev, A., Supaeva, G., Bakas, B., Dzholdosheva, T., Dzholdoshev, N., Balova, S. & Krinichansky, K. (2022). Investments in transport infrastructure as a factor of stimulation of economic development. Transportation Research Procedia, 63, 1359-1369.

Kamargianni, M., Matyas, M., Li, W., & Schafer, A. (2015). Feasibility Study for "Mobility as a Service" concept in London.

Litman, T. (2017). Evaluating transportation equity: Guidance for incorporating distributional impacts in transportation planning. Journal of Transport Geography, 16 (2), 92-99.
Ministry of Investments and European Projects, (2025). POR. Accessed on: https://mfe.gov.ro/programe/autoritati-de-management/por/
Ministry of Investments and European Projects, (2023). Planul Național de Redresare și Reziliență. Accessed on: https://mfe.gov.ro/pnrr/
Ministry of Transport. (2022). Strategia Națională pentru Mobilitate Urbană Durabilă. Accessed on: https://www.mt.ro/web14/documente/acte-normative/2022/07_23/2022.07.28-Strategia%20ITS_varianta%2028%20iulie.docx
Ministry of Transport. (2025). Program Transport 2021-2027. Accessed on: https://mt.ro/web14/strategia-in-transporturi/program-transport-2021-2027/5931-pt005062025
Mohammed, S., Alkhereibi, A. H., Abulibdeh, A., Jawarneh, R. N. & Balakrishnan, P. (2023). GIS-based spatiotemporal analysis for road traffic crashes; in support of sustainable transportation Planning. Transportation research interdisciplinary perspectives, 20, 100836.
Pedrana, M. (2013). Local economic development policies and tourism: An approach to sustainability and culture. Regional Science Inquiry, 5(1), 91-99.
Psaraki, V., & Pagoni, I. (2012). Capacity-Enhancing And Low-Ghg Emissions Intelligent Transport Systems (Its) Technologies. Regional Science Inquiry, 4(3), 11-24.
Pucher, J. & Buehler, R. (2017). The importance of public transportation in sustainable cities. Transport Policy, 16 (2), 60-69.
Rodrigue, J.P. (2020). The geography of transport systems (5th ed.). UK: Routledge.
Romero-Subia, J. F., Jimber-del Rio, J. A., Ochoa-Rico, M. S. & Vergara-Romero, A. (2022). Analysis of citizen satisfaction in municipal services. Economies, 10(9), 225.
Romanian Parliament, (2023). LEGE nr. 155 din 30 mai 2023 privind mobilitatea urbană durabilă. Published in Official Monitor no. 486 from 31 May 2023.
United Nations Development Programme - UNDP (2025). What is sustainable transport and what role does it play in tackling climate change? Accessed at: https://climatepromise.undp.org/news-and-stories/what-sustainable-transport-and-what-role-does-it-play-tackling-climate-change.
Schippl, J. & Arnold, A. (2020). Stakeholders' views on multimodal urban mobility futures: a matter of policy interventions or just the logical result of digitalization? Energies, 13(7), 1788.
Seliverstov, Y., Starichenkov, A., & Nikitin, K. (2020). Using mobile applications to evaluate quality of road networks and transport mobility. Transportation Research Procedia, 50, 636-646.
Siuhi, S., & Mwakalonge, J. (2016). Opportunities and challenges of smart mobile applications in transportation. Journal of Traffic and Transportation Engineering, 3(6), 582-592.
Vuchic, V. (2017). Transportation for livable cities. Routledge.
World Bank, (2016). Atlasul Zonelor Rurale Marginalizate și al Dezvoltării Locale din România. Accessed at: https://documents1.worldbank.org/curated/en/237481467118655863/pdf/106653-ROMANIAN-PUBLIC-PI-6-AtlasIunie2016.pdf).
Zhang, Y., & Cheng, L. (2023). The role of transport infrastructure in economic growth: Empirical evidence in the UK. Transport Policy, 133, 223-233.

MEASURING THE PERFORMANCE OF EXPORT ECONOMIC BRANCHES LOCATED INSIDE CLUSTERS: EVIDENCE FROM GREECE

Andreas GKOUZOS
Department of Regional and Economic Development, School of Applied Economics and Social Sciences, Agricultural University of Athens, Amfissa, Greece
agkouzos@aua.gr
ORCID ID: 0000-0003-3905-9205

Manolis CHRISTOFAKIS
Department of Business Administration, School of Business, University of the Aegean, Chios, Greece
mchri@aegean.gr
ORCID ID: 0009-0005-7416-0378

Abstract

The paper investigates the impact of clusters on the performance of export economic branches in Greek NUTS-2 regions for 2008 and 2018. The study employs a Cluster Index, statistical techniques and Exploratory Spatial Data Analysis, unveiling the intricate relationship between clusters and the competitiveness of export-driven economic branches. The findings illuminate the pivotal role clusters play in shaping export outcomes, indicating that regions in both mainland and insular space host multiple clusters that significantly influence export performance of economic branches. The outcomes of the research offer valuable insights for policy formulation, emphasising the need for custom-tailored strategies that harness sectoral-spatial patterns. In a broader context, the study's insights provide valuable implications for enhancing overall economies by leveraging agglomeration effects and promoting growth in export-driven branches. This study contributes to a deeper understanding of the complex dynamics between clusters and export performance, offering a roadmap for policymakers and stakeholders to foster economic advancement.

Keywords: clusters, export economic branches, Greek NUTS-2 regions, Cluster Index, economic base theory

JEL classification: C18, R12, R58

pp. 71-84

1. Introduction

The advantages of territorial firm agglomerations and the notion of industrial districts are rooted in the pioneering ideas of Alfred Marshall, who put forward at the beginning of the twentieth century (Giner-Pérez and Santa María, 2020). Industrial agglomeration is usually defined as the geographical concentration of companies and institutions with common or complementary properties in a specific field (Chen et al. 2021; Porter, 1998). The greatest advantage of an enterprise being close to other companies, in the same or related economic activities, is that it is easier to network between the companies. This in turn can benefit all companies that are part of the collaboration system. In this way, entrepreneurship in an area is strengthened and in the end it benefits the region as a whole. In recent years, a number of publications have raised greater interest in the performance of economic branches located inside or outside the clusters (Wennberg and Lindqvist, 2008; Beaudry and Swann, 2009; Segarra-Oña et al. 2012; De Vaan et al. 2013; Branco and Lopes, 2018; Hervas-Oliver et al. 2018; Sellitto and Luchese, 2018; Mendoza-Velázquez and Benita, 2019; Stojčić et al. 2019; Grashof, 2021; Ketels and Protsiv, 2021; Pavelkova et al. 2021). Wennberg and Lindqvist (2008) demonstrated that new Swedish firms from the technology and healthcare industry located within a cluster had positive effects on their survival, creating more jobs, higher tax payments, and higher wages to employees. Beaudry and Swann (2009) found that cluster effects were strongest in manufacturing, manufacturing- related, and infrastructure, but weaker in services. Segarra-Oña et al. (2012) displayed that hotels located inside tourism clusters perform better economically than those located outside the clusters in the Spanish tourism sector. De Vaan et al. (2013) studied the survival patterns of firms and subsidiaries in

the global video game industry and figured out that a positive net effect of clustering appeared after a cluster reached a critical size. Branco and Lopes (2018) demonstrated that the cluster experienced a remarkable growth especially during the development phase. Hervas-Oliver et al. (2018) noted that co-location in an agglomeration had a positive influence on a firm's innovative performance, although even agglomeration gains existed; however, not all firms benefited equally in Spanish economy. Sellitto and Luchese (2018) explored cooperation practices within a Brazilian furniture cluster, identifying four types of cooperative practices. Workforce development showed strong collaboration, but other practices had lower cooperation levels due to rivalry and distrust. Mendoza-Velázquez and Benita (2019) investigated Mexico's automotive sector, analyzing efficiency, productivity, and technological change across subclusters and regions, including the impact of the Great Crisis and identification of input congestion, with their findings highlighting congestion in certain regions and varying crisis resilience. Stojčić et al. (2019) distinguished that clusters had a positive impact on firm productivity, sales revenues, size, and export performance in the traditional wood-processing and furniture industries in Croatia and Slovenia between 2013 and 2016. Grashof (2021) examined a dataset with a significant number of companies in Germany and indicated that firms benefited unequally within the cluster, depending on the characteristics of the specific firm, the cluster and the conditions of the market. Ketels and Protsiv (2021) noticed a relationship between clusters and economic outcomes as industry-level wages associated with industry- and surrounding-cluster agglomeration levels to a similar degree through a data from 28 European countries. Pavelkova et al. (2021) failed to confirm any significant influence of firm localisation in the natural cluster or membership in the cluster organisation on financial performance for firms in the plastics and textiles sectors in the Czech Republic in the period of 2009–2016.

Moreover, the recent literature review presents the link between exports and the agglomeration of economic branches (Lovely et al. 2005; Koenig, 2009; Yilmazkuday, 2011; He et al. 2012; He et al. 2015; Liu and Wang, 2022). Lovely et al. (2005) examined the spatial concentration of headquarter activity of exporters to that of non-exporters and found that industries that export to countries with a financial risk had more highly agglomerated exporter headquarter activity. Koenig (2009) investigated the impact of proximity to other exporters on the export behavior of individual French manufacturers between 1986 and 1992; the researcher presented a distinct evidence of export-agglomeration economies, where local exporters were positively influenced by the probability of starting to export to a given country. Yilmazkuday (2011) examined the connection between economic agglomeration and trade patterns within the U.S. at the industry level; he demonstrated that agglomeration as a specialisation of industries played an important role in determining the patterns of trade, both intranationally and internationally. He et al. (2012) and He et al. (2015) revealed that exporters were significantly more geographically agglomerated than non-exporters using the annual survey of industrial firms in China. Liu and Wang (2022) presented that manufacturing firms should be encouraged to interact with local economies rather than merely engaging in exporting with straightforward assembling activities.

The study advances existing research by investigating the impact of clusters on the export performance of economic branches in Greek NUTS-2 regions. Unlike prior work that broadly explores agglomeration effects, this study explores the nuances of export-driven branches in the Greek context. The novelty lies in its comprehensive evaluation of export efficiency, allowing for inter-branch and regional comparisons. Additionally, the research introduces a unique approach to uncovering localised clusters' spatial relationships, revealing how agglomeration influences specific regions. By focusing on the export sector within Greek regions, this study provides a targeted analysis of clusters' effects on economic performance. Its original methodologies and concentrated focus contribute to the understanding of clusters' role in enhancing the competitiveness and growth of export-oriented branches within Greece, carrying implications for economic development and competitive strategies. The paper is arranged as follows: Section 2 explores the methodology and offers an overview of the analysis data. In section 3, the paper presents the research findings, and finally, section 4 provides the concluding remarks of the paper.

2. Research methodology

It is shown that firms in clusters experience stronger growth and higher innovation rates than those outside clusters (Audretsch and Feldman,1996 a, b; Baptista and Swann, 1998; Baptista, 2000; Broekel et al. 2015); at the same time fostering clusters is considered one important approach to improving regional competitiveness (Chen et al., 2020).

Based on the Sternberg and Litzenberger (2004) approach, the paper implements a Cluster Index that identifies clusters of economic branches in Greek economy:

$$CI_{ir} = ID_{ir} * IS_{ir} * \frac{1}{SB_{ir}} = \frac{\frac{e_{ir}}{\sum_{i=1}^{n} e_{ir}}}{\frac{i_r}{\sum_{r=1}^{n} i_r}} * \frac{\frac{b_{ir}}{\sum_{i=1}^{n} b_{ir}}}{\frac{a_r}{\sum_{r=1}^{n} a_r}} \quad (1)$$

Here, eir is the number of employees in NUTS-2 regions, bir is the number of local units per economic branch, ir is the number of inhabitants and ar is the size of the NUTS-2 region.

All three components of the CI (ID, IS, and PS) are defined between zero and infinity, implying that the whole index also has the potential range from zero to infinity; furthermore the main advantage of the CI is that a value for each analysed area/sector can be derived; also, comparison between areas/sectors is easier than with other measures such as the Gini coefficient, which does not consider the size of the statistical units (Giner-Pérez and Santa María 2020).

The economic base theory separates an economy by its sectoral approach. According to the theory, there are export economic branches that depend on the demand for their goods outside the region; also, there are local economic branches whose survival depends on the local economic circumstances of the specific region (Schaffer, 2020). Here, the paper uses the above theoretical approach through a quantitative method which estimates the export efficiency of each economic branch. That is estimated by the formula below (Isserman, 1977); so the size of each export activity for each Greek region is:

$$X_{ir} = \frac{E_{ir}}{E_{in}} - \frac{E_r}{E_n} * E_{in} \quad (2)$$

The one-way analysis of variance (one-way ANOVA) (Gelman, 2005) was applied to seek if the export economic branches perform better inside clusters than those located outside clusters, while Pearson's correlation index (Rodgers and Nicewander, 1988) measures the correlation between number of clusters and the total export employment data:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{[\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2]^{1/2}} \quad (3)$$

Into analysis, X represents the number of clusters, and Y represents the total export employment data.

While, each size of export economic branch for each Greek region is pictured through the spatial autocorrelation Moran's I. The common form of spatial autocorrelation Moran's I is (Hassan et al, 2020):

$$I = \frac{n}{W} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \quad (4)$$

Where, wij is the weight between observation i and j (geographic coordinates), and Wis the sum of all wij; x is the value of the variable (export economic branch) at location i and j. The normalised values of Moran's index range between -1.0 and 1.0, where values approaching 1 indicate positive autocorrelation and values closer to -1.0 mean negative autocorrelation.

Finally, the local indicators of spatial association (LISA) developed by Anselin (1995) to identify local clusters of positive or negative spatial autocorrelation. It is computed as (Cheng et al. 2013):

$$I_i = z_i \sum_j w_{ij} z_j \quad (5)$$

Where, zi is the standardised form of xi; and the wij is the same elements of the weight matrix as defined in the global Moran index. The sum of all the local Moran's indices is equal to the global Moran's index. The local indicators of spatial association (LISA) allow visualising four categories of local spatial association: high-high (HH) indicates a region with an above-average value is surrounded by neighbours whose values are above-average; high-low (HL) means an above average region is adjacent to below-average neighbours; and vice versa for low-low (LL) and low-high (LH) categories.

Below, Table 1 exhibits the 9 economic branches (Eurostat, 2024a) and Figure 1 illustrates the 13 Greek NUTS-2 regions are used in the analysis; Table 2 presents the population and the size of each region for the examined years (Eurostat, 2024b; 2024c).

Table 1: Economic Branches

A. Energy
B. Manufacturing
C. Construction
D. Wholesale and retail trade
E. Transportation and storage
F. Accommodation and food service activities
G. Information and communication
H. Real estate activities
I. Professional, scientific and technical activities-Administrative and support service activities

Source: Eurostat, 2024a

Figure 1: Greek NUTS-2 Regions

In the table below, the population data as the size of each Greek NUTS-2 region is displayed. This data can be used in the analysis of the paper.

Table 2: Greece Population and Area

	2018		2008		2018 and 2008	
Regions-Nuts 2	**Population**	**%**	**Population**	**%**	**Area, Km2**	**%**
Anatoliki Makedonia. Thraki	601175	5.60	605411	5.47	14179	10.74
Kentriki Makedonia	1875996	17.47	1905904	17.23	19166	14.51
Dytiki Makedonia	269222	2.51	286696	2.59	9471	7.17
Ipeiros	334337	3.11	344410	3.11	9164	6.94
Thessalia	722065	6.72	743919	6.73	14051	10.64
Ionia Nisia	204562	1.90	207508	1.88	2306	1.75
Dytiki Ellada	659470	6.14	693549	6.27	11327	8.58

Regions-Nuts 2	2018		2008		2018 and 2008	
	Population	%	Population	%	Area, Km2	%
Sterea Ellada	555623	5.17	555577	5.02	15561	11.78
Peloponnisos	576749	5.37	585892	5.30	15511	11.75
Attiki	3756453	34.97	3990727	36.08	3814	2.89
Voreio Aigaio	211137	1.97	198675	1.80	3854	2.92
Notio Aigaio	340870	3.17	329525	2.98	5305	4.02
Kriti	633506	5.90	613144	5.54	8340	6.32

Source: Eurostat, 2024b; 2024c and Authors' estimations

According to the most recent population data, Attiki concentrates 3756453 (34.97%) and Kentriki Makedonia contains 1875996 (17.47%) of the national population. Both regions share 5632449 (52.44%) of the Greek population. Furthermore, the two largest urban concentrations of the country are located in these two regions: Athens (the capital city of the country) is located in the region of Attiki and Thessaloniki (the second largest city of the country) is located in the region of Kentriki Makedonia.

Also, Kentriki Makedonia is the largest region in terms of area with 19166 Km^2 (14.51% of the country's surface) and is followed by the mainland regions of Sterea Ellada, 15561 Km^2 (11.78%) and Peloponnisos, 15511 Km^2 (11.75%). On the other hand, the region of Attiki is one of the smallest regions, 3814 Km^2 (2.89%).

Table 3: Local units and employment, 2018 and 2008

Regions- Nuts 2	2018				2008			
	Local Units		Employment		Local Units		Employment	
	No	%	No	%	No	%	No	%
Anatoliki Makedonia-Thraki	34122	4.45	96234	3.73	40442	4.59	105702	3.90
Kentriki Makedonia	124617	16.25	389446	15.10	146434	16.62	429499	15.83
Dytiki Makedonia	17035	2.22	40052	1.55	22279	2.53	54434	2.01
Ipeiros	22667	2.96	59460	2.31	26964	3.06	57743	2.13
Thessalia	45369	5.92	116458	4.51	51091	5.80	130479	4.81
Ionia Nisia	25885	3.38	74182	2.88	25625	2.91	53697	1.98
Dytiki Ellada	40244	5.25	95972	3.72	45738	5.19	108760	4.01
Sterea Ellada	33034	4.31	83840	3.25	40671	4.62	106123	3.91
Peloponnisos	38974	5.08	95971	3.72	45062	5.12	101036	3.72
Attiki	279768	36.48	1182885	45.86	330182	37.48	1303564	48.04
Voreio Aigaio	14762	1.93	34031	1.32	16115	1.83	36426	1.34
Notio Aigaio	39211	5.11	138635	5.37	38740	4.40	85032	3.13
Kriti	51145	6.67	172342	6.68	51610	5.86	140991	5.20
Total	766833	100.00	2579508	100.00	880953	100.00	2713486	100.00

Source: Eurostat, 2024a and Authors' estimations

Table 3 notes the number and percentage share of local units and employment for each Greek region. The regions of Attiki and Thessaloniki have the highest number and share in the specific data for 2018 – 2008 and are followed by the insular region of Kriti. In contrast, another insular region, Voreio Aigaio has the lowest number and share of local units and employment.

3. Research results and Discussions

Beginning the analysis, the table below shows the clusters are created by each economic branch and region, while the figure exhibits the number of clusters created for each region:

Table 4:Cluster Index, 2018 and 2008

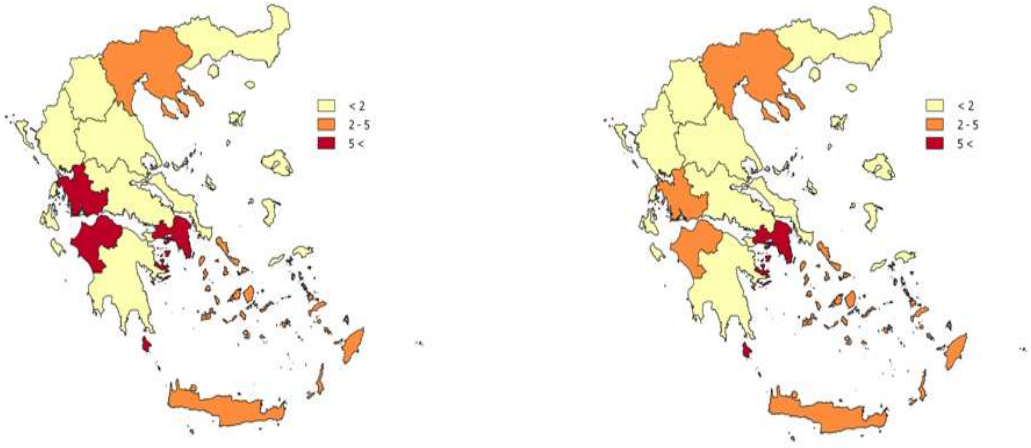
	A		B		C		D	
Regions-Nuts 2	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**
Anatoliki Makedonia-Thraki	0.60	1.81	0.42	0.39	0.25	0.42	0.31	0.32
Kentriki Makedonia	0.76	0.49	1.58	1.80	0.68	0.69	1.15	1.25
Dytiki Makedonia	0.42	10.37	0.41	0.60	0.49	0.40	0.19	0.20
Ipeiros	0.63	0.63	0.36	0.19	0.49	0.36	0.26	0.17
Thessalia	0.44	1.90	0.54	0.83	0.41	0.67	0.39	0.64
Ionia Nisia	0.07	0.16	0.08	0.08	0.50	0.29	0.23	0.18
Dytiki Ellada	1.67	0.85	1.60	1.80	2.40	2.64	2.28	2.15
Sterea Ellada	0.30	2.09	0.55	0.68	0.47	0.54	0.32	0.34
Peloponnisos	0.41	0.25	0.35	0.34	0.46	0.46	0.31	0.31
Attiki	16.66	0.10	14.53	13.39	13.38	14.01	16.84	17.03
Voreio Aigaio	0.21	0.52	0.26	0.28	0.87	0.78	0.46	0.45
Notio Aigaio	0.52	3.48	0.35	0.34	2.22	1.28	1.22	0.87
Kriti	0.88	0.47	0.74	0.62	1.72	1.21	0.95	0.85

	E		F		G		H		I	
Regions-Nuts 2	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**
Anatoliki Makedonia-Thraki	0.18	0.21	0.34	0.38	0.09	0.09	0.09	0.29	0.15	0.14
Kentriki Makedonia	0.64	0.90	0.80	0.99	0.40	0.37	0.62	1.36	0.90	0.67
Dytiki Makedonia	0.13	0.14	0.15	0.33	0.04	0.04	0.02	0.05	0.11	0.07
Ipeiros	0.29	0.16	0.53	0.32	0.08	0.04	0.08	0.04	0.19	0.12
Thessalia	0.28	0.41	0.45	1.00	0.07	0.11	0.10	0.13	0.28	0.27
Ionia Nisia	0.24	0.13	2.36	1.73	0.03	0.02	0.41	0.38	0.20	0.14
Dytiki Ellada	2.36	1.96	1.69	2.73	1.01	0.81	0.37	0.33	1.33	0.81
Sterea Ellada	0.38	0.46	0.34	0.47	0.05	0.07	0.08	0.12	0.17	0.22
Peloponnisos	0.29	0.33	0.46	0.50	0.04	0.09	0.10	0.31	0.15	0.12
Attiki	22.65	22.44	5.56	5.38	45.85	45.47	35.61	21.23	26.93	32.68
Voreio Aigaio	0.32	0.50	1.08	1.07	0.11	0.16	0.18	0.55	0.15	0.22
Notio Aigaio	1.05	0.65	11.55	7.43	0.17	0.12	1.64	1.89	0.82	0.49
Kriti	0.83	0.62	2.73	2.16	0.45	0.27	0.80	1.66	0.82	0.46

Source: Authors' estimation.

A: Energy, B: Manufacturing, C: Construction, D: Wholesale and retail Trade, E: Transportation and storage, F: Accommodation and food service activities, G: Information and Communication, H: Real estate activities, I: Professional, scientific and technical activities-Administrative and support service activities.

Figure 2: Number of clusters for each Greek Nuts-2 Region, 2018 and 2008



According to the table and figure above, more than two (2) clusters are located in the regions of Attiki, Dytiki Ellada, Notio Aigaio, Kentriki Makedonia and Kriti. Specifically, the metropolitan region of Attiki has the highest Cluster Index for each economic branch; also has the largest number of clusters located, compared to the rest regions. It is followed by the region of Dytiki Ellada, where almost all of the economic branches form clusters, with the exception of the branch of real estate activities for 2018.The specific region increases its number of cluster compared to 2008. Additionally, in the insular region of Notio Aigaio, economic branches of construction, wholesale and retail trade, transportation and storage, accommodation and food service activities and real estate activities form clusters. More than two (2) clusters can be found in the regions of Kentriki Makedonia (manufacturing, wholesale and retail trade) and Kriti (construction, accommodation and food service activities). Other regions with one (1) cluster are the rest two insular regions, Voreio Aigaio and Ionia Nisia (both regions in the accommodation and food service activities) for the most recent year.

Later, Table 5 pictures the export economic branches for each region, according to employment data. Figure 3 illustrates the size of total export employment in regions where more than two clusters are located.

Table 5: Export Economic branches, 2018 and 2008

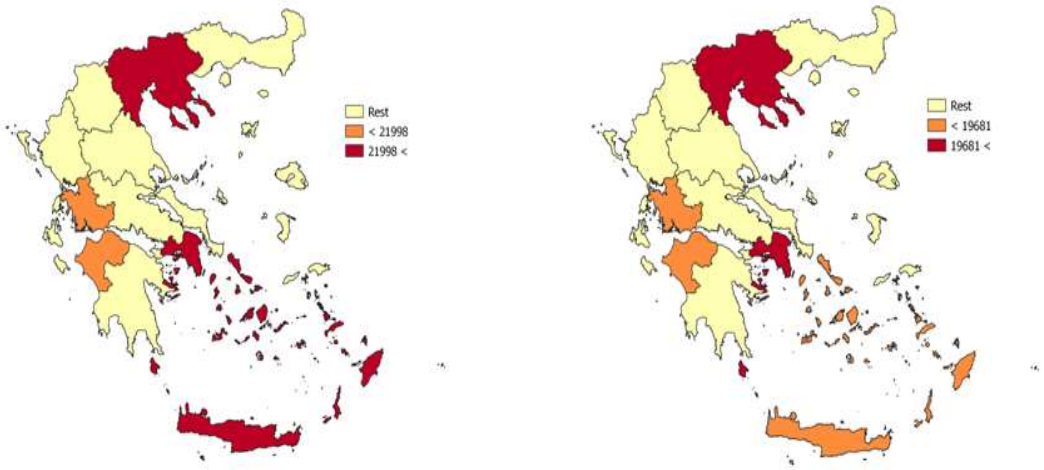
	A		B		C		D		E	
Regions-Nuts 2	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**
Anatoliki Makedonia, Thraki	1309	707	4329	5192	0	4006	785	0	0	0
Kentriki Makedonia	0	0	21313	24413	0	0	6769	12599	0	0
Dytiki Makedonia	367	8028	2217	1560	2752	977	0	0	0	0
Ipeiros	476	0	1056	447	809	2560	0	588	0	0
Thessalia	0	55	4728	5632	773	719	0	223	0	0
Ionia Nisia	0	0	0	0	115	0	0	0	0	0
Dytiki Ellada	0	0	0	224	1216	1976	4334	2580	665	0
Sterea Ellada	0	430	6789	13100	1120	0	0	0	7	0
Peloponnisos	35	0	187	1287	1202	928	936	50	0	483
Attiki	5387	0	0	0	0	0	15901	0	18323	8867
Voreio Aigaio	0	0	0	0	837	988	347	330	0	554
Notio Aigaio	0	738	0	0	0	0	0	0	0	0
Kriti	0	0	0	0	1637	1593	0	209	0	34

	F		G		H		I		TOTAL	
Regions-Nuts 2	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**	**2018**	**2008**
Anatoliki Makedonia, Thraki	1493	1026	0	0	0	74	0	0	7915	11005
Kentriki Makedonia	0	0	0	0	0	76	0	0	28083	37088
Dytiki Makedonia	0	487	0	0	0	0	0	0	5336	11052
Ipeiros	3005	350	0	0	0	0	0	0	5347	3945
Thessalia	1645	5789	0	0	0	0	0	0	7146	12418
Ionia Nisia	21376	10443	0	0	0	82	0	0	21491	10525
Dytiki Ellada	0	3462	0	0	0	0	0	0	6215	8243
Sterea Ellada	0	854	0	0	0	0	0	0	7916	14384
Peloponnisos	5304	4515	0	0	0	44	0	0	7665	7307
Attiki	0	0	26422	31237	3013	176	40788	64073	109835	104353
Voreio Aigaio	4246	2545	0	0	0	31	0	0	5430	4447
Notio Aigaio	46600	16334	0	0	0	155	0	0	46600	17227
Kriti	25355	11819	0	0	0	202	0	0	26991	13857

Source: Authors' estimation.

A: Energy, B: Manufacturing, C: Construction, D: Wholesale and retail Trade, E: Transportation and storage, F: Accommodation and food service activities, G: Information and Communication, H: Real estate activities, I: Professional, scientific and technical activities-Administrative and support service activities.

Figure 3: Regions more than two clusters of export economic branches have been identified, 2018 and 2008



Based on the table and figure above, four (4) regions have higher total export employment than the average (21998) for 2018. Those regions are the two metropolitan regions Attiki and Kentriki Makedonia from the mainland space and Notio Aigaio and Kriti from the insular space. Only Dytiki Ellada has fewer total export employment than the average for regions with more than two clusters for the recent year. In 2008, Attiki and Kentriki Makedonia were the only regions with more total export employment than the average (19681).

For the recent year, the largest number of export branches in regions with a significant number of clusters places in Attiki. More specifically, the export branches of energy, wholesale and retail trade, transportation and storage, information and communication, real estate activities, professional, scientific and technical activities-administrative and support

service activities contribute to the export-orientation of the region. The export branches of manufacturing, wholesale and retail trade are located in Kentriki Makedonia. Construction, accommodation and food service activities are located in Kriti and accommodation and food service activities are located in Notio Aigaio.

Later, the table below indicates the results of Pearson correlation between the total number of clusters and the sum of export economic branches exist in each region for the examined years.

Table 6: Pearson correlation index, 2018 and 2008

Employment		
2018	**Export Economic Branches**	**Number of Clusters**
Export Economic Branches	1.000	-
Number of Clusters	0.714	1.000
2008	**Export Economic Branches**	**Number of Clusters**
Export Economic Branches	1.000	-
Number of Clusters	0.745	1.000

Source: Authors' estimations

As a result, there is a quite strong correlation between the sum of export branches and the total number of clusters for 2018 and 2008. A link between clusters and export economic branches has been identified.

Next the paper focuses on the performance of export economic branches located inside or outside the related clusters. Therefore, the paper applies a one-way analysis of variance (one-way ANOVA).

Table 7: One-way Anova, 2018 and 2008

Export economic branches		Means	F	P-value
2018	Clusters	43545	6.372	0.028**
	Rest	8531		
2008	Clusters	36153	3.798	0.077*
	Rest	9385		

* p<0.10;**p< 0.05; ***p < 0.01

Source: Authors' estimations

Therefore, the means for export branches located inside the clusters are significantly higher than for export branches located outside the clusters. Furthermore, it can be noted that p-value becomes more significant for 2018 than it was in 2008. This indicates that the difference in performance between the two groups (inside and outside clusters) is even more pronounced in 2018 than in 2008, indicating that the clustering effect on export branch performance has strengthened over time.

Furthermore, Table 8 demonstrates the employment change of the export economic branch for each region; Figure 4 presents the employment change of the export economic branch for each region where more than two clusters have been identified.

Table 8: Employment change of export economic branches, 2008-2018

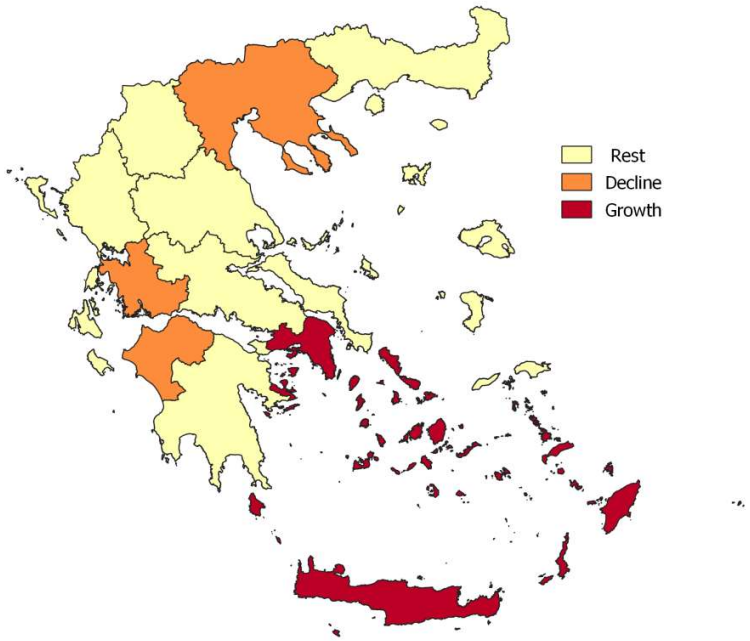
Regions-Nuts 2	A	B	C	D	E	F	G	H	I	TOTAL
Notio Aigaio	-100.00	0.00	0.00	0.00	0.00	185.30	0.00	-100.00	0.00	170.51
Ionia Nisia	0.00	0.00	0.00	0.00	0.00	104.70	0.00	-100.00	0.00	104.20
Kriti	0.00	0.00	2.76	-100.00	-100.00	114.52	0.00	-100.00	0.00	94.79
Ipeiros	0.00	136.00	-68.38	-100.00	0.00	759.75	0.00	0.00	0.00	35.54
Voreio Aigaio	0.00	0.00	-15.24	5.11	-100.00	66.87	0.00	-100.00	0.00	22.09
Attiki	0.00	0.00	0.00	0.00	106.66	0.00	-15.41	1609.03	-36.34	5.25
Peloponnisos	0.00	-85.45	29.53	1784.86	-100.00	17.48	0.00	-100.00	0.00	4.90
Kentriki Makedonia	0.00	-12.70	0.00	-46.27	0.00	0.00	0.00	-100.00	0.00	-24.28

Regions-Nuts 2	A	B	C	D	E	F	G	H	I	TOTAL
Dytiki Ellada	0.00	-100.00	-38.48	67.95	0.00	-100.00	0.00	0.00	0.00	-24.60
Anatoliki Makedonia. Thraki	85.31	-16.63	-100.00	0.00	0.00	45.47	0.00	-100.00	0.00	-28.07
Thessalia	-100.00	-16.06	7.49	-100.00	0.00	-71.59	0.00	0.00	0.00	-42.46
Sterea Ellada	-100.00	-48.18	0.00	0.00	0.00	-100.00	0.00	0.00	0.00	-44.97
Dytiki Makedonia	-95.43	42.07	181.85	0.00	0.00	-100.00	0.00	0.00	0.00	-51.72

Source: Authors' estimation.

A: Energy, B: Manufacturing, C: Construction, D: Wholesale and retail Trade, E: Transportation and storage, F: Accommodation and food service activities, G: Information and Communication, H: Real estate activities, I: Professional, scientific and technical activities-Administrative and support service activities.

Figure 4: Employment change of export economic branches in regions more than two clusters have been identified, 2008-2018



According to the table and figure above, Notio Aigaio, Kriti and Attiki are among the regions with export employment growth for the examined period. Especially, Notio Aigaio shows the highest export employment growth, which is mainly due to the employment growth of the export economic branch of accommodation and food service activities. This implied that growth could be attributed to an increase in demand for tourism from the region. It is important to note that this statement only refers to the export economic branch of accommodation and food service activities, meaning that there are no other economic branches within the region experiencing levels of growth in export employment. Finally, the export branches of construction, accommodation and food service activities contribute to the export employment growth in Kriti and transportation and storage, as well as real estate activities contribute to the export employment growth in Attiki. On the other side, it appears that Kentriki Makedonia and Dytiki Ellada have experienced a decline in export employment between 2008 and 2018.

Table 9: Global Moran index, 2018

Economic Branches	I	E[I]	mean	sd	z-value	P-value
Energy	-0.103	-0.083	-0.080	0.086	-0.264	0.374
Manufacturing	0.110	-0.083	-0.086	0.126	1.558	0.076*
Construction	-0.218	-0.083	-0.079	0.193	-0.719	0.219

Economic Branches	I	E[I]	mean	sd	z-value	P-value
Wholesale and retail trade; repair of motor vehicles and motorcycles	-0.065	-0.083	-0.082	0.132	0.129	0.358
Transportation and storage	-0.048	-0.083	-0.080	0.038	0.841	0.245
Accommodation and food service activities	0.402	-0.083	-0.089	0.171	2.867	0.018**
Information and communication	-0.059	-0.083	-0.080	0.036	0.599	0.241
Real estate activities	-0.059	-0.083	-0.080	0.036	0.599	0.241
Prof-admin	-0.059	-0.083	-0.080	0.036	0.599	0.324

* p<0.10;**p< 0.05; ***p < 0.01
Source: Authors' estimations

Figure 5: Local Moran index, 2018

Table 9 and Figure 5 implement measurements of spatial autocorrelation for export branches in regions. The global indicator presents a positive spatial dependence in manufacturing and accommodation and food service activities. However, the more significant spatial clustering shows the export economic branch of accommodation and food service activities in Notio Aigaio, as is illustrated by the local indicator for 2018. So, a large number of economic activities that are involved in exporting goods and services related to accommodation and food services are located in Notio Aigaio.

4. Conclusions

The paper explores the impact of clusters on the export performance of economic branches in Greek NUTS-2 regions. Analysis focuses on the nuances of export-driven branches within the Greek context, offering a comprehensive evaluation of export efficiency, inter-branch and regional comparisons, and uncovering spatial relationships in localised clusters. The paper's methodologies and goal bring valuable contributions to understanding the role of clusters in enhancing the competitiveness and growth of export-oriented branches in Greece. Unique to this research is the utilisation of the Cluster Index in conjunction with techniques drawn from economic base theory, encompassing both statistical and spatial methodologies. These methodological choices provide a novel approach to uncovering the intricate relationship between clusters and export performance, contributing to the methodological toolkit of agglomeration research. The robust findings highlight the positive impact of agglomeration

on economic growth and efficiency, reinforcing the importance of fostering clusters as a means to enhance the competitiveness of export-oriented economic branches.

Furthermore, the in-depth exploration of the Greek context not only fills a gap in the literature but also offers a fresh perspective that bridges the gap between theory and practice. This paper brings forth a plethora of novel contributions when juxtaposed with the works of the mentioned authors. It transcends Alfred Marshall's foundational notions by embarking on a contemporary and empirical analysis of clusters' impact on export performance within Greek NUTS-2 regions. Extending Giner-Pérez and Santa María's (2020) exploration of territorial firm agglomerations, this study narrows its gaze to the Greek context, enhancing the comprehension of how agglomeration shapes export outcomes in this unique geographical and economic milieu. In contrast to Lovely et al.'s (2005) focus on exporters' headquarters, this research shifts its focus to Greek NUTS-2 regions, unveiling how clusters influence export efficiency and competitiveness across diverse economic branches. Diverging from He et al.'s (2012; 2015) study on Chinese industrial firms, this paper ventures into Greek NUTS-2 regions and their export-oriented sectors, enriching the understanding of the relationship between clusters and export performance in a distinctive geographic and economic setting. While Segarra-Oña et al. (2012) scrutinised tourism clusters, this research extends its scope to encompass a broader array of export-oriented branches within diverse Greek regions, unraveling how clusters impact various sectors' export efficiency and competitiveness. By extrapolating the insights of Wennberg and Lindqvist (2008), Beaudry and Swann (2009), Yilmazkuday (2011) to Greek NUTS-2 regions, this analysis ushers in a fresh perspective on clusters' influence on export performance, expounding their effects across diverse economic branches in a distinct cultural and economic context.

From a policy perspective, paper's findings underscore the significance of tailoring strategies to foster sectoral-spatial patterns based on Greek insular and mainland regions, as well as export branches. The identification of clusters within specific economic branches and regions provides a roadmap for policymakers to target their efforts effectively. For instance, the prominence of export-oriented clusters in larger populated mainland regions such as Attiki and Kentriki Makedonia calls for targeted initiatives to further strengthen these regions' competitiveness in manufacturing, transportation and wholesale and retail trade. These clusters can serve as hubs for advanced manufacturing and logistics, attracting investments and enhancing the export potential of related economic branches. Moreover, the distinct growth in export efficiency within insular regions such as Ionia Nisia, Notio Aigaio and Kriti highlights the potential of nurturing the accommodation and food service activities sector in these areas, aligning with their geographical advantage for tourism; fostering collaborative efforts among hospitality businesses, cultural institutions, and local governments can amplify the impact of clustering, enhancing the overall tourism experience and driving export revenues.

By aligning policy interventions with the unique sectoral-spatial dynamics identified in the study, policymakers can catalyse growth and competitiveness in regions where clusters exhibit varying levels of export potential. This tailored approach acknowledges the diverse strengths and opportunities that each insular/mainland region and economic branch bring to the table, fostering a holistic and strategic path toward enhancing export economic performance.

5. References

Anselin, L. (1995). "Local indicators of spatial association—LISA". Geographical analysis, 27, 93-115.

Audretsch, D.B. & Feldman, M. (1996a). "R&D spillovers and the geography of innovation and production". The American Economic Review, 86 (3), 630–640.

Audretsch, D.B. & Feldman, M.P. (1996b). "Innovation clusters and the industry lifecycle." Review of Industrial Organization, 11 (2), 253–273.

Baptista, R. (2000). "Do innovations diffuse faster within geographical clusters?" International Journal of Industrial Organization, 18 (3), 515–535.

Baptista, R. & Swann, P. (1998). "Do firms in clusters innovate more?" Research Policy, 27 (5), 525–540.

Beaudry, C. & Swann, G. P. (2009). “Firm growth in industrial clusters of the United Kingdom.” Small Business Economics, 32, 409-424.
Branco, A. & Lopes, J. C. (2018). “Cluster and business performance: Historical evidence from the Portuguese cork industry.” Investigaciones de Historia Económica - Economic History Research, 14 (1), 43–53.
Broekel, T., D. Fornahl, D. & Morrison, A. (2015). “Another cluster premium: Innovation subsidies and R&D collaboration networks.” Research Policy, 44 (8), 1431-1444.
Chen, Z., Zhu, H., Zhao, W., Zhao, M. & Zhang, Y. (2021). “Spatial agglomeration of China’s forest products manufacturing industry: Measurement, characteristics and determinants.”Forests, 12, 1006.
Chen, X., Wang, E., Miao, C., Ji, L. & Pan, S. (2020). “Industrial clusters as drivers of sustainable regional economic development? An analysis of an automotive cluster from the perspective of firms’ role.” Sustainability, 12 (7), 2848.
Cheng, F.F., Boerboom, L., Geertman, S. & Hooimeijer, P. (2013). “Changing spatial concentration of sectoral employment in China’s Pearl River Delta 1990–2005.” Tijdschrift Voor Economische En Sociale Geografie, 104 (3), 261–277.
De Vaan, M., Boschma, R. & Frenken, K. (2013). “Clustering and firm performance in project based industries: The case of the global video game industry, 1972–2007.”Journal of Economic Geography, 13 (6), 965–991.
Eurostat. (2024a). “SBS data by NUTS 2 regions and NACE Rev. 2 (from 2008 onwards).” Available at: https://ec.europa.eu/eurostat (accessed December 5, 2024).
Eurostat. (2024b). “Population on 1 January by age, sex and NUTS 2 region, 2018.” Available at: https://ec.europa.eu/eurostat (accessed December 5, 2024).
Eurostat. (2024c). “Total and land area by NUTS 2 region.” Available at: https://ec.europa.eu/eurostat (accessed December 7, 2024).
Gelman, A. (2005). “Analysis of variance – Why it is more important than ever.” The Annals of Statistics, 33 (1), 1–53.
Giner-Pérez, J. M. & Santa-María, M. J. (2020). “Spatial agglomerations in the Spanish food industry: Does sectorial disaggregation matter?” International Regional Science Review, 44 (5), 515–559.
Grashof, N. (2021). “Spill over or Spill out? – A multilevel analysis of the cluster and firm performance relationship.” Industry and Innovation, 28 (10), 1298-1331.
Hassan, M. M., Alenezi, M. S., & Good, R. Z. (2020). “Spatial pattern analysis of manufacturing industries in Keraniganj, Dhaka, Bangladesh.” GeoJournal, 85, 269–283.
He, C., Guo, Q., & Ye, X. (2015). “Geographical agglomeration and co-agglomeration of exporters and nonexporters in China.” GeoJournal, 81 (6), 947–964.
He, C., Ye, X. & Wang, J. (2012). “Industrial agglomeration and exporting in China: What is the link?”Regional Science Policy and Practice, 4 (3), 317–333.
Hervas-Oliver, J. L., Sempere-Ripoll, F., Rojas Alvarado, R. & Estelles-Miguel, S. (2018). “Agglomerations and firm performance: who benefits and how much?” Regional Studies, 52 (3), 338–349.
Isserman, Andrew M. (1977). “The Location Quotient Approach to Estimating Regional Economic Impacts.” Journal of the American Institute of Planners, 43:1, 33-41.
Ketels, C. & Protsiv, S. (2021). “Cluster presence and economic performance: a new look based on European data.” Regional Studies, 55 (2), 208-220.
Koenig, P. (2009). “Agglomeration and the export decisions of French firms.”Journal of Urban Economics, 66 (3), 186-195.
Liu, Q. & Wang, A., J. (2022). “Spatial Agglomeration and Firm Productivity: Does Trade Status Matter?” Regional Science Policy and Practice, 14 (2),5-18.
Lovely, M. E., Rosenthal, S. S. & Sharma, S. (2005). “Information, agglomeration, and the headquarters of U.S. exporters.” Regional Science and Urban Economics, 35 (2), 167–191.
Mendoza-Velázquez, A. & Benita, F. (2019). “Efficiency, productivity, and congestion performance: Analysis of the automotive cluster in Mexico.” Journal of Industry, Competition and Trade, 19 (4), 661–678.
Pavelkova, D., Zizka, M., Homolka, L., Knapkova, A. & Pelloneova, N. (2021). “Do clustered firms outperform the non-clustered? Evidence of financial performance in traditional industries.” Economic Research-Ekonomska Istraživanja, 34 (1), 3270–3292.
Porter, M. E. (1998). “Clusters and the new economics of competition.” Harvard Business Review, 76 (6), 77–90.
Rodgers, L. J. & Nicewander, W.A. (1988). “Thirteen ways to look at the correlation coefficient.” The American Statistician, 42 (1), 59–66.
Schaffer, W.A. (2020). “Regional Impact Models.” Morgantown: Regional Research Institute, West Virginia University.

Segarra-Oña, M. D. V, Miret-Pastor, L.G., Peiro-Signes, A. & Verma R. (2012). "The effects of localization on economic performance: Analysis of Spanish tourism clusters." European Planning Studies, 20 (8), 1319–1334.
Sellitto, M. A., & Luchese, J. (2018). "Systemic cooperative actions among competitors: The case of a furniture cluster in Brazil." Journal of Industry, Competition and Trade, 18, 513–528.
Sternberg, R. & Litzenberger, T. (2004). "Regional clusters in Germany: Their geography and their relevance for entrepreneurial activities." European Planning Studies, 12 (4), 767–792.
Stojčić, N., Anić, I. D. & Aralica, Z. (2019). "Do firms in clusters perform better? Lessons from wood-processing industries in new EU member states." Forest Policy and Economics, 109, 102043.
Wennberg, K. & Lindqvist, G. (2008). "How do entrepreneurs in clusters contribute to economic growth?" SSE/EFI Working Paper Series in Business Administration, 3.
Yilmazkuday, H. (2011). "Agglomeration and trade: State-level evidence from US industries." Journal of Regional Science, 51 (1), 139–166.

SUSTAINABLE REGIONAL DEVELOPMENT AND COMPLEX ADAPTIVE SYSTEMS: A METHODOLOGICAL PROPOSAL THROUGH SOCIAL NETWORK ANALYSIS

Diego Andrés CARREÑO DUEÑAS
School of Mines, National University of Colombia (Universidad Nacional de Colombia), Medellin, Colombia; Professor, School of Industrial Management, Pedagogical and Technological University of Colombia (Universidad Pedagógica y Tecnológica de Colombia), Duitama, Colombia.
dicarrenod@unal.edu.co, diego.carreno@uptc.edu.co

Walter Lugo RUIZ CASTAÑEDA
Professor, Department of Organizational Engineering, School of Mines, National University of Colombia (Universidad Nacional de Colombia), Medellin Colombia.
wlruizca@unal.edu.co

Abstract
The evolution of the main theories that have shaped Sustainable Regional Development (SRD) is traced in this paper, with the progressive incorporation of economic, social, environmental, and institutional dimensions showing how it is configured as a complex phenomenon. Based on this conceptual foundation, the study links the analysis of SRD to the Complex Adaptive Systems (CAS) framework and, within this approach, to Social Network Analysis (SNA) as a tool for modelling interactions among regional stakeholders. Finally, it introduces a correlation between the resulting regional network metrics and the Departmental Innovation Index (IDIC) indicators for Colombia's regions, offering an alternative perspective for analysing regional disparities.

Keywords: Sustainable Regional Development; Divergence, Complex Adaptive Systems, Social Network Analysis
JEL classification: O20, R11
pp. 85-99

1. Introduction

The analysis of Sustainable Regional Development (SRD) represents one of the main challenges for the social, economic, and territorial sciences in the current context. The profound transformations of global capitalism, the growing pressure on ecosystems, and the persistent socioeconomic inequalities across regions within countries have created a scenario in which traditional theoretical frameworks have proven insufficient to understand and manage the complexities of regional development divergences (Pike et al., 2017; Rodríguez-Pose, 2013; Toro, 2007).

Over the past fifty years, theories of SRD have evolved from perspectives focused exclusively on economic growth towards multidimensional approaches that integrate social, environmental, spatial and institutional aspects (Bedrunka 2020; Sen 1990). This shift towards complexity has increased attention on the potential relationship between regional actors and SRD performance. This relationship highlights the necessity for tools that are capable of capturing non-linear, interdependent dynamics and the adaptive processes that occur within regions (Levin et al. 2013; Neely 2015).

It is evident that phenomena such as globalization, the adoption of neoliberal free-market policies, and a marked trend towards reducing the role of the state (Useche Arévalo 2002), have shaped a complex economic, political, and social scenario in Colombia. Regional development gaps highlight socioeconomic and environmental disparities. This divergence, initially measured through Gross Domestic Product (GDP), reveals that over the past forty years, three regions namely—Bogotá Region, Antioquia, and Valle del Cauca—out of Colombia's thirty-two regions, have concentrated on average 50% of the national GDP (DANE 2024).

These regional disparities, or divergences, are also reflected in social indicators. According to data from the 2024 National Quality of Life Survey (DANE 2024), the mean years of

schooling in Caribbean and Pacific municipal centers was recorded as 8.4, in comparison to 10.5 in the Bogotá Region. Coccia (2018) posits that such regional disparities can engender poverty, unemployment, social problems, income inequality, violence, and underdevelopment. These data confirm not only the persistence of economic divergences but also the economic and social polarization in Colombia over the past four decades.

It is evident that reducing divergences between regions can lead to more just and prosperous societies (Polyzos and Tsiotas 2025). The present study aims to deepen the understanding of this divergent phenomenon, as such understanding could contribute to the design of more precise and effective public policies to promote balanced and convergent regional development (Alexiadis, 2020; Mnatsakanyan et al., 2021).

In view of this economic and social scenario of divergence, an alternative approach through Complex Adaptive Systems (CAS) provides a distinctive theoretical framework to facilitate a more profound understanding of the possible causes of regional divergences in SRD. The CAS framework conceptualizes regions as open, dynamic, and relational systems, wherein interactions among agents or actors give rise to emergent and adaptive patterns (Naudé 2012). In the context of the analytical tools associated with this perspective, Social Network Analysis (SNA) is distinguished by its capacity to identify, represent, and measure relationships among actors. It has also been demonstrated that this method can be utilized to identify key structures and assess how these configurations influence regional performance (Holgado Ramos, 2016; Zhou et al., 2022).

Despite its analytical potential, the integration of SNA into the study of SRD has not received sufficient attention, and only a limited number of works can be found. For instance, within the domain of regional innovation analysis, studies have been conducted that examine the evolution of inventor networks within a German region (Cantner and Graf 2006), compare German territories to assess the role of universities and public research centers (Graf and Henning 2009), and measure scientific collaboration across European regions to determine its relationship with SRD (Hoekman et al., 2010). In the Latin American context, there are only two cases: one studying patent networks across cities or regions in Chile (Pinto et al., 2019) and another in Brazil (Mejdalani et al., 2021).

Taken together, these studies highlight how the structure of relationships among different actors—identifying who collaborates with whom and how close certain actors are to others—reveals the coordinating potential of specific agents. In this sense, network structures may be linked to improved outcomes in economic development, technological advancement, scientific productivity, and regional innovation, while also integrating social and environmental results. However, it is important to note that none of these works has connected regional network metrics derived from SNA with composite socioeconomic indicators such as Colombia's Departmental Competitiveness Index (IDIC) (DNP, 2020). The integration proposed here, as a strategy for comparison and analysis of regional development divergences, identifies an alternative opportunity to advance an innovative methodological framework that systematically links and correlates SNA metrics (e.g., density, centrality, modularity) (Carrington et al., 2005) across regions with economic, sustainability, competitiveness, and social indicators such as the IDIC for the same territories.

Based on the above, this paper develops the proposed linkage and association of concepts in three stages. First, a historical and conceptual review of SRD is undertaken, tracing its foundations after World War II up to its interpretation as a complex and multidimensional framework. Second, a bibliographic review examines the main tools derived from CAS applied to the analysis of SRD, including neural networks, fuzzy logic, agent-based simulation, system dynamics, and SNA. Finally, the third stage presents a methodological proposal to correlate SNA metrics—obtained from modeling the networks of different regions—with SRD performance, using economic, innovation, social, and environmental indicators. The idea behind this methodological proposal is that it is based on solid theory, can be repeated and used in other situations with little alteration, and provides a different way of looking at the reasons for differences in SRD between regions.

2. Theoretical Framework

One of the objectives of tracing the origins and main theoretical advances in regional economic science—without attempting to encompass all currents and schools of thought—is

to understand the most relevant principles that have contributed to the theoretical and conceptual evolution of Sustainable Regional Development (SRD) and that have enabled it to be regarded as a complex and multidimensional phenomenon. This review outlines how different theoretical, conceptual, and methodological approaches have shaped the foundations of this field while simultaneously identifying the factors that have led SRD to be conceived as a complex phenomenon. The inclusion of variables beyond Gross Domestic Product (GDP) over time serves to further illustrate the inherent complexity of the phenomenon under investigation. The addition of social, environmental, institutional and governance indicators has resulted in a more comprehensive understanding of regional development, thereby reflecting its complex and interdependent nature.

2.1. Origins and Foundations of Regional Thought (1950–1970)

According to Polese (1999), modern regional development reached a turning point after World War II, when economic reconstruction and the consolidation of global capitalism gave rise to analytical frameworks still dominated by neoclassical theory—the basis of the growth and economic development propositions advanced by Perroux (1950) and Boudeville (1965). This convergent neoclassical influence led many authors to assert, a priori, that inequality between regions was transitory and would be corrected by market forces. However, this assumption was later challenged by the persistence and widening of inequalities in development levels, not only across countries but also among regions (Moncayo Jiménez 2003; Capello 2006).

In this context, (Knox and Myrdal (1960) introduced the theory of uneven development, which posited that growth is naturally divergent (Dhimitri et al., 2015). In Latin America, Carrillo Arronte (1978) warned against importing foreign models that disregarded the Latin American context—characterized by "caciquismo" (concentration of power) and social heterogeneity—arguing that such models were both risky and insufficient for understanding these realities. From its origins, therefore, regional thought has combined theoretical tensions and contextual diversity, elements that later opened the door to more flexible and adaptable approaches. The body of the text consists of different sections which describe the content of the article (for example: Method, Findings, Analysis, Discussion, etc.).

2.2. From Endogenous Growth to the Territorial Dimension (1980–1990)

During the 1980s, theories of endogenous growth and "bottom-up" development gained prominence. These approaches emphasized the internal potential of regions to generate employment and productivity through the strategic use of their own resources (Bogdański 2012). In this regard, Romer (1986) and Lucas (1988) refined theoretical advances in economic development, orienting them toward endogenous aspects and consolidating the idea that technological change and investment in human capital are key factors for development.

Porter (1990) formulated the theory of regional competitive advantage, highlighting the role of clusters and innovation as pillars of territorial competitiveness. Meanwhile, Krugman (1991) introduced a renewed spatial perspective with the New Economic Geography, and Stiglitz (2002) contributed insights into how information asymmetries affect regional opportunities. This shift toward endogenous and territorial perspectives paved the way for understanding regions as interconnected systems, emphasizing the role of social capital in regional development (Papadaskalopoulos and Nikolopoulos 2018). In doing so, it anticipated, perhaps, the integration into the language of CAS, which would later become central to the analysis of SRD.

2.3. The Emergence of the Sustainability and Institutional Approach (1987–2010)

The publication of the Brundtland Report (1987) marked the formal introduction of sustainability into the regional development agenda, defining Sustainable Development as the ability to meet present needs without compromising those of future generations. This perspective integrated economic, social, and environmental dimensions into a unified analytical framework (Moncayo Jiménez 2003). Complementarily, Ostrom (1990) demonstrated that local communities can manage natural resources more efficiently than the

state, while Acemoglu and Robinson (2012) emphasized the importance of inclusive institutions in preventing the concentration of power. Meadowcroft (2007) stressed that SRD requires not only economic performance but also strong institutional frameworks, participatory processes, and constant social engagement. Meanwhile, Piketty (2015) warned of the tendency for divergences to persist in the absence of redistributive mechanisms guided by the state.

In this sense, the incorporation of sustainability, institutional frameworks, and social dimensions broadened the scope of regional development analysis, introducing a complexity that demands methodologies capable of integrating multiple dimensions, variables, and actors.

2.4. Endogenous and Exogenous Factors: A Persistent Debate

According to Salguero Cubies (2006), the debate on SRD largely revolves around the weight of endogenous versus exogenous factors. The former—such as local resources, capacities, and institutions—fall under a degree of regional control (Millar 2014; Šabić and Vujadinović 2017). In contrast, exogenous factors depend on external forces such as global trends, national policies, or international investments (Merchand, 2007; Trippl et al., 2018).

Complementarily, Bogdański (2012) and Nijkamp and Abreu (2020) note that most contemporary studies recognize the interaction between these two dimensions. Additionally, Stimson et al. (2011) call for research that integrates these scales and approaches. Cooke et al. (1997) further argue that regional innovation systems serve as spaces where such interactions generate unique development trajectories, with public policies exerting a significant regulatory effect on regional divergences (Panjawa et al., 2018). This debate on internal and external factors reinforces the idea that regional development is neither linear nor predictable but rather an emergent process with multiple interdependencies.

2.5. Evolution in the Measurement of SRD

As early as the 1970s, Seers (1972) warned that GDP alone was insufficient to measure development, proposing instead the inclusion of variables such as poverty, unemployment, and inequality. Sen (1990) advanced this line of thought with the Human Development Index (HDI), which incorporated dimensions of health, education, and income. Boutros Boutros-Ghali (1995) identified five pillars for regional development: peace, economy, environment, justice, and democracy. Gualdrón Guerrero (2011) provided an insightful analysis for Colombia, comparing economic growth measured through departmental GDP with development measured by the HDI.

More recently, Bedrunka (2020) and Jackson et al. (2019) have proposed indicators integrating economic, environmental, spatial, and innovation dimensions. For example, Rodríguez Miranda et al. (2021) developed a system of 24 indicators distributed across eight dimensions, applicable to Latin American contexts. Regional indicators that go beyond GDP thus open new possibilities for understanding regions more comprehensively Tektas et al. (2016). Similarly, Ladias et al. (2023) emphasize that the adoption of regional economic indicators could help identify and address regional disparities; as well as guide public policy priorities (Fedotova, Zhiglyaeva, and Stolyarova 2018)—one of the main challenges facing developing countries Pourmohammadi et al. (2014). In this sense, Pike et al. (2017) synthesize this evolution, highlighting that regional development is an adaptive process, rooted in territory, and shaped by multiple interactions. This evolution in measurement reflects a growing recognition of the complexity of SRD, paving the way for analytical frameworks capable of identifying its nonlinear and interdependent dynamics.

2.6. Synthesis

The historical and conceptual trajectory of SRD demonstrates its transformation from an essentially economic framework to a multidimensional and dynamic vision, thereby becoming a complex phenomenon (Boschma and Martin 2010). This trajectory, marked by the interaction of endogenous and exogenous factors, the incorporation of economic, social, and environmental dimensions, and the adoption of comprehensive measurement systems, underscores the need for approaches capable of integrating these interdependencies and constant adaptations to new realities in order to understand divergences in regional

development (Martin and Sunley 2007). In this regard, the CAS paradigm and tools such as SNA emerge as suitable approaches to better comprehend and explain, from a different perspective, the persistence—or perhaps the overcoming—of divergences in regional development.

3. Analysis of Tools for the Study of SRD from the Perspective of Complex Adaptive Systems

This study adopts a qualitative and exploratory approach aimed at articulating the concepts of Sustainable Regional Development (SRD) with tools derived from Complex Adaptive Systems (CAS), among which the following stand out: Neural Networks, Fuzzy Logic, Agent-Based Simulation, System Dynamics, and Social Network Analysis. Based on the assumption that combining SRD concepts with these tools generates complex and multidimensional constructs, an inductive and interpretive approach was chosen, grounded in a review of academic literature and theoretical content analysis (Hernández Sampieri, Roberto; Baptista Lucio and Fernández Collado 2016). This approach is particularly useful for exploring fields that are either poorly systematized in combination or still emerging, with the aim of identifying initial patterns and building theoretical hypotheses.

The bibliographic search was carried out in databases such as Scopus, Web of Science, and Google Scholar, using the following search equations:

Sustainable regional development AND *Imbalances* OR *Disparities* AND *Neural Networks;*

Sustainable regional development AND *Imbalances* OR *Disparities* AND *Fuzzy Logic;*

Sustainable regional development AND *Imbalances* OR *Disparities* AND *Agent-Based Model;*

Sustainable regional development AND *Imbalances* OR *Disparities* AND *Systems Dynamics;*

Sustainable regional development AND *Imbalances* OR *Disparities* AND *Social Network Analysis*.

The inclusion criteria were publications between 2010 and 2024 that addressed the central concepts. The search was refined to topics related to economics, development, geography, regional science, and public administration. The selected literature was examined through qualitative content analysis following the methodologies described by Mayring (2004) and Schreier (2024). Key thematic categories such as territoriality, sustainability, governance, and social capital were identified; these concepts facilitated the mapping of convergences and tensions across approaches. Furthermore, the organization and coding of information were managed using an Excel matrix.

In a subsequent stage, a preliminary relational framework was developed to integrate the key concepts, following an abductive logic (Timmermans and Tavory 2012). This exercise sought to connect the principles of SRD with the foundations of CAS and their associated tools, in order to identify which tool could provide a distinctive and alternative perspective in the analysis of regional disparities.

3.1. Complex Adaptive Systems Perspective

The initial findings showed that SRD can be conceived as a CAS, where actors with heterogeneous interests, resources, and capacities interact in a non-linear manner, generating emergent and unpredictable patterns (Levin et al. 2013; Naudé 2012). According to Buchholz and Bathelt (2021), adopting a relational perspective on actors enhances the understanding of territorial differences and regional adaptation processes.

This approach aligns with transdisciplinary perspectives that integrate economics, geography, political science, and sociology (ten Broeke and Tobi 2021). Moreover, (Merchand 2007) emphasizes that tools derived from general systems theory and chaos theory overcome the limitations of traditional methodologies, offering a holistic and integrated view of SRD. Complementarily, the use of tools developed primarily outside the traditional economic field—such as those rooted in complex adaptive systems theory—has gained

credibility and importance in the modeling of socioeconomic phenomena. These models are notable for their ability to provide policymakers with comprehensive and quantitative information that supports improved decision-making (Beaussier et al., 2019).

3.2. Analytical Tools Derived from CAS

The literature review made it possible to identify studies and methodologies associated with the analysis of complex phenomena applied to SRD, including neural networks, fuzzy logic, agent-based simulation, system dynamics, and social network analysis (SNA). The tools and the total number of works found across the different databases are presented in Table 1.

Table 1. Studies identified for each tool related to SRD

Methodology	Scopus	Web of Science	Google Scholar	Total
Neural Networks	31	77	115	223
Fuzzy Logic	0	61	55	116
Agent-Based Simulation	1	12	10	23
System Dynamics	59	43	126	228
Social Network Analysis.	30	208	98	336
Total	**121**	**401**	**404**	**926**

Source: Adapted from the review of databases (Scopus, Web of Science, and Google Scholar).

From the total number of studies identified for each tool, a screening process was carried out to eliminate duplicates and to retain only those works that effectively met the criteria based on the combination of defined search terms. In this sense, the number of studies that specifically address the analysis of divergences in SRD is presented in Table 2.

Table 2. Specific Studies by Tool Related to Divergences in SRD

Methodology	Total Studies	Specific Studies
Neural Networks	223	6
Fuzzy Logic	116	10
Agent-Based Simulation	23	12
System Dynamics	228	6
Social Network Analysis.	336	7
Total	**926**	**41**

Source: Adapted from the review of databases (Scopus, Web of Science, and Google Scholar).

Based on the specific studies identified for each tool, a more detailed analysis was conducted with the aim of identifying aspects related to SRD divergences across regions. This analysis examined the methodologies employed, the sources of information, as well as the economic elements considered in these comparisons. The most relevant findings for each tool are presented below.

3.2.1. Neural Networks

Neural networks have been employed to forecast regional economic indicators such as GDP, inflation, unemployment, or HDI (Chen 2022; Churikanova and Lysenko 2021; Kuriksha 2021), thereby facilitating resource allocation and the detection of growth opportunities (Ugulava 2019). Although effective in pattern recognition (Gue et al., 2020), they present limitations in capturing interdependencies and feedback loops that characterize complex systems (Shi, James, and Guo 2004).

3.2.2. Fuzzy Logic

Fuzzy logic enables the simultaneous representation of social, economic, and environmental dimensions through membership levels, as demonstrated in the model of Andriantiatsaholiniaina et al. (2004). It has been applied to support the design of specific policies (Fedrizzi et al., 1993; Rizzo et al., 2022; Shevchenko, 2021), but its acceptance in economics remains limited due to its complexity, high computational demand, and the ambiguity of interpreting results (Díaz & Morillas, 2011; Ferrer-Comalat et al., 2021; Ratiu et al., 2009; Stojić, 2012; Trillas, 2015; Wu & Xu, 2021).

3.2.3. Agent-Based Simulation

Agent-based simulation facilitates the analysis of emergent dynamics arising from interactions among heterogeneous agents (Al-Zinati and Wenkstern 2019; Gómez Cruz 2018), integrating economic, social, environmental, and spatial dimensions (Akopov et al., 2017; Muto et al., 2020; Sebestyén & Varga, 2019). It has also been applied to the study of regional innovation systems (Ponsiglione et al., 2017; Quintero Ramirez et al., 2017). However, its validity is often context-specific and may oversimplify real-world behavior (Lippe et al. 2019; Macal 2016; Terra and Passador 2018).

3.2.4. System Dynamics

System dynamics analyzes interconnections and feedback loops under the premise that changes in one part of the system affect the whole (Martinez-Moyano 2019). Examples include models applied to territorial planning (Cheng, Li, and Zhang 2004; Lektauers 2015). Nevertheless, it faces difficulties in adequately representing the behavioral complexity of real economic systems (Ma et al., 2024; Pejic Bach et al., 2020).

3.2.5. Social Network Analysis

SNA not only captures the relational structure among actors but also facilitates the inclusion of environmental and socio-ecological (Semitiel García and Noguera Méndez 2004) dimensions in the analysis of SRD. This makes it a particularly valuable methodology for examining interdependencies and feedback processes in complex regional systems (Hu & Zhou, 2021; Reid et al., 2008; Semitiel García & Noguera Méndez, 2004). The work of Yokura et al. (2013) highlights its utility for mapping local cooperation and innovation, while Hu and Zhou (2021) applied it to analyze the influence of state financial intervention on urban structure and regional performance. More recently, Filenta and Kydros (2022,2023) have shown how network metrics allow for the evaluation of territorial inequalities.

3.2.6. Main Findings of the Review

Each tool presents distinct advantages and limitations. For example, neural networks are useful for forecasting economic indicators, yet less effective at capturing feedback loops (Shi, James, and Guo 2004). Likewise, fuzzy logic allows for representing uncertainty, but its interpretation may be ambiguous for decision-makers unfamiliar with such models (Trillas 2015). Agent-based simulation supports the modeling of micro-level interactions, though with limited scalability for generalizing across contexts (Macal 2016). System dynamics models can identify interdependencies and scenarios but still face skepticism in traditional economic domains (Radzicki 2011). Finally, SNA provides a structural perspective of actor interactions and has demonstrated its capacity to inform inclusive and sustainable policies (Filentaa and Kydros 2023; Zhou et al. 2022).

In this regard, SNA can provide a complementary and enriching perspective compared to pattern-based or simulation models, as it explicitly incorporates social, economic, and environmental relationships as integral parts of the system under analysis. This offers direct inputs for the design of comprehensive and sustainable public policies.

4. Link Between SNA and SRD Indicators

In international contexts, it has been noted that the density of local networks positively influences regional competitiveness (Gautam Ahuja 2000; Lundvall 1992). For example, Ter Wal and Boschma (2009) identified that the position of actors within collaborative networks conditions the capacity for territorial innovation. Similarly, Batterink et al. (2010) studied research networks and found that structured cooperation enhances the outcomes of development projects.

The international literature has described that the structural properties of networks are associated with innovation capacity, institutional resilience, and regional competitiveness. Borgatti et al. (2009) highlight that metrics such as centrality and density are predictors of organizational performance. Balland et al. (2015), as well as Crespo et al. (2014), argue that regions with dense networks and strategically positioned actors exhibit superior performance in innovation and productive diversification; Additionally, network governance based on triple helix actor networks could improve institutional efficiency and promote DRS (Ziaril and Mohammadi 2016).

However, Huggins and Thompson (2017) point out that there is limited empirical evidence supporting the extent to which actor networks influence regional development or growth outcomes. Additionally, in Latin America, the application of this approach remains scarce, and no studies have been identified that systematically link SNA metrics across different regions with SRD performance through indicators associated with the Colombian Departmental Competitiveness Index (IDIC).

5. Methodological Proposal

Subsequent to the establishment of the characteristics of SNA as a tool for analyzing SRD, and from a comparative perspective, this stage proposes the development of a correlation matrix. The data will be drawn from the results of structural SNA metrics (e.g., network size, average degree, diameter) applied to different regions, together with the socioeconomic indicators of those same regions. In the case of Colombia, the indicators to be considered will be those associated with the Departmental Competitiveness Index (IDIC).

The methodological proposal is structured in three stages, which are described below:

Stage 1

In this first stage, official information sources containing indicators related to SRD performance levels will be used to identify regions with different levels of performance. Where possible, these regions will be classified into intervals to allow comparative analysis. The indicators will be represented by Yi, as the values of the dependent variables or comparative measures for each region, respectively.

As the objective is to potentially describe some of the causes behind the differences in SRD levels across regions, regions showing divergent performance in SRD indicators will be identified using data from official sources. Where possible, these performance levels will be classified into intervals such as high, medium-high, medium, and low.

Stage 2

Once the regions with different performance levels have been established, a preliminary review will be conducted to assess the availability of information (primary and secondary) necessary to apply SNA methodology (Hanneman and Riddle 2005; Wasserman 1994). The goal is to obtain relevant information on the structure and resulting network metrics. These metrics will be represented by Xi, as the values of the independent or comparative variables, including general network measures such as network size, average degree, diameter, among others.

Stage 3

Following the collection of information in Stage 1 (SRD performance indicators) and the subsequent analysis of results in Stage 2 (network metrics), a correlation analysis will be conducted between these two sets of data. The following methodology will be employed: firstly, the correlation coefficient will be obtained from the pairs of variables (*Xir, Yir*), the correlation coefficient will be obtained, where *X* represents the SNA metric and *Y* represents the performance indicator. Here, *i* varies by metric and indicator, and *r* varies by each analyzed region. For example: *X11 = Network Size, Y11 = Regional GDP; X21 = Average Degree, Y21 = GDP per capita*. These pairs of variables for Region 1 will then be used to calculate the corresponding Pearson correlation coefficient, as shown in Table 3.

Table 3. Pairs of variables (*Xir, Yir*)

Network Metric	SRD Indicator	Network Metric	SRD Indicator
X11 = Network Size	Y11 = Regional GDP	X21 = Average Degree	Y21 = GDP per capita
X12 = Network Size	Y12 = Regional GDP	X22 = Average Degree	Y22 = GDP per capita
X13 = Network Size	Y13 = Regional GDP	X23 = Average Degree	Y23 = GDP per capita
X1n = Network Size	Y1n = Regional GDP	X2n = Average Degree	Y2n = GDP per capita
Pearson r	r =	Pearson r	r =

Source: Methodological proposal for correlation coefficient

The use of the Pearson correlation is justified by its ability to measure the strength and direction of the linear relationship between two continuous variables. Additionally, other statistical methods such as regression analysis could be considered for further exploration of

causal relationships, as well as introducing control variables to account for potential confounding factors.

The combination of elements derived from network metrics—such as size, average degree, and density, among others (Hanneman and Riddle 2005; Wasserman 1994). enables the exploration of correlations between the relational structure of regions and their performance in indicators associated with SRD.

In Latin America, studies have been limited and mostly focused on urban or sectoral innovation networks, without establishing a direct link with composite indicators of competitiveness or sustainability. In this regard, the present proposal aims to identify this academic gap for future research addressing divergences in SRD across regions, states, or departments at the second administrative level of countries, using CAS and SNA as the methodological framework.

6. Discussion

The review of the different theories and concepts that have shaped SRD shows that an integral analysis cannot be carried out from a single dimension. Early approaches placed particular emphasis solely on economic growth measured through GDP. In contrast, the inclusion of social, institutional, and environmental dimensions has framed SRD as a complex and multidimensional phenomenon (Capello 2019; Neely 2015). This complexity largely justifies the need for alternative approaches capable of identifying interdependencies and non-linear dynamics—approaches proposed within the framework of CAS (Beaussier et al. 2019). From this standpoint, a number of instruments exist that facilitate the modelling of interactions and interdependencies among actors, as well as their territorial dimensions. It is evident that SNA is distinguished by its capacity to incorporate the social dimension whilst concomitantly unveiling relationships that transcend the confines of mere social phenomena.

One contribution of this work is to propose the systematic association of network metrics obtained from modeling the networks of various regions within countries with the performance indicators of the SRD, which in the particular Colombian case is the Departmental Innovation Index for Colombia (IDIC). This articulation allows for a comparison between regions and thus establishes an empirical approach for a possible explanation of the persistent divergences in the SRD. In this case, there are few studies that address this combination, focusing on European or Asian contexts (Balland, et al. 2015; Crespo, et al. 2014). demonstrating a high novelty and relevance for Latin America, where divergences are quite noticeable not only between countries but also between regions. Despite the theoretical evolution in the DRS, these divergences remain and, in many cases, are accentuated.

7. Conclusions

The historical and conceptual review developed in this study shows that Sustainable Regional Development (SRD) has shifted from linear, growth-centered economic approaches toward more complex theoretical and methodological frameworks that integrate social, environmental, spatial, and institutional dimensions. This theoretical and conceptual evolution has generated the need to identify tools capable of capturing the interdependence, adaptability, and non-linear dynamics that characterize regional development processes.

In this regard, the association and incorporation of the Complex Adaptive Systems (CAS) paradigm allows regions to be interpreted as open and evolving systems, where interactions among actors generate emergent patterns and relational governance becomes a key factor for development. Within this context, Social Network Analysis (SNA) emerges as a particularly suitable tool to represent, measure, and analyze the relational configurations that shape the adaptive capacity of regions in terms of SRD.

The methodological analysis carried out demonstrates that, although multiple tools derived from CAS—such as neural networks, fuzzy logic, agent-based simulation, and system dynamics—are applicable, SNA offers unique advantages for the study of SRD, especially when integrated with composite metrics such as the Departmental Competitiveness Index (IDIC). This integration represents an innovative contribution to the Latin American context

and, in particular, for the Colombian case, where no prior studies have been identified that combine both perspectives.

The proposal to correlate network metrics (e.g., density, centrality, modularity) with IDIC dimensions opens a research avenue that links relational structures with socioeconomic and institutional outcomes. This correlational approach provides the possibility of designing more precise and adaptive public policies, grounded in empirical evidence and in a deeper understanding of territorial dynamics (Jiménez Romera and Piaggio 2020).

8. References

Acemoglu, Daron, and James A. Robinson. 2012. "Why Nations Fail: The Origins of Power, Prosperity and Poverty." ASEAN ECONOMIC BULLETIN 29 (2). https://doi.org/10.1355/ae29-2j.

Akopov, Andranik S., Levon A. Beklaryan, and Armen K. Saghatelyan. 2017. "Agent-Based Modelling for Ecological Economics: A Case Study of the Republic of Armenia." Ecological Modelling 346. https://doi.org/10.1016/j.ecolmodel.2016.11.012.

Al-Zinati, Mohammad, and Rym Wenkstern. 2019. "Modeling Agent-Environment Interactions in Large-Scale Multi-Agent Based Simulation Systems." In Proceedings of the International Joint Conference on Autonomous Agents and Multiagent Systems, AAMAS, 2:763–71. Montreal QC, Canada: International Foundation for Autonomous Agents and Multiagent Systems. https://dl.acm.org/doi/10.5555/3306127.3331767.

Alexiadis, Stilianos. 2020. "Regional Convergence: Theory and Empirics." Regional Science Inquiry 12 (1).

Andriantiatsaholiniaina, Luc A., Vassilis S. Kouikoglou, and Yannis A. Phillis. 2004. "Evaluating Strategies for Sustainable Development: Fuzzy Logic Reasoning and Sensitivity Analysis." Ecological Economics 48 (2). https://doi.org/10.1016/j.ecolecon.2003.08.009.

Balland, Pierre Alexandre, Ron Boschma, and Koen Frenken. 2015. "Proximity and Innovation: From Statics to Dynamics." Regional Studies 49 (6). https://doi.org/10.1080/00343404.2014.883598.

Batterink, Maarten H., Emiel F.M. Wubben, Laurens Klerkx, and S. W.F. Omta. 2010. "Orchestrating Innovation Networks: The Case of Innovation Brokers in the Agri-Food Sector." Entrepreneurship and Regional Development 22 (1). https://doi.org/10.1080/08985620903220512.

Beaussier, Thomas, Sylvain Caurla, Véronique Bellon-Maurel, and Eleonore Loiseau. 2019. "Coupling Economic Models and Environmental Assessment Methods to Support Regional Policies: A Critical Review." Journal of Cleaner Production 216: 408–21. https://doi.org/10.1016/j.jclepro.2019.01.020.

Bedrunka, Karina. 2020. "Concepts of the Sustainable Development of the Region." In Studies in Systems, Decision and Control. Vol. 198. https://doi.org/10.1007/978-3-030-11274-5_2.

Bogdański, Marcin. 2012. "Modern Theories of Regional Development – a Review of Some Concepts." Oeconomia Copernicana 3 (2): 25–41. https://doi.org/10.12775/oec.2012.007.

Borgatti, Stephen P., Ajay Mehra, Daniel J. Brass, and Giuseppe Labianca. 2009. "Network Analysis in the Social Sciences." Science. https://doi.org/10.1126/science.1165821.

Boschma, Ron, and Ron Martin. 2010. The Handbook of Evolutionary Economic Geography. The Handbook of Evolutionary Economic Geography. Vol. 90. Cheltenham: Edward Elgar Publishing. https://doi.org/10.1111/j.1435-5957.2011.00390.x.

Boudeville, Jacques R. 1965. "Frontiers and Interrelations of Regional Planning." In Problems in Economic Development. https://doi.org/10.1007/978-1-349-15223-0_27.

Broeke, Guus ten, and Hilde Tobi. 2021. "Mapping Validity and Validation in Modelling for Interdisciplinary Research." Quality and Quantity 55 (5): 1613–30. https://doi.org/10.1007/s11135-020-01073-8.

Buchholz, Maximilian, and Harald Bathelt. 2021. "Models of Regional Economic Development: Illustrations Using U.S. Data." Zeitschrift Fur Wirtschaftsgeographie 65 (1): 28–42. https://doi.org/10.1515/zfw-2020-0040.

Cantner, Uwe, and Holger Graf. 2006. "The Network of Innovators in Jena: An Application of Social Network Analysis." Research Policy 35 (4). https://doi.org/10.1016/j.respol.2006.01.002.

Capello, Roberta. 2006. "La Economía Regional Tras Cincuenta Años: Desarrollos Teóricos Recientes y Desafíos Futuros." Investigaciones Regionales Otoño (009).

———. 2019. "Regional Development Theories and Formalised Economic Approaches: An Evolving Relationship." Italian Economic Journal 5 (1). https://doi.org/10.1007/s40797-019-00085-0.

Carrillo Arronte, Ricardo. 1978. "Luis Unikel y Andrés Necochea (Comps.), Desarrollo Urbano y Regional En América Latina. Problemas y Políticas, Serie Lecturas, 15, México, Fondo de Cultura Económica, 1975." Estudios Demográficos y Urbanos 12 (02). https://doi.org/10.24201/edu.v12i02.414.

Carrington, Peter J., John Scott, and Stanley. Wasserman. 2005. Models and Methods in Social Network Analysis. Cambridge University Press.

Chen, Hongshou. 2022. “Research on Sustainable Development Indicator Prediction of Regional Economic Subsystem Based on Artificial Neural Network.” Scientific Programming 2022. https://doi.org/10.1155/2022/1896462.

Cheng, Ye Qing, Tong Sheng Li, and Ping Yu Zhang. 2004. “Application of System Dynamic Model in Regional Sustainable Development Planning.” Xitong Gongcheng Lilun Yu Shijian/System Engineering Theory and Practice 24 (12).

Churikanova, O., and M. Lysenko. 2021. “MODELING THE SUSTAINABLE DEVELOPMENT OF THE UKRAINIAN REGIONS BY NEURAL NETWORKS.” Financial and Credit Activity Problems of Theory and Practice 2 (37): 192–201. https://doi.org/10.18371/fcaptp.v2i37.230128.

Coccia, Mario. 2018. “An Introduction to the Theories of National and Regional Economic Development.” Turkish Economic Review 5 (4).

Cooke, Philip, Mikel Gomez Uranga, and Goio Etxebarria. 1997. “Regional Innovation Systems: Institutional and Organisational Dimensions.” Research Policy 26 (4–5). https://doi.org/10.1016/s0048-7333(97)00025-5.

Crespo, Joan, Raphael Suire, and Jerome Vicente. 2014. “Lock-in or Lock-out? How Structural Properties of Knowledge Networks Affect Regional Resilience.” Journal of Economic Geography 14 (1). https://doi.org/10.1093/jeg/lbt006.

DANE. 2024. “Boletín Técnico Pobreza Monetaria En Colombia Boletín Técnico.” Bogotá. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.dane.gov.co/files/operaciones/PM/bol-PM-2023.pdf.

Departamento Nacional de Planeación. 2020. “Índice Departamental de Innovación Para Colombia IDIC 2020.” Departamento Nacional de Planeación.

Dhimitri, Eva, GABETA Aida, and Majlinda BELLO. 2015. “REGIONAL DEVELOPMENT THEORIES AND MODELS, A COMPARATIVE ANALYSE. CHALLENGE OF REGIONAL DEVELOPMENT IN ALBANIA.” The USV Annals of Economics and Public Administration 15 (2).

Díaz, Bárbara, and Antonio Morillas. 2011. “Some Experiences Applying Fuzzy Logic to Economics.” In Soft Computing in Humanities and Social Sciences, edited by R., Sanz González, V. Seising, 273:347–79. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-24672-2_19.

Fedotova, Marina Gennadyevna, Anastasia Viktorovna Zhiglyaeva, and Elena Valentinovna Stolyarova. 2018. “Methodological and Practical Aspects of Human Potential Management in the Region.” Regional Science Inquiry 10 (2).

Fedrizzi, Mario, Michele Fedrizzi, and Walenty Ostasiewicz. 1993. “Towards Fuzzy Modelling in Economics.” Fuzzy Sets and Systems 54 (3). https://doi.org/10.1016/0165-0114(93)90371-N.

Ferrer-Comalat, Joan Carles, Dolors Corominas-Coll, and Salvador Linares-Mustarós. 2021. “A Fuzzy Economic Dynamic Model.” Mathematics 9 (8). https://doi.org/10.3390/math9080826.

Filenta, Pagona, and Dimitrios Kydros. 2022. “Literature Review of Economic and Regional Development through Quantitative Methods and Social Network Analysis.” European Journal of Interdisciplinary Studies 14 (1–6): 188–206. https://doi.org/10.24818/ejis.2022.11.

Filentaa, Pagona, and Dimitrios Kydros. 2023. “Economic and Regional Development through SNA: The Case of the Unemployment Rate in NUTS 2 Regions of the EU.” Eastern Journal of European Studies 14 (1). https://doi.org/10.47743/ejes-2023-0114.

Gautam Ahuja. 2000. “Collaboration Networks , Structural Holes , and Innovation : Longitudinal Study Gautam Ahuja.” Sage Publications, Inc. 45 (3).

Gómez Cruz, Nelson Alfonso. 2018. “Simulación Basada En Agentes: Una Metodología Para El Estudio de Sistemas Complejos.” In Construcción de Problemas de Investigación: Diálogos Entre El Interior y El Exterior, edited by G. Vélez-Cuartas, C. E. Maldonado, & G. Guerrero Pino (Eds.) M. L. Eschenhagen, 230–68. Medellin: Universidad de Antioquia. https://doi.org/10.17533/978-958-5413-68-9_9.

Graf, Holger, and Tobias Henning. 2009. “Public Research in Regional Networks of Innovators: A Comparative Study of Four East German Regions.” Regional Studies 43 (10). https://doi.org/10.1080/00343400802251460.

Gualdrón Guerrero, Carlos Andrés. 2011. “Desarrollo Humano y Crecimiento Económico En Colombia.” Cuadernos Geográficos 48.

Gue, Ivan Henderson V., Aristotle T. Ubando, Ming Lang Tseng, and Raymond R. Tan. 2020. “Artificial Neural Networks for Sustainable Development: A Critical Review.” Clean Technologies and Environmental Policy. https://doi.org/10.1007/s10098-020-01883-2.

Hanneman, Robert a, and Mark Riddle. 2005. “Introduction to Social Network Methods.” Riverside, CA: University of California, Riverside. On-Line Textbook 46 (7). https://doi.org/10.1016/j.socnet.2006.08.002.

Hernández Sampieri, Roberto; Baptista Lucio, Pilar;, and Carlos Fernández Collado. 2016. “Metodología de La Investigación.” McGraw-Hill Interamericana.

Hoekman, Jarno, Koen Frenken, and Robert J.W. Tijssen. 2010. “Research Collaboration at a Distance: Changing Spatial Patterns of Scientific Collaboration within Europe.” Research Policy 39 (5). https://doi.org/10.1016/j.respol.2010.01.012.

Holgado Ramos, Daniel. 2016. “Analizando Redes Sociales.” Redes. Revista Hispana Para El Análisis de Redes Sociales 27 (2). https://doi.org/10.5565/rev/redes.637.

Hu, Zunguo, and Jujing Zhou. 2021. “Convergence of City Relational Network, Production Sector Structure, and Regional Development.” Discrete Dynamics in Nature and Society 2021. https://doi.org/10.1155/2021/8913858.

Huggins, Robert, and Piers Thompson. 2017. “Networks and Regional Economic Growth: A Spatial Analysis of Knowledge Ties.” Environment and Planning A 49 (6). https://doi.org/10.1177/0308518X17692327.

Jackson, Randall W, Geoffrey J. D. Hewings, Serge Rey, and Nancy Lozano Gracia. 2019. Regional Development Overview: Challenges, Adopted Strategies, and New Initiatives. Regional Development Overview: Challenges, Adopted Strategies, and New Initiatives. https://doi.org/10.1596/1813-9450-9056.

Jiménez Romera, Carlos, and Juan Martín Piaggio. 2020. “Sistema de Indicadores Para Una Caracterización Multidimensional de Los Municipios de Colombia.” Cuadernos Geográficos 59 (1). https://doi.org/10.30827/cuadgeo.v59i1.8143.

Knox, A. D., and Gunnar Myrdal. 1960. “Economic Theory and Under-Developed Regions.” Economica 27 (107). https://doi.org/10.2307/2601684.

Krugman, P. 1991. “Increasing Returns and Economic Geography.” Journal of Political Economy 99 (3). https://doi.org/10.1086/261763.

Kuriksha, Artem. 2021. “An Economy of Neural Networks: Learning from Heterogeneous Experiences.” PIER Working Paper No. 21-027, November, 1–49. https://doi.org/10.2139/ssrn.3973697.

Ladias, Christos A.P., Filipos Ruxho, Fernando José Calado e.Silva Nunes Teixeira, and Susana Soares Pinheiro Vieira Pescada. 2023. “THE REGIONAL ECONOMIC INDICATORS AND ECONOMIC DEVELOPMENT OF KOSOVO.” Regional Science Inquiry 15 (1).

Lektauers, Arnis. 2015. “System Dynamics Framework for Sustainable Development Analysis of Local Governments.” Eastern European Business and Economics Journal 1 (2): 85–101.

Levin, Simon, Tasos Xepapadeas, Anne Sophie Crépin, Jon Norberg, Aart De Zeeuw, Carl Folke, Terry Hughes, et al. 2013. “Social-Ecological Systems as Complex Adaptive Systems: Modeling and Policy Implications.” Environment and Development Economics 18 (2). https://doi.org/10.1017/S1355770X12000460.

Lippe, Melvin, Mike Bithell, Nick Gotts, Davide Natalini, Peter Barbrook-Johnson, Carlo Giupponi, Mareen Hallier, et al. 2019. “Using Agent-Based Modelling to Simulate Social-Ecological Systems across Scales.” GeoInformatica 23 (2): 269–98. https://doi.org/10.1007/s10707-018-00337-8.

Lucas, Robert E. 1988. “On the Mechanics of Economic Development.” Journal of Monetary Economics 22 (1). https://doi.org/10.1016/0304-3932(88)90168-7.

Lundvall, Bengt-Åke. 1992. “National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Towards a Theory of Innovation and Interactive Learning .” London, Pinter.

Ma, Haichao, Qingsong Wang, Yujie Zhang, Muhammad Bilal Hussain, Yue Xu, Shu Tian, Xueliang Yuan, Qiao Ma, Renxiao Yuan, and Yanshuang Jia. 2024. “Research on Sustainable Development Evaluation and Improvement Path of Resource-Based Cities Based on Coupling of Emergy and System Dynamics.” Environment, Development and Sustainability 26 (3). https://doi.org/10.1007/s10668-023-02946-2.

Macal, C. M. 2016. “Everything You Need to Know about Agent-Based Modelling and Simulation.” Journal of Simulation 10 (2): 144–56. https://doi.org/10.1057/jos.2016.7.

Martin, Ron, and Peter Sunley. 2007. “Complexity Thinking and Evolutionary Economic Geography.” Journal of Economic Geography 7 (5). https://doi.org/10.1093/jeg/lbm019.

Martinez-Moyano, Ignacio J. 2019. “A Primer for System Dynamics Modeling and Simulation.” In Proceedings - 2018 Winter Simulation Conference (WSC), 2018-December:261–75. Gothenburg, Sweden. https://doi.org/10.1109/WSC.2018.8632550.

Mayring, Philipp. 2004. “FORUM : QUALITATIVE SOCIAL RESEARCH SOZIALFORSCHUNG 2 . History of Content Analysis.” Analysis 1 (December).

Meadowcroft, James. 2007. “Who Is in Charge Here? Governance for Sustainable Development in a Complex World.” Journal of Environmental Policy and Planning. https://doi.org/10.1080/15239080701631544.

Mejdalani, Alexandre, Eduardo Gonçalves, and Rodrigo Siqueira Rodriguez. 2021. “Why Cooperate? The Determinants of Forming Inter-Regional Connections in the Brazilian Patent Network.” EconomiA 22 (1). https://doi.org/10.1016/j.econ.2020.11.001.

Merchand, Rojas Marco Antonio. 2007. Teorías y Conceptos de Economía Regional y Estudios de Caso. Teorías y Conceptos de Economía Regional y Estudios de Caso. http://biblioteca.clacso.edu.ar/Mexico/cucosta-udeg/20170515050418/pdf_1190.pdf.

Millar, David. 2014. "Endogenous Development: Some Issues of Concern." Development in Practice 24 (5–6): 637–47. https://doi.org/10.1080/09614524.2014.938615.

Mnatsakanyan, Tigran, Ruben Hayrapetyan, and Dejan Molnar. 2021. "Measuring Regional Development Disparities: Some Methodological Contributions and Evidence from Armenia and Serbia." Regional Science Inquiry 13 (2).

Moncayo Jiménez, Édgard. 2003. "Nuevas Teorías y Enfoques Conceptuales Sobre El Desarrollo Regional ¿hacia Un Nuevo Paradigma." Revista de Economía Institucional 5 (8): 32–65.

Muto, Tito Julio, Elias Buitrago Bolivar, and Enrique González. 2020. "Bdi Multi-Agent Based Simulation Model for Social Ecological Systems." In Highlights in Practical Applications of Agents, Multi-Agent Systems, and Trust-Worthiness. The PAAMS Collection. PAAMS 2020. Communications in Computer and Information Science, edited by F., et al. De La Prieta, 1233 CCIS:279–88. Springer, Cham. https://doi.org/10.1007/978-3-030-51999-5_23.

Naudé, Marita. 2012. "Sustainable Development and Complex Adaptive Systems." Corporate Ownership and Control 10 (1 F,CONT5). https://doi.org/10.22495/cocv10i1c5art5.

Neely, Kate. 2015. "Complex Adaptive Systems as a Valid Framework for Understanding Community Level Development." Development in Practice 25 (6). https://doi.org/10.1080/09614524.2015.1060949.

Nijkamp, Peter, and Maria Abreu. 2020. "Regional Development Theory." International Encyclopedia of Human Geography 11 (2): 1–12.

Ostrom, E. 1990. "Governing the Commons: The Evolution of Institutions for Collective Action." Governing the Commons: The Evolution of Institutions for Collective Action. https://doi.org/10.2307/3146384.

Panjawa, Jihad Lukis, Rizky Samudro, and Maqnus Soesilo. 2018. "Regional Economic Disparities In Eastern Indonesia and Determinants: Comparative Analysis of Origin District And New District." Regional Science Inquiry X (1).

Papadaskalopoulos, Athanasios, and Panagiotis Nikolopoulos. 2018. "The Role of Social Capital in Regional Development." Regional Science Inquiry X (1).

Pejic Bach, Mirjana, Emil Tustanovski, Andrew W.H. Ip, Kai Leung Yung, and Vasja Roblek. 2020. "System Dynamics Models for the Simulation of Sustainable Urban Development: A Review and Analysis and the Stakeholder Perspective." Kybernetes 49 (2). https://doi.org/10.1108/K-04-2018-0210.

Perroux, François. 1950. "Economic Space: Theory and Applications." Quarterly Journal of Economics 64 (1). https://doi.org/10.2307/1881960.

Pike, Andy, Andrés Rodríguez-Pose, and John Tomaney. 2017. "Shifting Horizons in Local and Regional Development." Regional Studies 51 (1). https://doi.org/10.1080/00343404.2016.1158802.

Piketty, Thomas. 2015. "Capital, Inequality and Justice: Reflections on Capital in the Twenty-First Century." Basic Income Studies 10 (1). https://doi.org/10.1515/bis-2015-0014.

Pinto, Pablo E., Andres Vallone, and Guillermo Honores. 2019. "The Structure of Collaboration Networks: Findings from Three Decades of Co-Invention Patents in Chile." Journal of Informetrics 13 (4). https://doi.org/10.1016/j.joi.2019.100984.

Polese, Mario. 1999. "From Regional Development to Local Development: On the Life, Death and Rebirth (?) Of Regional Science as a Policy Relevant Science." Canadian Journal of Regional Science 22 (3).

Polyzos, S, and D Tsiotas. 2025. "SPATIAL DISPARITIES IN THE EUROPEAN UNION: A MACROSCOPIC REVIEW." Regional Science Inquiry. Vol. XVII.

Ponsiglione, Cristina, Ivana Quinto, and Giuseppe Zollo. 2017. "Regional Innovation Systems: An Agent-Based Laboratory for Policy Advice." In Innovation Networks for Regional Development. Economic Complexity and Evolution, edited by B., Paier, M. (eds) Vermeulen, 185–214. Springer, Cham. https://doi.org/10.1007/978-3-319-43940-2_8.

Porter, Michael E. 1990. "The Competitive Advantage of Nations. (Cover Story)." Harvard Business Review 68 (2): 73–93. https://doi.org/Article.

Pourmohammadi, Mohammad Reza, Mojtaba Valibeigi, and Mir Sattar Sadrmousavi. 2014. "The Quality of Life and Regional Convergence in Iranian Provinces." Regional Science Inquiry 6 (1).

Quintero Ramirez, Santiago, Walter Lugo Ruiz Castañeda, and Jorge Robledo Velásquez. 2017. "Learning in the Regional Innovation Systems: An Agent Based Model." Cuadernos de Administración 33 (57). https://doi.org/10.25100/cdea.v33i57.4535.

Radzicki, Michael J. 2011. "Complex Systems in Finance and Econometrics." Complex Systems in Finance and Econometrics, no. November 2010. https://doi.org/10.1007/978-1-4419-7701-4.

Ratiu, Ioan Gheorghe, Claudia Carstea, Lucian Patrascu, Doru Plesea, and Mircea Boscoianu. 2009. "Fuzzy Modeling Economics." In Proc. 9th WSEAS Int. Conf. Simulation, Modelling and Optimization, SMO '09, 5th WSEAS Int. Symp. Grid Computing, Proc. 5th WSEAS Int. Symp. Digital Libraries, Proc. 5th WSEAS Int. Symp. Data Mining, 51–56. Budapest, Hungary: World Scientific and Engineering Academy and Society (WSEAS). https://dl.acm.org/doi/10.5555/1627368.1627382.

Reid, Neil, Bruce W. Smith, and Michael C. Carroll. 2008. "Cluster Regions: A Social Network Perspective." Economic Development Quarterly 22 (4). https://doi.org/10.1177/0891242408322719.

Rizzo, Cristian, Gianluigi Guido, Giovanni Pino, Tommaso Pirotti, and Luca Anzilli. 2022. "A Fuzzy Expert System for Sustainable Local Development." Regional Studies 56 (5). https://doi.org/10.1080/00343404.2021.1959908.

Rodríguez-Pose, Andrés. 2013. "Do Institutions Matter for Regional Development?" Regional Studies 47 (7). https://doi.org/10.1080/00343404.2012.748978.

Rodríguez Miranda, Adrián, Camilo Vial Cossani, and Alejandra Alejandra Parrao. 2021. "ÍNDICE COMPUESTO Y MULTIDIMENSIONAL DE DESARROLLO REGIONAL: UNA PROPUESTA PARA AMÉRICA LATINA." Revista Iberoamericana de Estudios Municipales.

Romer, Paul M. 1986. "Increasing Returns and Long-Run Growth." Journal of Political Economy 94 (5). https://doi.org/10.1086/261420.

Šabić, Dejan, and Snežana Vujadinović. 2017. "Regional Development and Regional Policy." Zbornik Radova - Geografski Fakultet Univerziteta u Beogradu, no. 65-1a: 463–77. https://doi.org/10.5937/zrgfub1765463v.

Salguero Cubies, Jorge. 2006. "Enfoques Sobre Algunas Teorías Referentes Al Desarrollo Regional." Sociedad Geográfica de Colombia, 20.

Schreier, Margrit. 2024. Qualitative Content Analysis in Practice. Qualitative Content Analysis in Practice. https://doi.org/10.4135/9781529682571.

Sebestyén, Tamás, and Attila Varga. 2019. "Knowledge Networks in Regional Development: An Agent-Based Model and Its Application." Regional Studies 53 (9): 1333–43. https://doi.org/10.1080/00343404.2019.1622663.

Seers, Dudley. 1972. "What Are We Trying to Measure?" The Journal of Development Studies 8 (3). https://doi.org/10.1080/00220387208421410.

Semitiel García, María, and Pedro Noguera Méndez. 2004. "Los Sistemas Productivos Regionales Desde La Perspectiva Del Análisis de Redes." Redes. Revista Hispana Para El Análisis de Redes Sociales 6 (2). https://doi.org/10.5565/rev/redes.54.

Sen, Amartya. 1990. "Development as Capability Expansion." In Human Development and the International Development Strategy for the 1990s. https://doi.org/10.1007/978-1-349-21136-4_3.

Shevchenko, O. V. 2021. "Elaboration of a Mechanism for Regulating Disparities of Regional Socio-Economic Development by Fuzzy Logic Methods." Science and Innovation 17 (1). https://doi.org/10.15407/scine17.01.018.

Shi, Chun, Philip James, and Zhong Yang Guo. 2004. "Application of Artificial Neural Network in Complex Systems of Regional Sustainable Development." Chinese Geographical Science 14 (1). https://doi.org/10.1007/s11769-004-0001-7.

Stiglitz, Joseph E. 2002. "Information and the Change in the Paradigm in Economics." American Economic Review. https://doi.org/10.1257/00028280260136363.

Stimson, Robert, Roger R. Stough, and Peter Nijkamp. 2011. Endogenous Regional Development: Perspectives, Measurement and Empirical Investigation. Endogenous Regional Development: Perspectives, Measurement and Empirical Investigation.

Stojić, Gordan. 2012. "Using Fuzzy Logic for Evaluating the Level of Countries' (Regions') Economic Development." Panoeconomicus 59 (3): 293–310. https://doi.org/10.2298/PAN1203293S.

Tektas, Arzu, Asli Deniz Helvacioglu, and Abdulmecit Karatas. 2016. "The Potential Impact of Regional beyond GDP Indicators on Elections." Regional Science Inquiry 8 (2).

Terra, Leonardo Augusto Amaral, and João Luiz Passador. 2018. "Strategies for the Study of Complex Socio-Economic Systems: An Approach Using Agent-Based Simulation." Systemic Practice and Action Research 31 (3): 311–25. https://doi.org/10.1007/s11213-017-9427-6.

Timmermans, Stefan, and Iddo Tavory. 2012. "Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis." Sociological Theory 30 (3). https://doi.org/10.1177/0735275112457914.

Toro, Francisco. 2007. "El Desarrollo Sostenible: Un Concepto de Interés Para La Geografía." Cuadernos Geográficos 40.

Trillas, Francesc. 2015. "Fuzzy Logic and Modern Economics." In Towards to the Future of Fuzzy Logic, edited by Rudolf Seising, Enric Trillas, and Janusz Kacprzyk, 325:55–64. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-18750-1_4.

Trippl, Michaela, Markus Grillitsch, and Arne Isaksen. 2018. “Exogenous Sources of Regional Industrial Change: Attraction and Absorption of Non-Local Knowledge for New Path Development.” Progress in Human Geography 42 (5): 687–705. https://doi.org/10.1177/0309132517700982.

Ugulava, Gocha. 2019. “USE OF ARTIFICIAL NEURAL NETWORKS TO PREDICT TERRITORIAL ECONOMIC INDICATORS.” Globalization and Business 4 (8). https://doi.org/10.35945/gb.2019.08.019.

Useche Arévalo, Alejandro José. 2002. “Neoliberalismo, Educación y Desarrollo Económico En Colombia.” Civilizar 2 (2). https://doi.org/10.22518/16578953.862.

Wal, Anne L.J. Ter, and Ron A. Boschma. 2009. “Applying Social Network Analysis in Economic Geography: Framing Some Key Analytic Issues.” Annals of Regional Science 43 (3 SPEC. ISS.). https://doi.org/10.1007/s00168-008-0258-3.

Wasserman, Stanley. 1994. Social Network Analysis: Methods and Applications:Social Network Analysis: Methods and Applications. American Ethnologist. Vol. 24.

Wu, H., and Z. S. Xu. 2021. “Fuzzy Logic in Decision Support: Methods, Applications and Future Trends.” International Journal of Computers, Communications and Control 16 (1). https://doi.org/10.15837/ijccc.2021.1.4044.

Yokura, Yutaka, Hiroshi Matsubara, and Rolf Sternberg. 2013. “R&D Networks and Regional Innovation: A Social Network Analysis of Joint Research Projects in Japan.” Area 45 (4). https://doi.org/10.1111/area.12055.

Zhou, Yang, Hankun Wang, Zuqiang Wang, and Xiang Dai. 2022. “The Improvement Path for Regionally Coordinated Green Development: Evidence from Social Network Analysis.” International Journal of Environmental Research and Public Health 19 (18). https://doi.org/10.3390/ijerph191811703.

Ziaril, Keramatollah, and Alireza Mohammadi. 2016. “Pathology of Regional Development Management in Iran during the Period 2005-2015.” Regional Science Inquiry.

REGIONAL ECONOMIC RESILIENCE AND TOURISM DEMAND: THE CASE OF GREECE

Dimitrios TSIOTAS
Assistant Professor, Department of Regional and Economic Development; Agricultural University of Athens; Drosou Kravvartogiannou, Nea Poli; Amfissa 33100, Greece,
tsiotas@aua.gr
(Corresponding Author)

Thomas KRABOKOUKIS
Ph.D, Department of Planning and Regional Development, University of Thessaly, Pedion Areos, Volos, 38334, Greece,
tkrabokoukis@uth.gr

Dimitrios KANTIANIS
Assistant Professor, Department of Business Administration, School of Business, University of the Aegean, 8, Michalon St., GR-82132 Chios, Greece;
dkantianis@aegean.gr

Abstract

The resilience of spatial economies is driven by a high degree of complexity, as the behavior of economic systems, both in response to disturbances from their external environment and to the transformative dynamics that develop internally, is a multivariable process depending on economic, structural, social, geographic, environmental, institutional, political, and other related factors. Conceptualizing the inherent capacity of economic systems to resist, recover, adapt, or evolve when faced with different types and forms of disturbances, the study of regional economic resilience can shed light both on the mechanisms promoting regional development and on the design of more targeted regional policy actions. Assuming that an economic crisis can be interpreted as a 'disturbance' to the functional equilibrium of open economies, this paper examines the extent to which the 2008 economic crisis affected the resilience of Greece's regions in terms of their tourism demand. The study focuses on tourism, considered one of the country's key economic sectors, and analyzes tourism demand data (accommodation occupancy) and annual employment for the period January 2000 – December 2018, using a three-dimensional (3D) economic resilience index recently proposed by Tsiotas and Katsaiti (2025), along with location quotients and statistical analysis techniques. The research investigates the extent to which a region's sectoral specialization is related to aspects of its economic resilience in tourism demand, providing insights into the spatial asymmetry that generally characterizes the relationship between a region's basic sector and the vulnerability of its economy due to its core specialization.

Keywords: three-dimensional (3D) economic resilience index, engineering resilience, ecological resilience, evolutionary resilience, regional economics and development, tourism economics and development

JEL classification: R11, R15, R58, Z32

pp. 101-116

1. Introduction

In the era of global interconnectedness (Tsiotas, 2022; Tsiotas and Tselios, 2022) and constantly evolving social, technological, and geographic conditions (Ruxho and Ladias, 2022; Ladias et al., 2023; Ruxho et al., 2023; Sequeira et al., 2023; Uzsayilir and Baycan, 2024), the economic resilience of spatial economies (Xanthos and Dulufakis, 2023; Tsiotas and Katsaiti, 2025) emerges as one of the most critical factors for understanding and enhancing the sustainable development (Sepetis, 2024; Tsiotas and Katsaiti, 2025) of regions (Tsiotas and Katsaiti, 2025). The concept of economic resilience describes the ability of an economic system to respond effectively to disturbances, whether originating internally (endogenously) or externally (exogenously), to adapt to new conditions, and ultimately to recover while maintaining its original functionality (Tsiotas et al., 2023).

The scientific conceptualization of economic resilience is grounded in a dual conceptual framework (Tsiotas and Katsaiti, 2025). On the one hand, it is defined through the engineering and ecological approaches to equilibrium, where resilience is understood as the capacity to return to a previous state of functionality or to shift to a new state of equilibrium. On the other hand, it is conceived by the evolutionary perspective (Sdrolias et al., 2022), according to which economic resilience suggests a dynamic process of continuous change, adaptation, and learning (Tsiotas and Katsaiti, 2025). These three perspectives are complementary, as the structure and function of an economic system are interdependent, interactive, and co-evolving concepts.

The complexity of economic systems and the contemporary demand for their resilience have given rise to further conceptual specializations of 'sectoral' and 'regional' resilience. Sectoral resilience is defined purely functionally, within the context of a specific economic activity, branch (a group of related activities), or sector (a group of branches), whereas the regional economic resilience is geographically conceived, focusing on the capacity of local economies to withstand and recover from crises, such as economic recessions or epidemiological shocks. As contextually implied, economic resilience is an interdisciplinary concept incorporating material derived from equilibrium and evolutionary theory across economics (Krugman and Wells, 2024; Tsiotas, 2022), social sciences, geography, engineering, and mathematics. An economic system (viewed as a complex and dynamic network of interactions) comprises social units – such as individuals – and economic units – such as firms and clusters – (Lincaru et al., 2011; Napolskikh and Yalyalieva, 2019), resources and production factors (e.g., capital, labor, natural resources), institutions and legal norms, social and cultural capital, etc., and can be studied at different economic or spatial scales (Ladias and Stamatiou, 2006; Ladias et al., 2011) and within various temporal and functional contexts (Tsiotas and Kallioras, 2025), evolving in multiple ways through its interaction with the surrounding environment.

Modeling a spatial economy's resilience is a complex task posing challenges in understanding the multiple dimensions and explanatory variables characterizing it. Similar to its thematic complexity, the literature lacks a unified methodology or universally accepted quantitative approach for measuring economic resilience (Sdrolias et al., 2022; Tsiotas et al., 2023), resulting in diverse computational approaches. Some rely on the simple assessment of indicators, such as GDP, employment, or Gross Value Added, while others involve the development of multivariate econometric and statistical models. In an effort to synthesize existing theoretical streams (which conceptualize economic resilience either as response and recovery from disturbances; or as a transition to a different level of functionality; or as a self-reinforcing adaptive process) Tsiotas and Katsaiti (2025) proposed a composite three-dimensional (3D) vector index for measuring economic resilience, consisting of a engineering (R_{en}), an ecological (R_{ec}), and an evolutionary (R_{ev}) component. By utilizing its vector form (and its ability simultaneously to capture information separately for each response mechanism to a disturbance, and therefore to assess overall economic resilience as the resultant of its three component dimensions), the authors computed the proposed index using time-series GDP data from 200 countries worldwide, examining the effects of 15 international economic crises over the last 50 years on each country. The empirical analysis provided insights into the relative intensity of the global 2008 crisis on the resilience of the countries worldwide and, methodologically, highlighted the potential of the proposed index in detecting various facets of economic resilience.

A direction for further research in the use of the 3D resilience index of Tsiotas and Katsaiti (2025) can be the measurement of economic resilience either at the sectoral level or at the regional administrative–geographical scale. In the case of Greece, particular interest lies in the analysis of regional resilience in the tourism sector, given that tourism is a key economic component that has consistently accounted for approximately 15–20% of GDP (Kalantzi et al., 2017). Theoretically, a region's specialization in tourism, as in the cases of Crete, the South Aegean, and the Ionian Islands (Polyzos, 2019), may endow its development model with significant dynamism through the enhancement of economic activity driven by tourism demand. At the same time, it may generate characteristics of economic vulnerability, such as, for instance, when tourist destinations become strongly dependent on externalities in tourism flows (Tsiotas et al., 2020, 2021) and consequently subject to the seasonality of tourism

demand. Studies such as those by Psycharis et al. (2014) and Sdrolias et al. (2022) have shown that Greek regions demonstrating notable resilience during the economic crisis of the previous decade (2008) were specialized in the tourism sector, highlighting tourism specialization as a key determinant of economic resilience.

From a structural perspective, Sdrolias et al. (2022) identified features of complementarity between the tourism sector and primary production, confirming an organic relationship between the 'basic' and 'non-basic' sectors, or correspondingly the 'propulsive' and 'auxiliary industries', as discussed in well-known regional development theories (Polyzos, 2019; Tsiotas, 2022; Tsiotas and Kallioras, 2025), such as the export-base theories of Tiebout (1956) and North (1955), and the growth-pole theory of Perroux (1950). Recently, through a longitudinal analysis of input–output tables for Greece, Tsiotas et al. (2025) showed that the resilience of tourism in the country appears to derive to a greater extent from the derived demand generated through its interconnections with other sectors of the economy, rather than from tourism's direct product. Moreover, the COVID-19 pandemic (Tsiotas and Tselios, 2022; Tsoulias and Tsiotas, 2024) served as an epidemiological condition revealing the limits of economic resilience in tourism. The dependence of many domestic economies on international tourism, the need for social distancing, and strong seasonality rendered many countries and regions vulnerable (Tsiotas and Tselios, 2022; Tsiotas et al., 2023). A recent study by Tsoulias and Tsiotas (2024) showed that the pandemic had a transformative effect on the economic geography of tourism, favoring the development of tourism markets in peripheral locations compared to the previous model of spatial concentration of tourism demand in more popular destinations.

Within this conceptual and theoretical framework, the tourism sector offers a promising field for studying the resilience of regional economies in Greece, not only due to the country's sectoral specialization but also due to its accompanying geographical and social complexity. From the regional science's perspective, the interconnection of tourism with the key pillars of the so-called 'regional problem' in Greece (Polyzos, 2019), expressed in demographic and population asymmetries, urban concentration, educational levels, sectorial specialization of production, welfare levels, productive dynamism, and geomorphology, highlights the intrinsic relationship between tourism and regional inequalities in the country (Xanthos et al., 2012; Lv, 2019; Krabokoukis et al., 2024). This relationship clearly has two sides: alongside the recognized resilience of tourism economies (Psycharis et al., 2014; Sdrolias et al., 2022; Tsiotas et al., 2025), the over-concentration of tourism activity, the seasonality of tourism demand (Rossello and Sanso, 2017; Tsiotas et al., 2020, 2021), the strain on destination carrying capacity (Polyzos, 2022), and the associated environmental pollution (Polyzos, 2019, 2022) constitute threats and, conversely, characteristics of vulnerability for tourism regions. Based on this dual consideration, measuring the resilience of Greece's regions to tourism demand may prove to be of decisive importance for the country's regional and economic development (Polyzos, 2019; Tsiotas et al., 2020, 2021). Detecting the differentiated responses of regions to crises and understanding the factors that shape each region's resilience profile enables a deeper understanding of the mechanisms that drive an economy either toward growth or divergence, thereby facilitating the formulation of targeted policies aimed at regional and economic development or toward social and territorial cohesion.

Within this context, economic resilience is not merely a theoretical concept but a substantive analytical tool for examining economic systems and shaping economic and regional policy (Tsiotas and Katsaiti, 2025). Its understanding and measurement, particularly in critical sectors such as tourism, becomes essential for strengthening the sustainability (Polyzos, 2022; Ruxho, 2024) and adaptive capacity of local economies. Within this line of reasoning, the study of the resilience of Greece's regions to tourism demand constitutes a fundamental research direction in regional science, integrating geographical location (Thisse, 1987; Polyzos, 2019, 2023), sectorial structure and specialization (Tsiotas et al., 2025), social capital (Sepetis et al., 2024), institutional configurations (Polyzos, 2019), and the natural environment (Polyzos, 2019, 2022), both as a production factor and as a recipient of human activity, along with the corresponding functional linkages and evolutionary dynamics among these dimensions.

Being inspired by the study of Tsiotas and Katsaiti (2025) and the introduction of a new 3D (3D) index incorporating the three main theoretical dimensions of economic resilience

(engineering, ecological, and evolutionary), this paper applies the proposed index to tourism demand data for the regions of Greece. Assuming that tourism resilience, insofar as it is captured by the 3D index of Tsiotas and Katsaiti (2025) and its components, is governed by geographical (spatial) and structural (sectorial) characteristics, the research aims to identify the sectors and geographical advantages that determine regional resilience in the country. Overall, the study in this paper seeks to contribute to the understanding of the tourism sector's resilience in Greece and to inspire further research on regional inequalities and the spatial planning of tourism through the use of quantitative measurement methods.

2. METHODS AND DATA

The analysis in this paper is based on the calculation of the three-dimensional (3D) economic resilience index and its three components, as proposed by Tsiotas and Katsaiti (2025). More specifically, the proposed index relies on time-series analysis to capture the way an economic system responds to a (either external or internal) disturbance. For its calculation, a time series $X=\{x_1, x_2, \ldots, x_n\}$ is required, consisting of consecutive observations of a measurable characteristic (variable), such as GDP or employment. To estimate the economic resilience dimensions, the 3D-index method takes into account the occurrence of a disturbance at a specific point in time $t=k$, which divides the time series into two distinct periods: the *pre-disturbance* period $X_r=\{x_1, x_2, \ldots, x_k\}$, hereafter called as *the reference period*, and the *post-disturbance* period $X_p=\{x_{k+1}, x_2, \ldots, x_n\}$, hereafter called as *the performance period*. During the reference period, it is assumed that the system operates under 'normal' conditions, describing its typical functional behavior before the disturbance occurs. In contrast, the performance period represents the time interval following the disturbance, during which the system's performance is evaluated in relation to its typical levels of functionality. The index $\boldsymbol{R}(n, n_p)$ proposed by Tsiotas and Katsaiti (2025) is expressed in vector form and consists of three main components: Engineering resilience (R_{en}); Ecological resilience (R_{ec}); and Evolutionary resilience (R_{ev}), as shown in Equation (1).

$$\text{R(n, np)=(Ren, Rec, Rev)} \tag{1}$$

Each of the components of the index $\boldsymbol{R}(n, n_p)$ captures a different aspect of the system's resilience, in accordance with the theoretical perspectives described in the previous section. Specifically, the engineering component R_{en} expresses the speed of recovery of the system, that is, the rate at which it returns to its original operating state after the disturbance. From an algebraic viewpoint, the engineering component is calculated as the difference between the logarithm (a transformation applied to normalize the scale of the index to the unit interval) of the actual recovery time and the maximum possible recovery time, as shown in Equation (2) (Tsiotas and Katsaiti, 2025):

$$R_{en}=\frac{\log\left(\dfrac{n-t(c_r)}{t(x_{\in Xp}\geq c_r)-t(c_r)}\right)}{\log\left(n-t(c_r)\right)}=1-\frac{\log\left(t(x_{\in Xp}\geq c_r)-t(c_r)\right)}{\log\left(n-t(c_r)\right)} \tag{2}$$

In Equation (2), n represents the length of the time series, $t(x)$ denotes the time point at which the time series takes the value x, and c_r represents the characteristic level of functionality of the reference period. In the engineering component's algorithm, c_r is either taken as the maximum value of the reference period or is set at any level chosen by the researcher. If the system's recovery is immediate (that is, if the variable's time series score has reached or exceeded the characteristic reference period's level c_r after the disturbance), then the engineering component R_{en} takes its maximum value of 1. Conversely, if the variable's score never returns to its initial level, the component R_{en} becomes zero, indicating the system's inability to recover (Tsiotas and Katsaiti, 2025).

The second component, ecological resilience (R_{ec}), assesses the difference in the system's functionality before and after the disturbance. In other words, it measures the extent to which the system shifts to a differentiated (new) level of functionality relative to the typical reference period's level. The R_{ec} value is calculated, according to Equation (3), based on the relative difference between the characteristic functionality levels of the reference and performance periods (Tsiotas and Katsaiti, 2025). Exponential and logarithmic

transformations are applied to clearly capture the idea of positive change (higher level of functionality) or negative change (lower level of functionality).

$$R_{ec} = \left(\exp\left\{ \frac{|\, c_p - c_r \,|}{\max\{|c_r|, |c_p|\}} \right\} \right)^{\mathrm{sgn}^*\{c_p - c_r\}} \tag{3}$$

In this context, c_r and c_p represent the characteristic levels of functionality of the reference and performance periods, respectively, and the symbol *sgn** denotes the sign function modified so as to assign a positive sign even to zero values (that is, sgn*(x=0)=+1; sgn*(x>0)=+1; sgn*(x<0)=–1). If the system returns to the same level of functionality, R_{ec} gets the value 1. If the new level of functionality is higher than that of the reference period, the component becomes greater than 1 (R_{ec}>1), whereas if the level is lower, it takes values less than 1 (R_{ec}<1). According to its formulation, the ecological component captures the structural change of the economy resulting from the applied disturbance (Tsiotas and Katsaiti, 2025).

The third component, evolutionary resilience (R_{ev}), accounts for the variability and adaptive capacity of the system during the performance period. Specifically, it measures the deviations of the variable values from the new characteristic level of functionality, in accordance with the algebraic expression shown in Equation (4) (Tsiotas and Katsaiti, 2025):

$$R_{ev} = \exp\left\{ - \sum_{i \in \{1,2,\ldots,n(X_p)\}} \frac{c_r - x_i}{n(X_p) \cdot |c_r + c_p|} \right\} \tag{4}$$

Here, $n(X_p)$ represents the time series' length for the performance period, while c_r and c_p denote the characteristic levels of the time series for the reference and performance periods, respectively. The R_{ev} value increases in cases of small deviations, which indicate convergence toward the performance period's characteristic level of functionality, and decreases when variability is high. The lower the variability during the performance period, the higher the value of evolutionary resilience, as low variability is interpreted as a sign of stable and successful adaptation (Tsiotas and Katsaiti, 2025).

For the overall assessment of economic resilience, Tsiotas and Katsaiti (2025) also considered a scalar (one-dimensional) version of the R index, which is calculated according to the algebraic expression presented in Equation (5):

$$R(\boldsymbol{R}(n, n_p), c_r, c_p) \equiv R = \frac{\mathrm{sgn}^*\{c_p - c_r\}}{\sqrt{3}} \cdot \left\| (R_{en}, R_{ec}, R_{ev}) \right\|_2 \tag{5}$$

Here, the operator represents the Euclidean norm, while the remaining symbols were introduced in Equations (1)–(4) presented earlier. In the algebraic expression of the one-dimensional resilience measure R, the sign of the ecological component is carried over, allowing the index to take negative values when the economy, after the disturbance, ends up at a lower level of functionality. From its algebraic expression, the scalar resilience index captures jointly the speed and stability of recovery, as well as the level of functional adaptability (Tsiotas and Katsaiti, 2025).

Within this methodological framework, using regional data on tourism demand and specialization in Greece for the period 2000–2018, this paper identifies relationships between regional tourism resilience and sectoral regional specialization. The analysis is structured in three distinct stages: in the first stage, the 3D resilience index $\boldsymbol{R}(n, n_p)$ proposed by Tsiotas and Katsaiti (2025) is calculated for the 13 Greek NUTS II regions using tourism demand data, with reference to 2008. Specifically, tourism demand is measured by the annual percentage occupancy rates in overnight stays for the regions over the period 2000–2018, obtained from the surveys of Tsiotas et al. (2020) and (2021). The year 2008 is considered the reference period, assuming that the effects of the 2008 economic crisis were witnessed with a one-year lag. Under these assumptions, the 3D resilience index (including its engineering, ecological, and evolutionary components) is computed for each of the 13 Greek regions and forms three variables of length 13. In the second stage of the analysis, the location quotients (Polyzos, 2019) are calculated on interregional and inter-sectoral employment data in Greece, for each year of the period 2000–2018. The data were extracted from the Hellenic Statistical

Authority (ELSTAT, 2025) and include the employment levels across the 10 industries/sectors of the Greek economy listed in Table 1.

Table 1
The 10 sectors of the Greek economy that are considered in the analysis

Code	Sector Name
A	Agriculture, forestry, and fishing
BE	Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management, and remediation activities
F	Construction
GI	Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
MN	Professional, scientific and technical activities; administrative and support service activities
OQ	Public administration and defense; compulsory social security; education; human health and social work activities
RU	Arts, entertainment, and recreation; other service activities; activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; activities of extraterritorial organizations and bodies

In general, location quotients (*LQ*s) are a tool for quantitative analysis of economic activity in a geographic space and are used to determine the degree of a region's specialization in a sector, branch, or economic activity compared to national levels (Polyzos, 2019). From an algebraic perspective, the *LQ* is defined based on a characteristic (variable) *X* (usually employment), distributed both across sectors and regions, as the ratio of the regional share to the national share of characteristic X for sector *i*, according to Equation (6):

$$LQ_{ir} = \left(\frac{X_{ir}}{X_r}\right) \Big/ \left(\frac{X_i}{X_n}\right) \tag{6}$$

In Equation (6), X_{ir} represents the value of the characteristic (employment) in sector *i* and region *r*; X_r represents the total value of the characteristic in region *r*; X_i represents the value of the characteristic in sector *I*; and X_n represents the total value of the characteristic for the total population (country) (Polyzos, 2019). When $LQ>1$, the sector is represented at a higher proportion in the region compared to the national level, indicating that the region exhibits local specialization, which may reflect a competitive advantage or export capacity according to the export base theory of Tiebout (1956) and North (1955). Conversely, when $LQ<1$, the sector is underrepresented in the region compared to the national level, which indicates its possible role as a supporting sector according to related regional development theories (Polyzos, 2019; Tsiotas, 2022). As becomes apparent, *LQ*s allow the quantitative identification of economic activities (sectors, industries) in a geographic area that are represented at a proportion higher than the national average, indicating a tendency for competitive advantage and export activity in the sector.

In the third stage of the analysis, the results of the 3D tourism resilience index are compared with those of the *LQ* calculations. The comparison is carried out using (*i*) a graphical method based on constructing error bar plots for the mean values of variables' categories with a 95% confidence interval and (*ii*) correlation analysis (Walpole et al., 2012). In the first (error-bars) approach, the *LQ* results are used for the groupings: specifically, the grouping variables are constructed by consolidating the binary states 'specialized' ($LQ>1$) and 'not specialized' ($LQ\leq1$), which are derived from comparing the location quotient values to one for the entire period 2000–2018. From a technical standpoint, the procedure applies as follows: First, the location quotient matrices $\boldsymbol{LQ}=[LQ_{ir}]$ containing LQ_{ir} values for each region and sector are transformed into binary matrices $\boldsymbol{LQ}_{\text{bin,year}}=[\delta_{ir,\text{year}}]$, where $\delta_{ir,\text{year}}=0$ when the region is not specialized in the sector for the given year, and $\delta_{ir,\text{year}}=1$ when it is specialized for each reference year. In the next step, the annual binary matrices are consolidated, keeping a value of 1 for cases where the region has been specialized in the specific sector for all years (2000–2018), and assigning 0 otherwise. This procedure leads to the formation of a longitudinal location quotient matrix $\boldsymbol{LQ}_{\text{bin}}=[\delta_{ir}]$, in which $\delta_{ir}=1$ when the region maintained

its specialization throughout the period 2000–2018 in the specific sector, and zero otherwise. Furthermore, the $\boldsymbol{LQ}_{\text{bin}}$ matrix contains 10 binary (dummy) variables (corresponding to the available sectors), which are used as grouping variables for the error bar analysis. From an interpretive standpoint, when two error bars overlap, no statistically significant difference can be detected between the mean values (considered as parameters) of the two compared groups (with a probability of only 5% for error). Conversely, when they do not overlap, it can be concluded with 95% confidence that the mean values (considered as parameters) of the compared groups are different. In the second (correlation analysis) approach, the *LQ* variables do not subject to any conversion and are uses as sectorial variables participating in correlation analysis applied to pairs (LQ_i, R_j), with *i*=A, BE, F, GI, J, K, L, MN, OQ, and RU expressing sectors, and *j*=scalar, engineering, ecological, and evolutionary expressing aspects of the 3D resilience index. In this analysis, we use *Pearson's bivariate coefficient of correlation* (Norusis, 2011; Devore and Berk, 2012; Walpole et al., 2012), which is defined as:

$$r_{XY} = \frac{\text{cov}(X,Y)}{\sqrt{\text{var}(X)} \cdot \sqrt{\text{var}(Y)}} \tag{7}$$

where cov(*X*,*Y*) is the *covariance* of variables *X*, Y, and $\sqrt{\text{var}(\cdot)}$ is the sample standard deviation. Pearson's correlation coefficient ranges within the interval [-1,1] and detects linear relations when $|r_{XY}| \to 1$ (Devore and Berk, 2012). Negative and positive signs of the coefficients indicate a negative and positive analogy, respectively, in the relationship between variables *X*, *Y*. Overall, through the comparative analysis of the components of the tourism resilience index and the location quotients, valuable insights can be drawn regarding the relationship between sectorial specialization and tourism resilience of Greece's regions, aiming to deepen the study of the complex phenomenon of economic resilience in regional economies.

3. RESULTS AND DISCUSSION

The results of the calculation of the 3D tourism resilience index are shown in Table 2 and Figure 1. A very interesting observation that emerges here concerns the zero values appearing universally in the engineering resilience component (R_{en}) across all 13 NUTS II Greek regions. These results (concerning the zero values of the index) suggest that hotel occupancy did not return to pre-crisis levels in any of the Greek regions. At first glance, this outcome may seem contradictory to studies that report a recovery of tourism in Greece in the period following the 2008 crisis (Kapiki, 2012; Sdrolias et al., 2022). However, considering that tourism demand in this paper is measured in terms of accommodation occupancy (rather than arrivals or length of stay), the results of the engineering component in Table 2 should be evaluated in conjunction with the evolution of the country's hotel capacity.

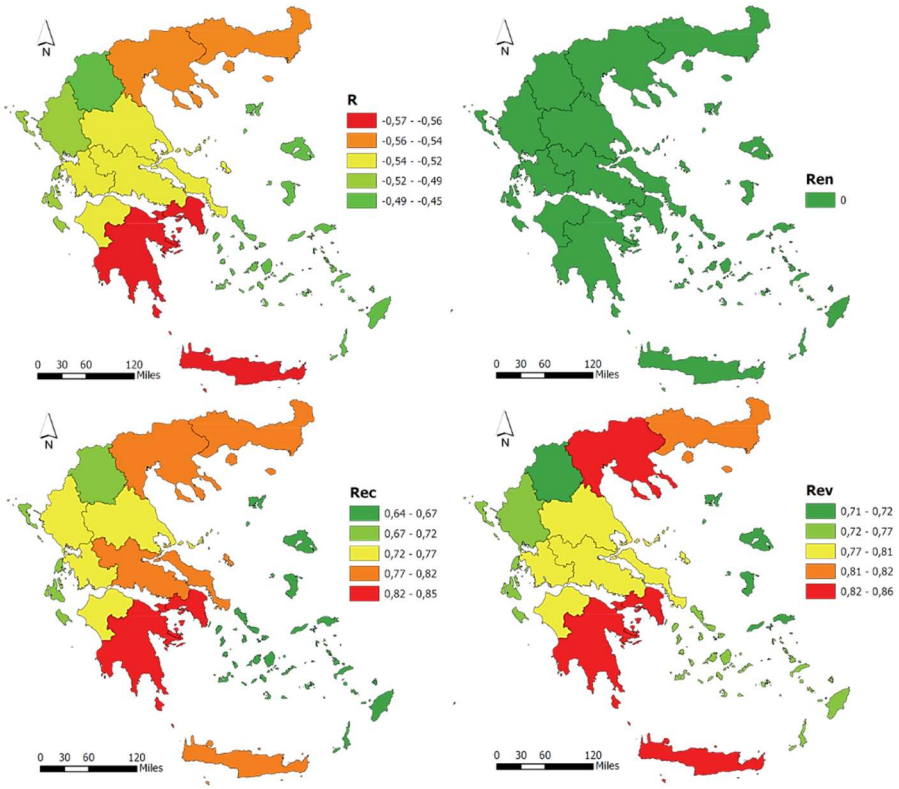
Table 2
Results of the calculation of the 3D tourism resilience index for the NUTS II regions of Greece

NUTS II	R	NUTS II	Ren	NUTS II	Rec	NUTS II	Rev
Peloponnese	-0.567	Eastern Macedonia & Thrace	0	Peloponnese	0.8534	Crete	0.8587
Crete	-0.5602	Attica	0	Attica	0.8349	Peloponnese	0.8477
Attica	-0.5593	North Aegean	0	Crete	0.8218	Attica	0.8431
Central Macedonia	-0.5516	Western Greece	0	Central Macedonia	0.817	Central Macedonia	0.8377
Eastern Macedonia & Thrace	-0.544	Western Macedonia	0	Eastern Macedonia & Thrace	0.8119	Eastern Macedonia & Thrace	0.8201
Central Greece (Sterea Ellada)	-0.5359	Epirus	0	Central Greece	0.8022	Western Greece	0.8115
Western Greece	-0.5255	Thessaly	0	Western Greece	0.7651	Central Greece	0.8056
Thessaly	-0.5226	Ionian Islands	0	Thessaly	0.7645	Thessaly	0.8034
Epirus	-0.5115	Central Macedonia	0	Epirus	0.7638	Epirus	0.7707
Ionian Islands	-0.4919	Crete	0	Western Macedonia	0.7233	Ionian Islands	0.7673

NUTS II	R	NUTS II	Ren	NUTS II	Rec	NUTS II	Rev
Western Macedonia	-0.4819	South Aegean	0	Ionian Islands	0.7083	South Aegean	0.7522
South Aegean	-0.474	Peloponnese	0	South Aegean	0.6699	Western Macedonia	0.7224
North Aegean	-0.4534	Central Greece	0	North Aegean	0.6462	North Aegean	0.7141

According to the Hellenic Chamber of Hotels (HCH, 2025a,b), Greece's hotel capacity increased by approximately 40% between 2000 and 2018, rising from 915,056 to 1,271,619 beds. Based on these levels, the lack of recovery reflected in the engineering resilience component captures the asymmetry between the growth rate of tourist arrivals and the growth rate of hotel capacity, showing a higher rate of expansion for the latter (hotel capacity). From an economic perspective, to the extent that a country's hotel capacity represents the fixed capital stock of the tourism sector (Polyzos, 2019), *the zero level of the engineering component in Table 2 indicates that, since the 2008 crisis, the fixed capital stock in Greece's tourism sector has been continuously underutilized*. This observation highlights a structural effect of the 2008 economic crisis in the country, highlighting the utility of the index proposed by Tsiotas and Katsaiti (2025) for analyzing economic resilience. The values of the other components in Table 2 suggest that the regions of the Peloponnese, Attica, Crete, and Central Macedonia exhibited a greater capacity to adapt to the new conditions affecting tourism demand in Greece after the 2008 economic crisis. These better performances may be attributed to the diversified tourism product (e.g., cultural, seaside, conference, and gastronomic tourism) characterizing these regions, which enhances the resilience of their local economies in the tourism sector, the level of development of their transport infrastructure (Polyzos, 2019), and potentially the more effective utilization of financial support instruments provided by the EU (Petrakos and Psycharis, 2016) for tourism development. In geographical terms, the maps in Figure 1 illustrate that tourism capacity in Greece is subject to a core-periphery rule, where the most resilient regions are either the metropolitan (Attica, Thessaloniki) or their adjacent ones.

Figure 1.
Maps with the spatial distribution of the 3D tourism resilience index for the NUTS II regions of Greece.



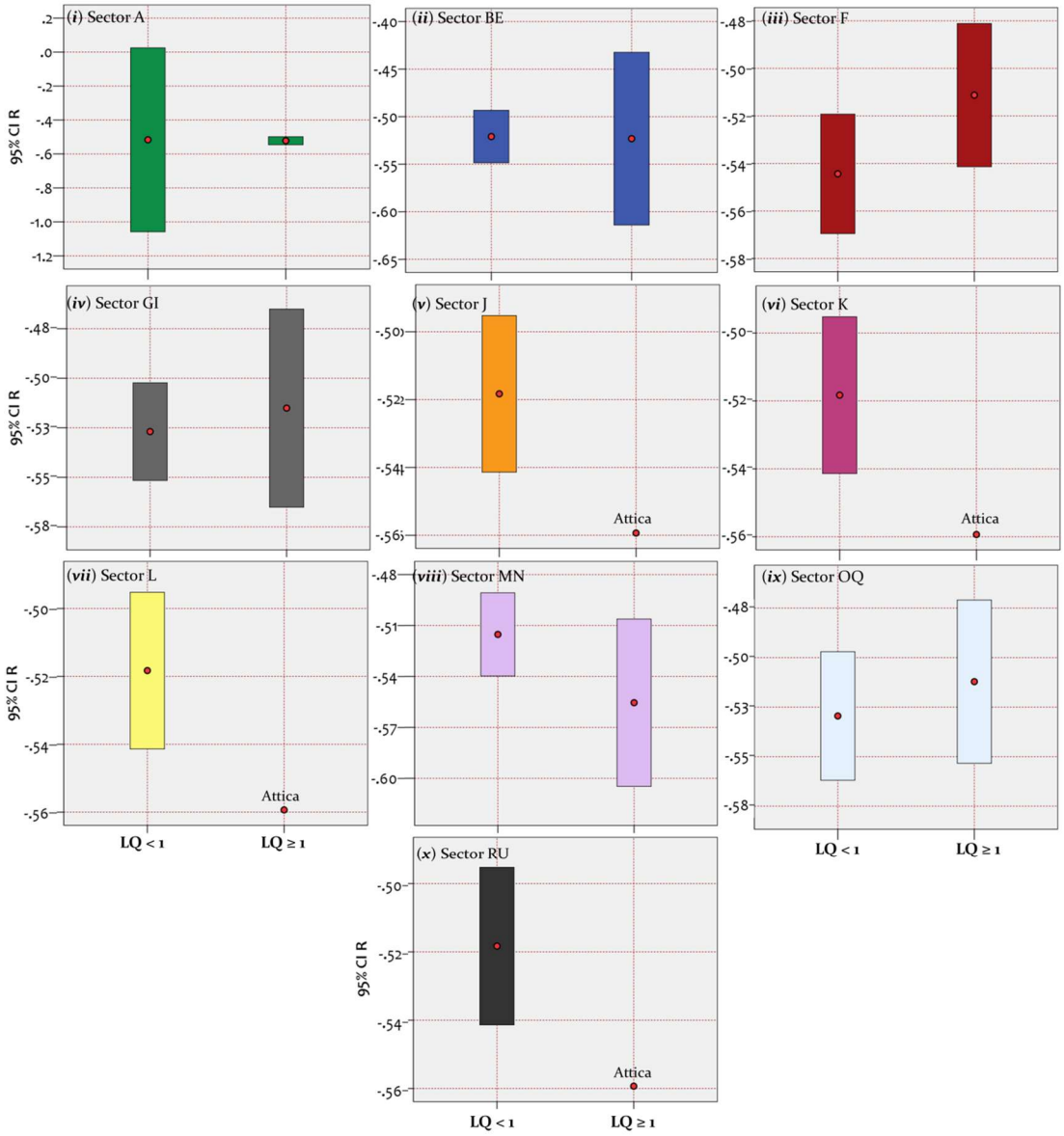
The next part of the analysis concerns the error bar calculations, which compare the temporal 'baseline' performance of economic sectors with the levels of either the scalar

resilience index (Figure 2) or the ecological (Figure 3) and evolutionary (Figure 4) components of the 3D index (the engineering component is not included in the analysis due to its zero values in Table 2). Since the sign of the scalar resilience index captures the property of engineering resilience (a negative sign indicates the inability of the regional economy to recover at its initial levels of functionality), the numerical results in Figure 2 should be interpreted inversely (i.e., smaller algebraic values indicate higher resilience). Based on this observation, Figures 2*i* and 2*ii* do not provide any additional information beyond the heterogeneity characterizing the resilience of regions that are not specialized in agricultural production versus those that are specialized in the sectors of natural resources, manufacturing, and energy.

From Figure 2*iii*, it appears that the NUTS II Greek regions that are not specialized in construction (sector F) tended to exhibit higher tourism resilience than the others. One possible interpretation of this trend is linked to the high cyclicality (Polyzos, 2019; Krugman and Wells, 2024), which makes construction-specialized economies more vulnerable to external shocks. This finding is consistent with Tsiotas et al. (2025), who suggest that the dynamics of the tourism sector can be attributed more to its complementarity with other interacting sectors than to the tourism product itself. In this context, the tourism sector's complementarity with the highly cyclical construction sector may reduce resilience. Next, Figure 2*v* shows that the regions specialized in the information and communication sector (sector J) exhibited higher tourism resilience. A possible explanation here regards the role of information and communication in tourism marketing, which gives regions specialized in sector J a comparative advantage in attracting tourist demand (Brune et al., 2024). The presence of a developed IT, digital communication, and technology sector equips these regions with advanced infrastructure, resources, and skilled human capital, therefore enhancing the ability of tourism businesses to adapt to crises by leveraging information and communication technologies to promote their services.

In Figure 2*vi*, we can observe that regions specializing in financial and insurance activities (sector K) showed a higher tourism resilience. This specialization exclusively concerns the Attica region, providing a trivial grouping. A possible explanation for this relationship lies in Attica's complex tourism development model, which is more diversified, including city tourism, conference, sports, and health tourism (Polyzos, 2023), representing a smaller share of the mass 3S (sea, sun, sand) tourism model. According to Samora-Arvela et al. (2018), product diversification provides a resilience strategy for tourism in the Mediterranean, and this can describe the case of the Attica region. Another plausible explanation is that financial specialization implies the presence of developed administrative structures, organized business networks, and better access to financing tools, which are features supporting the tourism sector and enhancing its adaptability to disruptions. Considering that Sdrolias et al. (2022) identified characteristics of engineering and ecological resilience in sector K, and Tsiotas et al. (2025) found that tourism sector dynamics depend heavily on related sectors, the relationship in Figure 2*vi* may also reflect the interdependence of the tourism and financial and insurance activities sectors.

Figure 2.
95% confidence interval error bar charts of the mean values of the scalar tourism resilience index for the regions of Greece, comparing regions with and without specialization in the 10 sectors of Table 1.



In Figure 2*vii*, regions specialized in real estate management (sector L) demonstrated higher tourism resilience. Although this specialization (trivially) concerns only the Attica region, it indicates a proportional relationship between tourism resilience and advanced activity in real estate markets. Regions specialized in real estate management benefit from substantial infrastructure capital and high-quality tourist accommodations, which are factors supporting urban development mechanisms (Polyzos, 2019), contributing to the competitiveness of the tourism product and the adaptability mechanisms of tourism resilience in the regional economy. Next, in Figure 2*viii*, we can observe that the regions specializing in professional, scientific, and technical activities, as well as administrative and support services (sectors MN), tended to exhibit higher tourism resilience. One possible explanation for this relationship can be provided by the endogenous growth theory of Lucas (1988) and Romer (1994), according to which knowledge- and technology-intensive production mechanisms can generate increasing returns promoting economic and regional development. Regions with a strong presence of highly skilled human capital, knowledge economy, and administrative structures enjoy a favorable business and economic environment, facilitating tourism development and enhancing its resilience during crisis periods.

Figure 3.
Error bar diagrams showing the 95% confidence intervals of the mean values of the ecological resilience (R_{ec}) component for the regions of Greece, with ($LQ \geq 1$) and without specialization ($LQ < 1$) in the 10 sectors listed in Table 1.

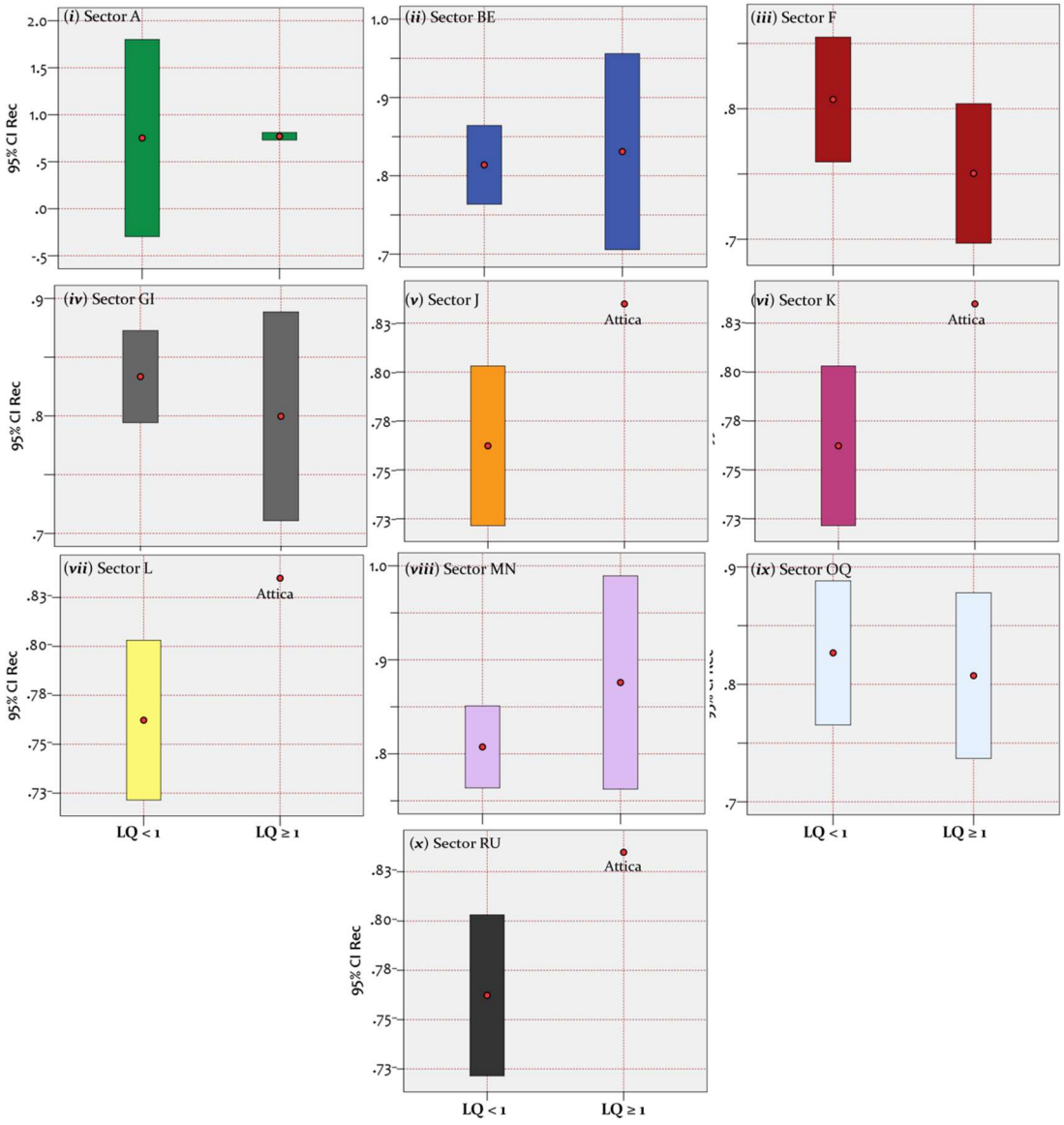
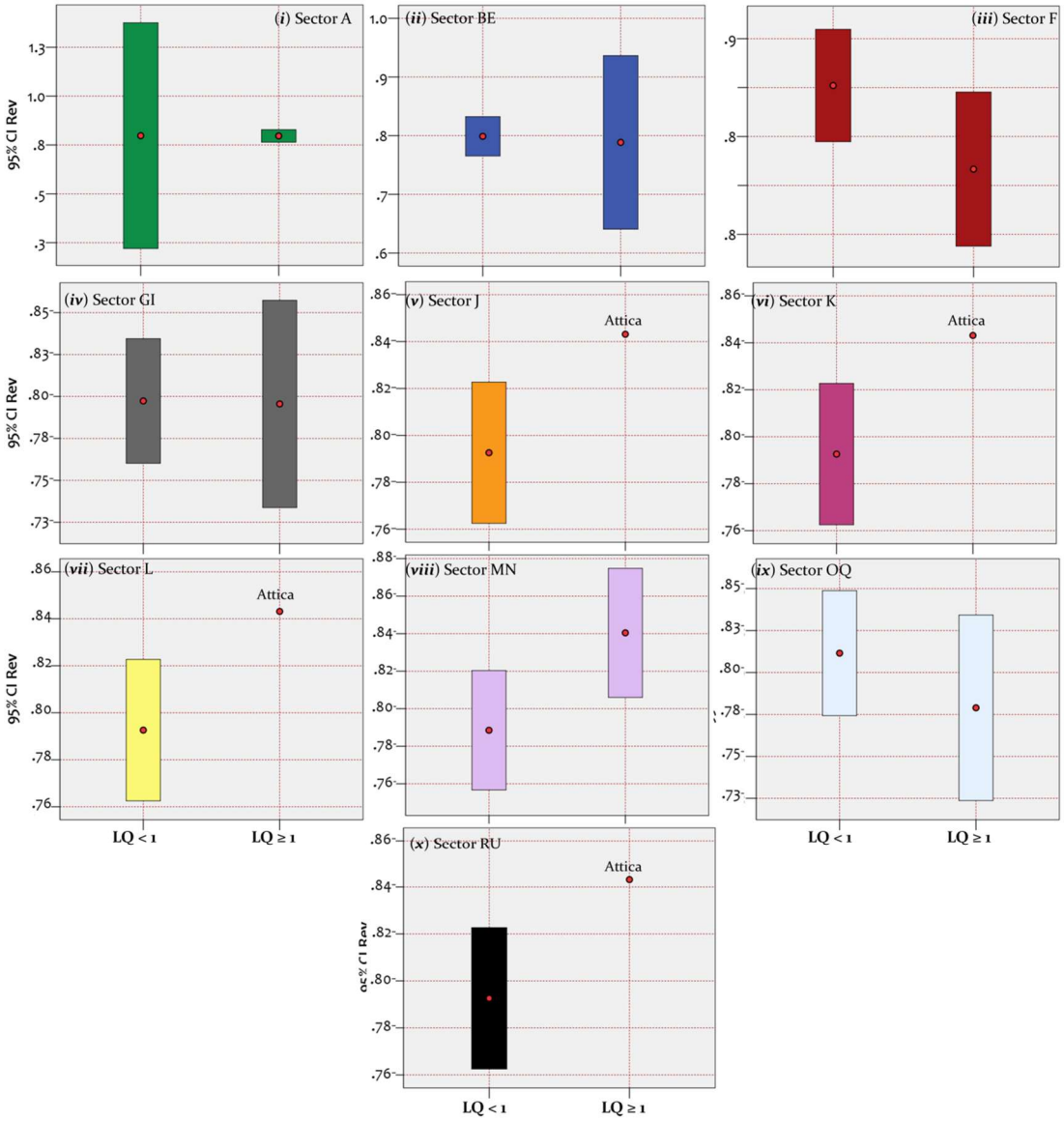


Figure 4. Error bar charts with 95% confidence intervals of the mean values of the evolutionary resilience (R_{ev}) component for the regions of Greece, comparing those specialized ($LQ \geq 1$) and not specialized ($LQ < 1$) in the 10 sectors of Table 1.



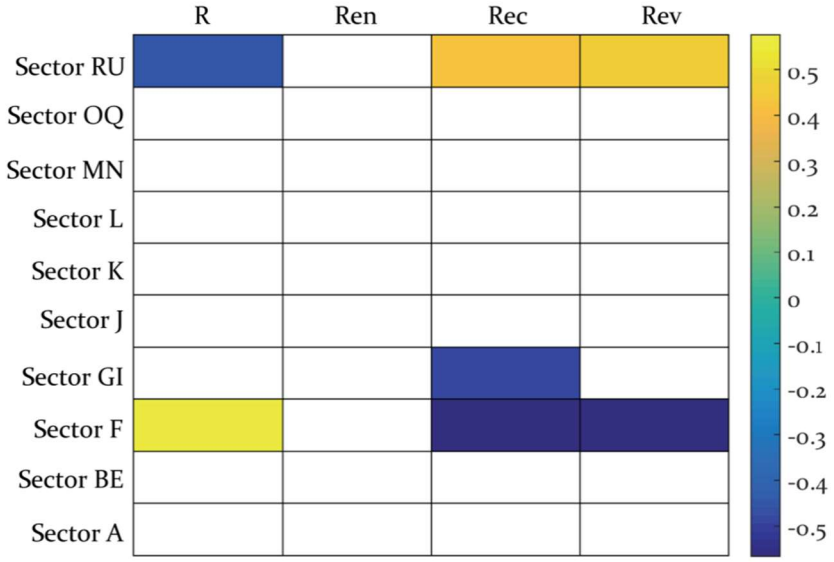
Next, in Figure 2*ix*, we can observe that the regions that are not specialized in sector OQ (public administration and defense, compulsory social security, education, human health and social work activities) showed a slight tendency toward higher tourism resilience. This trend may be interpreted based on the greater organizational flexibility and resource allocation capacity of economies that rely less on public or institutional sectors, which (while stable) are also rigid during periods of crisis or disruption (Kuhlmann and Bouckaert, 2016; Ballantine et al., 2022). Finally, in Figure 2*x*, we can observe that the regions specialized in sector RU (arts, entertainment, and recreation, along with other services, household activities as employers or for own use, and activities of extraterritorial organizations) exhibited a higher tourism resilience. Although (from a computational standpoint) the specialization corresponds uniquely to the Attica region, the statistically significant difference in the error bar chart allows induction of the finding that a component of tourism resilience is determined by the cultural character of the local economy and the tourism product. This result aligns with the literature (Bui et al., 2020; Chen and Li, 2022), which recognizes the cultural and creative capital of destinations as a factor of tourism resilience.

Furthermore, the error bar patterns shown in Figures 3 and 4 are complementary to those in Figure 2. Given the zero values for engineering resilience (indicating an inability of tourism to recover following the 2008 economic crisis), the results in Figures 3 and 4 initially suggest that specialization in sector J (information and communication), K (financial and

insurance activities), L (real estate management), and RU (arts, entertainment, recreation, and other activities) is positively associated with both ecological (shift to a new state of functionality) and evolutionary (ongoing adaptability of the regional economy induced by disruption) tourism resilience. On a second reading, given that the Attica region formed the single unit in the statistically significant cases examined, the tourism resilience factors that were detected from the analysis cannot be separated from the economic and tourism development model exemplified by Attica. The tourism development model of the metropolitan Attica region is based on (Tsiotas et al., 2020, 2021; Polyzos, 2023) mechanisms of economies of scale, agglomeration economies, knowledge and information economies, and the relative differentiation of the region's tourism product from the mass 3S (sea, sun, sand) model.

Finally, the significant results of the correlation analysis are shown in the heat map of Figure 5. As it can be observed, sector RU (arts, entertainment, recreation, and other activities) is positively and significantly correlated with both ecological and evolutionary tourism resilience, illustrating the positive economies induced by the core development model of Attica, as previously discussed. This is also the case for the r(RU, R) correlation, which should be read inversely due to the thematic meaning of the negative algebraic sign of the scalar regional resilience (R) component. Further, the correlation analysis detects the significance of the negative association between the construction (sector F) and tourism resilience, which was interpreted in the context of economic cyclicality (Polyzos, 2019; Krugman and Wells, 2024).

Figure 5. Correlation matrix of the significant correlations between the sectorial *LQ*s (shown in rows) and the scalar *R* and the 3D resilient index components (shown in columns).



However, the correlation analysis in Figure 5 detects a significant negative association that was unobserved in the error bar analysis between tourism resilience and sector GI (Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities), which is a hybrid trade-tourism-transportation sector. This significant correlation interprets those regions with high trade and transportation activities as those with less deviation from the state of their reference period's tourism functionality due to the 2008 economic crisis. This interpretation implies a balancing role of the trade and transportation industries in tourism resilience, which can be attributed to the complementarity between the tourism, trade, and transportation industries. Overall, the correlation analysis provides evidence of the inferential dynamics of the association between tourism resilience, on the one hand, and the construction sector and the trade and transportation industries, on the other hand, beyond the specific case of the Attica developmental model.

4. CONCLUSIONS

Interpreting the 2008 economic crisis as a disruption to the equilibrium of the national economic system, this paper examined the tourism resilience of Greek regions with respect to tourism demand, using a 3D economic resilience index recently proposed in the international literature by Tsiotas and Katsaiti (2025). The quantification of the economic resilience components (engineering, ecological, and evolutionary) using the 3D index during the 2008 crisis allowed the relationship between a region's sectoral specialization and its resilience in tourism demand to be examined. The empirical analysis was conducted using inter-sectoral and inter-regional labor data (to determine local specialization) and accommodation occupancy data (to determine tourism demand). The results of the engineering resilience component initially revealed that the regions of the country did not recover to pre-2008 occupancy levels. Combining this result with data on the country's hotel capacity for the beginning (2000) and the end (2018) of the period studied, it was found that, from the 2008 crisis onward, the fixed capital stock in Greece's tourism sector has been consistently underutilized. In other words, *the analysis in this paper suggests that tourism infrastructure in the country's regions has been expanding faster than the increase in tourism demand, describing an 'inflationary' mechanism of tourism capital degradation, which could lead in the long term to a reduction both in its intrinsic value and in the overall tourism product of the regions*. This finding highlights a structural issue in the tourism development model of the regions, which could be addressed through a mix of regional and tourism development policies and practices (Petrakos and Psycharis, 2016; Polyzos, 2019, 2023) based on extending the tourism season, diversifying the tourism product, socially leveraging and redefining the uses of tourism capital, and spatially redistributing and training tourism and human resources.

The analysis also highlighted that specialization in the information and communication sector, financial and insurance activities, real estate management, and arts, entertainment, recreation, and other activities is positively associated with the ability to restore operational levels (ecological resilience) and with the ongoing adaptability (evolutionary resilience) of the regional economy to disruptions in tourism demand. However, these factors appear closely linked to the economic and tourism development model of Attica, which has been developed based on mechanisms of scale economies, agglomeration, knowledge and information economies, and relative differentiation of the tourism product from the mass 3S model. Moreover, the correlation analysis showed that the positive association between tourism resilience, on the one hand, and sectors F (construction) and RU (arts, entertainment, recreation, and other activities), on the other hand, can be attributed beyond the specific development case of Attica and is generalizable. The correlation analysis also highlighted the significant supportive role of trade and transportation to tourism resilience.

Finally, by applying the Tsiotas and Katsaiti (2025) index for the analysis of economic resilience in the case of Greece, this paper provided a further empirical application of the proposed index at a different geographic scale (regional) and sectoral focus (tourism). The empirical results suggest that the index is useful for measuring the economic resilience of spatial economies and are presented with the aim of inspiring further research.

ACKNOWLEDGMENTS

The authors would like to express sincere thanks to Prof. Emeritus Serafeim Polyzos for his initiative in assembling the author team and fostering the collaboration resulting in this paper.

5. References

Ballantine, J. A., Wall, T., and Ward, A. M. (2022). Flexible working in the public sector–a case of inflexibility: senior managers' experiences. Employee Relations: The International Journal, 44(6), 1273-1289.

Brune, S., Knollenberg, W., and Vilá, O. (2024). Building Tourism Resilience through Communication. Tourism and Hospitality, 5(1), 51-59.

Bui, H. T., Jones, T. E., Weaver, D. B., and Le, A. (2020). The adaptive resilience of living cultural heritage in a tourism destination. Journal of Sustainable Tourism, 28(7), 1022-1040.

Chen, X., and Li, B. (2022). Rethinking cultural creativity and tourism resilience in the post-pandemic era in Chinese traditional villages. Sustainability, 14(19), 12371.
Devore, J. and Berk, K. (2012). Modern Mathematical Statistics with Applications, Springer-Verlag Publications, London, UK.
Hellenic Chamber of Hotels – HCH. (2025a). Hotel capacity in Greece 2018 – total country. Retrieved June 21, 2025 from URL: https://www.grhotels.gr/ksenodocheiako-dynamiko-elladas-2018-synolo-choras/.
Hellenic Chamber of Hotels – HCH. (2025b). Hotel capacity in Greece 2000 – total country. Retrieved June 21, 2025, URL: https://www.grhotels.gr/ksenodocheiako-dynamiko-elladas-2000-synolo-choras/.
Hellenic Statistical Authority – ELSTAT. (2025). Employment by geographic zone, region, and sector (Provisional data) (2000–2022) [Time series]. Retrieved March 10, 2025 from URL: https://www.statistics.gr/el/statistics/-/publication/SEL54/-.
Kalantzi, O., Tsiotas, D., Polyzos, S. (2017). The contribution of tourism in national economies: evidence of Greece. European Journal of Business and Social Sciences (EJBSS), 5(10), pp.41–64 (10.48550/arXiv.2302.13121).
Kapiki, S. (2012). The impact of economic crisis on tourism and hospitality: Results from a study in Greece. Central European Review of Economics and Finance, 2(1), 19-30.
Krabokoukis, T., Tsiotas, D., and Polyzos, S. (2024). Assessing the effectiveness of regional development planning in Greece through the detection of changes in recent developmental laws. Planning Practice & Research, 1-21.
Krugman, P. R., and Wells, R. (2024). Economics, 7th edition. Macmillan
Kuhlmann, S., and Bouckaert, G. (2016). Local public sector reforms in times of crisis. London: Palgrave Macmillan.
Ladias, Christos Ap., and Stamatiou, E. (2006). The Macro Region As An Economic Entity And Of Regional Planning. Montenegrin Journal of Economics, 2(3), 127-138.
Ladias, Christos Ap., Hasanagas, N., and Papadopoulou, E. (2011). Conceptualising 'macro-regions': Viewpoints and tools beyond NUTS classification. Studies in Agricultural Economics, 113(1316-2016-102776), 138-144.
Ladias, Christos, Ap., Ruxho, F., Teixeira, F. J. C. S. N., Pescada, S. S. P. V. (2023). The Regional Economic Indicators and Economic Development of Kosovo. Regional Science Inquiry, 14(1), pp.73-84.
Lincaru, C., Ghenta, M., Atanasiu, D., Ciuca, V., Dragoiu, C., and Chiriac, B. (2010). Regional Development and Diversity/Variety of Firms: The Case Of Romania. Regional Science Inquiry, 2(2), 119-132.
Lucas Jr, R. E. (1988). On the mechanics of economic development. Journal of monetary economics, 22(1), 3-42.
Lv, Z. (2019). Deepening or lessening? The effects of tourism on regional inequality. Tourism Management, 72, 23-26.
Napolskikh, D., and Yalyalieva, T. V. (2019). Modeling of regional economic development based on innovative clusters. Regional Science Inquiry, 11(2), 73-81.
North, D. C. (1955). Location theory and regional economic growth. Journal of political economy, 63(3), pp.243-258.
Norusis, M., (2011). IBM SPSS statistics 19.0 guide to data analysis. New Jersey: Prentice Hall.
Papadimitriou, V., Polyzos, S., Tsiotas, D. (2023). Renewable Energy Project Appraisal using the Real Options Methodology. Regional Science Inquiry, 15(1), pp.85-96.
Perroux, F. (1950). Economic Space: Theory and Applications. The Quarterly Journal of Economics, 64: 89–104.
Petrakos, G., and Psycharis, G. (2016). Regional Development in Greece (2nd ed.). Athens: Kritiki Publications [in Greek].
Polyzos, S. (2019). Regional Development (2nd ed.). Athens: Kritiki Publications [in Greek].
Polyzos, S. (2022). Natural resources management and sustainable development. Thessaloniki: Tziolas Publications [in Greek].
Polyzos, S. (2023). Urban Development (2nd ed.). Athens: Kritiki Editions [in Greek].
Psycharis, Y.; Kallioras, D.; Pantazis, P. (2014). Economic crisis and regional resilience: Detecting the 'geographical footprint' of economic crisis in Greece. Reg. Sci. Policy Pract., 6, 121–141
Romer, P. M. (1994). The origins of endogenous growth. Journal of Economic perspectives, 8(1), 3-22.
Rossello, J., & Sanso, A. (2017). Yearly, monthly and weekly seasonality of tourism demand: A decomposition analysis. Tourism Management, 60, 379-389.
Ruxho, F. (2024). Kosovo employee's perception of economic growth and decent work according to sustainability. Sustainable Regional Development Scientific Journal, 1(3), 53-66.

Ruxho, F., and Ladias, C. A. (2022). Increasing Funding for the Regional Industry of Kosovo and the Impact on Economic Growth. Regional Science Inquiry, 14(1), 117-126.
Ruxho, F., Ladias, Christos Ap., Tafarshiku, Ali, Abazi, Edib, (2023) Regional employees perceptions on decent work and economic growth: labor market of Albania and Kosovo. Regional Science Inquiry, 15(2), pp.13-24.
Samora-Arvela, A., Vaz, E., Ferrão, J., Ferreira, J., and Panagopoulos, T. (2018). Diversifying mediterranean tourism as a strategy for regional resilience enhancement. Resilience and Regional Dynamics: An International Approach to a New Research Agenda, 105-127.
Sdrolias, L., Semos, A., Mattas, K., Tsakiridou, E., Michailides, A., Partalidou, M., Tsiotas, D., (2022). Assessing the agricultural sector's resilience to the 2008 economic crisis: The case of Greece. Agriculture, 12: 174 (10.3390/agriculture12020174).
Sepetis, A., (2024). The implementation of social protection policies at local level according to inclusive and sustainable development. Regional Science Inquiry, 16(2), pp.111-130.
Sepetis, A., Krupavicius, A., and Ladias, C. A. (2024). Social protection in Greece and sustainable development leaving no one behind. Sustainable Regional Development Scientific Journal, 1(1), 83-92.
Sequeira, T., Goncalves, H., Francisco, B. S., Pirra, A., Joukes, V. (2023). Well-Being and Quality of Life: Different Perspectives in Rural and Peri-Urban Areas in the North of Portugal. Regional Science Inquiry, 15(1), pp.13-28.
Thisse, J. F. (1987). Location theory, regional science, and economics. Journal of Regional Science, 27(4), 519-528.
Tiebout, C. M. (1956). Exports and regional economic growth. Journal of political economy, 64(2), pp.160-164.
Tsiotas, D. (2022). A network-based algorithm for computing Keynesian income multipliers in multiregional systems. Regional Science Inquiry, 14(2), pp.25-46.
Tsiotas, D., and Katsaiti, M. S. (2025). A 3D index for measuring economic resilience with application to modern financial crises. Journal of International Development, 37(2), 371-404.
Tsiotas, D., and Tselios, V. (2024). Detecting geographical patterns in the EU's interregional flows: a multilayer hierarchical approach. Progress in Economic Geography (10.1016/j.peg.2024.100017).
Tsiotas, D., Dialesiotis, S., Christopoulou, O. (2023). Examining the relationship between regional economic resilience and epidemiologic spread of COVID-19: evidence from Greece. Environment, Development and Sustainability (10.1007/s10668-023-04240-7).
Tsiotas, D., Giannakis, E., Papadas, C.T. (2025). A modularity decomposition model of evolving Input-Output sectorial structure. Regional Science Inquiry 17(1), pp. 107-133.
Tsiotas, D., Kallioras, D. (2025). Detecting patterns of hierarchy in the geography of Local Labor Markets in Greece using the network paradigm: toward a "status-polus" model. Journal of Economic Geography (10.1093/jeg/lbae052).
Tsiotas, D., Krabokoukis, T., Polyzos, S. (2020). Detecting interregional patterns in tourism seasonality of Greece: a principal components analysis approach. Regional Science Inquiry, 12(2), pp.91-112.
Tsiotas, D., Polyzos, S., Krabokoukis. T. (2021). Detecting interregional patterns of tourism seasonality: A correlation-based complex network approach for the case of Greece. Tourism and Hospitality, 2(1), pp.113-139.
Tsiotas, D., Tselios, V. (2022). Understanding the uneven spread of COVID-19 in the context of the global interconnected economy. Scientific Reports, 12: 666 (10.1038/s41598-021-04717-3).
Tsoulias, G., Tsiotas, D. (2024). Geographical and structural changes in the Global Tourism Network due to COVID-19. Theoretical and Empirical Researches in Urban Management, 19(2), pp.28-54.
Uzsayilir, A., and Baycan, T. (2024). Regional specialization in the context of deindustrialization: the case of Türkiye. Regional Science Inquiry, 16(2), pp.33-42.
Walpole, R. E.; Myers, R. H.; Myers, S. L.; Ye, K. (2012) Probability and Statistics for Engineers and Scientists, ninth ed., New York, Prentice Hall Publications 2012, ISBN 9780321629111.
Xanthos, G., Ladias, C. A., and Genitsaropoulos, C. (2012). Regional Inequalities in Greece A Proposition for their Depiction. Regional Science Inquiry, 4(2), 191-196.
Xanthos, G.J., and Dulufakis, E.N. (2023). Measurement approaches of regional economic resilience: a literature review. Regional Science Inquiry, 15(2), pp.47-60.

Announcements, Conferences, News

ICEG 2026: 20
International Conference on Economic Geography
September 07-08, 2026 | Rome, Italy.

Event Overview

The International Conference on Economic Geography (ICEG 2026), organized by the World Academy of Science, Engineering and Technology (WASET), will be held on September 07-08, 2026, in Rome, Italy, to bring together academic scientists, researchers, and research scholars to exchange and share their experiences and research results on all aspects of Economic Geography.

ICEG 2026 serves as an interdisciplinary platform for presenting contemporary research, exchanging ideas, and discussing new trends and challenges across the full spectrum of economic geography. Key themes include (but are not restricted to) global and regional economic dynamics, spatial economics, economic growth, financial and environmental economics, sustainable development, labor and migration, fintech ecosystems, economic policy, urban and regional development, and many emerging subfields.

Prospective authors are invited to submit abstracts, full papers, or e-posters showcasing original research, whether conceptual, empirical, or theoretical. All submissions undergo blind peer review by three independent reviewers. Accepted papers are published in indexed conference proceedings and considered for special journal issues.

The conference supports academic exchange through presentations, discussions, and networking opportunities, offering value to students, educators, and industry professionals.

ICEG 2026 also provides sponsorship and exhibitor opportunities for organizations wishing to engage with the global research community.

With its strong emphasis on innovation, interdisciplinary dialogue, and global collaboration, ICEG 2026 aims to deepen the understanding of economic geography in a rapidly evolving world and to inspire new research trajectories that address contemporary economic, social, and spatial challenges.

Key dates:

Abstracts/Full-Text Paper Submission	December 17, 2025
Notification of Acceptance/Rejection	December 31, 2025
Final Paper (Camera Ready) Submission & Early Bird Registration	May 17, 2026
Conference Dates	September 07-08, 2026

More information:

Website URL: https://waset.org/economic-geography-conference-in-september-2026-in-rome
Program URL: https://waset.org/conferences-in-september-2026-in-rome/program
Contact URL: https://waset.org

Event overview edited by Dimitrios Tsiotas,
Assistant Professor, RSI J.

International Conference on Urban Economy and Regional Development (ICUERD-26)

26–27 February 2026 | Rome, Italy | Hybrid

Event Overview

The International Conference on Urban Economy and Regional Development (ICUERD-26) will take place on 26–27 February 2026 in Rome, Italy. This interdisciplinary event serves as a forum for researchers, scientists, academicians, policymakers, and industry experts from all backgrounds to convene and share their expertise and insights. Attendees will have the opportunity to engage in stimulating discussions, exchange ideas, and establish valuable connections.

ICUERD-26 welcomes contributions on topics such as urban economy, regional development strategies, economic geography, innovation districts, urban competitiveness, smart city economics, economic resilience, and sustainable development. Oral and poster sessions offer opportunities for researchers to showcase their work and gain recognition.

The event is hosted under the umbrella of the Scholars Network for Research and Innovation (SNRI), an organization dedicated to professional development and global knowledge exchange.

The event emphasizes networking, collaboration, and academic excellence.

Key dates:

Early Registration Deadline	27th January 2026
Paper Submission Deadline	6th February 2026
Registration Deadline	11th February 2026
Conference Date	26th - 27th February 2026

More information:

https://www.snrischolars.com/event/call-for-paper.php?id=3414014

Event overview edited by Dimitrios Tsiotas,
Assistant Professor, RSI J.

Academic Profiles

Professor Simona Iammarino

Professor **Simona Iammarino** is a Professor of Applied Economics at the Department of Economics and Business of the University of Cagliari, Italy. She is also a Visiting Professor at the Department of Geography and Environment of the London School of Economics (LSE), where she previously held the position of Professor of Economic Geography (2009–2022).

During her tenure at LSE, she served as Head of the Department of Geography and Environment (2014–2017) and as an academic member of the LSE Council (2016–2020). She is additionally affiliated with the Gran Sasso Science Institute (GSSI) in L'Aquila, Italy, and is a member of the Board of the LSE–Cañada Blanch Centre. Since 2023, she has been in the Scientific Committee of the Luiss Institute for European Analysis and Policy (LEAP), Rome.

Prof. Iammarino's research lies in the intersection of the fields of Multinational corporations, globalization and local economic development; Economic geography of innovation and technological change; Regional systems of innovation; and Regional and local economic development and policy. She has published more than 70 articles in major peer-reviewed journals, two co-authored books, around 30 book chapters, and numerous working papers, policy reports, and other publications. Her research has so far over 15,200 citations according to the Google Scholar database.

Prof. Iammarino possesses editorial and institutional activity, serving as a Co-Editor in the *Journal of Economic Geography* (Oxford Academic), and she is a member of the RSA Board and Chair of the RSA Journal Committee. She has long-term experience in externally funded international research projects, and in consultancy projects for various international organisations (such as the EU Commission, OECD, United Nations, ADB) and numerous government agencies.

Prof. Iammarino has recently been recognized for her leading contributions to economic geography and regional science and policy with two prestigious awards: the "ERSA European Prize in Regional Science 2024", from the European Regional Science Association, and the "Giacomo Becattini" Prize 2024, from the Italian Society of Economics and Industrial Policy (SIEPI). She also actively contributes to policy-relevant research on spatial inequalities by being a member of the EU project ESSPIN[1] (Economic, Social and Spatial Inequalities in Europe in the Era of Global Mega-trends).

Overall, Prof. Simona Iammarino is an internationally renowned scholar with a significant record of research in economic geography and regional science, teaching, and institutional services in the Regional Science community.

Academic Profile by **Dimitrios Tsiotas**
Assistant Professor, RSI J

References

https://www.lse.ac.uk/people/simona-iammarino
https://web.unica.it/unica/page/en/simona_iammarino
https://cepr.org/about/people/simona-iammarino
https://scholar.google.com/citations?user=enmTEFEAAAAJ&hl=en

[1] https://cordis.europa.eu/project/id/101061104.

Professor Ugo Fratesi

Professor Ugo Fratesi is a Full Professor of Regional Economics and Policy at the Polytechnic School of Milano (Politecnico di Milano), Italy. He holds a five-year full-time undergraduate Degree and a Master's in Economics from Bocconi University (Italy), a Master of Science in Local Economic Development (with Distinction) from the London School of Economics, and a PhD in Economics from the University of Ancona, Italy.

He speaks Italian (native speaker), French, English, and Portuguese, and has a long-standing engagement with the regional science community, serving as councilor of the Italian Section of the Regional Science Association International (AISRe) and its Treasurer for the period 2010-2013. During his professional career, he has been involved with various roles in a large number of research projects, especially at the European level, financed by the ESPON, FP5, FP7, Horizon, and PRIN programmes, or the European Commission directly. He also has a lengthy experience of university teaching at the undergraduate, master's, and Ph.D. levels, as well as in training policymakers and civil servants within the Italian National School of Administration (SNA).

Professor Fratesi is the Editor-in-Chief of the reputable journal Spatial Economic Analysis (Taylor & Francis), and he has held several prominent editorial roles, including Editor of Main Section Papers and Book Review Editor of Regional Studies (Taylor & Francis) for eight years, as well as Book Review Editor of the Italian Journal of Regional Science for five years.

He is the author of the textbook Regional Policy: Theory and Practice (Routledge, ISBN: 9780815364078), alongside multiple academic books and numerous articles published in top-tier refereed journals. His research covers a broad range of topics central to regional science, including (without being exhaustive) regional economics and policy, primarily on the themes of regional growth and development, policy assessment, cohesion policy, territorial capital, the models for forecasting regional growth, the theory and measurement of regional disparities, and the territorial aspects of human capital and innovation.

Professor Fratesi is an internationally recognized scholar for his contributions to regional growth theory, cohesion policy, and territorial development dynamics, and his work has so far received over 6100 citations according to the Google Scholar database.

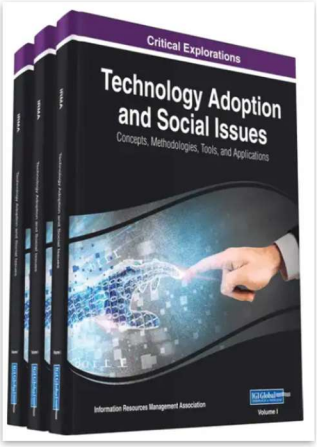
Professor Fratesi's work stands at the intersection of scientific depth and policy relevance, placing him amongst Europe's most influential economists in regional development and policy.

Academic Profile by:**Dimitrios Tsiotas**
Assistant Professor, RSI J

References

http://web.tiscali.it/Fratesi/cv_brief_en.htm
https://scholar.google.com/citations?user=s6hcod8AAAAJ&hl=it
https://www.arch.hku.hk/event_/ugo-fratesi/
https://www.fratesi.net/
https://www.gssi.it/people/professors/lectures-social-science-gssi-cities/item/1042-fratesi-ugo?tmpl=component&print=1
https://www.regionalstudies.org/people/ugo-fratesi/

Book Reviews



Technology Adoption and Social Issues: Concepts, Methodologies, Tools, and Applications
2018 | Edited by | IGI Global | ISBN: 9781522552017 | p.1736

Technology Adoption and Social Issues: Concepts, Methodologies, Tools, and Applications is a comprehensive three-volume book collection offering an extensive examination of technological adoption and its social implications in scientific research. Edited by Mehdi Khosrow-Pour (the Executive Editor of IGI Global) and supported by an international team of associate editors and contributors (originating from the USA, UK, Egypt, Finland, and Poland), the collection includes 80 chapters spanning foundational theories, methodological developments, applied research, and critical social perspectives. It provides a reference for researchers, practitioners, and institutions engaged in understanding the multifaceted processes through which societies adopt, negotiate, and integrate technological innovations.

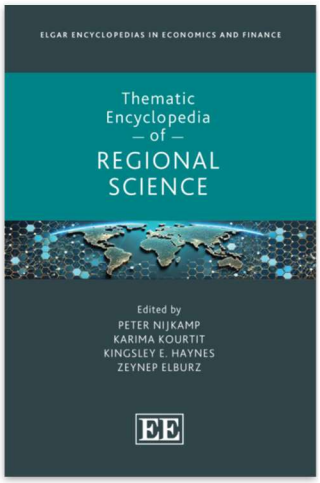
The structure of the series is deliberate and progressive. The first volume (including 2 sections and 24 Chapters) introduces the Fundamental Concepts and Theories that have shaped the field of technology adoption. The second volume (including 2 sections and 28 Chapters) shifts focus toward methodological frameworks, tools, and applied technological models. The third volume (including 2 sections and 28 Chapters) advances into broader organizational and social implications.

A distinctive strength of the entire collection is its international and interdisciplinary orientation. The chapters draw on research conducted by researchers originating from various countries across all continents, allowing readers to compare how technological adoption unfolds throughout diverse spatial economies. This diversity enriches the technology adoption analysis and offers a holistic view of how cultural norms, institutional capacities, governance frameworks, and socio-economic conditions shape adoption patterns, serving the spatial dimension through its embodiment of geographical diversity of empirical case studies.

Overall, this three-volume book provides a valuable resource for academics researching technological innovation, for practitioners confronting the challenges of digital transformation, and for policymakers aiming to design inclusive and culturally sensitive technology strategies.

More information can be found at the URL:
https://www.igi-global.com/book/technology-adoption-social-issues/187119#description

Book Review by Dimitrios Tsiotas,
Assistant Professor, RSI J



The Thematic Encyclopedia of Regional Science

ISBN: 9781800379275

Edited by Peter Nijkamp, Karima Kourtit, Kingsley E. Haynes, and Zeynep Elburz

The *Thematic Encyclopedia of Regional Science* (2025) offers a comprehensive, structured, and interdisciplinary exploration of the diverse concepts, theories, and analytical tools defining Regional Science. Edited by Peter Nijkamp, Karima Kourtit, Kingsley E. Haynes, and Zeynep Elburz, the volume brings together global expertise to provide a coherent synthesis of how regions, cities, and spatial systems function within the modern economy.

This work systematically maps the multifaceted body of knowledge encompassing spatial economics, urban and regional development, environmental systems, technological change, governance, and socio-economic dynamics. Through hundreds (over 300) of expert-written entries, the Encyclopedia highlights the interdisciplinary nature of the field, examining the wide range of concepts, theories, methods, and models that shape spatially oriented approaches to the social sciences.

Organized into seven major thematic domains (Space and time; Actors and society; Goods and markets; Services and economy; Transport and interactions; Governance and policy; and Methods and techniques), the Encyclopedia covers a vast range of topics such as location theory, land use, regional disparities, urban systems, environmental sustainability, innovation ecosystems, transport and mobility, spatial econometrics, governance structures, and place-based policy approaches. Entries are designed to be accessible yet rigorous, offering definitions, analytical perspectives, and insights into emerging research trajectories.

Acclaimed by leading figures such as Paul Krugman[1] and Saskia Sassen[2], the Encyclopedia highlights the dynamism and global relevance of regional science, capturing both advanced and emerging world contexts. It serves as an essential resource for students, scholars, policymakers, and professionals working in urban and regional economics, human geography, spatial planning, environmental studies, transportation, and related fields.

Rich in scope and analytical depth, the *Thematic Encyclopedia of Regional Science* stands as a definitive guide to understanding the spatial dimensions of contemporary economic, social, and environmental transformations.

More information can be found at the URL:
https://www.e-elgar.com/shop/gbp/thematic-encyclopedia-of-regional-science-9781800379275.html?srsltid=AfmBOoprzxKTF3-NEWRsM5IFSKVc_2jTw5E6AspXa_b_7dyYTntA5jnG

Book Review by Dimitrios Tsiotas,
Assistant Professor, RSI J

[1] *"In recent decades Regional Science has shown amazing dynamism all over the world. It has turned into a great collection of place-based analytical knowledge on the functioning of cities and regions. This Encyclopedia is the first of its kind synthesizing the multi-faceted body of knowledge on the economic and social geography of our world in a systematic and thematic way".*

[2] *"The world of Regional Science covers a wide array of disciplinary approaches; it offers an amalgam of many scientific perspectives, often of a pluriform or contradictory nature. In light of the prevailing panoramic images of Regional Science, this thematic Encyclopedia provides a refreshing and coherent mapping of the complex field of Regional Science. This ambitious opus is relevant not only for the OECD part of our contemporaneous world, but also for the global South. This book is a rich and original source of synthetic information for anyone involved in spatial, urban, regional, environmental, demographic or socio-economic dimensions of our modern global economy".*

GUIDELINES

for the Writers & a format model for the articles submitted to be reviewed & published in the journal

Regional Science Inquiry Journal

(EconLit, Scopus, RSA I) – www.rsijournal.eu

Guidelines for the Writers & a format model for the articles submitted to be reviewed & published in the journal

The Title of the paper must be centered, and the font must be Times New Roman, size 12, in Uppercase, in Bold

For the writers' personal information use the Times New Roman font, size 11, in bold, and centered. Use lowercase for the first name and uppercase for the last name. The line below the name includes the professional title and workplace; use the Times New Roman font, size 10, centered. In the third line write only the contact e-mail address in Times New Roman 10, centered.

Name LAST NAME
Professional Title, Workplace
E-mail Address

Name LAST NAME
Professional Title, Workplace
E-mail Address

Abstract

The abstract consists of a single paragraph, no longer than 250 words. The font must be Times New Roman, size 11. The text must be justified. The title "Abstract" must be aligned left, in Times New Roman, size 11, in bold. A space of one line must be left between the title and the text of the abstract. The abstract must contain sufficient information, be factual, and include the basic data of the paper.

Keywords: Use 3 to 5 keywords, separated by commas

JEL classification: We kindly request that you classify your paper according to the JEL system, which is used to classify articles, dissertations, books, book reviews, and a variety of other applications. The use of the JEL classification is necessary so that your paper be properly indexed in databases such as EconLit. Select the codes that represent your article and separate them by commas. You can find information on the JEL system here: https://www.aeaweb.org/jel/guide/jel.php

1. Introduction

All articles must begin with an introduction, a section which demarcates the theoretical background and the goals of the paper.

The present document provides the necessary information and formatting guidelines for you to write your article. We recommend that you copy this file to your computer and insert your own text in it, keeping the format that has already been set. All the different parts of the article (title, main text, headers, titles, etc.) have already been set, as in the present document-model. The main text must be written in regular Times New Roman font, size 11, justified, with a 0.5 cm indent for the first line of each paragraph.

We recommend that you save this document to your computer as a Word document model. Therefore, it will be easy for you to have your article in the correct format and ready to be submitted. **The only form in which the file will be accepted is MS Word 2003**. If you have a later version of Microsoft Office / Word, you can edit it as follows:

- Once you have finished formatting your text, create a pdf file, and then save your file as a Word "97-2003" (.doc) file.

- Compare the two files – the pdf one and the Word "97-2003" (.doc) one.
- If you do not note any significant differences between the two, then – and only then – you can submit your article to us, **sending both the pdf and the Word "97-2003" (.doc) files** to our e-mail address.

If you use a word processor other than Microsoft Word, we recommend that you follow the same procedure as above, creating a pdf file and using the appropriate add-on in order to save your document in MS Word "97-2003" (.doc) form. Once you compare the two files (and find no significant differences), send us both.

2. General Guidelines on Paper Formatting

2.1. Body

The body of the text consists of different sections which describe the content of the article (for example: Method, Findings, Analysis, Discussion, etc.). You can use up to three levels of sections – sub-sections. For the Body of the text, use the default format style in Word, selecting the Times New Roman font, size 11, justified, with a 0.5 cm indent for the first line of each paragraph (this is further detailed in the section "Paragraphs").

2.2. References

The references included in the paper must be cited at the end of the text. All references used in the body of the paper must be listed alphabetically (this is further detailed in the section "References").

2.3. Appendices

The section "Appendices" follows the section "References".

3. Page formatting

3.1. Page size

The page size must be A4 (21 x 29,7 cm), and its orientation must be "portrait". This stands for all the pages of the paper. "Landscape" orientation is inadmissible.

3.2. Margins

Top margin: 2,54cm
Bottom margin: 1,5cm
Left and right margins: 3,17cm
Gutter margin: 0cm

3.3. Headers and Footers

Go to "Format" → "Page", and select a 1,25cm margin for the header and a 1,25cm margin for the footer. Do not write inside the headers and footers, and do not insert page numbers.

3.4. Footnotes

The use of footnotes or endnotes is expressly prohibited. In case further explanation is deemed necessary, you must integrate it in the body of the paper.

3.5. Abbreviations and Acronyms

Abbreviations and acronyms must be defined in the abstract, as well as the first time each one is used in the body of the text.

3.6. Section headers

We recommend that you use up to three sections – sub-sections. Select a simple numbering for the sections – sub-sections according to the present model.

3.7. First level header format

For the headers of the main sections use the Times New Roman font, size 11, in bold and underlined, and leave a size 12 spacing before the paragraph and a size 6 spacing after the paragraph. The header must be aligned left. Use a capital letter only for the first letter of the header.

3.8. Second level header format

For second level headers, follow this model. Use the Times New Roman font, size 11, in bold, and leave a size 12 spacing before the paragraph and a size 3 spacing after the paragraph. Select a 0.5 cm indent. The header must be aligned left. Use a capital letter only for the first letter of the header.

3.8.1. Third level header

For third level headers, follow this model. Use the Times New Roman font, size 11, in bold and italics, and leave a size 6 spacing before the paragraph and a size 0 spacing after the paragraph. The header must be aligned left, with a left indent of 1 cm. Use a capital letter only for the first letter of the header.

4. Paragraphs

In every paragraph, use the Times New Roman font, size 11, with single line spacing. We recommend you modify the default (normal) format style in Word and use that in your text. For all paragraphs, the spacings before and after the paragraph must be size 0, and the line spacing single. Use a 0,5cm indent only for the first line of each paragraph. Leave no spacings nor lines between paragraphs.

4.1. Lists

In case you need to present data in the form of a list, use the following format:

- Bullet indent: 1,14cm
- Text:
    - Following tab at: 1,5 cm
    - Indent at: 1,5cm

Use the same format (the above values) if you use numbering for your list.

1. Example of numbered list 1
2. Example of numbered list 1

5. Figures, images, and tables

5.1. Figures and images

Insert your figures and images directly after the part where they are mentioned in the body of text. They must be centered, numbered, and have a short descriptive title.

Figures put together "as they are", using Office tools, are absolutely inadmissible. The figures used must have been exclusively inserted as images in Word, in gif, jpg, or png form (with an analysis of at least 200dpi), and in line with the text. The width of an image must not exceed 14,5cm so that it does not exceed the margins set above.

The images, figures, and tables must be inserted "as they are" in the text, in line with it. **Figures and images which have been inserted in a text box are absolutely inadmissible.**

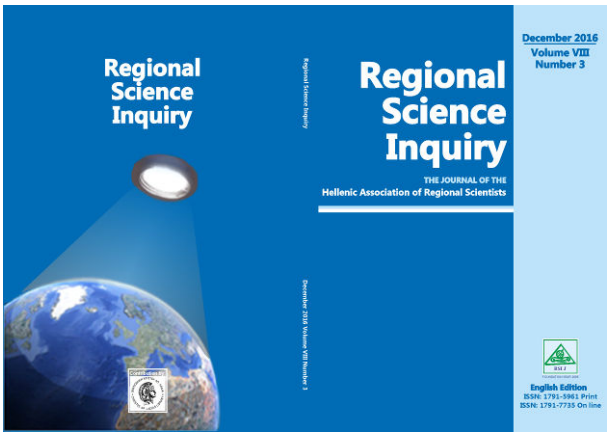
5.1.1. Reference inside the text

Avoid phrases such as "the table above" or the "figure below" when citing figures and images. Use instead "in Table 1", "in Figure 2", etc.

5.1.2. Examples

A model of how to format figures/images follows. For the title, use the Times New Roman font, size 10, in bold. Write the title above the figure, and set a size 6 spacing before the title and a size 0 spacing after it. The line spacing of the title must be 1.5 line. Both the image and its title must be centered.

Image 1: Title



Source: cite the source

Directly below the figure you must cite the source from which you took the image, or any note regarding the figure, written in Times New Roman, size 10. Write it below the figure, leaving a size 0 spacing before and after it, use a line spacing of 1.5 line, and make it centered.

5.2. Tables

For the title, use the Times New Roman font, size 10, in bold. Write the title above the table, and set a size 6 spacing before the title and a size 0 spacing after it. The line spacing of the title must be 1.5 line. Both the table and its title must be centered. The width of the table must not exceed 14,5cm so that it does not exceed the page margins set.

Table 1. Example of how a table must be formatted

Age	Frequency	Percentage %
Under 40	44	32.1
40 - 49	68	49.6
Over 50	25	18.2
Total	**137**	**100.0**

Source: cite the source

If the table needs to continue on the next page, select in the "Table properties" that the first line be repeated as a header in every page, as in the above example of Table 1. **Tables (or figures or images) which are included in pages with a "Landscape" orientation are absolutely inadmissible.**

Every table must have horizontal lines 1 pt. wide at the top and bottom, as shown in the example. The use of vertical lines and color fill at the background of the cells is strictly prohibited.

Directly below the table you must cite the source or any note regarding the table, written in Times New Roman, size 10. Write it below the table, leaving a size 0 spacing before and a size 6 spacing after it, and make it centered.

6. Mathematical formulas

There is a variety of tools in order to insert and process mathematical formulas, such as the "Mathematics", found in the most recent editions of Word, "Math Type", "Fast Math Formula

Editor", "MathCast Equation Editor", "Math Editor". Since it is impossible for us to provide you with compatibility with all these tools in all their editions, **we can only admit your paper if it contains mathematical formulas solely in the form of images.**

Keep a continuous numbering for the mathematical formulas and center them in the page, as shown in the following example:

$$y = ax^2 + bx + c \tag{1}$$

The same stands for formulas or particular mathematical symbols you may have integrated in your text. For instance, if you want to use the term ax^2 in your text, you must insert it as an imaged, in line with the text. The images containing the mathematical formulas must be legible (at least 300dpi).

In the exceptional case of a text which may contain a great number of mathematical formulas, the writer may send it to us in TeX form if they so wish.

7. References

We recommend that you use the Chicago Manual of Style Author-Date system, as it is recommended by the AEA (American Economic Association) for the journals included in the EconLit database, and it is the dominant style of bibliography in the field of Economics. For more information you can go to the following links:

- https://www.aeaweb.org/journals/policies/sample-references
- http://www.chicagomanualofstyle.org/tools_citationguide.html
- http://libguides.williams.edu/citing/chicago-author-date#s-lg-box-12037253

7.1. Online references (internet citations)

Check your links again before sending your file, to confirm that they are active.

Avoid long internet links. Where possible, also cite the title of the website operator-owner. Return the font color to black, and remove the hyperlink. Links such as the following are impractical and distasteful, therefore should be avoided.

Example of an inadmissible hyperlink

https://el.wikipedia.org/wiki/%CE%9F%CE%B9%CE%BA%CE%BF%CE%BD%CE%BF%CE%BC%CE%B9%CE%BA%CE%AC

7.2. References Formatting

For your list of references, use the Times New Roman font, size 10, with single line spacing. The paragraph format must include a size 0 spacing before the paragraph and a size 0 spacing after it, aligned left. Use a 0,5 cm indent only for the first line of each paragraph. Leave no spacings or lines between paragraphs.

7.3. Example of how References must be formatted

Bureau of Labor Statistics. 2000–2010. "Current Employment Statistics: Colorado, Total Nonfarm, Seasonally adjusted - SMS08000000000000001." United States Department of Labor. http://data.bls.gov/cgi- bin/surveymost?sm+08 (accessed February 9, 2011).

Leiss, Amelia. 1999. "Arms Transfers to Developing Countries, 1945–1968." Inter-University Consortium for Political and Social Research, Ann Arbor, MI. ICPSR05404-v1. doi:10.3886/ICPSR05404 (accessed February 8, 2011).

Romer, Christina D., and David H. Romer. 2010. "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks: Dataset." American Economic Review. http://www.aeaweb.org/articles.php?doi=10.1257/aer.100.3.763 (accessed August 22, 2012).

Ausubel, Lawrence M. 1997. "An Efficient Ascending-Bid Auction for Multiple Objects." University of Maryland Faculty Working Paper 97–06.

Heidhues, Paul, and Botond Kőszegi. 2005. "The Impact of Consumer Loss Aversion on Pricing." Centre for Economic Policy Research Discussion Paper 4849.

Zitzewitz, Eric. 2006. "How Widespread Was Late Trading in Mutual Funds?" http://facultygsb.stanford.edu/zitzewitz.