Regional Science Inquiry

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Contents

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

Regional Science Inquiry, Vol. XVII, (1), 2025
Editorial Note

In the first semester of 2025, the Regional Science Inquiry Journal (RSIJ), a scientific journal published under the aegis of the Hellenic Association of Regional Scientists, launched the first issue (1) of its seventeenth volume (Vol. XVII) since its first day of publication.

RSIJ is an international, open-access, peer-reviewed journal publishing research across the broad and multidisciplinary field of Regional Science. The journal aims to promote global academic dialogue in Regional Science by supporting scientific inquiry and advancing high-quality empirical, methodological, and theoretical contributions. RSIJ acts as a platform for scholars, researchers, policymakers, and practitioners to exchange insights on regional development and its various aspects. According to the SCImago journal rank database, the RSIJ improved its ranking in 2024 and is now included in the Q2 quartile of the "Sociology and Political Science" category. The RSIJ community thanks the Editor-in-Chief, the Editorial Board, its Reviewers, Authors, and Readership for this achievement. Dedicated to its high standards and values, RSIJ will pursue improvement.

This current issue (RSIJ, Vol. XVII, (1), 2025) presents 9 papers that were carefully selected to meet the journal's high standards. These papers cover traditional and contemporary topics in Regional Science, such as spatial disparities, regional demographics, marginalized areas, and comparative advantages in production, input-output models, direct investments and economic growth, sustainability, climate change awareness and tourism, gas emissions, and waste management, and are described in brief as follows:

The first paper, titled "SPATIAL DISPARITIES IN THE EUROPEAN UNION: A MACROSCOPIC REVIEW", authored by Serafeim POLYZOS and Dimitrios TSIOTAS, analyzes and reviews the root causes of inequalities in Europe, along with the policies designed to mitigate them, and the future obstacles in achieving a more united and socially just European Union. In the unique confederation context of the EU, where economic cohesion, inequalities reduction between Member States, and balanced development pose significant challenges, the paper reveals significant inequalities among European countries, highlighting that countries can still be classified as "industrial" and "developed", whereas others remain in the "less developed" stature, as differences are still immanent in terms of prosperity, development levels, production patterns, technology, education level, and population concentrations.

The second paper, titled "HOW DOES GLOBAL AND LOCAL CLIMATE CHANGE AWARENESS INFLUENCE TOURISTS' WILLINGNESS TO CONTRIBUTE TO ENVIRONMENTAL SOLUTIONS?", authored by Angeliki, N. MENEGAKI, and Can Tansel TUGCU, investigates the influence of both global and local climate change awareness on tourists' willingness to contribute, either financially or through time donations, to climate change mitigation efforts. Drawing on survey data from 650 respondents, the findings indicate that global awareness significantly enhances tourists' propensity to take action, whereas local awareness exerts no statistically significant effect. Tourists who recognize the global dimensions of climate change are more inclined to support environmental initiatives within their home country. These results suggest that promoting a broader, global understanding of environmental issues is more effective in fostering pro-environmental behavior among tourists than focusing on localized impacts. The implications for policymakers regard giving an emphasis on global environmental awareness to promote sustainable tourism, integrating global climate education into tourism programs, and providing accessibility.

The third paper, titled "GRADUALLY SHIFTING THE NATIONAL PRODUCTION MODEL'S CENTER OF GRAVITY: INVESTING IN REGIONAL COMPARATIVE ADVANTAGES FOR DEMOGRAPHIC RESTRUCTURING", authored by Theodoros DIMOPOULOS, Aristi TSOKANI, Christos GENITSAROPOULOS, Georgios XANTHOS, Angeliki MENEGAKI, Eleni KAPRELI, and Nikolaos STRIMPAKOS, portrays the demographic trajectory both at an EU and at a national level, coupled with providing at a certain extend insights about relevant projections, and emphasizes on the case of the Regional Unity of Fthiotida (Greece) and the depopulation recorded between 2011-2021, while it describes Central Greece's current tourism performance and its impact in terms of economic indicators. Building on a review and content analysis of current literature, the paper aims to provide various insights towards promoting current public discourse on the necessity of the effective utilization of the region's natural thermal resources, concluding with the well-founded assumption that exploiting Fthiotida's natural resources in terms of thermal/hot springs, as a complementary component, may contribute to the creation of an integrated tourism product, able to support regional economy, enforce the argument of gradual shifting the country's productive model center of gravity, and establish conditions that may put a curb on population bloodletting.

The fourth paper, titled "EFFICIENCY OF THE WASTE MANAGEMENT SYSTEM AS A PRECONDITION FOR THE REGIONAL SUSTAINABILITY OF THE ISLANDS", authored by Antonio DEKANIĆ, Marinela KRSTINIĆ NIŽIĆ, and Christos Ap. LADIAS explores tourists' views on the islands' waste management systems through qualitative research and in-depth expert interviews with the utility companies of the Croatian islands. The paper aims to expand the understanding and

explore the principles of waste management on the Croatian islands and evaluate their effectiveness. The paper analyzes the established waste management systems and examines whether effective waste management can make the island sustainable, providing a widely applicable model that is expected to contribute to political decision-makers, decision-makers in utility companies and managers, creators of measures and regulations regarding waste management, representatives of municipalities and cities of island tourist destinations.

The fifth paper, titled "STABLECOIN DP2P: INNOVATION AND SUSTAINABILITY IN FIAT CURRENCIES", authored by Fernando TEIXEIRA, Susana Soares Pinheiro Vieira PESCADA, Christos Ap. LADIAS, Murat HULAJ, Filipos RUXHO, and Valter MACHADO, investigate the potential of decentralized stablecoins (dP2P) as financing mechanisms and currency stabilizers in developing economies. It applies a quantitative, exploratory, and correlational approach, based on the hypothetical-deductive method, to data from the period 2010 – 2020 to examine the main hypothesis that dP2P offers greater exchange rate stability compared to fiat currencies in emerging economies. Applying simple moving averages (SMA) to assess exchange rate volatility and compare the performance of dP2P with traditional currencies, the analysis reveals that during the analyzed decade, several fiat currencies experienced significant depreciations, while dP2P exhibited lower volatility. The main study provides an empirical validation of stablecoins, as a viable alternative to mitigate exchange rate volatility in emerging economies, and the introduction of SMA, as an effective tool for analyzing the stability of crypto assets, expanding the application of statistical methods in evaluating decentralized finance (DeFi).

The sixth paper, titled "A MODULARITY DECOMPOSITION MODEL OF EVOLVING INPUT-OUTPUT SECTORIAL STRUCTURE", authored by Dimitrios TSIOTAS, Elias GIANNAKIS, and Christos PAPADAS, builds on the network paradigm to model the evolving input-output (IO) economic structure of Greece into a multiplex network (GION) and reveals structural changes from 2005 to 2015, particularly relating to the 2008 economic crisis. The results illustrate some interesting structural properties of the GION, with a major finding describing that the tourism industry is dynamic more due to its dependence on supportive economies than intrinsic industrial productivity. The structural analysis provides insights into distinguishing three stages in the GION's evolution: the pre-crisis (2005-2007), the on-crisis (2008-2010), and the post-crisis (2011-2015) periods, each described by distinct structural characteristics. The analysis also reveals a diversified configuration in the Greek economy compared to the three-sector classical breakdown, composed of "tourism" and "transportation and energy" sector-like components, and the traditional secondary and tertiary sectors, and reveals solid and fragment-favorable economic interactions in the GION's structure.

The seventh paper, titled "FOREIGN DIRECT INVESTMENT IN REAL ESTATE IN ALBANIA AND ITS IMPACT ON GDP", authored by Antoneta POLO, Enkela CACA, Ilirjana ZYBERI, Christos Ap. LADIAS, and Filipos RUXHO, examine the relationship between real estate FDI and Gross Domestic Product (GDP) in Albania over a five-year period, analyzing whether foreign investment in the real estate sector has acted as a driver of economic growth or merely reflected broader macroeconomic trends. The empirical findings suggest that FDI in real estate (RE) has had a positive contribution to GDP growth, particularly through increased urban development and rising property values in key economic centers like Tirana and coastal cities. The study emphasizes the need for strategic reforms to enhance the benefits of real estate FDI while mitigating risks associated with speculative activities, providing valuable insights for policymakers,

The eighth paper, titled "NET JOBS GENERATION AND NET GHG EMISSIONS REDUCTION FROM PARTIAL REPLACEMENT OF FOSSIL FUELS WITH RENEWABLE ENERGY SOURCES IN SOUTHERN BRAZIL", authored by Gustavo FERRO, M. Priscila RAMOS, and Carlos A. ROMERO, explores the reach of net job creation and net emissions reduction from the partial substitution of conventional (fossil) energy sources by renewables in Southern Brazil. The paper examines a subset of renewable energy sources, namely, biogas, and applies input-output analysis to account for production and industrial chain relationships, ordering information, and tracing the interrelations between industries. The analysis considers different scenarios of fossil fuel substitution by biogas and determines values for net job creation and net emissions generation, highlighting the favorable impacts of the development of biogas to produce electricity generation in terms of greater production and net job creation while saving GHG emissions.

Last but not least, the ninth paper, titled "MARGINALISED ZONES AS STATISTICAL INSTRUMENTS TO NAVIGATE PERMACRISIS IMPACTS IN EUROPEAN REGIONS", authored by Cristina LINCARU, Gabriela TUDOSE, Adriana GRIGORESCU, Speranța PÎRCIOG, and Cristina STROE, explores the ways marginalized areas can be conceptualized and operationalized through spatial statistical methodologies and policy frameworks that support just transition processes. Drawing on a critical review of empirical studies and strategic European and Romanian documents, the analysis synthesizes the main tools used to identify territorial disparities, such as Principal Component Analysis (PCA), clustering algorithms, fuzzy logic, spatial econometrics, and machine learning, observing that these methods allow for more nuanced territorial diagnostics and typologies, which are essential for evidence-based and place-based policies. The paper argues for the paradigm shift from periphery to

policy, where marginalized regions evolve from passive recipients of aid to active instruments of just transition.

All these interesting works are available on the next pages of the RSIJ intending to promote the academic dialogue in Regional Science. Overall, the Editor in Chief, Prof. Christos Ap. Ladias, the Editorial Board, and the signatory 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

SPATIAL DISPARITIES IN THE EUROPEAN UNION: A MACROSCOPIC REVIEW

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Abstract

The European Union (EU) is a unique and challenging project aimed at integrating countries with diverse languages, cultures, and histories. While economic cohesion is a key objective, reducing inequalities between Member States and ensuring balanced development for all citizens remains a significant challenge. Despite the progress made, Europe continues to face considerable geographical and economic disparities, impacting living standards, productive capacity, and technological advancement. Analyzing these inequalities, their determinants, and their mitigating policies is crucial for understanding the EU's challenges. The allocation of EU financial resources and strategic initiatives, such as the Structural Funds, strive to reduce disparities and promote social cohesion, while also tackling emerging issues such as migration and reliance on public expenditure. This article reviews the root causes of inequalities in Europe, the policies designed to mitigate them, and the future obstacles in achieving a more united and socially just European Union.

Keywords: spatial inequalities; European Union's enlargements; economic indicators; European growth; cohesion.

JEL classification: O18, R11, I38, D63, F15

1. Introduction

The European Union (EU) is a unique confederation project that seeks to unite states with different languages, cultures, and historical backgrounds (McCormick, 2020). Despite the current progress achieved in terms of economic, social, and territorial integration, there remain significant spatial disparities between Member States, which affect the cohesion and prosperity of the Union (Tsiotas and Tselios, 2024). These disparities are reflected in various macroeconomic indicators (Ladias et al., 2023) such as GDP per capita, high-skilled employment, Research and Development (R&D) expenditure, high-tech exports and the number of patent applications (Polyzos, 2019). The study of the spatial distributions of these indicators provides insights into the comprehension of the underlying dynamics ruling geographical patterns of development in the EU (Martin, 2009). In particular, the identification of areas with a high concentration of economic activity, technological development and innovation, reveals the intensity of disparities (Iammarino et al., 2019; Polyzos, 2019), which are not limited to economic aspects, but also extend to social, territorial and institutional dimensions. The study of spatial disparities (Constantin and Volintiru, 2024) is a major challenge for the EU, undermining cohesion and putting pressure on development policies (Iammarino et al., 2019; Fratesi, 2023). In this context, the study of spatial disparities is extremely important, as it identifies areas lagging behind in key areas and allows for the formulation of targeted cohesion policies. Through the empirical knowledge it provides, it orients towards a mix of more effective regional policies (Polyzos, 2019; Fratesi, 2023), contributing to sustainable development (Sepetis, 2024), serving fairness, enhancing the long-term competitiveness of the Union, and promoting the economic, social, and territorial cohesion requirements (Tsiotas and Tselios, 2024). Moreover, it provides a useful tool for anticipating and managing future crises, ensuring resilience (Xanthos and Dulufakis, 2023; Tsiotas and Katsaiti, 2024) and balance in regional strategies. Within this context, this paper undertakes a macroscopic study of socioeconomic indicators socio-economic indicators

across the countries of the European Union and close to the BREXIT period, aiming to comprehensively delineate spatial inequalities within the EU. Furthermore, through this macroscopic analysis, the paper seeks to deepen the understanding of the economic, social, and geographical dimensions of the regional disparities in Europe. This deeper insight aspires to inform the development of more effective cohesion policies inspired by this enhanced knowledge.

2. THE HISTORICAL FRAMEWORK OF EU

The conclusion of World War II divided Europe into two major political and social systems (Polyzos, 2019): Central and Western Europe, characterized by a mixed economic system, and Eastern Europe, defined by a centrally planned economy. With the political changes in Eastern Europe and the dissolution of this division in the early 1990s (Bideleux and Taylor, 2002), the concepts of the European Space and the European Union (EU) began to be used interchangeably. This overlap is largely due to the strong economic and political relationships between the EU and non-Member States (Eriksen and Fossum, 2015), fostering the integration of these ideas. The EU's primary objective is to ensure peace and prosperity for its people by fostering economic and political union (Polyzos, 2019; Iammarino et al., 2019; Fratesi, 2023). Member States have committed to this goal by cooperating within the framework of the Union (Polyzos, 2019).

Historically, the EU is a confederation of twenty-eight (28) states, formally established in 1992 through the Maastricht Treaty on the European Union. However, its origins date back to the 1950s with the establishment of the European Coal and Steel Community (ECSC) by West Germany, France, Italy, Luxembourg, the Netherlands, and Belgium (Lee, 2004; Glockner and Rittberger, 2012), as it is shown in Table 1. This community was formalized by the Treaty of Paris, signed in 1951 (Roos, 2017), widely regarded as the starting point of the EU's history. The primary objectives of this initiative were both political and economic. On the economic perspective, the focus was on fostering growth through industrial and energy integration (Glockner and Rittberger, 2012; Polyzos, 2019; Papadimitriou et al., 2023). Politically, the initiative sought to end conflicts in Europe, particularly in light of the recent devastation of World War II, by ensuring peaceful coexistence among European nations and contributing to global order and security. Additional political aims included safeguarding human rights, strengthening democracy, and promoting freedom, justice, legality, and popular sovereignty (Polyzos, 2019). These goals were intrinsically linked to achieving material prosperity, economic cohesion among states, scientific and technological progress, and a dedication to principles of cooperation and mutual understanding. In the same decade, the Treaty of Rome (1957) established the European Economic Community – EEC (Lee, 2004), which created the first full customs union, as well as the European Atomic Energy Community (EURATOM) to support cooperation in the use of nuclear energy (Cusack, 2003; Polyzos, 2019). In 1967, the EEC, ECSC, and EURATOM merged to form the European Community (Polyzos, 2019).

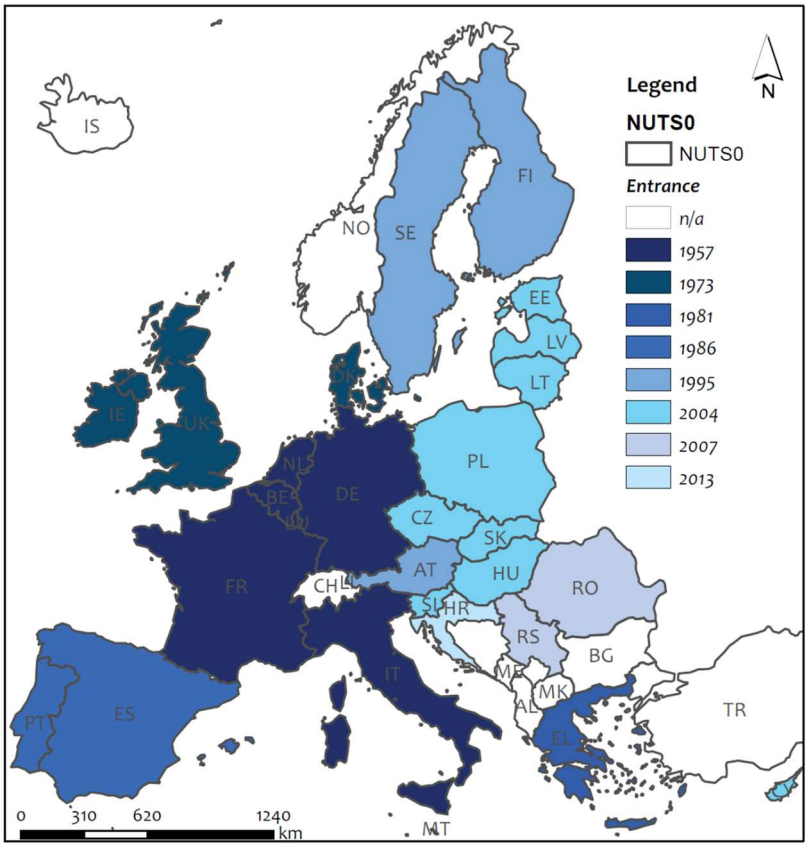
Table 1

Year	Member States	No. of Members
1957	Belgium, France, Germany1 , Italy, Luxembourg, Netherlands, France	6
1973	Denmark2 , Ireland, United Kingdom	9
1981	Greece	10
1986	Portugal, Spain	12
1995	Austria, Finland, Sweden	15
2004	Cyprus, Czech Republic, Slovakia, Estonia, Latvia, Lithuania, Poland, Hungary, Malta, Slovenia, Latvia, Lithuania,	25
2007	Bulgaria, Romania	27
2013	Croatia	28
2016	UK decision to leave the EU	27

The history of the successive EU enlargements

In 1973, the EEC expanded (Figure 1) to include Denmark, Ireland, and the United Kingdom (Polyzos, 2019). The first direct elections to the European Parliament followed in 1979 (Lodge and Herman, 1982; Roos, 2019). From the 1980s onward, the EU experienced successive "waves" of enlargement, alongside an extension of its competences (Polyzos, 2019). During the 1980s, Greece, Spain, and Portugal became members. In 1985, the Schengen Treaty was signed, enabling the abolition of systematic border controls among participating countries (O'Keeffe, 1991; Davis and Gift, 2014). In 1986, the EU adopted its flag (Foret, 2009), featuring twelve stars, representing the original Member States that signed the 1992 Treaty, on a blue background. Additionally, the Single European Act was signed that year.

Figure 1



A map with the successive expansions of the EU's growth history

The reunification of Germany in 1990 led to East Germany joining the EU as part of a unified Germany (Anderson, 1999). With enlargement toward Eastern Europe now a priority, the Copenhagen criteria for new member admission were established (Polyzos, 2019). The EU was formally founded on 1 November 1993, following the enforcement of the Maastricht Treaty in 1992 (Holmes, 1993). In 1995, Austria, Sweden, and Finland joined the EU (Breuss, 2003), and the Treaty of Amsterdam was signed in 1997 (Shaw, 1998). The euro (€) was introduced as a common currency in 1999, initially adopted by 11 Member States, creating what became known as the EUROZONE (Iversen, 2016; Polyzos, 2019). In 2004, a European Constitution was signed in Rome (Piris, 2006), but it was not fully ratified after being rejected in French and Dutch referendums. To address this, the 2007 Reform Treaty amended parts of the Constitution without replacing all existing treaties (Polyzos, 2019). Bulgaria and Romania joined the EU in 2007 (McKee et al., 2007; Andreev, 2009), as it is shown in Figure 1, and Slovenia adopted the euro (Banerjee et al., 2011). The euro's adoption continued with Cyprus and Malta in 2008 (Polyzos, 2019) and Slovakia in 2009 (Gabrisch and Kampfe, 2013). In 2013 Croatia jointed the EU (Maldini, 2016). By that time, the euro had become the official currency in 19 of the 28 Member States (Polyzos, 2019). Today, it is used by 20 of the 27 Member States (Polyzos, 2019; Bulmer and & Lequesne, 2020), forming the euro area or EUROZONE, which includes Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France,

Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

The EU is considered the most robust union of states in world history, characterized by its economic, political, social, and cultural dimensions, and it continues to pursue European integration (Polyzos, 2019; Giannakis et al., 2024; Tsiotas and Tselios, 2024). Covering a total area of 4,324,782 km², with a population density of 112 inhabitants/km², and 23 official languages (Polyzos, 2019), the EU is one of the largest economic and political entities globally. In 2017, the EU had a total population of 493 million and a combined nominal GDP of €15.3 trillion (Polyzos, 2019). Although the EU represents just 6.9% of the world's population, it accounts for approximately 15.6% of global trade in exports and imports (Polyzos, 2019). Alongside the USA and China, it is a leading global trade player (Men et al., 2019). Notably, in 2016, EU Member States held the second-largest share of global goods imports and exports (Polyzos, 2019).

As a single market, the EU maintains a unified trade policy, a common agricultural (Gray, 2000; Martinho, 2023; Tsiotas and Tselios, 2024) and fisheries policy (Symes, 1997), and a regional policy (Hooghe and Keating, 1994; Fratesi and Wishlade, 2017) aimed at developing its least developed areas. While the EU has no official capital, Brussels is often seen as its de facto capital due to the concentration of its main institutions there (Polyzos, 2019). Originally, an economic union aimed at establishing a single European market, the EU now encompasses diverse activities and objectives, including ensuring the free movement of people, goods, services, and capital. At the political level, the EU seeks to foster European citizenship and political life (Smith, 1992; Mikkeli, 1998), granting citizens the right to vote in local government and European Parliament elections in any Member State. The European Parliament actively promotes pan-European political parties, with almost all Member States participating in federations of national political parties.

On 23 June 2016, the United Kingdom voted to leave the EU in a referendum (Goodwin and Heath, 2016; Clarke et al., 2017), with 51.9% of voters supporting Brexit. Since 1972, when France approved the EEC's enlargement to include Britain, Ireland, and Denmark through a referendum, numerous referendums have been used to balance national legitimacy with European dynamics (Polyzos, 2019).

3. SPATIAL INEQUALITIES IN THE EU

This section macroscopically examines the inequalities persisting within the EU, which are significant and reflect the varying economic levels of its Member States. The substantial disparities between regions within a country or a union of states, such as the EU, pose a major challenge to improving social cohesion and achieving functional integration. The economic differences among European countries represent a significant barrier to the process of European integration (Polyzos, 2019; Tsiotas and Tselios, 2024). Consequently, the wide disparities in development levels among Member States, along with differences in citizens' living standards and overall well-being (Sequeira et al., 2023), hinder the creation of a unified European area. These disparities also impede the development of a shared identity among EU citizens as members of a single entity or as "European citizens" (Polyzos, 2019).

If regional inequalities within the EU persist or worsen, the process of European integration (including economic, social, and territorial cohesion) faces the risk of long-term failure. Such inequalities undermine social consensus (Krupavicius et al., 2024) and prevent the fostering of solidarity between states and their citizens (Polyzos, 2019). The causes of economic inequalities in the EU stem from the functioning of markets and economic systems, as well as the trajectory of European integration (Martin, 2009). This issue has evolved dynamically over time, influenced by the EU's continuous enlargements over the past 20 years and the potential accession of new countries, such as those in the Balkans (Todri et al., 2024) and Turkey (Heidenreich, 2003; Polyzos, 2019; Uzsayilir and Baycan, 2024). The intensity of these inequalities is far greater between Member States than within them, and the differing rates of development across Europe have led to geographically distinct patterns of inequality (Tsiotas and Tselios, 2024). For instance, the economic challenges faced by the "Mediterranean countries" differ from those of the "European North" or the less developed nations of "South-East Europe".

The geographical polarization of inequalities within the EU continues to grow (Tsiotas and Tselios, 2024), partly because new Member States tend to have lower levels of development than the European average and are geographically located on the periphery. Reducing regional disparities is particularly challenging due to the changing size of the EU and the dynamics of its economy and population. The EU has an institutional obligation to address economic disparities among its members (Polyzos, 2019). To this end, significant resources have been allocated in recent years to promote the development of less developed regions, particularly in the newer Member States of Eastern Europe. Various "Structural Funds" and "Cohesion Funds" (Polyzos, 2019; Tsiotas and Tselios, 2024) have been established to address regional disparities and foster development in these regions. Additionally, the EU supports research and technological development through its funding programs (Polyzos, 2019; Ruxho and Ladias, 2022). Other initiatives include emergency aid and financial support for candidate countries to help them meet EU standards. Examples include the PHARE, ISPA, and SAPARD programs, as well as the TACIS program, which supports the Commonwealth of Independent States (Polyzos, 2019).

In this context, this section conducts a macroscopic analysis of inequalities across the EU's regions, drawing on statistical data extracted from Eurostat (2017, 2019). Specifically, it examines demographic and social data of Member States, which indirectly reflect living standards, as well as data on employment, unemployment, productivity, education, and technological development.

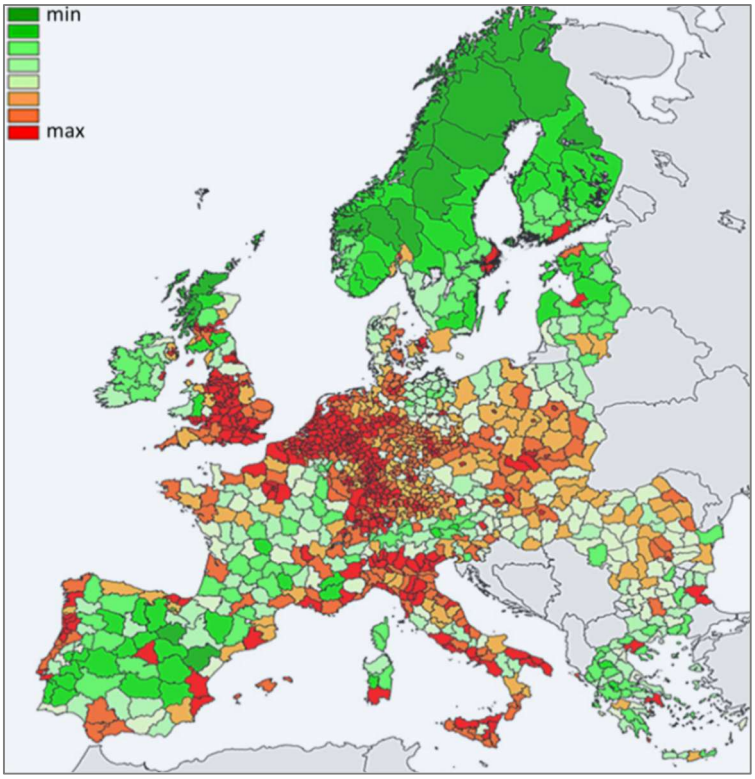
3.1. Population and social characteristics

This section examines some demographic characteristics of the EU Member States and other European countries maintaining economic cooperation and mutual influence with the EU, thus making their demographic profiles relevant. The analysis of these characteristics allows obtaining insights into the demographic profiles of individual nations.

3.1.1. Population Density

Population density is defined as the number of inhabitants per area unit (square kilometer - km^2) in a country (Becker et al., 1999). According to Figure 2 and Figure 3a, countries with high population density are Malta (MT), the Netherlands (NL), Belgium (BE), Luxembourg (LU), and (in some regions) Germany (DE). Conversely, northern European nations, such as Iceland (IS), Finland (FI), Sweden (SE), and Norway (NO), exhibit low population density, primarily due to harsh climatic conditions that make many areas less habitable (Polyzos, 2019). In between, Central France, Central Spain, and Eastern European countries show intermediate density values. The visual representation of European population density in Figure 2 and Figure 3a highlights densely and sparsely populated countries and regions. The population is heavily concentrated along the coasts and in a "corridor" extending from Northern Italy through Germany, the Netherlands, and Belgium to the Southern and Central regions of the United Kingdom. This area is often referred to as the "blue banana" (Polyzos, 2019; Tsiotas and Tselios, 2024).

Figure 2



Europe's millennium population density for NUTS3 regions. The most densely populated areas of Europe are the lowland regions of countries surrounding the North Sea. In contrast, the northernmost parts of the Scandinavian Peninsula are the most sparsely populated. The remaining countries exhibit medium population densities (Sources: IIASA, 2002; Polyzos, 2019).

3.1.2. Population Change

Population change refers to the difference between a country's population at the beginning and end of a specific period (Weber and Sciubba, 2019). It is calculated by the sum of natural population growth and net migration. Figure 3b is computed on 2015–2018 data and reveals significant population increases in countries such as Austria (AT), Malta, Luxembourg, Iceland, Ireland (IE), Sweden, and Montenegro (ME), largely attributable to high immigration rates during the last decade (Polyzos, 2019). In contrast, Bulgaria (BG), Croatia (HR), Latvia (LV), and Lithuania (LT) experienced notable population declines, mainly due to emigration to more developed European countries (Skuflic et al., 2018) in search of employment opportunities.

3.1.3. Life Expectancy at Birth

Life expectancy at birth is defined by the average number of years a newborn is expected to live under current mortality conditions (Bilas et al., 2014; Martin Cervantes et al., 2020). This metric is a vital indicator of living standards and the overall well-being of a country's population (Polyzos, 2019). According to Figure 3c, the average life expectancy across the EU is approximately 81 years, spanning from 75 to 84 years. The gap between the lowest life expectancy (~75 years) and the highest (~84 years) spans approximately nine years.

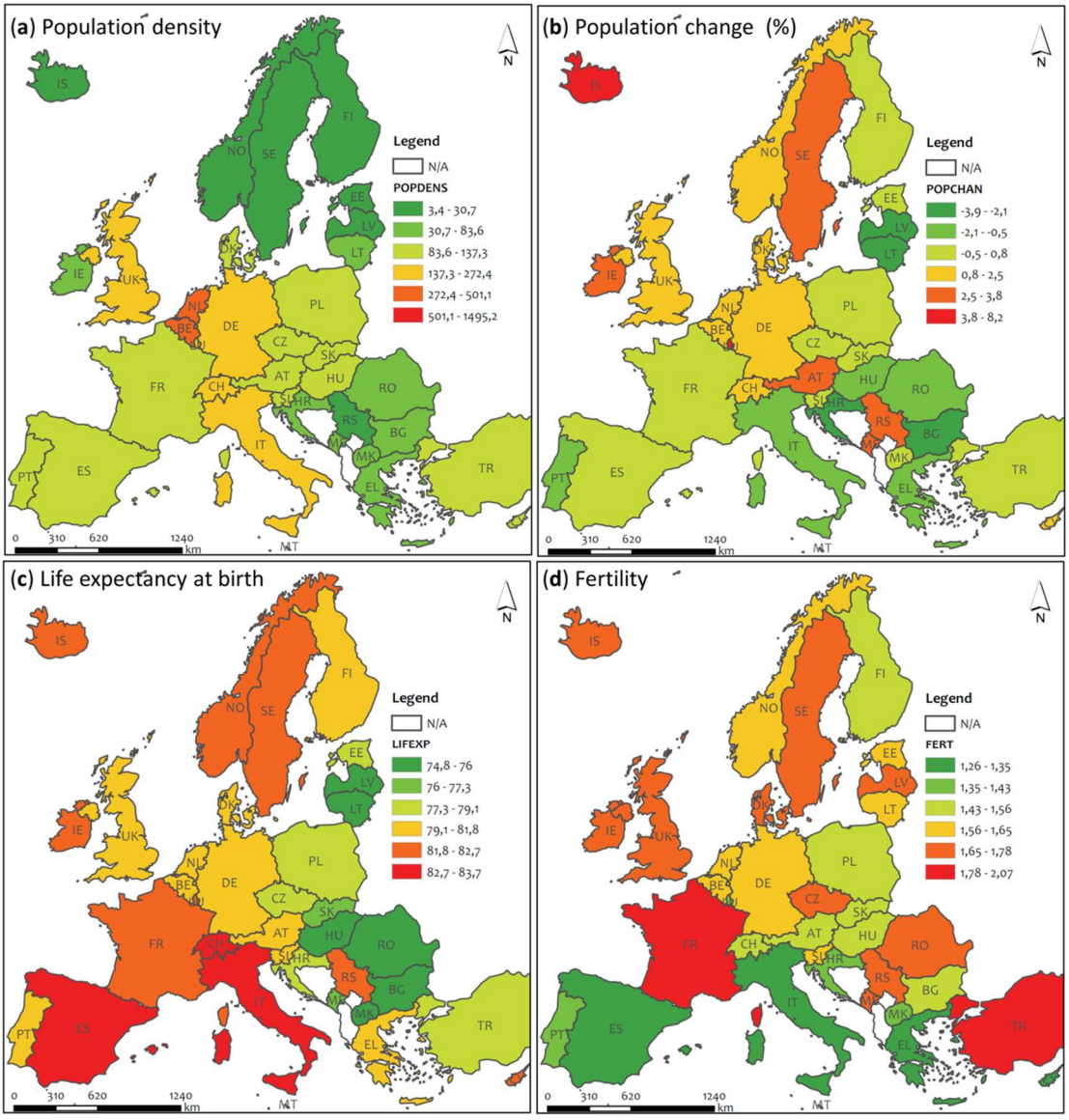
Countries such as Switzerland (CH), Italy (IT), and Spain (ES) are in a more favorable position, while Bulgaria, Latvia, and Lithuania are less favorable. It is evident that the countries in the first group are more economically developed compared to those in the second group, which, rank lower in terms of economic development (Polyzos, 2019). This underscores a positive correlation between a country's life expectancy and its level of development and prosperity.

3.1.4. Total Fertility Rate

The total fertility rate is defined as the average number of children a woman is expected to have during her lifetime. This indicator reflects both the natural replacement rate of the population and each country's prospects for population growth (Lesthaeghe, and Willems, 1999). According to Figure 3d, Turkey (TR), Denmark (DK), Italy, and Montenegro exhibit

the highest fertility rates, while Malta, Spain, Italy, and Cyprus (CY) exhibit the lowest rates. A general observation from the data in Figure 3d is that no clear positive relationship can be established between the level of economic development and the fertility rates of European countries (Polyzos, 2019). Economically developed nations appear in both the high and low fertility rate categories.

Figure 3



Demographic characteristics of the European countries. Reference years: (a) 2017, (b) 2015-2018, (c) 2017, and (d) 2017

3.2. Welfare Level and Standard of Living

A comprehensive understanding of the well-being of European populations, as well as the European average, builds on key indicators that are used to illustrate both the quantitative and qualitative aspects of life (Polyzos, 2019). This section focuses on indicators related to the population at risk of poverty, the inability to acquire basic goods, and poverty due to very low labor intensity.

3.2.1. Population at Risk of Poverty

The “poverty threshold” is a reference level used to estimate the percentage of the population at risk of poverty (Navicke et al., 2014; Polyzos, 2019; Mussida, 2020). This threshold is defined as 60% of the median equivalent total disposable household income, based on the modified OECD equivalence scale (Polyzos, 2019). The calculation considers total net income after taxes and social security contributions. As shown in Figure 4a, Serbia

(RS), Bulgaria, and Romania (RO) exhibit higher poverty rates, placing them in a less favorable position. Conversely, the Czech Republic (CZ) and Iceland perform better on this indicator, with lower percentages of their populations at risk of poverty.

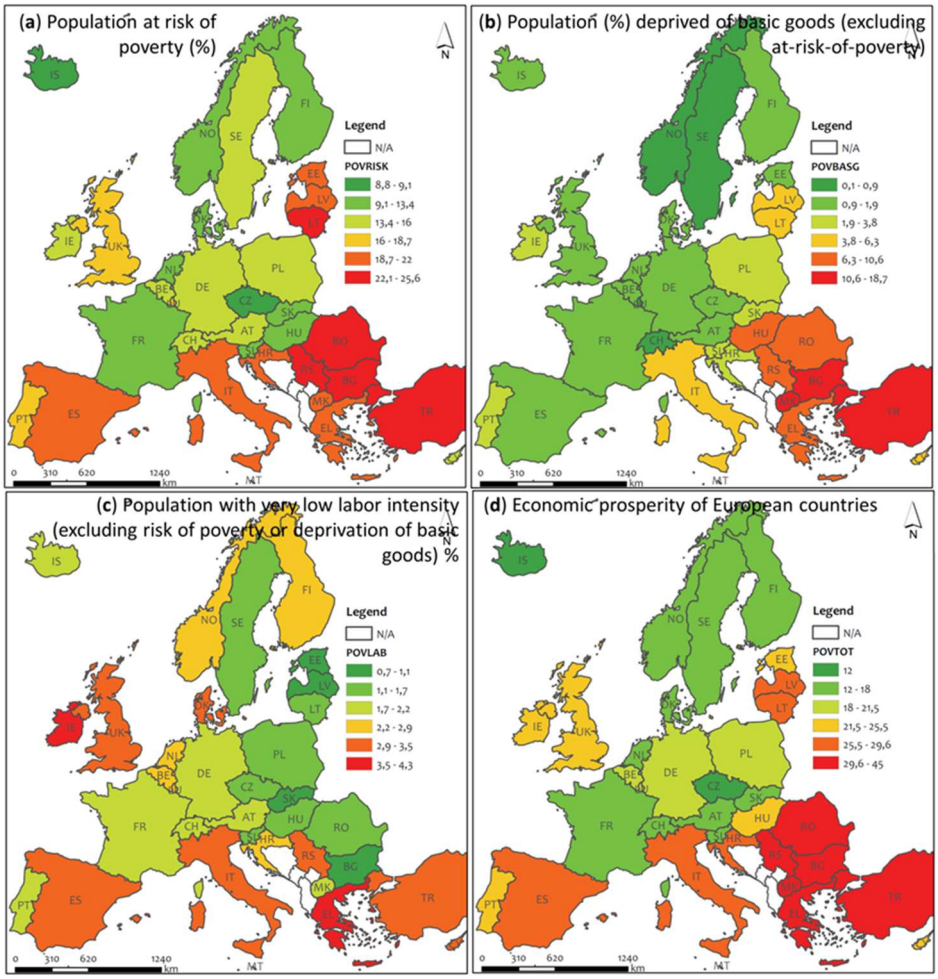
3.2.2. Population Deprived of Basic Goods

Deprivation of basic goods, as defined by ELSTAT and EUROSTAT, refers to the inability of individuals or households to meet certain basic economic needs (Townsend, 1987; McKay, 2004; Polyzos, 2019). These needs include the capability of having one week of holiday per year, adequate food, proper home heating, and to access to basic goods (such as a telephone and television). According to Figure 4b, Turkey, North Macedonia (MK), and Bulgaria are in the worst position, while Norway, Luxembourg, and Sweden are in the most favorable position, with very low percentage levels (less than 1%) in this indicator.

3.2.3. Population with Very Low Labor Intensity

This indicator refers to the proportion of the population aged 0-59 living in households where members worked less than 20% of their usual working hours during the previous year (Rastrigina et al., 2015). Household work intensity is calculated as the ratio of the number of months all household members worked in the previous year to the total number of months they could theoretically have worked in the same period (Polyzos, 2019). Economically active household members are those aged 18-59 (Rastrigina et al., 2015). According to Figure 4c, Bulgaria, Malta, and Slovakia (SK) have low values for this indicator, while Greece (EL), Turkey, and Ireland have high values. An overall conclusion that can be made based on Figure 4 is that disparities in poverty indicators are substantial, raising concerns about the effectiveness of the measures implemented or planned to address the so-called "regional problem" (Polyzos, 2019; Tsiotas and Tselios, 2024) in Europe.

Figure 4



Economic prosperity of European countries. The diagram illustrates the significant inequalities between European countries regarding the ability of their populations to acquire basic goods and maintain a basic standard of well-being (year 2017)

3.3. Economic Performance and Welfare Level

Figure 5 visualizes economic data that are related to the well-being of the inhabitants of each country. These data include inequalities in GDP per capita expressed in Purchasing Power Parity (PPP); changes in GDP; the distribution of disposable income; and expected healthy life expectancy at birth. The analysis in this section is limited to the 28 EU member countries, as statistics for other European countries were unavailable.

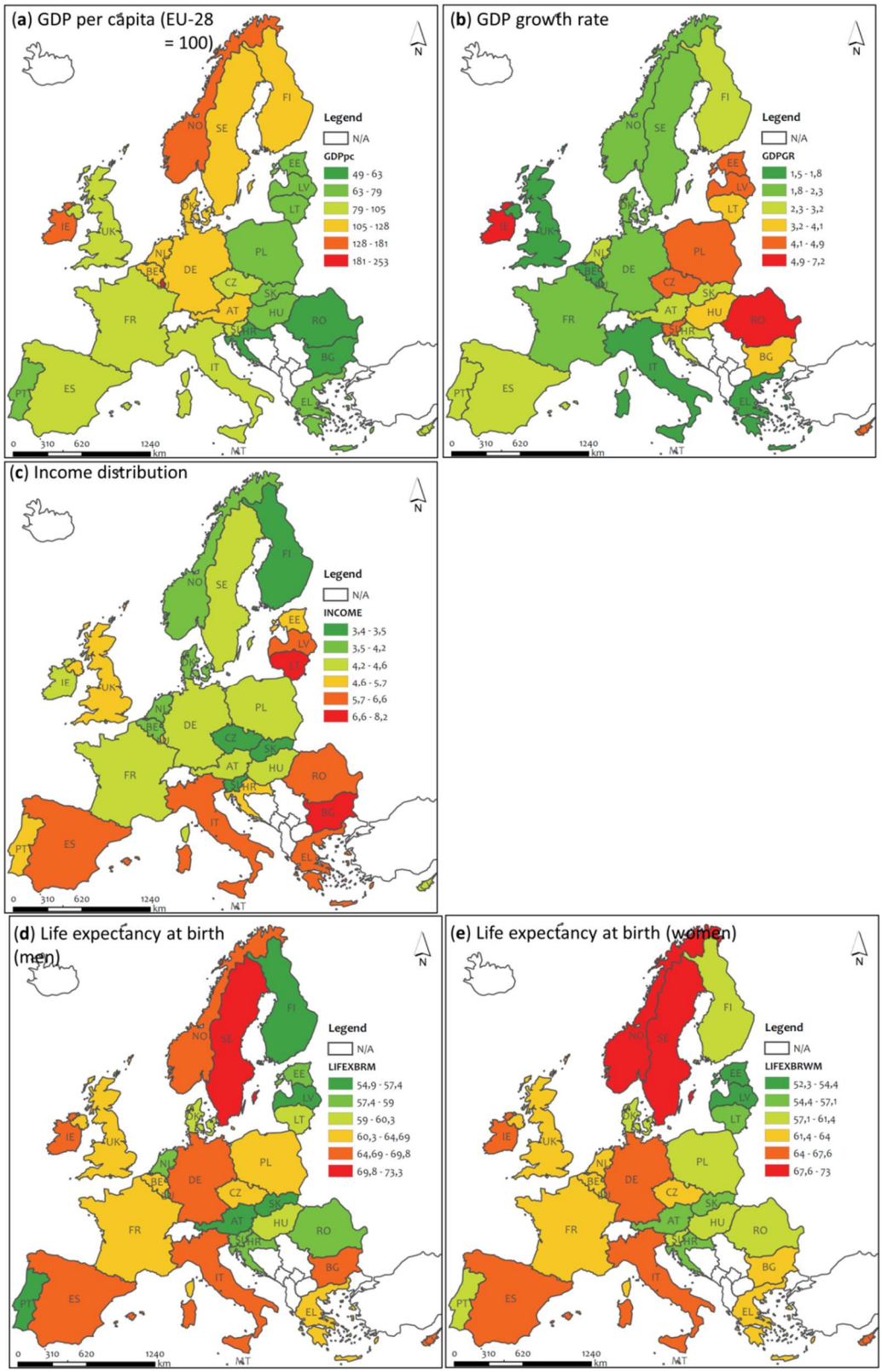
3.3.1. GDP per Capita in Purchasing Power Parity (PPP) Units

In general, GDP is a measure of economic activity, but dividing it by the total population of a country provides an indicator of the population's standard of living (Dipietro and Anoruo, 2016). That is, although it has been subjected to criticism, the GDP per Capita can operate as a raw welfare index, as it represents the share of production attributed to one social (population) unit of an economy (Polyzos, 2019). In adjusted PPP terms, the values for this indicator are adjusted so that the average value for all EU countries equals 100. In general, PPP compares the cost of goods and services between different countries by taking into account differences in price levels, aiming is to determine the relative "purchasing power" of one currency comparatively to another (Rogoff, 1996; Seshaiah and Tripathy, 2018). It assumes that, in an ideal world without trade barriers or changes in exchange rates, the same good or service should cost the same in all countries when expressed in a common currency unit (Rogoff, 1996). The PPP adjustment allows for country-to-country (cross sectional) comparisons but not comparisons over time (Polyzos, 2019). If a country's index is above 100, its GDP per capita is higher than the EU average, and vice versa. Within this context, Figure 5a highlights significant inequalities between European countries for this indicator. The GDP per capita scores of developed countries are 2.0 to 2.5 times higher than those of less developed ones. The highest values are observed in the economically developed countries of Western Europe, such as Luxembourg, Ireland, Germany, Norway, Denmark, Austria, and Sweden. At the bottom of the ranking are countries from Southeastern Europe, such as Bulgaria, Romania, Croatia, and Greece.

3.3.2. Real GDP Growth Rate

The real GDP growth rate is defined by relative annual GDP differences for European countries over a given period, allowing for the analysis of each economy's dynamics and comparisons between countries' growth trajectories (Canning et al., 1998; Banerjee et al., 2005). Even a small difference in annual GDP growth rates between two countries can lead to large divergences in their growth levels over time (Polyzos, 2019). In Figure 5b, we can see that for the last decade, the countries with the highest growth rates in the EU were Ireland, Malta, Romania, Slovenia, Estonia (EE), and Poland (PL). Most of these countries joined the EU during the recent enlargements, as it is shown in Table 1. In contrast, cases with negative growth rates are also evident, spanning both developed and less developed categories. This is likely linked to the broader economic crisis and recession of the period 2009-2018 (Polyzos, 2019). The countries with the lowest growth rates were Greece, Italy, and Luxembourg. Notably, all European countries displayed positive overall growth rates, with the exception of Greece, Italy, and Croatia. Ireland, Malta, and Poland experienced the highest growth rates, marking them as the countries with the strongest economic momentum during this period. The joint consideration of Figure 5a and Figure 5b can provide insights into the correlation between the overall growth rate of European countries and their average GDP per capita. In general, for economic convergence to occur, a negative relationship should be evident between these two variables, implying that countries with lower GDP per capita should experience faster growth than those with higher GDP per capita (Polyzos, 2019). This is evident by the inverse color palette between these two figures, showing that countries with higher GDP per capita experienced relatively lower growth rates, while those with lower GDP per capita showed slower growth.

Figure 5



Economic growth rates of European countries in the last decade. Half of the European countries had growth rates below the EU average, while the other half exceeded the average. Greece (EL), Italy (IT), and Croatia (HR) showed negative overall growth rates during this period. Reference years: (a) 2017, (b) 2016-17, (c) 2017, (d,e) 2016

This indicator primarily reflects the level of inequality within a country and serves as a measure of the distribution of income (Rodriguez-Pose and Tselios, 2009). Income inequality (disposable income equivalent) is calculated by comparing the income received by the top 20% of the population (highest income quartile) to that of the bottom 20% (lowest income

quartile). As indicated in Figure 5c, Bulgaria, Lithuania, Romania, Greece, and Spain, whose economies are either transitioning or experiencing severe economic crises (Polyzos, 2019), enjoy high values for this indicator, signifying significant income inequality. In contrast, countries such as the Czech Republic, Slovenia, Finland, Belgium, and Norway exhibit lower inequality values.

3.3.3. Healthy life expectancy

Life expectancy is assessed using the "disability-free life expectancy" (DFLE) indicator, which reflects the years a person can expect to live in good health at birth (Imai and Soneji, 2007; Polyzos, 2019). This indicator is calculated by integrating mortality and morbidity (illness development) data, reflecting factors such as living and working conditions (Nielsen et al., 2021). In Figure 5d, Malta, Sweden, Norway, and Ireland enjoy the highest values for life expectancy, whereas Latvia, Austria, Portugal, and Slovakia have the lowest.

3.4. Employment

Achieving satisfactory economic growth is closely linked to increasing employment (Polyzos, 2019; Ferro et al., 2024) and utilizing the labor force. Additionally, employing labor helps mobilize other production factors and contributes to overall economic growth (Ruxho et al., 2023; Tsiotas and Kallioras, 2025). The goal of full employment, first established after the 1929-33 economic crisis (Polyzos, 2019), has since become a central objective in the development programs of all countries, prioritizing political and ideological principles, as well as the development goals of the EU. Numerous studies have explored the causes of unemployment and changes in employment levels, but there is no universally accepted explanation or interpretation in this topic. Some argue that the decline in employment is linked to the natural increase in the unemployment rate, beyond which efforts to reduce unemployment may lead to inflation.

Paul Krugman (1994) supported that technological advancements have elevated demand for skilled workers while reducing demand for less-skilled workers. However, in many European countries, welfare systems that provide benefits to the unemployed have a negative effect on employment growth, as individuals are unwilling to accept reductions in wages and welfare benefits. This view has been criticized by some, such as Jackman et al. (1997), who highlighted the differences between the US and European unemployment in response to economic shocks due to the diverse endogenous structural, functional, and institutional characteristics of their economies.

The unemployment phenomenon has been the subject of extensive research, with explanations ranging from Keynesian views, which attribute unemployment to insufficient demand, to neoclassical perspectives, which argue that it results from rigid high real wages in the labor market (Polyzos, 2019).

3.4.1. Employment rate

The employment rate is calculated by dividing the number of employed individuals aged 15-64 by the total population of the same age group (Stanila et al., 2014; Krugman and Wells, 2024). This rate reflects the extent to which a country's working-age population is engaged in productive work, thus contributing to economic growth (Krugman and Wells, 2024). Figure 6a shows that economically developed countries tend to enjoy the highest employment rates, while less developed countries tend to exhibit lower rates. Countries such as Iceland, Sweden, Norway, Germany, Estonia, and the Czech Republic exhibit high employment rates, while Greece, Croatia, and Italy rank among the lowest. Generally, it seems that developed countries maintain higher employment rates, while countries that have undergone economic crises or are less developed show lower rates.

3.4.2. Harmonized unemployment rate

The harmonized unemployment rate represents the proportion of unemployed individuals within the labor force (Polyzos, 2019), which includes both employed and unemployed persons aged 15 to 74, as defined by the International Labor Organization (ILO). According to Figure 6b, countries experiencing high rates of harmonized unemployment were those whose economies experienced the highest impacts of the 2008 economic crisis (Polyzos,

2019), such as Greece, Spain, and Italy. Conversely, countries with stronger economic growth, like Germany, Iceland, and the Czech Republic, reported lower unemployment rates.

3.4.3. Total unemployment rate

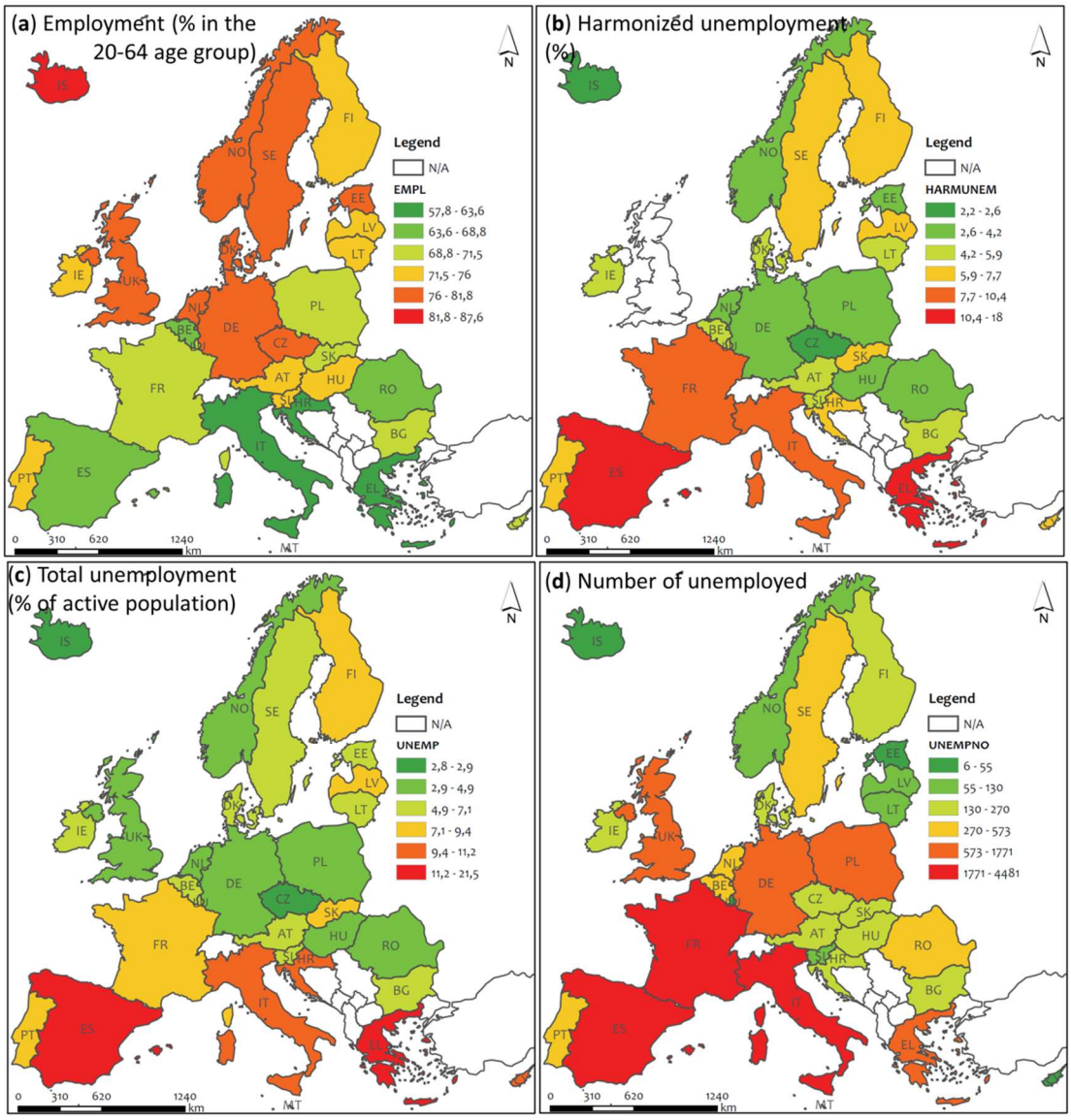
The total unemployment rate is the percentage of unemployed individuals within the entire labor force, defined as all persons aged 15 to 74 who are either employed or seeking employment (Cain, 1979; Krugman and Wells, 2024). An unemployed person is anyone available for work and actively looking for employment. Unemployment statistics are typically gathered through population surveys or by registering jobseekers with relevant organizations and services. However, the reliability of unemployment measurements has been questioned due to imperfections in data collection methods and uncertainties surrounding the definition of "unemployment" (Polyzos, 2019).

The challenge in measuring unemployment arises from individuals who may be in an intermediate state, such as those who are neither working nor fully classified as unemployed (inactive population) (Krugman and Wells, 2024). Furthermore, the classification of an individual as "unemployed" depends on their active search for work and willingness to work. The existence of unofficial or informal work can also hinder the accurate recording of unemployment figures, especially during economic crises, when the informal economy tends to grow (Polyzos, 2019). Despite these challenges, we assume the unemployment statistics provided by Eurostat as reliable, with minor discrepancies unlikely to significantly alter the real unemployment map. Figure 6c indicates that the highest unemployment rates in Europe were in Greece, Spain, Italy, and Cyprus, all of which experienced the effect of economic recession the last decade. These countries showed the highest levels of unemployment, particularly of a structural or long-term nature. It is worth noting that some countries experiencing strong economic growth still maintain relatively high unemployment rates, especially when considering other economic indicators. This is likely due to the presence of a "welfare state", where extended unemployment benefits act as a disincentive for individuals to seek employment (Polyzos, 2019). Notably, countries with low unemployment rates tend to belong to the category of economically developed nations, such as Iceland and Germany, as well as less developed countries, like the Czech Republic.

3.4.4. Number of unemployed

The unemployment rate in each country indirectly reflects the number of unemployed individuals (Polyzos, 2019; Krugman and Wells, 2024). Figure 6d shows the number of unemployed people in each country, where the spatial distribution of this indicator appears proportional to the country's population and unemployment rate.

Figure 6



Employment and unemployment indicators of European countries (year 2017)

3.5. Employment Characteristics

In addition to the employment and unemployment indicators, the characteristics of employment and unemployment offer crucial insights into the EU disparities interpretation. Figure 7 presents some of these characteristics that highlight the qualitative dimension of employment.

3.5.1. Long-term unemployment rate

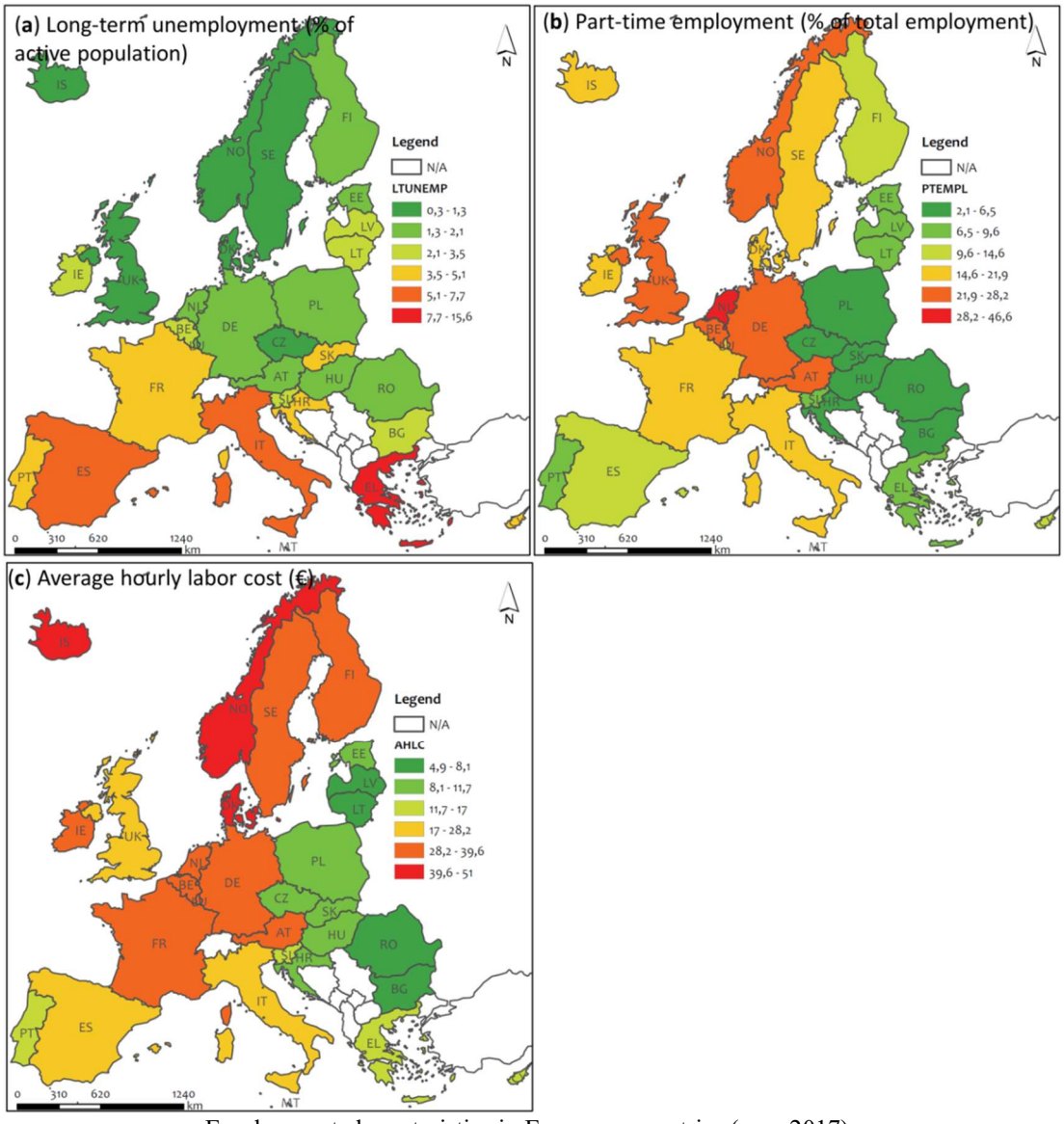
Long-term unemployment refers to individuals who have been out of work for 12 months or more. This indicator shows the proportion of long-term unemployed in the total labor force of each country (Duell et al., 2016). Long-term unemployment is influenced by short-term unemployment and the duration of unemployment benefits. Generally, the longer unemployment benefits are provided, the higher the incidence of long-term unemployment is, as individuals have more time to search for a job (Polyzos, 2019). Figure 7a indicates that long-term unemployment rates are relatively high in Greece and Spain, both of which experienced a severe economic crisis. On the other hand, countries with very low long-term unemployment rates include the Czech Republic, Denmark, Germany, Poland, Sweden, the United Kingdom, Iceland, and Norway. In terms of the relationship between long-term and total unemployment, it is evident that many countries with high long-term unemployment rates also experience high overall unemployment rates, and vice versa (Polyzos, 2019). However, when examining the relationship between benefits and long-term unemployment,

no clear positive correlation emerges. Interestingly, Nordic countries (where generous and long-duration unemployment benefits are provided) do not exhibit high long-term unemployment rates. This suggests that factors other than just the length or amount of unemployment benefits influence the rate of long-term unemployment.

3.5.2. Part-time employment

This indicator measures the proportion of individuals working part-time relative to total employment in each country and is directly linked to labor market flexibility (Duell et al., 2016). For some researchers, part-time employment contributes positively to boosting economic productivity and increasing employment, while others argue that it can lead to the exploitation of workers by employers (Polyzos, 2019). Figure 7b reveals a weak but positive correlation between part-time employment and economic growth, as well as a slight reduction in unemployment. Countries with a high level of growth, such as the Netherlands, Austria, Denmark, and Italy, exhibit flexible labor markets, whereas countries like Bulgaria, Croatia, and Hungary (lacking strong growth) show less flexible labor markets. Additionally, countries with high overall unemployment rates, such as Greece, Spain, Italy, and Cyprus, have medium levels of part-time employment.

Figure 7



Employment characteristics in European countries (year 2017)

3.5.3. Hourly labor costs

This indicator reflects the average hourly labor cost, calculated by dividing total labor costs by the total number of working hours (in full-time equivalents) over the course of the

year. Labor costs are an important component of the total production cost in an economy and are often associated with the level of development of a country or region. However, labor costs solely are not a good proxy factor for an economy's competitiveness (Polyzos, 2019). The integration of advanced technologies in production processes can raise labor productivity, allowing wages and labor costs to increase without leading to higher prices for produced goods. In Figure 7c we can observe that countries with higher growth rates also tend to have higher labor costs. Western European countries such as Denmark, Norway, Iceland, Belgium, and Germany undertake labor costs five to six times higher than those in less developed Eastern European countries, such as Bulgaria, Romania, Latvia, and Lithuania. Despite the large disparity in labor costs, the productivity and competitiveness of the developed countries remain significantly higher, thereby offsetting the higher labor costs.

3.6. Public expenditure on education

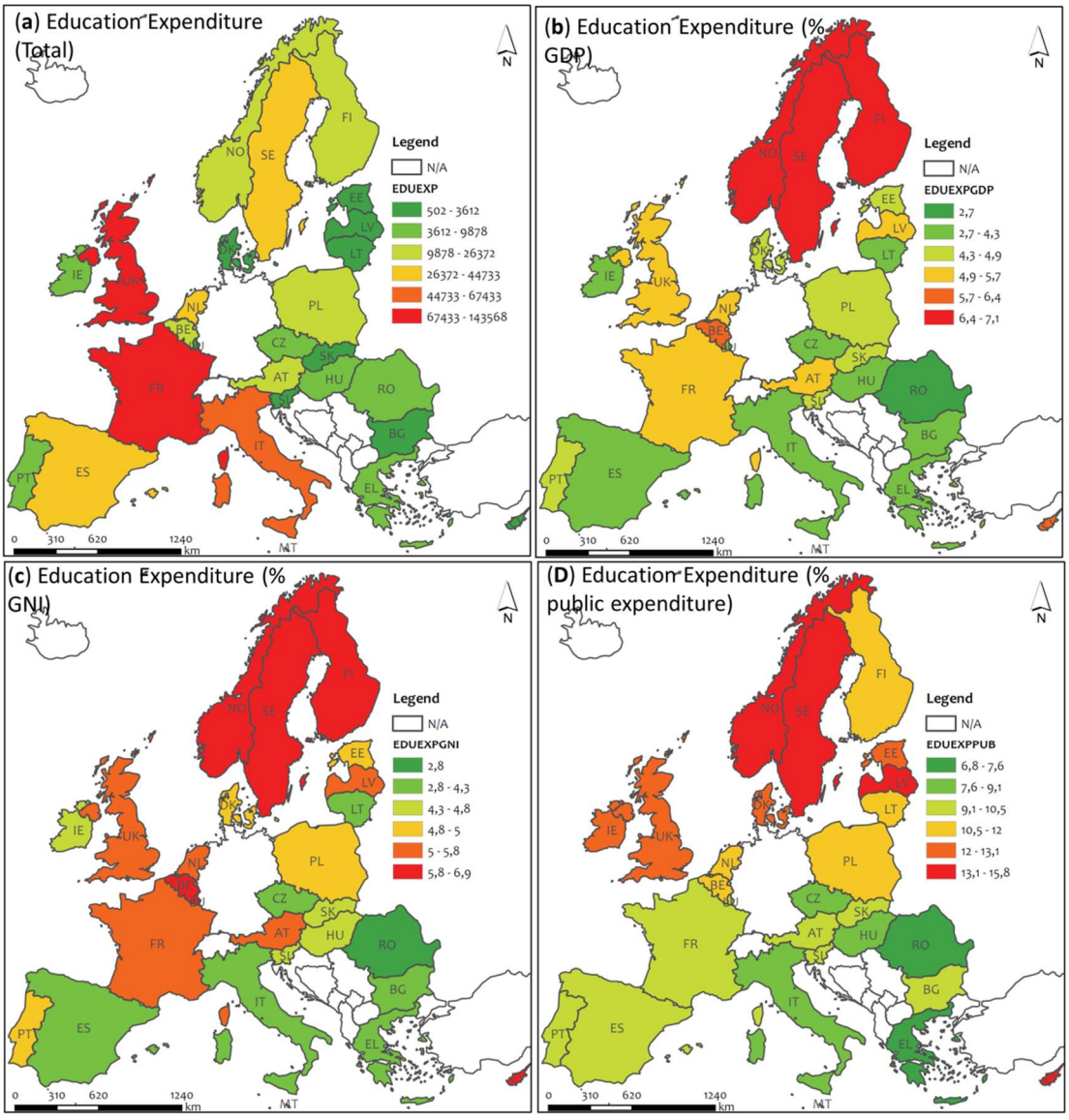
The relationship between economic and social development and the education system is widely recognized (Polyzos, 2019). Numerous studies have shown that improving the educational level of a society is positively correlated with economic growth (Neycheva, 2010; Marginean, 2014; Agasisti, 2014), particularly in countries with lower education levels or lower productivity. Strengthening education serves as a tool for economic growth by enhancing worker efficiency and improving labor productivity. As modern technologies and advanced means of production require a more educated workforce (Krugman and Wells, 2024), investing in education enables workers to better adapt to technological advancements, thereby increasing output and supporting economic growth. Furthermore, higher education levels also contribute to strengthening social cohesion within a country or region (Capello, 2016). The accumulation of human capital (Hussain and Chandra Das, 2023) through education, which fosters knowledge acquisition and critical thinking, primarily takes place within the educational system (Rossidis et al., 2018; Polyzos, 2019). Given the importance of education in fostering economic development, Figure 8 presents data on public expenditure on education across European countries.

3.6.1. Public expenditure on education as a share of GDP

Figure 8a shows total educational expenditure in millions of euros for each country, including payments for tuition fees, teaching materials, school transport, and other related costs. Since comparing these expenditures directly can be challenging, Figure 8b expresses public expenditure on education as a share of GDP. These indicators, along with those in Figures 8c and 8d, offer a qualitative insight into the standard of living (Polyzos, 2019) in each country.

In Figures 8a and 8b we can observe that countries with the highest public expenditure on education as a share of GDP are Finland, Sweden, Norway, and Cyprus, while the lowest levels of expenditure are met in Greece, Romania, and Bulgaria. From a broader perspective, it is evident that more developed countries generally allocate a higher proportion of their GDP to public education compared to less developed (Polyzos, 2019). However, it is important to note that this indicator does not provide a complete picture of total education expenditure, as private spending on education is not included.

Figure 8



Main indicators of public expenditure on education in European countries (year 2015)

3.6.2. Public expenditure on education as a share of GNI and total public expenditure

The next two categories in Figure 8c and 8d reflect public expenditure on education as a share of Gross National Income (GNI) and as a share of total public expenditure. The patterns observed in these categories are similar to those of public expenditure as a share of GDP. Overall, the spatial distributions of these indicators in the EU geographical space drives to the conclusion that developed economies tend to allocate a larger share of both GNI and total public expenditure to education compared to less developed countries (Polyzos, 2019).

3.7. Productivity indicators

Improving productivity is considered a critical factor in enhancing an economy's competitiveness. Increased competitiveness contributes to economic growth, higher per capita income, and improved living standards (Capello, 2016). The key factors that influence and boost the productivity of firms (and, by extension, the overall economy) include (Polyzos et al., 2013; Polyzos, 2019) the amount of fixed capital employed, technological and organizational advancements in firms or sectors, the existence of economies of scale, and changes in the utilization of production factors (e.g., labor intensification). Relevant research has shown that in the short term improvements in productivity may lead to higher unemployment (Capello, 2016; Krugman and Wells, 2024), often referred to as "technological unemployment". However, in the long-run, enhanced productivity reduces

production costs and increases consumer surplus, which boosts demand, output, and employment (Polyzos, 2019). The ideal policy objective for any state is to foster economic growth while simultaneously increasing productivity and employment. This section discusses aspects of productivity in European countries shown in Figure 9.

3.7.1. Labor productivity change

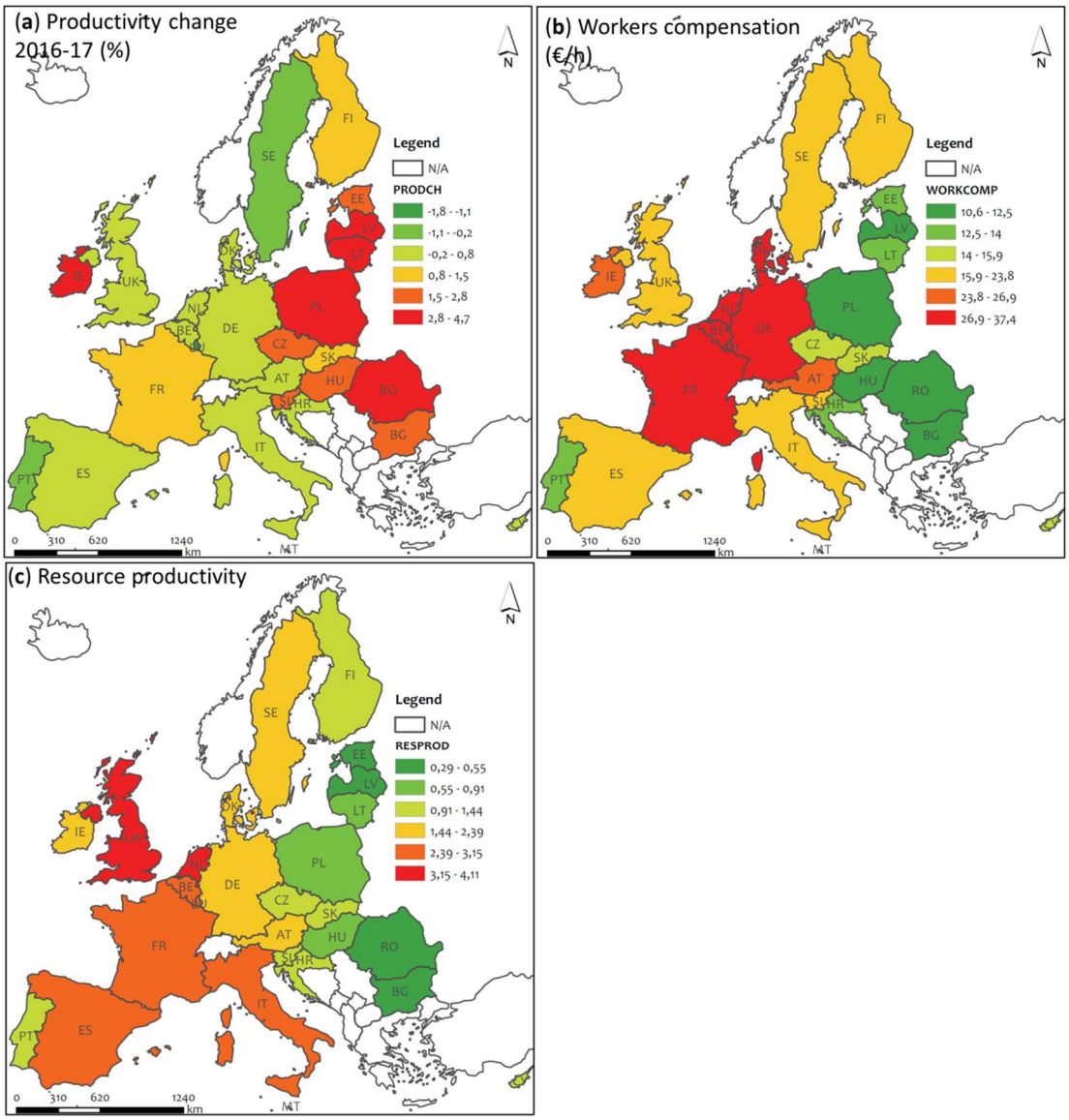
Labor productivity is defined as the output produced per unit of labor (Baily et al., 2001; Polyzos, 2019). The labor productivity index is a key indicator of labor's ability to generate a certain amount of output, and it is influenced by various factors, including technological advancements and improvements in worker training and education. Key strategies to increase productivity include the adoption of advanced production technologies and the enhancement of workers' skill levels (Polyzos, 2019).

Measuring the change rate in labor productivity per working hour offers a clearer insight into productivity developments within an economy than labor productivity per person employed, as it accounts for differences in full-time and part-time employment. This indicator reflects the relative change in labor productivity for the years under consideration 2016-2017. As it is shown in Figure 9a, high productivity growth rates are observed in less developed countries like Latvia and Lithuania. These nations are still transitioning from centralized to market economies (Polyzos, 2019). Ireland, which was recovering from an economic crisis during the same period, also experienced a notable increase in productivity growth. In contrast, economically developed countries experienced very low or even negative productivity growth, as seen in Luxembourg, Malta, and Sweden. This is likely due to the broader international economic crisis of 2008, which had adverse effects on their economies (Polyzos, 2019). Similarly, negative or zero productivity growth rates were recorded in Portugal (Delgado and Sequeira, 2024) and Greece, both of which underwent significant economic crises. This brings up the valid question of why Ireland, despite facing a similar economic crisis, achieved high productivity growth while Greece and Portugal did not.

3.7.2. Working compensation

Labor costs play a crucial role in shaping both productivity and competitiveness, but they are not the only or most influential factor (Polyzos, 2019; Krugman and Wells, 2024). Total employees' compensation contributes to the overall labor costs for businesses and thus affects labor productivity (Polyzos, 2019). As shown in Figure 9b, countries with higher labor costs tend to exhibit higher productivity and higher GDP per capita, such as Luxembourg, Belgium, the Netherlands, and France. On the other hand, countries with lower labor costs generally show lower productivity and lower GDP per capita, such as Bulgaria, Romania, and Poland. The disparity between developed and developing countries can largely be attributed to the quality of technology used and other factors that enhance productivity. As a result, economically and technologically advanced countries are able to offer higher wages while maintaining higher levels of productivity compared to less developed countries.

Figure 9



Main productivity indicators in European countries. Reference years: (a,b) 2017, (c) 2016.

3.7.3. Resource productivity

Resource productivity is defined as the ratio of GDP to the domestic materials consumption (DMC) used in production. DMC refers to the total quantity of materials used directly by an economy during the production process. More specifically, DMC measures the total amount of materials used within an economy, calculated as the annual quantity of raw materials imported, plus the physical materials produced domestically, minus any exported materials (Polyzos, 2019). According to Figure 9c, developed European countries (excluding Malta, Austria, Finland, and Sweden) generally show high resource productivity values, contrasting with the lower values observed in less developed countries.

3.8. Research and Technological Development

Achieving maximum efficiency in an economy requires the rational use of production factors, selecting and combining them according to the characteristics of the production process and input prices. Efficiency can be broken down into two main categories (Polyzos, 2019): technical efficiency, which is the optimal technical utilization and combination of production factors for a given level of output; and distribution efficiency, which is linked to the selection of inputs in a way that maximizes their value-added use. Improving efficiency leads to overall productivity improvements, enabling the same inputs to produce more output at lower costs. A significant factor in improving efficiency is the integration of technological progress into the production process. Technological advancements are directly related to

productive efficiency and productivity (Capello, 2016; Krugman and Wells, 2024), which are closely tied to economic growth and development. Increasing productivity, through new technologies and the pursuit of maximum productive efficiency, contributes to economic growth by making better use of available resources.

As such, Research and Development (R&D) plays a crucial role in improving productivity and establishing a competitive advantage (Bilbao-Osorio and Rodriguez-Pose, 2004). Countries that incorporate high levels of research and technological knowledge into their production processes tend to exhibit higher growth rates and competitiveness. However, the role of research and technological knowledge in economic growth is often misunderstood and underestimated (Polyzos, 2019). To better understand the relative levels of research and technological development across European countries, some key indicators are examined. These include data on R&D expenditure, high-tech product exports, and employment in knowledge-intensive sectors, which will be compared with data from previous sections to draw conclusions about the interdependence of factors influencing growth.

3.8.1. Research and Development (R&D) Expenditure

This indicator reflects the percentage of gross expenditure on R&D (GERD) relative to a country's GDP. The EU's research and innovation policy, outlined in 2015, has three main objectives (Polyzos, 2019) Open Innovation, Open Science, and Global Outreach. Research and innovation contribute to enhancing living and working conditions, improving competitiveness, boosting growth and employment, and creating new products and services. Horizon 2020, the EU's largest ever research and innovation framework program was launched in 2014 with nearly €80 billion in funding for 2014–2020. As shown in Figure 10a, R&D investment correlates with a country's level of economic development. In 2010, the EU set a target for R&D expenditure to reach 3% of total GDP (Polyzos, 2019), but by 2017, only Sweden, Austria, Denmark, and Germany had reached or exceeded this target (Polyzos, 2019). Most other European countries, particularly those in Eastern Europe, fall significantly short of this target. This highlights the relatively low levels of R&D funding in Europe compared to other regions.

3.8.2. Exports of High-Tech Products

This indicator measures the exports of high-tech products (e.g. aeronautical products, computers, pharmaceuticals, scientific instruments, etc.) as a share of the total exports (Polyzos, 2019). It provides insights into the technological advancement of a country's manufacturing sector (Braja and Gemzik-Salwach, 2020; Jurak, 2020). As it is shown in in Figure 10b, developed countries generally export a larger proportion of high-tech products compared to the European average; whereas less economically developed countries, particularly in Eastern Europe, lag behind.

3.8.3. "Knowledge Intensity" Employment

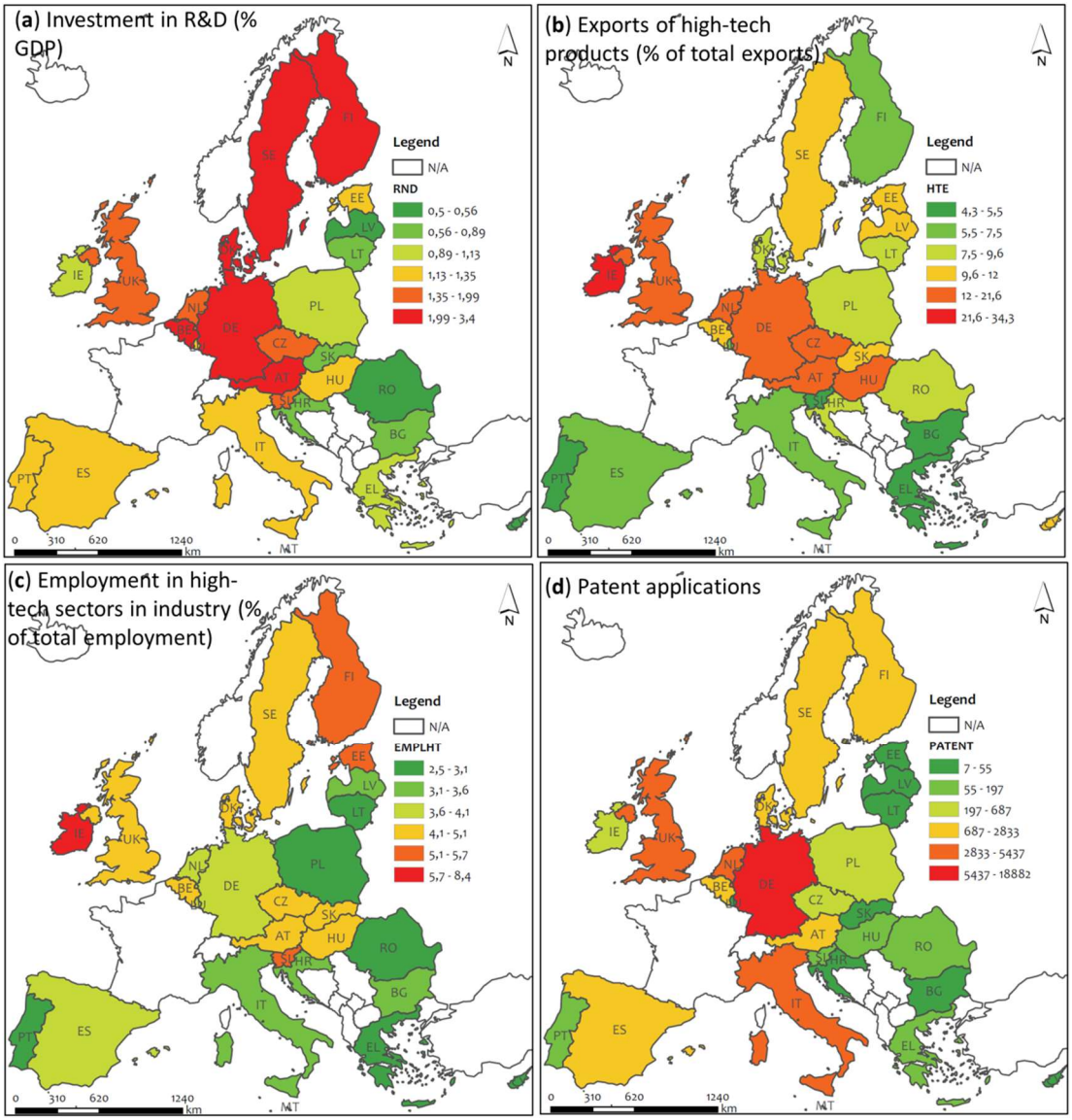
This indicator shows the percentage of knowledge-intensive employment in industrial sectors, reflecting the share of highly skilled workers in these sectors. The data in Figure 10c demonstrate that developed countries tend to have a higher proportion of knowledge-intensive employment compared to less developed countries. Countries such as Ireland, Malta, Finland, and Slovenia rank highest in terms of knowledge-intensive employment, which is a trend linked to their production structure, labor market demands, and workforce education levels (Polyzos, 2019). In contrast, countries such as Greece, Lithuania, Romania, and Portugal, which face growth challenges, have lower values for this indicator. Surveys indicate that future employment growth will be concentrated in occupations that require higher levels of knowledge and skills, such as technical and administrative roles (Polyzos, 2019). This shift suggests that investment in education and technological innovation is a key to fostering future employment growth in these sectors.

3.8.4. Patent Applications

European patent applications concern requests for the protection of inventions filed either directly with the European Patent Office – EPO (Melvin, 2002) or under the Patent Cooperation Treaty – PCT (Mulder, 2015), which the EPO manages (Polyzos, 2019). These applications, regardless of whether they are granted, provide key indicator of innovation and technological progress per country (Cudic, 2021). If an application has multiple inventors, the

application is divided equally between them, as well as across their countries of residence to prevent double counting. According to Figure 10d, it is evident that economically developed countries submit a significantly higher number of patent applications compared to less developed countries. This reflects the stronger innovation ecosystems and higher levels of research and technological development in these more advanced economies. In this context, countries with more robust economies and R&D infrastructure tend to file more patents, showcasing their capacity to produce new technologies and ideas.

Figure 10



Main research and technology indicators in European countries (year 2017)

4. CONCLUSIONS

The EU is a complex and historically unique project. Its difficulty lies in the challenge of uniting people with diverse languages, traditions, cultural elements, and historical backgrounds into a single entity, promoting peaceful integration while advancing economic cooperation and prosperity for its Member States. Effective integration requires reducing inequalities between Member States and fostering a shared sense of fairness in the distribution of prosperity and balanced development. The previous review revealed significant inequalities among European countries. Some countries differ greatly in terms of prosperity, development levels, production patterns, technology, education level, topography, and climate. Some countries have large urban centers and substantial population concentrations, primarily due to their economic growth. These countries can be classified as “industrial” and “developed”,

whereas others remain in the "less developed" stature. This divergence extends to cultural, historical, and political dimensions.

The general perception of spatial disparities in development across Europe suggests that regional differences in living standards and economic performance not only cause problems for underdeveloped regions, but, in the long run, can harm the interests of more developed areas as well. Regarding the geography of development, on one hand, there is the development potential of Central and Western Europe and the growth prospects of countries in the Mediterranean and Atlantic Arcs. On the other hand, there is the relative underdevelopment of the countries in the Eastern Arc. Existing economic and social inequalities across EU and European countries pose a significant problem and a threat to social cohesion. While some of these inequalities stem from the economic crisis that began in 2008, they also have more deep-rooted causes, as inequalities existed prior to the crisis. Rising unemployment, particularly among young people, unequal access to education and healthcare, and the increasing poverty rate within European populations represent harsh realities with far-reaching negative effects on social well-being.

The key concern for policymakers is the evolution of inequalities in socio-economic indicators among EU countries. Many scholars agree that the growing importance of knowledge-intensive sectors in economic growth, combined with the concentration of economic activities in specific regions, is likely to exacerbate inequalities. Regions with high growth rates, and the cities within them, will continue to thrive by leveraging their potential for self-sustaining growth. In contrast, less productive regions will struggle to close the gap with more developed areas, especially during economic crises when over-reliance on public sector employment leaves them vulnerable to cuts in government spending. As is evident by the previous review, differences in living standards between and within European countries are substantial. Consequently, the EU has established Financial Instruments to develop various spatial regions and reduce inequalities, aiming to improve living standards in poorer or less developed regions.

The current regional economic policy in the EU aims to achieve both economic solidarity and economic integration. Solidarity seeks tangible benefits for citizens and regions lagging behind, while social cohesion is based on the principle that reducing income and wealth disparities between regions serves the collective interests of all. The growing economic and social inequalities within and between EU countries raise important questions and concerns about the effectiveness of policies aimed at regional development, as well as the ability of both national and European policy systems to reduce inequalities and strengthen social cohesion. However, the impact of these policies will only be fully assessed after several years of implementation. Lastly, it is crucial to recognize that Europe's challenges have been further exacerbated in recent years by both internal and external migration, which has led to significant economic and political "friction" or "turbulence". The solutions to the issues arising from migration are not simple and depend on factors such as the current economic climate, the stage of economic growth or contraction, and the social and demographic characteristics of both host societies and migrant-sending countries.

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HOW DOES GLOBAL AND LOCAL CLIMATE CHANGE AWARENESS INFLUENCE TOURISTS' WILLINGNESS TO CONTRIBUTE TO ENVIRONMENTAL SOLUTIONS?

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Abstract

Our study investigates the influence of both global and local climate change awareness on tourists' willingness to contribute, either financially or through time donations, to climate change mitigation efforts. Drawing on survey data from 650 respondents, the findings indicate that global awareness significantly enhances tourists' propensity to take action, whereas local awareness exerts no statistically significant effect. Tourists who recognize the global dimensions of climate change are more inclined to support environmental initiatives within their home country. These results suggest that promoting a broader, global understanding of environmental issues is more effective in fostering pro-environmental behavior among tourists than focusing on localized impacts. The implications for policymakers and the tourism sector are clear: public awareness campaigns and interventions should emphasize global environmental awareness to promote sustainable tourism. Specifically, integrating global climate education into tourism programs and providing accessible, cost-effective options for sustainable practices can help translate tourists' willingness into tangible action.

Keywords: Climate change, sustainable tourism, willingness to pay, global and local impacts, Structural Equation Modelling

JEL classification: Q01, Q54, Q56, Z32

1. Introduction

Climate change is one of the most pressing global challenges of the 21st century, with profound consequences for both natural ecosystems and human societies. The tourism sector is uniquely positioned in this global context, as it contributes to environmental degradation while being highly vulnerable to its effects (Spinks and Kopf, 2018). Tourism-related activities, such as transportation, accommodation, and recreation, are major sources of greenhouse gas (GHG) emissions, which contribute to global warming. Simultaneously, tourism destinations, especially those that depend on natural and cultural resources, are increasingly exposed to the adverse effects of climate change, including rising sea levels, extreme weather events and biodiversity loss (Higham et al., 2014). These environmental changes not only threaten the attractiveness of tourist destinations, but also jeopardize the livelihoods of communities dependent on tourism (Gössling & Hall, 2005; Ivanova et al., 2021)

Greece, a country with a tourism-dependent economy, is particularly vulnerable to climate change impacts. With its rich cultural heritage, world-renowned beaches and favorable Mediterranean climate, Greece attracts millions of tourists each year. In 2019, the tourism sector contributed nearly 21% of the country's gross domestic product, highlighting its economic significance (United Nations, 2020). However, the tourism industry in Greece faces critical challenges due to climate-related risks, including increasing temperatures, prolonged droughts, and coastal erosion (Amelung et al., 2007). These impacts not only degrade natural environments, but also undermine the sustainability of tourism in the country. As climate change continues to pose escalating risks, understanding tourists' behavior in relation to climate change is essential for developing effective mitigation strategies (Tsartas, 2003; Prasada et al., 2021).

Tourists play a pivotal role in ensuring the sustainability of the tourism industry. Their behaviors and decisions significantly influence the sector's environmental footprint (Becken & Hay, 2012). Pro-environmental behaviors, such as reducing carbon emissions, supporting conservation initiatives and adopting sustainable practices, are essential for mitigating the negative environmental effects of tourism (Gossling, 2002; Shimamoto, 2018). However, the motivations that drive tourists to engage in such behaviors are intriguing. A critical factor influencing pro-environmental behavior is tourists' awareness of climate change and its impacts, which shapes their attitudes and willingness to contribute to climate change mitigation efforts (Aman et al., 2021).

Climate change awareness can be categorized into two dimensions: global and local awareness. Global awareness refers to the recognition of climate change as a worldwide phenomenon, encompassing an understanding of its causes, consequences and the need for international action (Gössling and Hall, 2005). Local awareness, on the other hand, relates to the specific impacts of climate change on individual regions or sectors, such as its effects on tourism destinations and local ecosystems (Puspita et al., 2023). While global awareness fosters a broad understanding of climate change, local awareness may have a more immediate influence on behavior by highlighting direct risks to personal experiences and destinations (Halady and Rao, 2010; Goula et al., 2015). This study aims to explore the interaction between global and local awareness in shaping Greek tourists' willingness to contribute to climate change mitigation.

The concept of willingness to contribute encompasses a variety of pro-environmental behaviors, such as monetary donations to environmental causes, participation in conservation activities and personal efforts to reduce the environmental impact of travel (Higham et al., 2016). Understanding the factors that drive this willingness is crucial for designing targeted interventions to promote sustainable tourism (Becken, 2013). Previous research has demonstrated that environmental awareness is a key determinant of individuals' willingness to engage in environmental actions, as it enhances understanding of the urgency of climate issues and fosters a sense of responsibility (Bassi and Martin, 2024). However, a more comprehensive understanding of how global and local awareness interact to influence behavior is necessary. Global awareness may lead to a broad recognition of climate change as a serious issue, while local awareness may provide a more tangible connection to the impacts that directly affect tourists' experiences (Weber, 2015).

To investigate these dynamics, this study employs a semi-structured survey administered to a sample of 650 Greek tourists. The survey captures demographic and socio-economic characteristics such as gender, age, education and income, as well as tourists' global and local awareness of climate change. Additionally, it assesses respondents' willingness to spend time and money on climate change mitigation efforts in Greece, including donations to reduce carbon footprints and participation in environmental conservation activities. By analyzing these variables, this research aims to provide insights into the relative importance of global and local awareness in shaping pro-environmental behavior among Greek tourists.

Methodologically, the study applies Confirmatory Factor Analysis and Structural Equation Modeling to test the hypothesized relationships between climate change awareness and willingness to contribute. Confirmatory Factor Analysis is used to identify latent variables for global and local awareness, as well as willingness to act, and to assess the overall fit of the measurement model. Structural Equation Modeling is then employed to explore the structural relationships between these variables and to test two primary hypotheses: (1) that global awareness of climate change positively influences tourists' willingness to contribute to climate change mitigation in Greece, and (2) that local awareness similarly influences willingness, though to a lesser extent.

Preliminary results from Confirmatory Factor Analysis suggest that both global and local awareness are significant predictors of tourists' willingness to engage in climate change solutions. However, global awareness appears to have a stronger effect, indicating that tourists are more motivated by a broad understanding of climate change as a global crisis than by specific concerns about its local impacts on Greece. This finding aligns with previous research, which stresses the importance of global environmental awareness in fostering pro-environmental behavior. Conversely, the weaker effect of local awareness may reflect tourists'

perception that the local impacts of climate change are not as immediate or severe as those occurring globally.

The Structural Equation Modeling analysis supports these findings, showing a significant positive relationship between global awareness and willingness to contribute, while the influence of local awareness remains relatively weak. These results suggest that efforts to increase tourists' willingness to engage in climate change mitigation should prioritize enhancing global awareness and emphasizing the broader consequences of climate change, rather than focusing solely on local impacts (Becken, 2013). This study contributes to the growing literature on the role of environmental awareness in shaping pro-environmental behavior within the tourism sector. By examining both global and local awareness, the research provides valuable insights for policymakers and tourism stakeholders in designing effective strategies for promoting sustainable tourism practices.

The rest of the paper is structured as follows: Part 2 is the literature review, part 3 is the methodology, part 4 the results, part 5 the discussion and last part 6 the conclusion.

2. Literature review

The relationship between tourism and climate change is well-established in academic literature, emphasizing both the tourism sector's contribution to environmental degradation and its vulnerability to the impacts of climate change. Tourism is recognized as a significant emitter of greenhouse gases, especially through transportation and accommodation activities. Concurrently, the sector is at risk from the consequences of climate change, such as extreme weather events, rising sea levels, and shifts in climate patterns that may alter the attractiveness and viability of tourist destinations. Given the increasing urgency of addressing climate change, recent scholarly efforts have focused on the role of tourists in mitigating these impacts, particularly by exploring their awareness and willingness to engage in pro-environmental behavior. This literature review synthesizes the key findings from previous research on the role of tourism in climate change, tourists' awareness of environmental issues and the factors influencing their willingness to contribute to climate change mitigation efforts.

2.1. The contribution of tourism to climate change

The tourism sector's contribution to climate change, particularly through greenhouse gas emissions, is a topic of significant scholarly concern. Lenzen et al (2008) estimate that tourism activities account for approximately 8% of global carbon emissions, with transportation, particularly air travel, being the primary contributor. Becken (2019) emphasizes that air travel alone constitutes the largest share of the emissions from the tourism sector, making it a critical area for mitigation strategies. As global travel increases, the carbon footprint of the tourism industry grows correspondingly, raising questions about the sector's long-term sustainability and the need for substantial shifts in both supply-side operations and demand-side behaviors.

Efforts to mitigate the environmental impact from tourism have primarily focused on promoting sustainable tourism practices, such as adopting energy-efficient technologies in accommodations, reducing waste and encouraging sustainable transport options (Higham et al., 2014). However, scholars argue that these measures are often limited by economic considerations and the absence of robust consumer demand for sustainable tourism products (Cohen, et al. 2014). Thus, the role of tourists in actively participating in and supporting climate change mitigation initiatives has become a critical focus of recent research, particularly in light of the industry's dependency on consumer behavior.

2.2. Climate change awareness and its role in tourism

Environmental awareness, particularly in the context of climate change, is a key determinant of tourists 'willingness to adopt pro-environmental behavior. Climate change awareness can be understood as an individual's knowledge and understanding of the causes, consequences, and potential solutions to climate change (Amankwah-Amoah, 2023). In tourism, this awareness is crucial for fostering responsible behavior among tourists, as it

influences their choices and actions regarding sustainable travel and participation in environmental conservation efforts (Hares, et al., 2010).

The existing literature suggests that although many tourists are aware of climate change and its impact, this awareness does not consistently translate into pro-environmental actions. Juvan and Dolnicar (2014) explore this phenomenon, known as the "attitude-behavior gap," which reflects the inconsistency between tourists' expressed concern for climate change and their actual travel behavior. Barriers such as convenience, cost, and the perceived importance of maintaining travel enjoyment often prevent tourists from making environmentally conscious decisions, even when they are fully aware of the environmental consequences of their actions (Miller et al., 2010). These findings show the difficulty of influencing tourist behavior solely through awareness.

Further, the literature distinguishes between global and local climate change awareness. Global awareness refers to the recognition of climate change as a worldwide issue with far-reaching implications, while local awareness pertains to the understanding of how climate change impacts specific destinations or tourism-related activities (Buzinde et al., 2010). Research by Antimova et al., (2012) suggests that while global awareness is critical in fostering a broader concern for climate change, local awareness can be more effective in motivating immediate behavior change when tourists perceive a direct threat to the destinations they visit or the activities they engage in. Nevertheless, the integration of global and local perspectives is essential for promoting a holistic understanding of climate change and its relevance to tourism.

2.3. Pro-environmental behavior in the context of tourism

Pro-environmental behavior refers to actions taken by individuals that contribute to the preservation and sustainability of the environment, often at a personal cost or inconvenience (Kollmuss & Agyeman, 2002). In the tourism context, such behaviors include reducing energy and resource consumption, minimizing waste, choosing environmentally friendly travel options and supporting conservation initiatives. Scholars have sought to understand the factors that influence tourists' willingness to engage in these behaviors, drawing on a range of theoretical frameworks.

The theory of planned behavior (Ajzen, 1991) is among the most widely applied frameworks in tourism research. This theory posits that individuals' behavioral intentions are shaped by their attitudes toward the behavior, subjective norms (i.e., perceived social pressure to perform the behavior) and perceived behavioral control (i.e., the belief that one can successfully perform the behavior). Studies applying this framework to tourism have demonstrated that tourists are more likely to adopt pro-environmental practices when they hold positive attitudes toward sustainability, perceive social support for their actions, and feel that they have the ability to make a meaningful impact (Juvan and Dolnicar, 2016).

In addition to attitudes and norms, personal values play a critical role in shaping pro-environmental behavior. The Value-Belief-Norm theory, proposed by Stern et al., (1999), suggests that individuals' pro-environmental behavior is driven by their environmental values, beliefs about the severity of environmental issues and a sense of moral obligation to act. In the tourism context, this theory helps explain why some tourists are more willing than others to make sacrifices, such as paying higher prices for eco-friendly accommodations or choosing low-carbon travel options, to reduce their environmental impact (Cohen, et al., 2014).

2.4. Tourists' willingness to pay for and contribute to climate change mitigation

Tourists' willingness to pay for environmentally sustainable products and services is often used as an indicator of their commitment to supporting climate change mitigation efforts. Willingness to pay reflects an individual's readiness to incur additional costs, either through higher prices for sustainable tourism options or through financial contributions to environmental conservation initiatives. Several studies have examined the factors that influence tourists' willingness to pay, with mixed results. For example, Brouwer et al., (2008) found that although many tourists express a willingness to pay for carbon offsetting schemes, the amounts they are willing to contribute are often modest, limiting the overall impact of these initiatives.

Kang et al., (2012) found that tourists with higher incomes and stronger pro-environmental values are more likely to exhibit a willingness to pay for green initiatives. However, financial considerations frequently outweigh environmental concerns, particularly among lower-income tourists, who may prioritize cost savings over sustainability. Moreover, even when tourists express a willingness to pay, the actual implementation of environmentally friendly practices may be constrained by other factors, such as the availability of affordable and convenient sustainable alternatives (Pulido-Fernández and López-Sánchez, 2016).

In addition to financial contributions, tourists' willingness to contribute time and effort to environmental conservation activities has gained attention in recent literature. Hands-on participation, such as engaging in tree planting or beach clean-up initiatives, allows tourists to directly contribute to the preservation of the destinations they visit. These participatory activities not only enhance the tourists' connection to the destination, but also foster a deeper sense of responsibility for its conservation (Buzinde et al., 2010). However, similar to willingness to pay, tourists' willingness to engage in such activities is influenced by personal values, convenience, and the perceived benefits of participation.

The extant literature on climate change awareness and pro-environmental behavior in tourism highlights the complexities of influencing tourist behavior. While awareness of climate change is a necessary precondition for behavioral change, it is often insufficient to drive significant action. Global awareness is particularly important in fostering a broad understanding of the severity of climate change, but local awareness may play a more immediate role in motivating tourists to act when they perceive that their experiences or destinations are directly threatened. Moving forward, the promotion of sustainable tourism requires a comprehensive approach that raises both global and local awareness, addresses barriers to behavioral change, and offers tourists meaningful opportunities to contribute to climate change mitigation.

3. Methods

3.1. Data collection procedure

The aim of this study is to examine the behavior of Greek consumers in the tourism market in relation to climate change and to assess how both global and local awareness of the issue influence their willingness to invest time and money in addressing climate change in Greece. To this end, the study has employed a semi structured questionnaire that was administered through purposive sampling and a web survey in all major Greek cities. The data collection started for three months, namely from March 2024 to May 2024. The survey was anonymous and has been approved by the Ethics Committee of the Agricultural University of Athens with the approval number 17_01/03/2024.

Table 1 presents the demographic and socio-economic characteristics of the study's respondents, highlighting a balanced gender distribution with 50.8% male and 49.2% female participants. The age groups are also evenly split, with 48.5% aged 18-35 and 51.5% over 36. Most participants (58.3%) hold a university degree, reflecting a well-educated sample, while the majority (84%) have an annual income below €20,000/per capita. In terms of travel preferences, 32.9% of respondents prefer to travel by ship, closely followed by 30.8% who choose to travel by car. Hotel accommodation is the most popular choice, with 62.3% opting for it, while 66.6% of participants spend between 5 and 10 days on holiday in Greece. These characteristics provide a detailed picture of Greek tourists, many of whom are well-educated, middle-income individuals who favor mid-length vacations and traditional accommodation options such as hotels.

Table 1. Demographic and Socio-Economic Characteristics of the Respondents

Demographics	Frequencies	Percentages (%)
	Gender	
Male	330	50,8
Female	320	49,2
	Age	
18-25	146	22,5
26-35	169	26

Demographics	Frequencies	Percentages (%)
36-45	138	21,2
45-55	113	17,4
>56	84	12,9
	Education	
Secondary or lower	173	26,6
High school	98	15,1
Graduate	266	40,9
Post-graduate	113	17,4
	Income	
<10.000 Euros	272	41,8
10.001-20.000 Euros	274	42,2
20.001-30.000 Euros	74	11,4
30.001-40.000 Euros	17	2,6
>40.001 Euros	13	2,0
	Transportation	
Airplane	133	20,5
Ship	214	32,9
Train	12	1,8
Bus	91	14
Car	200	30,8
	Accommodation	
Hotel	405	62,3
AirBnB	119	18,3
Friend	90	13,8
Camp	36	5,5
	Duration	
<5 days	39	6
5-10 days	433	66,6
11-20 days	133	20,5
21-30 days	34	5,2
>30 days	11	1,7

Source: Authors' compilation

3.2. Methodology

The study employs confirmatory factor analysis and path analysis both based on the structural equation modeling to investigate the issue in consideration. In the confirmatory factor analysis procedure, the factors being determined are defined as latent variables, and scaling models are developed to assess how survey statements explain these latent variables. Jöreskog and Sörbom (1993) noted that confirmatory factor analysis is a key technique for developing scaling models.

Table 2 delineates the measurement of the latent variables. The latent variable Willingness measures respondents' readiness to spend time or money to address climate change in Greece. It includes four statements (Willingness 1 to 4) ranked on a 0-10 scale, with 10 indicating the strongest agreement. Awareness_general captures respondents' perception of climate change as a global issue, consisting of six items (Global 1 to 6), also ranked 0-10. Lastly, Awareness_greece reflects the belief that climate change affects Greece's tourism sector, with two items (Local_1 to 2) ranked on the same scale.

Table 2. Variable Measurement

Latent Variables	Statements	Definition of statements	Range
Willingness	Willingness_1	I am willing to donate money for the reduction of the carbon footprint when being on holidays in Greece	0-10
	Willingness_2	I am willing to donate money for the solution of the climate change problem in Greece	0-10
	Willingness_3	I would love to learn more about the effects of climate change on Greece	0-10
	Willingness_4	I am willing to participate (with my own time) into tree planting actions in Greece in order to uphold climate change	0-10
Awareness_general	Global_1	The climatic change is a real fact	0-10
	Global_2	I worry about the climate change	0-10
	Global_3	Climate change is inevitable	0-10
	Global_4	Climate change is anthropogenic	0-10
	Global_5	Climate change is not so urgent to be solved compared	0-10

Latent Variables	Statements	Definition of statements	Range
		to other problems	
	Global_6	I am willing to inform other people on the effects of climate change	0-10
Awareness_greece	Local_1	I worry about the effects of climate change on Greek tourism	0-10
	Local_2	The activities I enjoy during my holidays in Greece are put at risk because of climate change	0-10

Source: Authors' compilation

4. Results

The confirmatory factor analysis does not assess the individual reliability of each latent variable or factor but evaluates the reliability of the entire model. Several fit indices are used to assess the reliability of a scaling model in confirmatory factor analysis. In this study, four fit indices are employed: the minimum discrepancy to degrees of freedom ratio, goodness of fit index, comparative fit index, and root mean square error of approximation and results are reported in Table 3. Accordingly, statements with factor weights below 0,5 are excluded from the analysis, starting with the lowest. After three iterations, the best-fitting model is achieved based on the aforementioned indices that are indicated by Hu and Bentler (1999).

Table 3. Confirmatory Factor Analysis

Statements	Latent Variables/Factors	Weights		
		1th	2nd	3th
Willingness_1	Willingness	0,935	0,935	0,935
Willingness_2		0,920	0,920	0,920
Willingness_3		0,545	0,546	0,546
Willingness_4		0,550	0,550	0,550
Global_1	Awareness_general	0,722	0,720	0,717
Global_2		0,906	0,905	0,908
Global_3		0,301	0,305	-----
Global_4		0,615	0,615	0,614
Global_5		-0,209	-----	-----
Global_6		0,784	0,785	0,785
Local_1	Awareness_greece	0,753	0,753	0,754
Local_2		0,832	0,831	0,831
Diagnostic Checking				
Minimum discrepancy to degrees of freedom ratio			3,607	
Goodness of fit index			0,975	
Comparative fit index			0,985	
Root mean square error of approximation			0,063	

Source: Authors' compilation

Table 3 demonstrates that the Confirmatory Factor analysis model is a good fit for the data, as indicated by the fit indices. The strong factor weights for most statements suggest that the latent variables Willingness, Awareness_general, and Awareness_greece are well represented by the corresponding survey statements. The exclusion of statements with lower factor weights (like Global3 and Global5) helps improve the model's accuracy and fit.

The identification of factors allows us to analyze the direct and indirect relationships between the variables under consideration. In this context, the study utilizes path analysis within the Structural Equation modelling framework, a methodology that tests and estimates causal relationships based on the research hypotheses. The research hypotheses that the current study has adopted are as follows:

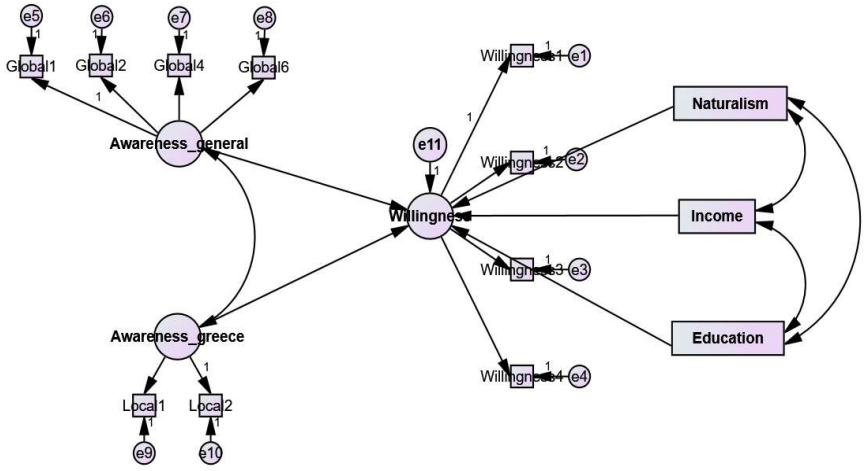
Hypothesis 1: Tourists' global awareness of climate change positively affects their willingness to spend time or money on addressing climate change-related issues in Greece.

Hypothesis 2: Tourists' local awareness of climate change positively affects their willingness to spend time or money on addressing climate change-related issues in Greece.

These two hypotheses create the hypothetical model of the Structural Equation modelling framework that is illustrated in Figure 1. Based on the results of the Confirmatory Factor analysis, the model is consisted of one endogenous (Willingness), two exogenous

(Awareness_general and Awareness_greece), and three control variables (Naturalism, Income, Education). Naturalism categorizes respondents' commitment to nature into three levels: naturalist, a bit naturalist, and non-naturalist. Income is grouped into five categories: below €10,000, €10,001–20,000, €20,001–30,000, €30,001–40,000, and above €40,001. Education is classified into four levels: secondary education or lower, high school education, undergraduate education, and postgraduate education.

Figure 1. Hypothetical Model



Source: The authors

One advantage of the structural equation modelling path analysis is its ability to link exogenous variables with covariances. This process enhances our understanding of how exogenous variables contribute to explaining the endogenous variables and improves the accuracy of model fitting. In this sense, the model is executed after drawing necessary covariances and results are presented in Table 4. Accordingly, in terms of the diagnostic checking, the model demonstrates an excellent fit (Hu and Bentler, 1999). The minimum discrepancy to degrees of freedom ratio value is below the upper threshold of 3, and the Goodness of fit index and Comparative fit index values, both above 0.95, indicate strong correspondence between the observed data and the hypothesized model. Additionally, the Root mean square error of approximation value of 0.054 is below the lower threshold of 0.06. Despite the statistical insignificance of Awareness_greece, the Hypothesis 1 is strongly accepted indicating respondents view climate change as a global issue rather than a local one, and their global awareness has a significant positive effect on their willingness to spend time or money in Greece to address the problem. Global awareness accounts for 143.3% of their willingness to invest in solving climate change issues in Greece.

Table 4. Path Analysis (Endogenous variable: Willingness to pay)

Statements	Exogenous and control variables	Coefficients
Global_1 Global_2 Global_4 Global_6	Awareness_general	1,433 (0.00)
Local_1 Local_2	Awareness_greece	-0,065 (0,19)
	Naturalism	0,099 (0.09)
	Education	0,036 (0.32)
	Income	0,057 (0.19)
Diagnostic Checking		
Minimum discrepancy to degrees of freedom ratio		2,862

Statements	Exogenous and control variables	Coefficients
	Goodness of fit index	0,968
	Comparative fit index	0,977
	Root mean square error of approximation	0,054

Source: Authors' compilation

5. Discussion

The findings in this paper align with existing literature that highlights the complexity of tourist behavior in relation to environmental issues and emphasize the critical role that awareness, both global and local, plays in shaping individuals' willingness to act. This section discusses the key findings in relation to the theoretical framework and previous research, addresses the implications of the results and offers directions for future research and policy development.

5.1. The role of global and local awareness

A central objective of this study was to examine how global and local awareness of climate change influence Greek tourists' willingness to contribute time or financial resources to address climate change issues in Greece. The results provide strong support for the hypothesis that global awareness significantly influences tourists' willingness to act. This finding is consistent with previous studies (Hares et al., 2010) which suggest that a broader understanding of climate change as a global crisis fosters a sense of urgency and responsibility, motivating pro-environmental behavior.

Tourists with a high level of global awareness are likely to recognize the interconnectedness of climate change impact and understand that actions taken in one region can have broader environmental consequences. This aligns with the theoretical framework provided by the Value-Belief-Norm theory (Stern et al., 1999), which posits that individuals who internalize global environmental values are more likely to develop a sense of moral obligation to engage in pro-environmental behaviors. The significant positive relationship between global awareness and willingness to contribute highlights the importance of fostering a global environmental consciousness among tourists to encourage more sustainable travel behavior.

In contrast, the impact of local awareness on tourists' willingness to act was found to be statistically insignificant. This result may initially seem counterintuitive, given that localized threats to tourism destinations, such as rising temperatures, coastal erosion, and ecosystem degradation, are direct and tangible risks that should, theoretically, prompt tourists to engage in protective behaviors. However, these findings echo the conclusions of other scholars, such as Buzinde et al., (2010), who argue that local awareness alone may not be sufficient to motivate significant behavioral change unless it is accompanied by a broader understanding of global environmental issues.

One possible explanation for the limited impact of local awareness is that tourists may not perceive the risks to Greek tourism as severe or immediate enough to warrant urgent action. While tourists may acknowledge that climate change could affect their experiences in Greece, the relatively slow onset of environmental changes compared to more immediate economic or logistical concerns may diminish the perceived relevance of local climate risks (Juvan & Dolnicar, 2014). Furthermore, the concept of "psychological distance" (Gifford, 2011) may also play a role in moderating the effects of local awareness. Tourists may perceive local climate change impacts as distant or abstract, reducing their motivation to take proactive steps toward environmental conservation.

5.2. The attitude-behavior gap in pro-environmental tourism behavior

The findings of this study contribute to the ongoing debate regarding the attitude-behavior gap in tourism, whereby tourists express concern about climate change, but do not consistently translate these attitudes into concrete pro-environmental actions (Juvan & Dolnicar, 2014). The results suggest that while global awareness increases the likelihood of

willingness to contribute, this willingness may not necessarily lead to tangible actions without additional interventions or incentives. This gap between willingness and action is a critical issue that has been well-documented in tourism research (Cohen, Higham, & Reis, 2014).

Several factors may contribute to this gap. First, economic considerations, particularly cost, play a significant role in tourists' decision-making processes. Even when tourists express a willingness to contribute to environmental causes, financial constraints or a perceived lack of affordable sustainable options may prevent them from doing so (Miller et al., 2010). This is particularly relevant in the context of Greek tourism, where many tourists may come from middle-income backgrounds and prioritize cost-efficiency over sustainability when planning their travel.

Second, convenience and enjoyment are powerful determinants of tourist behavior. Many tourists may be unwilling to sacrifice comfort or convenience for environmental reasons, particularly when it involves making trade-offs that could reduce their overall travel enjoyment. For instance, while tourists may express a willingness to donate to carbon offset programs or participate in environmental conservation activities, the actual uptake of these initiatives may be low if they are perceived as inconvenient or if they detract from the vacation experience Pulido-Fernández and López-Sánchez, (2016).

The findings, therefore, highlight the importance of addressing these barriers to translate awareness and willingness into action. Policies and initiatives aimed at promoting pro-environmental behavior among tourists must not only raise awareness, but also provide accessible and convenient options that align with tourists' economic and personal preferences. For instance, offering affordable and easy-to-use carbon offset programs at the point of booking or promoting environmentally friendly travel packages that do not compromise on convenience may help bridge the gap between attitude and behavior.

5.3. Implications for theory and practice

The results of this study have several implications for both theoretical and practical approaches to promoting sustainable tourism. From a theoretical perspective, the significant influence of global awareness on pro-environmental behavior supports the application of the Value-Belief-Norm theory in the tourism context. The findings suggest that tourists' willingness to contribute to climate change mitigation efforts is strongly tied to their global environmental values, highlighting the need for further research into how these values are shaped and how they can be leveraged to foster sustainable tourism behavior.

Additionally, the study findings on local awareness highlight the need for more comprehensive theoretical models that account for the interaction between global and local perceptions of climate change. While global awareness is clearly important, it may be that local awareness plays a more context-specific role, influencing behavior in regions where the impact of climate change is more immediate and visible. Future research should explore the conditions under which local awareness becomes a more salient predictor of pro-environmental behavior, particularly in destinations that are more severely affected by climate change.

From a practical perspective, the findings offer valuable insights for policymakers and tourism industry stakeholders. Efforts to promote sustainable tourism must focus on enhancing tourists' global awareness of climate change and its impact, as this appears to be a key driver of pro-environmental behavior. Public awareness campaigns, educational programs, and information provided at the point of travel decision-making should emphasize the global consequences of climate change and the role that individual tourists can play in mitigating its effects.

At the same time, practical interventions should aim to reduce the barriers that prevent tourists from acting on their willingness to contribute. For example, tourism providers could introduce more affordable and convenient sustainable options, such as offering carbon-neutral travel packages, incentivizing participation in conservation activities, or integrating sustainability into the overall travel experience. Providing tourists with clear, accessible and meaningful opportunities to engage in climate change mitigation is essential for translating awareness into action.

6. Conclusion

This study aimed to investigate the influence of global and local climate change awareness on Greek tourists' willingness to contribute to climate change mitigation efforts, either through financial support or by dedicating their time to environmental actions. The findings support the pivotal role of global awareness in fostering pro-environmental intentions, while local awareness was found to have an insignificant impact. These results bear significant implications for both theoretical frameworks in sustainable tourism and the development of practical policies aimed at encouraging climate-conscious behavior among tourists.

The prominent effect of global awareness corroborates existing literature, which suggests that a broader understanding of climate change as a global issue fosters a heightened sense of responsibility and urgency. Tourists who are more cognizant of the global ramifications of climate change are more likely to experience a moral obligation to contribute to its mitigation. This is consistent with the Value-Belief-Norm theory, which posits that individuals with strong environmental values are more inclined to engage in behaviors that support environmental sustainability.

Conversely, the finding that local awareness does not significantly affect tourists' willingness to contribute to climate change mitigation challenges expectations. While it would seem intuitive that an awareness of the local environmental threats to tourism destinations would motivate protective behavior, this study suggests that global awareness exerts a more substantial influence. This may be explained by the concept of psychological distance, wherein individuals perceive local environmental risks as distant or abstract, thus diminishing their immediate motivation to act. Additionally, it is possible that tourists do not yet view climate change as an imminent or severe threat in specific destinations, such as Greece.

The implications of these findings extend to both the tourism industry and policymakers. Firstly, efforts to promote sustainable tourism should prioritize increasing global climate change awareness among tourists. Educational programs and outreach strategies that emphasize the global nature of climate change and its far-reaching consequences may have a greater impact on motivating tourists to take action. These messages should be disseminated at various stages of the tourist experience, from the decision-making process during trip planning to the activities tourists engage in during their stay at the destination.

Secondly, this study highlights the need to address the gap between tourists' expressed willingness to act and their actual pro-environmental behaviors. While many tourists indicate a desire to contribute to climate change solutions, practical barriers such as cost, convenience, and the perceived impact on their travel enjoyment often inhibit action. Industry stakeholders must therefore focus on making sustainable travel options more accessible and appealing. This could be achieved by integrating environmentally friendly practices into tourism products without compromising comfort, affordability, or the overall travel experience.

In conclusion, this research advances the understanding of the role that climate change awareness plays in shaping pro-environmental behavior within the tourism sector. The results highlight the importance of global awareness as a key driver of tourists' willingness to engage in climate change mitigation efforts. Future research should continue to explore the dynamics between awareness, attitudes and behavior, particularly as the impact of climate change becomes more pronounced in major tourism destinations. Understanding these evolving relationships will be critical for developing effective interventions that promote sustainability in the tourism industry.

Future research should further investigate the relationship between global and local awareness, as well as explore other factors, such as cultural differences, that may influence tourists' pro-environmental behavior. Moreover, longitudinal studies could provide deeper insights into how tourists' awareness and behavior evolve over time and in response to changing environmental conditions. By addressing these gaps, scholars and practitioners can work together to develop more effective strategies for promoting sustainability within the tourism sector.

Declaration of interest statement

The authors declare that they have no conflict of interest.

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GRADUALLY SHIFTING THE NATIONAL PRODUCTION MODEL'S CENTER OF GRAVITY: INVESTING IN REGIONAL COMPARATIVE ADVANTAGES FOR DEMOGRAPHIC RESTRUCTURING

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Abstract

Greece records an extremely negative performance in terms of balance between birth and death rates while existing data highlight a clear imbalance regarding population outflow. The paper intends to portray the demographic trajectory both at an EU and at a national level, coupled with providing at a certain extend insights about relevant projections. Additionally, the paper emphasizes on the case of Fthiotida (a Regional Unity falling within the Region of Central Greece) and the depopulation recorded between 2011-2021, while it describes Central Greece's current tourism performance and its impact in terms of economic indicators. Taking those into consideration the paper's initial purpose is to provide various insights to promote current public discourse on the necessity of the effective utilization of the region's natural thermal resources as a mean that may result in attracting investments related to tourism industry, creating sustainable and well-paid health-related jobs, and subsequently build the foundations of curtailing demographic vaporization taking place in the forementioned area. The methodological approach adopted is related to the review and content analysis of current literature, subsequent inputs included in institutional reports, data derived by official documentation and high institutional level interventions taken place within the public discourse. The paper concludes to the well-founded assumption that exploiting Fthiotida's natural resources in terms of thermal/hot springs, as a complementary component, may contribute to the creation of an integrated tourism product, able to support regional economy, enforce the argument of gradual shifting the country's productive model center of gravity, starting from certain sectors which are able to thrive in Greek regions, and establish conditions that may put a curb on population bloodletting.

Keywords: demography, tourism, economic growth, Greece, Fthiotida

1. Introduction

A major challenge both many European Member States and Greece must deal with is the ongoing demographic crisis (Papadaki, 2012). Elaborating on recent demographic developments, current data show a clear differentiation regarding the population variations among EU countries (Eurostat, 2023). As regards Greece, recently, it was mentioned that "the demographic issue renders itself as an existential bet for our future", showcasing the issue's significance and severity (Primeminister.gr, 2023). Depicting the wider image of the country's productive model, tourism marks as one of the key drivers in the Greek economy (OECD, 2022), based on the long-lasting tourism-economic growth relationship throughout the years (Lolos et al., 2021).

According to recent data tourism contributes substantially to both domestic GDP and employment. For instance, tourism contribution to the Greek economy amounted to 28.5 billion euros in 2023, corresponding to 13% of the country's GDP, following an ascending trajectory reflected on 23.9 billion euros in 2022 (11.6% of the country's GDP), and on 23.1 billion euros (12.6% in terms of contribution to the domestic GDP) in 2019 (Ikkos and Koutsos, 2024). As regards employment, the Bank of Greece (2024) indicates that 116,649 new working positions have been created in 2023 contrary to 72,847 in 2022, a fact that mostly lies on tourism sector's contribution. By and large, available data underline that 810,000 working positions, both directly and indirectly linked to tourism industry have been created in total in 2023. This amount corresponds to 19.4% contribution to national employment (Institute of the Greek Tourism Confederation, n.d.). In the wider context, Dimopoulos et al. (2023) accentuate that five Greek Regions represent the 87% of tourism revenues recorded in 2020 placing emphasis on the strand of extended inequalities influencing Greek production role model. Those mentioned above are confirmed by recent analytic quantitative data following in Table 1 (Institute of the Greek Tourism Confederation, 2023; Ikkos and Koutsos, 2024).

Table 1. Allocation of tourism-related benefits across regions, 2022 – 2023

Region	Inbound tourism % revenue allocation		Ratio of direct tourism expenditure (in million euros)		Regional GDP (in million euros)		% of GDP corresponding to tourism expenditure		GDP per capita (in euros)	
	2022	2023	2022	2023	2022	2023	2022	2023	2020	2021
South Aegean	27%	27%	6.522	7.719	6.372	7.000	102%	110%	14.572	16.639
Crete	21%	26%	5.073	7.510	9.908	10.777	51%	70%	12.374	13.994
Attica	17%	19%	3.948	5.473	99.349	105.459	4%	5%	21.134	23.335
Ionian Islands	15%	10%	3.614	2.947	3.293	3.554	110%	83%	12.914	14.520
Central Macedonia	9%	8%	2.094	2.189	28.368	30.243	7%	7%	12.092	13.453
Peloponnese	3%	2%	628	554	9.659	9.920	6%	6%	13.456	14.407
Epirus	2%	2%	361	478	4.635	4.796	8%	10%	11.097	11.981
Eas. Mac. & Thrace	2%	2%	508	471	8.187	8.638	6%	5%	10.908	12.006
Thessaly	1%	1%	320	366	10.907	11.495	3%	3%	12.172	13.390
Western Greece	1%	1%	306	304	9.480	9.721	3%	3%	11.616	12.429
Central Greece	1%	1%	301	240	10.688	11.264	3%	2%	15.322	16.834
Northern Aegean	1%	1%	173	215	2.931	2.954	6%	7%	10.163	10.658
Western Macedonia	0%	0%	67	73	4.253	4.482	2%	2%	12.838	14.141
Country	100%	100%	23.914	28.539	208.030	220.303	11,5%	13%	15.461	17.058

Source: Institute of the Greek Tourism Confederation, 2023, Ikkos and Koutsos. (2024).

Exercising caution on the aspect of regional disparities, Psycharis et al. (2023) indicate that inequalities have widened during the economic crisis, with most municipalities outside the large metropolitan areas showing levels of declared income per capita below the country

average. OECD (2022a) stresses that territorial inequalities pose long-term risks for social cohesion, that can be ameliorated by future economic shocks. Thus, one of the main means to achieve wellbeing is investments, that can result in strengthening incomes, job creation and unlocking potential of regions and cities (Krabokoukis, et al., 2024, OECD, 2018). In his paper, Gunton (2003) points out that the development of natural resources has played a significant role in the expansion of many regional economies around the world. Provided that Greece possesses a considerable capacity in natural resources that amounts to 822 thermos-metallic springs in total, with 750 of them having the potential of becoming exploitable, and 348 of them are being used to a large or smaller degree (Dimopoulos et al., 2023), most of them located in many regions, it is assumed that there's concrete foundations onto wellness (and its derivative or similar products) can continue its steadily growing trajectory (Vakoula and Constantoglou, 2023). Taking into consideration of the fact that wellness policies will become far more prominent on the political agendas of national, regional and local governments[1], the paper intends to place emphasis on the need of exploitation of comparative advantages (e.g., existing natural resources) in the context of the shifting of the country's productive model center of gravity to certain sectors able to thrive in Greek regions, such that of wellness tourism, as a mean to gradually achieve demographic restoration.

2. Methodology

The methodological approach applied, placed emphasis on the better understanding of a complex phenomenon such as the one under the examination (Molina-Azorin, 2016; Battista and Torre, 2023). It consists in the review of current literature, inputs included in institutional reports and data derived by official documentation and high institutional level interventions. Trying to serve, in the best possible way, the purpose of strengthening the paper's conclusions, authors applied mix method research, using components of a bilateral nature, akin to the combination of targeted qualitative and quantitative data (Schoonenboom and Johnson, 2017). Concerning the demographic variables at a European level, the paper uses relevant official institutional sources (i.e., Eurostat) and reports (i.e., European Commission), entailing most of recent demographic quantitative and qualitative data. As regards, those at a domestic level, authors used data brought out by the official national authority (i.e., Hellenic Statistical Authority), and subsequent available literature based on data derived by it. As regards the description of the economic dimension and to the purpose of covering existing gaps regarding the depiction of the relevant projected impact in combination with providing sufficient justification for the intensification of efforts on the imminent effective use of extant natural thermal resources, the latest data of the Global Wellness Institute's reports have been used. Finally, the paper also consists of inputs regarding the latest relevant key legislative and operational developments that took place at a domestic level.

3. Brief description of EU demographic facts

According to a recent Eurostat (2023) on January 1st, 2023, the population increased to 448.4 million, from 446.7 million on January 1st, 2022. This amounts to an increase of 93.9 million compared to 354.5 million of 1960. Moreover, an increase in 20 countries has been observed, whereas a significant downward trend was recorded in 7 of them. Among those, recorded the highest rates of population decrease was Greece by -6.3%. To that extend, the European Commission (2023) indicated that a considerable number of EU Member States is assumed to experience a decline of its population by 2030 with countries such as Bulgaria, Latvia, Croatia, Italy, Lithuania, Hungary, Poland, Romania, and Greece shaping this deceleration course. Moreover, in 2021 there were more than 3 Europeans in a productive age per inhabitant of 65 years old and over, representing a dependence rate of 32.5%. It is indicated that by 2050 approximately 30% of Europe's population will age more than 65 years old. It is also assumed that less than 2 adults of a productive age will correspond to 1

[1] The trend articulated as above was recorded in the context of the Global Wellness Summit – GWS Wellness Master Class 2023 Trends Mid-year Update, organized on December 10th, 2023, uploaded on YouTube. https://surl.li/lahtqq

adult of 65 years old and on, amounting to dependence rate of 56.7%. Additional assumptions regarding the changing of the population at a European level speak about a plateau of about 449 million people before 2025 and then after 2030 a progressive slowdown to 424 million by 2070, equivalent to a 5% decrease in 50 years. (European Commission, 2020). In this respect, Eurostat (2023) provided sufficient data regarding the EU demographic balance and the evolution of population by country within Figure 1.

Figure 1. Population changes at national level

	Population, 1 January 2022	Live births	Deaths	Natural change (1)	Net migration and statistical adjustment (2)	Total change between 1 January 2022 and 2023	Population, 1 January 2023
EU (4)	446,735.3	3,885.6	5,148.6	-1,263.0	4,054.7	2,791.7	448,387.9
Belgium (3)	11,617.6	114.1	116.4	-2.3	138.7	136.4	11,754.0
Bulgaria (4)	6,838.9	56.6	118.8	-62.2	27.4	-34.8	6,447.7
Czechia	10,516.7	101.3	120.2	-18.9	329.7	310.8	10,827.5
Denmark	5,873.4	58.4	59.4	-1.0	60.2	59.2	5,932.7
Germany	83,237.1	738.9	1,066.3	-327.5	1,449.2	1,121.7	84,358.8
Estonia	1,331.8	11.6	17.3	-5.7	39.8	34.1	1,365.9
Ireland	5,060.0	57.6	35.1	22.5	111.8	134.3	5,194.3
Greece (3)(5)	10,459.8	75.9	140.0	-64.1	-1.7	-65.7	10,394.1
Spain (3)(4)	47,432.9	329.9	462.7	-132.8	695.7	562.9	48,059.8
France (3)	67,871.9	723.6	667.2	56.4	142.4	198.8	68,070.7
Croatia	3,862.3	33.9	57.0	-23.1	11.7	-11.4	3,850.9
Italy (3)(4)	59,030.1	392.6	713.5	-320.9	141.5	-179.4	58,850.7
Cyprus (3)	904.7	10.2	7.3	2.9	13.1	16.0	920.7
Latvia	1,875.8	16.0	30.7	-14.8	22.0	7.3	1,883.0
Lithuania	2,806.0	22.1	42.9	-20.8	72.1	51.3	2,857.3
Luxembourg	645.4	6.5	4.4	2.0	13.4	15.4	660.8
Hungary (4)	9,689.0	89.7	136.8	-47.2	36.6	-10.5	9,597.1
Malta (4)	521.0	4.3	4.2	0.1	21.8	21.9	542.1
Netherlands	17,590.7	167.5	170.1	-2.6	223.2	220.6	17,811.3
Austria	8,978.9	82.6	93.3	-10.7	136.5	125.8	9,104.8
Poland (4)	37,654.2	305.1	448.4	-143.3	7.3	-136.0	36,753.7
Portugal	10,352.0	83.7	124.3	-40.6	156.0	115.3	10,467.4
Romania (3)	19,042.5	183.6	272.0	-88.4	97.5	9.1	19,051.6
Slovenia	2,107.2	17.6	22.5	-4.9	14.5	9.6	2,116.8
Slovakia	5,434.7	52.7	59.6	-6.9	1.0	-5.9	5,428.8
Finland	5,548.2	45.0	63.2	-18.3	34.0	15.7	5,564.0
Sweden (3)	10,452.3	104.7	94.7	10.0	59.2	69.2	10,521.6
Iceland	376.2	4.4	2.7	1.7	9.8	11.5	387.8
Liechtenstein	39.3	0.4	0.3	0.1	0.3	0.4	39.7
Norway	5,425.3	51.5	45.8	5.7	58.0	63.7	5,489.0
Switzerland	8,738.8	82.4	74.4	7.9	66.0	73.9	8,812.7
Bosnia and Herzegovina	:	:	:	:	:	:	:
Montenegro	617.7	7.0	7.1	0.0	-0.9	-1.0	616.7
North Macedonia (6)	1,837.1	18.1	22.5	-4.4	-2.8	-7.2	1,830.0
Albania	2,793.6	24.7	24.0	0.7	-32.5	-31.8	2,761.8
Serbia	6,797.1	62.7	109.2	-46.5	-86.2	-132.7	6,664.4
Turkey	84,680.3	1,035.8	504.8	531.0	68.3	599.3	85,279.6
Ukraine	:	:	:	:	:	:	:
Georgia	:	:	:	:	:	:	3,736.4
Kosovo (*)	:	:	:	:	:	:	:
Moldova	:	:	:	:	:	:	2,512.8

Source: Eurostat. (2023).

To the same extent, OECD (2022) highlights that there were regions in 29 out 36 countries belonging to the organization that have seen their population contracting. It is also underlined that by 2050, more than 50% of the Regions pertain to the forementioned institution will record a significant loss of population, with large cities growing, whereas the smaller ones will be shrinking. At the same time, the shrinking and the ageing of population will impact on the reduction of in-comes and subsequently will raise costs per capita as regards services' provision. As indicated, it is expected to result in fiscal challenges and pressure upon local and regional authorities. Finally, the same entity stresses that the population will be contracting in 14 countries by 2040 and in 18 by 2100, with the biggest losses being recorded in Eastern and Southern European countries (OECD, 2023).

4. Brief decoding of the domestic demographic profile and key projections

According to the outcomes of the recent population census conducted by the Hellenic Statistical Authority (2023) the total population has been estimated at 10,413,982 million on January 1st, 2023, showing a decrease compared to 10,461,627 million people on January 1st, 2022. Latest data issued on December 31st, 2024, indicate that the total population amounts to 10,400,720 people (5,096,893 men and 5,303,827 women). The natural decrease of the population amounted to 55,920 people (71,249 live births and 127,169 deaths of people inhabiting within the territory and the net migration was estimated at 42,658 people. The following figure (Figures 2) provides a more detailed view on current population status (Hellenic Statistical Authority, 2024).

Figure 2. Estimated Population on 1st January 2024 by sex, Region and Regional Unit

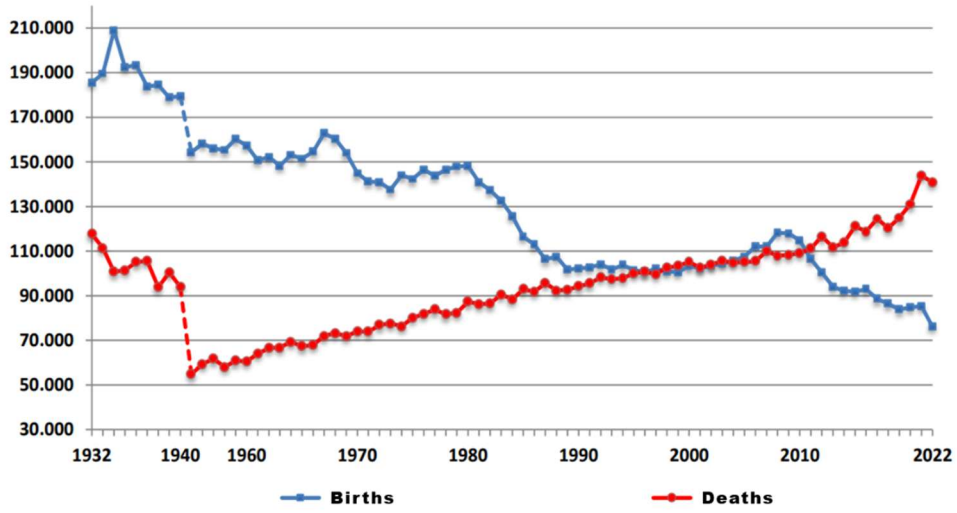
	MALES	FEMALES	TOTAL
TOTAL GREECE	5,096,893	5,303,827	10,400,720
Anatoliki Makedonia, Thraki	278,915	282,919	561,834
Drama	43,078	44,388	87,466
Evros	69,241	65,176	134,417
Kavala and Thasos*	61,261	65,036	126,297
Xanthi	53,706	54,254	107,960
Rodopi	51,629	54,065	105,694
Kentriki Makedonia	859,703	919,193	1,778,896
Imathia	63,921	65,604	129,525
Thessaloniki	517,564	569,363	1,086,927
Kilkis	34,616	34,976	69,592
Pella	60,186	62,391	122,577
Pieria	56,873	59,591	116,464
Serres	75,493	76,582	152,075
Chalkidiki	51,050	50,686	101,736
Dytiki Makedonia	123,090	124,180	247,270
Grevena	13,339	12,575	25,914
Kastoria	22,140	22,342	44,482
Kozani	66,267	67,028	133,295
Florina	21,344	22,235	43,579
Thessalia	334,717	344,030	678,747
Karditsa	51,388	52,552	103,940
Larisa	131,979	134,414	266,393
Magnisia and Sporades*	91,628	96,922	188,550
Trikala	59,722	60,142	119,864
Ipeiros	159,124	161,984	321,108
Arta	30,767	31,040	61,807
Thesprotia	20,107	20,208	40,315
Ioannina	81,571	83,383	164,954
Preveza	26,679	27,353	54,032
Ionia Nisia	99,036	101,606	200,642
Zakynthos	20,072	20,438	40,510
Kerkyra	48,570	50,585	99,155
Kefalonia and Ithaki*	19,136	19,435	38,571
Lefkada	11,258	11,148	22,406

Dytiki Ellada	322,365	317,878	640,243
Aitoloakarnania	93,454	93,253	186,707
Achaia	148,441	153,742	302,183
Ilia	80,470	70,883	151,353
Sterea Ellada	253,928	251,145	505,073
Voiotia	54,749	51,928	106,677
Evvoia	105,740	104,726	210,466
Evrytania	8,844	8,564	17,408
Fthiotida	66,191	67,745	133,936
Fokida	18,404	18,182	36,586
Peloponnisos	266,923	264,675	531,598
Argolida	44,976	46,150	91,126
Arkadia	38,902	37,378	76,280
Korinthia	68,007	68,656	136,663
Lakonia	44,024	40,638	84,662
Messinia	71,014	71,853	142,867
Attiki	1,821,687	1,962,878	3,784,565
Voreio Aigaio	104,423	96,584	201,007
Lesvos and Limnos*	55,775	50,636	106,411
Samos and Ikaria*	22,465	20,238	42,703
Chios	26,183	25,710	51,893
Notio Aigaio	165,462	161,784	327,246
Kalymnos, Karpathos, Kos, Rodos (Dodekanisos*)	106,828	102,360	209,188
Andros, Thira, Kea-Kythnos, Milos, Mykonos, Naxos, Paros, Syros, Tinos (Kyklades*)	58,634	59,424	118,058
Kriti	307,520	314,971	622,491
Irakleio	148,586	154,586	303,172
Lasithi	38,857	38,481	77,338
Rethymno	41,914	43,461	85,375
Chania	78,163	78,443	156,606

Source: Hellenic Statistical Authority. (2024).

Prior to that, in his research findings, Kotzamanis (2022) highlighted that only 13 Regional Unities (former Prefectures) experienced an increase in the size of their population. The greater positive change recorded on the island of Kos (+10%). On the other hand, the greater negative change recorded in the mainland, and the Regional Unity of Grevena (-16%). The following figure (Figure 3) portrays the population's natural mobility trajectory in Greece as of 1932 to 2022 (Hellenic Statistical Authority, 2023).

Figure 3. Population's natural mobility (thousands), 1932-2022



Source: Hellenic Statistical Authority. (2023).

Considering the forementioned facts, prominent demographic policy expert, Kotzamanis provided a brief analysis of the basic reasons for the country's population collapse. He stated that "Greece's population is being reduced over the last 12-13 years, from 2011 for two reasons. Because, as of 2011 we have more deaths than births and many more outflows than inflows", while he focuses on high-skilled, mid-skilled and low-skilled Greeks flee. This is a fact that impacts adversely on the recruitment of the appropriate staff in several sectors, including tourism[2]. In this respect, Labrianidis and Georgopoulos (2022) indicate that highest decreases are being noted in regions such as Western Macedonia, Eastern Macedonia & Thrace, and Central Greece where tourism interest is limited. Giving the full spectrum of

[2] Forementioned facts and information were delivered by prominent Professor, Vyronas Kotzamanis in the context of an interview elaborated on the demographic problem, uploaded on the research institute's "Dianeosis" YouTube account on May 8, 2023. https://surl.li/zpkkph

national weaknesses, it has to be mentioned that the country has suffered from a major surge of brain-drain, as a consequence of the global financial crisis of 2007 – 2009, with the loss of valuable, human capital in terms of social and economic growth and development (Tsertekidis, 2023), as most of it corresponded to young, healthy, well-educated, skilled, highly mobile and employable personnel (Lazaretou, 2022) that resulted in 15,3 billion euros in terms of economic loss, according to research findings[3].

Predestinating basic national demographic developments, Kotzamanis et al. (2016) point out that in 2050 Greece's population is estimated to reach between 10 million (positive scenario) and 8.3 million (adverse scenario), having an ageing rate between 2.04 and 2.73, when in 1951 the same indicator was 0.24. Moreover, Greece underperforms in most key demographic rates. For instance, approximately 1 in 4 women states that she is not willing to have children. Each year 50.000 more deaths will be recorded than births, whereas in 2050 there will be almost 800.000 people aged 65 years old or more[4]. In line with those above, the Foundation for Economic & Industrial Research (IOBE) (2022) says that between 2011 and 2021 the country's population decreased by 441.000 people akin to an average rate of 4%.

It also takes into consideration of a base scenario of demographic projections, that corresponds to a decline to 8.1 million people by 2100, meaning a decline of 2.5 million people, or 24% relevant to 2021. In terms of age structure, the old-age dependency ratio is expected to exceed 0.60 points after 2050, from 0.35 points in 2020 and 0.29 points in 2010. In parallel, an increase of the population aged over 65 years old is assumed, wherein from 22.9% of 2022 (21.2% in EU27) is estimated to accede to 33.5% in 2060, exercising pressure upon the insurance system and healthcare expenditure. Finally, according to Kotzamanis and Pappas (2023) Greece is heading towards an era in which it will face an immense combination of ageing and senility at its highest degree in more than 1 out of 4 Regional Units, where those aged 65 years and over will exceed 1/3 of their population, while at the same time 1/4 of them will be numbered among the category of senility.

4.1. Key demographic data in Central Greece and the Regional Unity of Fthiotida

Focusing on the Region of Central Greece, its 2021 permanent population was calculated in 508,254 inhabitants (254,511 of them are men and 253,743 of them are women) relevant to 547,390 of 2011 (277,475 were men and 269,915 of them were women), recording a decline of 7.1%. (Hellenic Statistical Authority, 2023a; 2023b). In the context of an average of -2.7% per 1,000 people in terms of crude rate of natural population change in 2021, Central Greece which represents 4.9% of total population records a -87.1 per 1,000 people concerning population change, while its Regional Unities contracted by; Fokida, -7.6 per 1000 people, Evrytania, -9.5 per 1000 people, Evoia, -6.5 per 1000 people, Voiotia, -7.1 per 1000 people, with Fthiotida toping the relevant scale by -10.0 per 1000 people (Eurostat, 2023).

According to the Hellenic Statistical Authority (2023) 3,270 people were born in Central Greece whereas 7,640 deaths have been recorded in 2022. OECD (2020) stressed that ageing has been an important challenge for Central Greece, as its share of population over 70 years old is higher than the Greek or EU scales, being increased on average by 2.9% within the period of economic crisis. In this respect, it is indicated that the elderly dependency ratio in 2019 amounted to 37.4%, while according to the Foundation for Economic and Industrial Research (2024) the ratio between the oldest age group relevant to people of working age (15 to 64 years old) is almost 42%. Fthiotida marks as one Central Greece's Regional Units (former Prefectures) that records the second most adverse rate of population decline by 12.9% behind neighboring Evrytania with a downturn of 13.2%, according to available official data (Hellenic Statistical Authority, 2023a). Table 2 lays out numeric data on population changes between 2011 – 2021.

[3] The forementioned figure and research information was showcased within Apostolos Lakasas piece in www.kathimerini.gr published on February 5th, 2018. https://surl.li/rgtujx

[4] Information above is included in Vasilis Kostoulas piece in www.kathimerini.gr, published on April 17th, 2023. The topic is entitled as "Greece has 2.7 million pairs of unused working hands" [Η Ελλάδα έχει αναξιοποίητα 2,7 εκατομμύρια ζευγάρια εργατικά χέρια]. https://surl.li/qxaoju

Table 2. Population of the Regional Unity of Fthiotida and changes between 2011-2021

Municipality	Population			
	2011	2021	change	% change
Lamia	75,315	66,657	-8,658	-11.50%
Amfikleia – Elateia	10,922	8,376	-2,546	-23.31%
Domokos	11,495	9,159	-2,336	-20.32%
Lokron	19,623	17,788	-1,835	-9.35%
Makrakomis	16,036	13,500	-2,536	-15.81%
Kamena Vourla	12,090	10,924	-1,166	-9.64%
Stylida	12,750	11,389	-1,361	-10.67%
Total	158,231	137,793	-20,438	-12.92%

Source: Hellenic Statistical Authority (ELSTAT). (2023a)

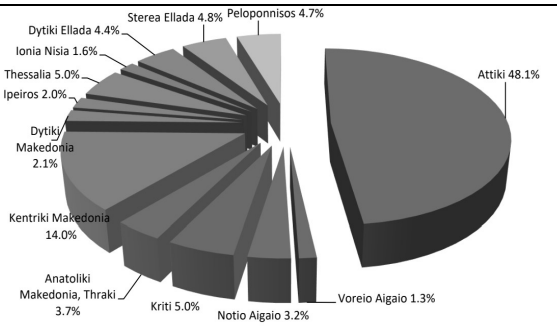
4.2. Socioeconomic aspects of the current regional demographic status

Giving an indicative picture of the concentration of economic activity in urban regions, OECD (2020) underlined that "Attica concentrates almost half (47%) of the country's GDP, above its share of the population (35%) and employment (36%). In contrast, the second largest region, Central Macedonia, concentrates a larger share of the population (17%) relative to GDP (14%) and about the same share of employment (17%)." (p. 52). Latest data brought out by the Hellenic Statistical Authority (ELSTAT) (2025) issued on January 31st, 2025, manifests the spectrum of disparities in terms of both total Gross Value Added per region and the contribution of each region to that (Figures 4-5), confirming extant research findings (Ladias and Stamatiou, 2006) and highlighting regional inequalities (Xanthos et al., 2012).

Figure 4. Total Gross Value Added per Region (in million euros)

Regions	2020	2021	2022*	Change (%) 2021/2020	Change (%) 2022/2021
Attiki	71,484	78,311	88,223	9.6%	12.7%
Voreio Aigaio	1,999	2,135	2,402	6.8%	12.5%
Notio Aigaio	4,378	4,968	5,842	13.5%	17.6%
Kriti	6,980	7,813	9,250	11.9%	18.4%
Anatoliki Makedonia, Thraki	5,508	6,031	6,763	9.5%	12.1%
Kentriki Makedonia	20,414	22,087	25,635	8.2%	16.1%
Dytiki Makedonia	3,093	3,317	3,776	7.3%	13.8%
Ipeiros	3,045	3,284	3,660	7.9%	11.5%
Thessalia	7,657	8,557	9,240	11.8%	8.0%
Ionia Nisia	2,268	2,556	2,990	12.7%	17.0%
Dytiki Ellada	6,499	6,997	8,066	7.7%	15.3%
Sterea Ellada	7,140	7,701	8,890	7.8%	15.4%
Peloponnisos	6,773	7,259	8,672	7.2%	19.5%
ELLADA	**147,236**	**161,015**	**183,409**	**9.4%**	**13.9%**

Figure 5. Regions contribution to total Gross Value Added (2022)



Source: Hellenic Statistical Authority (ELSTAT). (2025).

Approaching more demographic-related parameters in coordination with economic growth it is being indicated that adverse demographic projections possess an unpropitious impact on economy, with research data highlighting that a potential 10% increase of population over 60 years old will result in a downturn of GDP per capita enhancement pace by 5,5% (Pierrakakis, 2016). In the same context, the Foundation for Economic & Industrial Research (IOBE) (2022) macroeconomic emulations assume that "the real GDP in 2100 will be less than 58 billion euros (or 31%) relevant to 2019, employment by 2.1 million people (or 48%), financial revenue by 14 billion euros (or 19%) and GDP per capita by approximately 1,740 euros (or 10%) at 2019 constant prices" (p. 14).

Respectively, a pessimistic assessment by the same entity points out a downturn in terms of real GDP by 95 billion euros or 52% by 2100 compared to 2019, and about a decline by up to 4,000 euros in terms of GDP per capita. The magnitude of GDP per capita is an important factor that seems to affect fertility levels. To date relevant research out-comes show that new demographic transition is not linear and that it depends on extant social and economic circumstances, while at the same time policies implemented impact on it at a certain degree (Balourdos et al., 2019). Argirou (2018) also stresses that GDP marks as a parameter that is

being affected by demographic trends, and it is being consigned by the level of employment that in turn impacts on the level of productivity. Thus, the adoption of a new productive model for Greek economy is required, which besides others, will promote the national economy's extroversion and competitiveness. Moreover, Moody's chief analyst for Greece indicated that the country's current demographic situations is one of the aspects that prevented them from upgrading Greece to investment status[5]. As regards the strand of Central Greece's competitiveness (according to the relevant index[6]), the region is being ranked as portrayed bellow (Tables 3-4).

Table 3. Regional Competitiveness Index (domestically)

Region	2019	2022	2023
Attica	87,2	92,6	92,3
Central Macedonia	60,9	70,4	69,8
Thessaly	61,1	66,4	65,9
Central Greece	**57,8**	**53,4**	**53,2**
Crete	62,6	64,0	63,8
Peloponnese	54,8	61,1	61,4
Western Macedonia	57,0	60,3	60,9
Western Greece	58,9	59,2	59,4
Southern Aegean	55,9	56,6	57,4
Epirus	65,4	60,5	61,6
Northern Aegean	59,8	59,4	60,5
Ionian Islands	62,1	58,9	60,3
Eastern Macedonia –	57,5	55,8	56,2

Table 4. Regional Competitiveness Index (EU) – 10 bottom regions

Country	Region	Index (RCI 2.0-2022)	Ranking (among 234 EU Regions)
Greece	Eastern	56,2	225
Romania	Nord-Vest	56,0	226
Bulgaria	Yugoiztochen	53,4	227
Greece	**Central Greece**	**53,2**	**228**
Romania	Centru	52,5	229
Romania	Sud-Muntenia	52,1	230
Romania	Sud-Vest Oltenia	50,2	231
Bulgaria	Severozapaden	49,0	232
Romania	Nord-Est	47,0	233
Romania	Sud-Est	46,1	234

Source: European Commission. (2023a).

On behalf of the scientific community is ascertained that there is a percentage of 20% of non-used working human capital compared to other EU countries, which means that there are 2.7 million people of productive age that are being excluded by working environments[7]. On the other hand, according to Eurostat (2023) Central Greece suffered from a high rate of youth (aged between 15-29 years old) unemployment (36.5% in 2022), when at the same time it bottoms EU Regions as regards the threshold of high-skilled working staff (21.8% in 2022 and 20.9% in 2023) (Eurostat, 2023, 2024). This constitutes a crucial aspect, since Krupavičius et al. (2024) stress that high-educated people prefer to be integrated in socially equal perceived types of society. Another feature of the region's social profile is that there is a gap of 31.4% in employment between two genders, while at the same time there has been an increase of over 5% on material deprivation and social exclusion in 2023 relevant to 2019 (Eurostat, 2023).

The high employment gap between genders remains still high at 29.3% in the Region of Central Greece which is the highest in the EU (Eurostat, 2024). This negative point is also mentioned by the Foundation for Economic and Industrial Research (IOBE) (2024), pointing out that the region is ranked at the bottom of the relevant category. The same institution highlights the fact it also lags in terms of health system capacity coupled with its low performance with respect to tourism, which mostly concerns inbound tourists rather than those coming from abroad (Foundation for Economic and Industrial Research, 2024a). At this

[5] Information regarding the Greece's investment status is incorporated within Eleftheria Kourtali's piece, entitled as "Why Moody's kept its rating" and published in www.ekathimerini.com on March 20th, 2024. https://surl.li/wntace

[6] The Regional Competitive Index assesses a region's ability to offer an attractive environment for businesses and people to be able to live and work.

[7] Information above is included in Vasilis Kostoulas piece in www.kathimerini.gr, published on April 17th, 2023. The topic is entitled as "Greece has 2.7 million pairs of unused working hands" [Η Ελλάδα έχει αναξιοποίητα 2,7 εκατομμύρια ζευγάρια εργατικά χέρια]. https://surl.li/qxaoju

crucial juncture, all the above indicatively laid out stress the need for intensification of relevant endeavors towards the exploitation of stagnant or non-exploited natural resources related to the creation of a cohesive and complete tourism product (Roman, et al. 2023).

4.3. The broader concept of wellness and its economic impact

According to World Tourism Organization and European Travel Commission (2018) "health tourism covers those types of tourism which have as a primary motivation, the contribution to physical, mental and/or spiritual health through medical and wellness-based activities which increase the capacity of individuals to satisfy their own needs and function better as individuals in their environment and society" (p. 9), whereas it operates as an umbrella term for the subtypes: wellness tourism and medical tourism. The same institutes define wellness tourism as "a type of tourism activity which aims to improve and balance all the main domains of human life including physical, mental, emotional, occupational, intellectual and spiritual. The primary motivation for the wellness tourist is to engage in preventive, proactive, life-style enhancing activities such as fitness, healthy eating, relaxation, pampering and healing treatments" (p. 10). Mueller and Kaufmann (2001) made mention on the American doctor Halbert Dunn's notion articulated back in 1959, wrote about a special state of health comprising an overall sense of well-being which sees person as consisting of body, spirit and mind and being dependent on his environment.

Smith and Puczko (2009) as cited in Medina-Munoz, D. and Medina-Munoz, R. (2014) indicate that wellness includes components related to lifestyle, physical, mental, and spiritual well-being, being perceived as a type of health tourism. Referring to spas, in the context of their paper, Mak et al. (2009) incorporated the International Spa Association's definitional approach to overall well-being through the provision of a host of professional services that encourage the renewal of mind, body and spirit. They also point out that it is key for decision makers to understand motivations that trigger consuming interest. Čeperković and Čerović (2023) point to the Short Dictionary of Tourism approach that correlates spa tourism with accordingly monitored health-preventive and therapeutic interventions in the context of a leisure period, while at the same time they highlight the ascending trajectory of this sub-sector in countries such as Serbia, Hungary, Slovenia, and Croatia, over the years 2010-2019. Huang et al. (2022) say that hot springs is a category of wellness tourism, while at the same time it is being rendered as a form of health-related tourism, developing in locations with cultural elements and historical background. The wellness concept seems to be among the broader spectrum of choices that may meet modern people's needs regarding health (Lakićević et al., 2023).

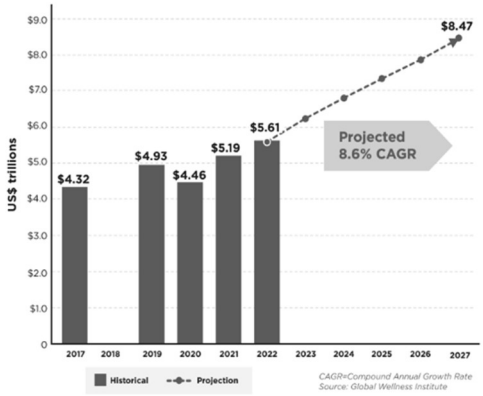
Smith and Puczko (2008) proceeded to a distinction within the wider framework of health tourism, placing the disease-related rehabilitation closer to medical tourism, whereas lifestyle-related rehabilitation between wellness tourism and medical tourism. The scientific community also stresses the importance of the potential positive impact through the utilization of thermal springs on a broad range of health issues coupled with the contribution to the gradual limitation of pharmaceutical interventions (Mao et al., 2023, Iosub et al., 2024). By and large, Pashkov et al. (2017) is believed to showcase the wider conceptual framework of this sensitive aspect, at a quite representative manner, highlighting that rehabilitation is the process that may facilitate people with disabilities and patients with chronic diseases physical, psychological and social functionality at the highest possible degree. The purpose of a considerable number of travelers is the pursuit of rehabilitation services, the improvement of their functionality, and the alleviation of negative implications derived by diseases or injuries in combination of an adequate wellbeing level.

Focusing on the dimension of wellness economy and its derivative impact Johnston et al. (2024) issued the standard Global Wellness report, providing the latest relevant economic data and indicators. According to those data it reached a new peak of 6.3 trillion dollars in 2023 (representing 6.03% of global GDP), which ascended from 5.6 trillion dollars in 2022 (Johnston et al., 2023). According to the latest projections the global wellness economy will develop at a robust rate of 7.3% on an annual basis during 2023-2028, following previous similar estimates of 8.6% annual growth rate till 2027 (Figure 6). The previous report states that certain sectors that constitute the broader wellness economy showcased their resilience,

having recovered from the shock that COVID-19 brought up. Wellness economy reached 125.7% of its corresponding market size as a share of 2019 level. Among others, physical activity grew by 4.1% annually during 2019-2023 and it reached 117% of its 2019 level. Prior to that, it declined by 14.6% during the first year of the pandemic crisis. Respectively, wellness tourism ascended by 4.5% annual growth 2019-2023 and in 2023 reached 119% of its 2019 level. It must be underlined that the wellness sector was the most adversely affected by COVID-19, reduced by 50.8% in 2020.

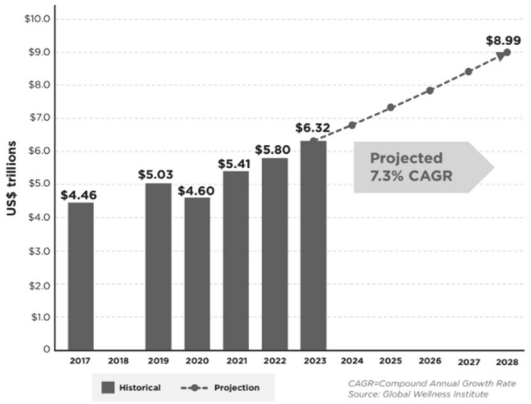
Figure 6. Global Wellness Economy Market Size and Growth Projections, 2017-2027 and 2017-2028

2017-2027



Source: Johnston et al. (2023).

2017-2028



Source: Johnston et al. (2024).

Spas and subsequently the relevant form of tourism has developed by 4.1% annually during 2019-2023. During the pandemic crisis this crucial sub-sector of the broader wellness economy was heavily battered by travel restrictions, business shutdowns, and instructions with respect to social isolation. This led to a significant drop of 38.2% in terms of revenues and a loss of 4,700 business in 2020. However, as of 2023, global relevant revenues have fully recovered, reaching 118% of their pre-pandemic level. Conversely, thermal/mineral springs recorded a negative 1.2% annual pace within 2019-2023. It must be stressed that the sub-sector's performance contracted by 40.3% in 2020, because of the restrictive measures applied. However, the sub-sector in 2023 reached 95.4% of its 2019 level. Following those mentioned above with respect to the robust growth rate of the wider wellness economy, the previously laid out sub-sectors demonstrate a promising trend. Specifically, wellness tourism is projected to grow by 10.2%, thermal/mineral springs by 9.2%, spas by 6.1% and physical activity by 5.8% (Johnston et al., 2024).

Global Wellness Institute's research staff provides specific data regarding wellness tourists' affordability and ability to spend for relevant purposes. For instance, it is said that wellness travelers spend more per trip than the average tourist, which marks as an ascertainment that refers to both international and domestic wellness tourists. As indicated, in 2022, international wellness tourists spent 1,764 dollars per trip on average, which is 41% more than the typical international tourist. Additionally, the premium for domestic wellness tourists is much higher, reaching 175% more than the typical domestic tourist (or 668 dollars per trip) (Johnston et al., 2023). Latest similar data show a slight downward trend, manifesting that in 2023, international wellness tourists spent on average 1,668 dollars per trip (96 dollars less than those of the previous year or -5.44% lower), which is 36% more than the typical international tourist. Respectively, domestic wellness tourists' spending capacity remains higher, at 163% more than the typical domestic tourist (or 673 dollars per trip, slightly more than the previous year's corresponding figure) (Johnston et al., 2024).

Delving into more data on wellness consumers spending abilities, the same institute's research outcomes show that per capita spending on wellness amounts to 788 dollars which is slightly higher than the average consumer out-of-pocket spending on health goods/medical services (746 dollars). As regards Europe, wellness-related spending per capita is estimated at 1,794 dollars in 2023, growing by 9.7% compared to the previous year. This is the second highest per capita spending on wellness behind that of North America (5,768 dollars). Exercising caution on the case of Greece, the country ranks 42nd as regards its wellness

economy size according to the relevant criteria and 45th regarding its wellness economy per capita performance (1,756 dollars). As regards the wellness economy percentage as share of GDP, Greece lies 27th by 7.65% according to the relevant table (Johnston, et al., 2025). Prior to the extraction of the latest data, the same institute indicated that as more consumers incorporate wellness-related choices into their lifestyles, an array of opportunities may rise for all businesses to infuse wellness into their set of offerings, providing the ability to capture spending by wellness travelers (Yeung and Johnston, 2018).

In the light of those above, opportunities for micro/small enterprises, entrepreneurship, and new business models coupled with boosting employment correspond to a sound anticipation (Yeung et al, 2019). Respectively, in terms of employability, indicatively laid out data coming from the US market offer sufficient justification on the need of intensifying efforts and derivative front-loaded initiatives in the broader sector. For instance, according to the International Spa Association – ISPA the total number of industry employees also continued on its upward trajectory in 2022, increasing by 4.6% to 360,700 workers from 345,000 (Spa Business, 2023), while the US wellness services industry unveils its intention to offer incentives to address existing workforce shortages through financial incentives, such as higher wages (61%), signing-on bonus (38%), along with flexible work schedules (66%) in combination with targeting those unemployed (28%) (Spa Business, 2023a). Finally, relevant assumptions were recorded within the national context. According to Tountas et al. (2019, 2021) additional 25,6 thousand working positions could be created on thermal tourism, while wellness tourism could contribute to 171,000 thousand jobs provided that 13,5 billion euros would be added to the national GDP.

4.4. Regional Unity of Fthiotida's comparative advantage

Greece prides itself for its significant wealth of natural resources including excellent quality waters, amounting to 822 health springs out of those 752 can be utilized (Georgakopoulou & Delitheou, 2020). However, there are some arguments on that, as it has been said that a notable amount of them should be perceived as just spots of thermal water gushing (Danas, 2023). According to the Ministry of Tourism there are 84 thermal/hot springs accredited through issuing a Government Gazette to date (February 11, 2025).[8] Apart from giving an updated picture of the regional infrastructure's latest situation and of the recent legislative developments and institutional intentions, Dimopoulos et al. (2023) grouped Fthiotida's natural capital in terms of thermal/hot springs in the following Figure 13. A considerable part of natural thermal resources included in this figure pertains to Hellenic Republic Asset Development Fund S.A. (HRADF). An entity that was established in 2011 according to its founding Law 3986/2011 with an initial mandate to leverage the State's private property assigned to it by the Hellenic Republic (Government Gazette, 2011). Its mission is to act as a strategic partner for the Greek State to attract investments, enhance the national economy's growth potential, strengthen its international credibility, and produce wealth (Hellenic Republic Asset Development Fund S.A., n.d.). Following those included in Figure 13, a brief review of the most significant developments related to the natural thermal resources' future utilization, that have happened so far, are taking place.

[8] Information and data are included into the Ministry of Tourism website that contains the Government Gazette Papers (FEK) of Accredited Thermal Springs [Φύλλα Εφημερίδας της Κυβερνήσεως (ΦΕΚ) των Αναγνωρισμένων Ιαματικών Πηγών]. Retrieved February 11st, 2025. https://surl.li/psmvsv

Figure 13. Hot/thermal springs of the Regional Unity of Fthiotida

Municipality	Accredited thermal springs	Thermal springs in process of accreditation
Lamia	Ypati's thermal waters, Thermopyles thermal waters	Kallidromo, Thermopyles
Kamena Vourla	former Molos Municipality borehole thermal waters, Koniaviti (Kallyntika) thermal spring, Georgala thermal springs	Borehole thermal waters GP1, GP4, GP8, Alamani/ Vourvoulaki, Mylos Koniaviti, Molos, Agios Konstantinos (school units), Elpiniki thermal spring (Ministry of Tourism, 2022), Thermal waters of Nova, Vasileiadi and Vlassi (Hellenic Public Properties Co. [HPPC], 2022a).
Makrakomi	Palaiovracha thermal spring, Klouvio thermal spring, Spring of "Thermal borehole" Platystomo waters (Ministry of Tourism, n.d.)	Omorfoneri/Morfoneri, Thermal (FREAR)[a,b]
Domokos		Ekkara Kolovo, Dranista – Kaitsa thermal waters (Loutradranistas-kaitsas.gr, n.d.; Ministry of Tourism, 2020a)[c]

[a]Entailed into an existing reference.
[b]Within the website of Municipality of Makrakomi https://dimosmakrakomis.gov.gr/ there is also the thermal spring of Archani which is not clearly articulated into the relevant official documents. As the website underlines this spring lies among a small group of five (5) unique thermal springs worldwide, including two (2) in California USA, one (1) in Oregon USA and one (1) in Kulasi, Bosnia Herzegovina.
[c]There is also the thermal spring of Gerakli.

Source: Dimopoulos et al. (2023).

4.4.1. Thermal Spring of Kamena Vourla

In the context of a brief description with respect to the Thermal Spring of Kamena Vourla this is a total area of 474,524 square meters. According to the press release issued on January 5th, 2023, an improved financial offer (highest bidder) has been submitted by the association of companies Galini Hotel Tourism and Commercial Enterprises S.A. and Staritem Investment PLC, for the development through a long-term lease of 40 years of the property "Loutropolis Kamena Vourla". The offer includes a one-off payment of 1,050,000 euros and an annual rent of 380,000 euros. The joint venture will undertake through the lease agreement to implement mandatory investments to upgrade and modernize the property (Hellenic Republic Asset Development Fund S.A., 2023).

4.4.2. Ypati Thermal Spring

Elaborating on the case of Loutra Ypatis, the whole range where the relevant asset is located upon is 700,722 square meters (Hellenic Republic Asset Development Fund S.A., 2022). According to available data, the area of interest contains an operating hydrotherapy unit of 82 baths of an exterior pool of 186 square meters and a laid-out refreshment booth, three non-operating/abandoned hotel units and other supporting facilities (Hellenic Republic Asset Development Fund S.A., n.d.-a). On December 19, 2022, the Municipal Authority of Lamia announced that local stakeholders related to tourism, accommodation industry and entrepreneurship submitted a report with respect to health and wellness tourism sustainable development, in accordance with provisions of the Law 4875/2021.[9] Deploying a different approach on the property's potential exploitation a Hellenic Republic Asset Development Fund S.A. (HRADF) representative made known (March 11, 2023) that the entity's intention is to proceed to a tender while one year later (March 9, 2024) unveiled that additional regulations are needed to concisely define what can be done within the relevant area.[10] Those

[9] Information presented as above is included into an official press release issued by the Municipality of Lamia (2022, December 19), being entitled as "Submission of proposal to the Ministry of Tourism on the designation of the Municipal Unity of Ypati, Municipality of Lamia, as a Prototype Tourism Destination of Integrated Management" [Υποβολή πρότασης, στο Υπουργείο Τουρισμού, χαρακτηρισμού Πρότυπου Τουριστικού Προορισμού Ολοκληρωμένης Διαχείρισης της περιοχής «Λουτρά Υπάτης - Υπάτη» της Δημοτικής Ενότητας Υπάτης του Δήμου Λαμιέων]. https://surl.li/aztsvn
[10] The forementioned information correspond to insights provided by the Hellenic Republic Asset Development Fund S.A. (HRADF) representative in the context of his address in Thermopylae Forum (2023, March 11st) https://surl.li/udfrox and respectively Thermopylae Forum. (2024, March 9th) https://surl.li/cjasgj

intentions are also being confirmed by recent domestic media insights with regard to the "Growthfund's" efforts to attract investors.[11]

4.4.3. Platystomo Thermal Spring

According to the Hellenic Republic Asset Development Fund S.A. (2022, n.d.-b) the shape of the property is cyclical with a 500m radius, at an altitude of 250 m, and is level in the center with hill-like peripheral protrusions. Within the range of the property, which accounts for 785,398.00 square meters there have been operating two hotel units coupled with a thermal spring and wellness-related facility. Another thing that needs to be considered is that a hotel facility has been operating for years next to a non-accredited thermal/hot spring, having an illegally located construction upon the existing water stream, which still has no relevant license, according to an official statement by the former Minister of Finance[12]. The relevant facilities are derelict and neglected. It was said that "neither central administration, neither local government, nor private initiatives managed to exploit this natural wealth to the benefit of the area and of the local economy"[13]. The managing body's expressed intention is to turn the wider asset into a spa tourism center, a rehabilitation center, and a unit facilitating sports (Hellenic Republic Asset Development Fund S.A., 2022).

4.4.4. "Koniavitis" Thermal Spring

The asset that contains the "Koniavitis" Thermal Spring & Camping extends upon a range of 783,320.90 square meters out of 523,000.00 can be used in the future (Hellenic Republic Asset Development Fund S.A., 2022). The relevant area consists of two parts. Part A' corresponds to a plot outside the urban planning zone which covers 520,515.75 square meters with a seacoast of about 1,200 meters. Respectively, part B' represents a plot outside the urban planning zone with an area of 37,211.37 square meters, that includes two hot/thermal springs, those of "Mylos Koniavitis" and "Kallyntikon", with the second one officially being accredited (Hellenic Republic Asset Development Fund S.A., 2023c). There are also abandoned camping facilities constituting an infrastructure for 250 caravans, receptions building, 50 huts, 5 stores, staff buildings, etc. (Hellenic Republic Asset Development Fund S.A., n.d.-c). The managing entity announced that it has received one financial offer for the exploitation of the asset above by INMO PARCK INVEST FOREIGN BRANCH S.A. (Hellenic Republic Asset Development Fund S.A., 2023a). The previous mentioned company declared as preferred investor for the development of the whole property, submitting an offer of 9,338,842.98 euros for area A' and 1,679,341.76 euros for area B', pledging its intention to proceed to an investment of at least 200 million euros (Hellenic Republic Asset Development Fund S.A., 2024).

4.4.5. Thermopylae Thermal Spring

One of the most emblematic and of great cultural significance, historic landmark is Thermopylae (Kalotas and Metaxas, 2024). The archaeological area of Thermopylae contains an accredited hot/thermal spring, an abandoned hydrotherapy center and two hotels (Hellenic Republic Asset Development Fund S.A., n.d.-d.), incorporated into the national policy, as a temporary reception of migrants and refugees (Ministry of Migration & Asylum, n.d.) in accordance with the Law 4375/2016 (Government Gazette, 2016). Government-related officials mentioned that interventions towards the improvement of the archeological area of

[11] The "Growthfund" is a holding company established in 2016 with the Greek State. One of its core missions is maximize the value of public assets. That being said, Antiopi Schina in www.liberal.gr (2025, March, 12nd), recently mentioned that assets including thermal/hot springs located in the Regional Unity of Fthiotida (Thermopylae, Platystomo, Ypati), are among those being promoted to real estate exhibitions worldwide in order to attract investing interest. https://ln.run/Ne5ti

[12] The forementioned information were part of the former Minister of Finance and currently Minister of Transport & Infrastructure speech in Thermopylae Forum (2023, March 11st) https://surl.li/udfrox

[13] Articulation shown as above is included into Katsonis, P. and Chachopoulou, L. (2019, October 19) autopsy in the asset of Platystomo. The piece issued is entitled as "Platystomo: How thermal gold turned into charcoal/Long lasting responsibilities, abandonment, those "occupied" and the "saviours" [Πλατύστομο: Πώς το χρυσάφι των ιαματικών έγινε κάρβουνο/Οι διαχρονικές ευθύνες, η εγκατάλειψη, τα "κατεχόμενα" και οι "σωτήρες"] and it was published on Lamianow.gr. https://surl.li/ytckft

Thermopylae, funded by the Recovery and Resilience Facility (RRF), are a part of a broader integrated plan to deal with the demographic problem[14]. More extensively, the Ministry of Finance and the Ministry of Culture made known that the exploitation of this area, including the thermal/hot spring, will be accomplished through targeted interventions of a budget that amounts to 1.7 million euros (Hellenic Government, 2023). It was also clarified that only 115 acres out of approximately 800 of them can be substantially utilized in a very moderate way, which makes it a very difficult proposition[15]. The development scenario includes the construction of tourism, leisure facilities, a health and wellness center and a historic thermal resort (Hellenic Republic Asset Development Fund S.A., 2022). Currently, the thermal spring's utilization brings no direct profit to the wider area's economy[16].

4.4.6. Rest of the Regional Unity's thermal/hot springs

Intending to establish a functional mechanism that would draw a pathway towards thermal/hot springs' long-term exploitation, current administration put in place Law 4875/2021. An entity named "Greek Thermal Springs S.A." was established following the forementioned legal framework (Government Gazette, 2021), yet that initiative ended abruptly, in the context of the Law 5061/2023 as the organization above was repealed (Government Gazette, 2023). This marks an obvious diversification of plans. The main justification of this legislative action was that the "Greek Thermal Springs S.A." operational costs did not bring outcomes anticipated, and that services of the main administrational mechanism of the Ministry of Tourism can deliver effectively on their own.[17]

Reflecting on some additional key local-level developments about the rest of the Regional Unity's thermal/hot springs, it is worth mentioning that in the case of Kallidromo natural thermal resource, the Hellenic Public Properties Co. (HPPC) (2022) indicated that through a collaboration with the Municipal authority responsible are trying to co-shape a scheme that will result in tangible benefits for the local community, because the 25year convention signed in 2014 was never actually put in place. Moreover, the official accreditation of the forementioned natural thermal resource is pending, whereas the Municipal Authority of Lamia acknowledged that it submitted a proposal with respect to the concession of its utilization.[18] Natural thermal/hot resources of boreholes GP8, GP4, GP1, Vourvoulaki – Alamani, Milos Koniaviti, Frear Thermi – Omorfoneri lacking the necessary accreditation, with the relevant process ongoing. As regards the cases of Elpiniki (Kamena Vourla), Molos thermal spring (school facilities), Agios Konstantinos of the Municipality of Kamena Vourla, Kolovo Ekkara of the Municipality of Domokos there is a need for further supporting documentation to the purpose of their accreditation.[19] Exercising more caution to the Municipality of Domokos, it contains three (3) natural aquatic resources. The forementioned,

[14] The reference with respect to the existence of a broader integrated plan that embeds prescience on the demographic issue is included in a press release of the former Government Spokesman and Member of the Hellenic Parliament, elected in Fthiotida, issued on 2022, November 11st. https://surl.gd/ntmmgx

[15] The forementioned information correspond to insights provided by the Hellenic Republic Asset Development Fund S.A. (HRADF) representative in the context of his address in Thermopylae Forum. (2024, March 9th) https://surl.li/cjasgj

[16] Information laid out above was extracted from a recent Maria Tsatzali's piece which was based on an in-person news story, and it was published on www.tvstar.gr on February 16th, 2025. The piece is entitled as "French, Germans, Chinese for bathing in the thermal spring of Thermopylae cost free and without profits for the region" [Γάλλοι, Γερμανοί, Κινέζοι στην Ιαματική Πηγή των Θερμοπυλών για μπάνιο με μηδέν κόστος και μηδέν όφελος για την περιοχή!]. https://ln.run/-TAxl

[17] This constitutes an official justification within the Explanatory Report that accompanies the relevant provisions of the Law 5061/2023 on the strengthening of sustainable tourism development. This report has been excerpted by the official website of the Hellenic Parliament, www.hellenicparliament.gr. https://surl.li/cgcwhu

[18] A reference on the submission of proposal on behalf of Municipality of Lamia, regarding the accreditation of the thermal/hot spring, has been acknowledged in the context of a press release published on 2024, October 16. https://surl.li/miabiw

[19] Information and data laid out as above were extracted by official documentation issued by the Ministry of Tourism in the context of the Parliamentary monitoring process (Documents with protocol number 671/06-05-2021 https://surl.li/xzmtxe and 4035/21-03-2022 https://surl.li/squcdq).

Ekkara spring constitutes a promising but at the same time stagnant natural resource. The second resource of Dranista - Kaitsa is located on the junction of the Municipality of Domokos, Regional Unity of Fthiotida, Region of Central Greece and the Municipality of Sofades, Regional Unity of Karditsa, Region of Thessaly and operates under the authority of a bilateral managing scheme. It is considered that it can strengthen local economy coupled with attracting foreign visitors.[20]

However, according to existing official documentation no proposal on the exploitation of the natural aquatic resources located in the Municipality of Domokos, and particularly those of Kaitsa – Dranista, Ekkara, and Gerakli (3rd resource, also mentioned in Figure 13) has submitted so far[21] without prejudice to the existence of more recent, relevant initiatives. Finally, the natural thermal resource of Palaiovracha, located in the Municipality of Makrakomi is fully utilized during late spring and summer in the context of a private initiative,[22] while the respective spring of Archani (also mentioned in Figure 13) remains underutilized and non-accredited.[23]

5. Discussion

According to Institute of the Greek Tourism Confederation (SETE) Greek Action Plans with a timescale towards 2030, say that wellness and tourism engage elderly, and it is forecasted to present significant growth due to global demographic developments, even though it is being rendered as a secondary tourism product (Institute of the Greek Tourism Confederation, 2021). This argument is being grounded due to projections articulated, recording that between 2021 and 2050, the share of the population aged 80 years old and over is foreseen to double on average across OECD member countries, from 4.8% to 9.8% (OECD, 2023a). Wellness industry experts expect that the sector's future is going to be totally different, as by 2050 spa and wellness will be absorbed or merged with public health, under the wider umbrella of prevention (Spa Business, 2023a).

Economou et al. (2023), expect that overall economic growth will be substantially and positively affected by the contribution of wellness tourism. In this regard current State initiatives count on the exploitation of EU resources coming from the Recovery and Resilience Fund. A total budget of approximately 28,458,000 euros foresees to renovate and upgrade a notable part of thermal tourism facilities or even fuel the creation of new ones.[24] However, according to a mandate of the Central Union of Municipalities (411/14-11-2024), municipal authorities raised concerns as regards delays on the evaluation of proposals about projects dealing with the upgrading of current thermal/hot spring facilities, requesting the intensification and the acceleration of efforts, given that available funding absorption in combination with submitted projects implementation must end till December 31st, 2025.[25]

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[20] Relevant information is embedded within the Operational Program of the Municipality of Domokos 2024 – 2028. https://surl.li/ajxbmh

[21] This is indicated within an official document issued by Ministry of Development & Investments, in the context of its response to the Parliamentary Question with protocol number 7957/03-07-2020, (91320/02-09-2020). https://surl.li/wdawjp

[22] The nature of the relevant thermal facility's operation is mentioned in Efthymios Kakos's piece in www.kathimerini.gr, published on April 24th, 2019. Its title is "Fthiotida: In the spring" [Φθιώτιδα: Στην πηγή]. https://surl.li/ptxsgj

[23] Description entailed as above is included within a piece published on regional media, and specifically on Lamianow.gr. (2025, February 11). The piece is based on an in-person autopsy, and it is entitled as "Baths of Archani: Tens of visitors in a non-utilized thermal spring that pends accrediting (Photos, Video, Audio)" [Λουτρά Αρχανίου: Δεκάδες Επισκέπτες σε Μια Ανεκμετάλλευτη Ιαματική Πηγή που περιμένει πιστοποίηση (Φώτο, Video, Audio)]. https://surl.li/dflizg

[24] This is entailed into an official Ministry of Finance mandate, issued on 2021, December 8th on the accession mandate of the project "Health & Wellness Tourism through thermal spring utilization" – Action 16931 (Code: OPS TA 5153454) [Απόφαση Ένταξης του Έργου «SUB3: Τουρισμός υγείας και ευεξίας με την αξιοποίηση ιαματικών πηγών– Δράση 16931» (Κωδικός ΟΠΣ ΤΑ 5153454)]. https://surl.li/pcyexx

[25] Information laid out as above is included into the Central Union of Municipalities records of the Convention of the Board of Directors published on November 14th, 2024. https://surl.li/qqkdym

Investments' promotion counts on the effective implementation of Law 4487/2022, as it marks a recent key legislative tool that intends to facilitate the attraction of investments in this sector (Dimopoulos et al., 2023), coupled with subsequent inputs, reflected for instance to the provisions of article 54 of the Law 4688/2020. They have set the initial theoretical foundation akin to a first, small step of telemedicine operation within thermal therapy units and thermal tourism – thalassotherapy centers (Government Gazette, 2020), which seems to comply with a request articulated on July 25th, 2024, by the Hellenic Association of Municipalities with Thermal Springs. Still, the prescribed secondary legislation is pending coupled with the abolishment of the provisions of paragraph 1, article 22 of Law 4582/2018, as it has also been requested.[26]

Delineating the future of the domestic economy, the Governor of the Bank of Greece, called on the reduction of the investment gap through boosting public and private investment, through the efficient and prompt exploitation of the European Union's Structural Funds and the Recovery and Resilience Facility (Stournaras, 2023). However, a Greek thermal tourism expert unveiled that only 11 investment proposals were submitted, based on both the Recovery and Resilience Facility funding (15,887,096 euros) and the Public Investments Program (3,812,903 euros) since there was little time between the day of the relevant call issuance (July 26th, 2024) and the closing date (September 15th, 2024)[27]. This is thought to be key for the Regional Unity of Fthiotida, given Government officials' statements about the potential development of modern university-related facilities with focus on rehabilitation[28] and it complies with recent insights laid out by scientific human capital. For instance, according to Nöbauer et al. (2025) regional centers, and the physical services and centers they provide will remain vital to supporting the quality of life of some residents, stressing that though someone might feel comfortable with digital services still needs physical access for things like physiotherapy. The competitive environment deployed in neighboring regions that pride themselves on the existence of an extended healthcare and rehabilitation ecosystem must also be taken into consideration (Giannake, G. et al., 2023)[29].

Approaching the aspect of institutional instruments that may facilitate the indicated necessity of the sustainable promotion of destinations and subsequently their tourism products (Amoiradis, et, al, 2021), destination management organizations (DMOs) play an important role, as they can integrate therapeutic programs and hot/thermal springs as an inextricable component of its wellness capacity (Yao et al., 2023). Therefore, the Greek State, in the context of the Law 4875/2021 has established that instrument coupled with the launching of the subsequent project named "Destination Management and Marketing Organizations" financed with over 14,000,000 euros by the Recovery and Resilience Fund (Hellenic Republic, 2022). By and large, the whole concept elaborated as above should be embedded

[26] This is a part of the set of proposals acknowledged by the Hellenic Association of Municipalities with Thermal Springs, in the context of a press release issued on 2024, July 25th [Οι προτάσεις του ΣΔΙΠΕ για την ανάπτυξη του Ελληνικού Ιαματικού Τουρισμού]. https://surl.li/ukzzgg

[27] Information showcased above is included into an interview of the General Secretary of the Hellenic Association of Municipalities with Thermal Springs in Naftemporiki.gr. The interview was undertaken by A. Angelopoulou on February 10, 2025. https://surl.li/ukzzgg

[28] Two elected Members of the Hellenic Parliament, belonging to the constituency of the Regional Unity of Fthiotida, and former Ministers of the current Administration highlighted the perspective of the existence of a Rehabilitation Center, operating in collaboration or under the jurisdiction of the existing Department of Physiotherapy of the University. According to Tyligada, R. piece on www.tvstar.gr published on March 10th, 2021, a teleconference between a Member of the Hellenic Parliament for the forementioned constituency and Lamia academic community's representatives elaborated on the possibility of a rehabilitation center creation https://surl.li/lnrcam, while on May 5th, 2023, another elected representative of the Regional Unity of Fthiotida, in the context of an interview, made mention on the Department of Physiotherapy's ability to support the promotion of rehabilitation. https://surl.li/eumqgc

[29] Besides relevant research insights, targeted references with respect to the Region of Thessaly future developmental perspectives on health tourism are being included in Giannis Papadimitriou piece in www.kathimerini.gr on February 18, 2025, entitled as "Can Larisa be evolved into a health tourism national hub?" [Μπορεί η Λάρισα να εξελιχθεί σε εθνικό κόμβο για τον τουρισμό υγείας;]. https://surl.li/tmjqqz

into a tailored mix of policies addressing specific challenges faced by each region, targeting among others demographic issues, economic productivity, sectorial specialization, and infrastructure upgrading (Tsiotas and Tselios, 2023).

6. Conclusions

Through an extensive set of facts and data derived by the review of research data, official documentation and institutional public interventions, ought to be embodied into existing literature, authors provide initially, a representative description of demographic situation and trends at a European, national, regional, and intra-regional level (with focus on the Regional Unity of Fthiotida). The deployment of key qualitative and quantitative data foresees to affect future initiatives ought to be undertaken on behalf of those being responsible. They also aspire to shape a framework which includes all recent developments with respect to wellness tourism and its related products, by providing the most recent trends in terms of economic potential that may provenly result in strengthening employment. Especially, provided the necessity of curtailing brain-drain through repatriating high-skilled personnel, that is missing from the wider Region of Central Greece and subsequently maintaining the existing one within the region.

Authors also showcase the notable diversification of current domestic policy, that has recently been reflected on the partial modification of plans in terms of recent legislative initiatives related to the sector under investigation, highlighting at the same time the structural problem of the fragmentary manner of legislating. The paper does also describe the level of maturity in terms of mid-term or long-term utilization of each natural thermal resource in the Regional Unity of Fthiotida. It is believed that this varies due to a set of priorities established by the forementioned managing body that are correlated with each area's tourism potential, coupled with the fact that a lack of consensus, inadequacy and inefficiency are among those being ascertained at a local level.

By and large, the paper's strategic intention is to stimulate and/or contribute to the current public discourse that is being elaborated on the topic of demographic crisis and depopulation diminution, by highlighting at the same time the need of diverting the current productive and economic model towards the regional level, through exercising caution on existing natural resources substantial and sustainable utilization. Thus, through highlighting indicators laid out as above, coupled with portraying a considerable amount of Fthiotida's high-valued natural thermal resources, it is believed that they provide sufficient justification on the necessity of placing emphasis on the exploitation of the area's comparative advantage, with its hot/thermal springs being a predominant part of that. This marks as a process that may impact positively on the gradual and long-term alleviation of demographic bloodletting through raising benefits in terms of economic enhancement, creation of modern tourism-related or health and research-related facilities and infrastructure with focus on rehabilitation, jobs' creation, and consequently to enforce arguments related to the necessity of shifting the center of gravity of the country's production model towards the country's regions in a balanced, targeted and calibrated manner.

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EFFICIENCY OF THE WASTE MANAGEMENT SYSTEM AS A PRECONDITION FOR THE REGIONAL SUSTAINABILITY OF THE ISLANDS

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Abstract

The waste management system on the islands is complex and does not involve a traditional municipal service, mainly due to the strong seasonality of tourism, limited space and regional differences. Wastemanagement is a big challengefor tourist destinations during the tourist season, when there is a significant influx of tourists, which results in larger amounts of waste. Theaim of this paper is to exploretheir views through qualitativeresearch through in-depth interviews with representatives or waste management experts in the utility companies oftheCroatianislands. Thepurposeoftheresearchis to expand theunderstanding and explore the principles of waste management on the islands in Croatia and evaluate their effectiveness. The authors analyze the established waste management systems and, using in-depth interviews, examine whether effective waste management can make the island sustainable. This is one of the few pieces of research on the topic of waste management in terms of sustainabletourism development, which refers to island utility companies in Croatia that deal with waste management. Theconducted research is focused on theCroatian islands, but the model is more widely applicable. It is expected that the results of the research will contribute to political decision makers, decision makers in utility companies and managers, creators of measures and regulations regarding waste management, representatives of municipalities and cities of island tourist destinations.

Keywords: Regional sustainability, waste management, development, Croatian islands,
JEL classification: Q01, Q56, R11

1. Introduction

Human activities generate large amounts of waste, which has negative consequences for the environment and poses serious challenges and threats to the sustainable development of tourism. Disposal of waste without sorting leads to serious environmental problems and the exploitation of natural resources. Proper sorting can significantly reduce the amount of unusable waste. Therefore, the aim is to sort as much as possible so that the amount of waste that can no longer be used is as small as possible (Črnjar M. and Črnjar K. 2009, p. 432; Damjanić 2014; Zhang et al. 2019). An important aspect of an efficient waste management system is recycling – the process in which used materials are collected, recycled and reused, and in which theinhabitants play a main role(Babaei et al. 2015; Bezzina and Dimech 2011). The transition from a linear to a circular economy is one of the models that supports the concept of sustainable development which involves the reuse of materials for which the first step is sorting waste (Marcuta et al. 2021; Šverko Grdić et al. 2019). A higher rate of use of secondary raw materials results in lower production of municipal waste and contributes to sustainability (Šverko Grdić et al. 2020).

Waste management represents a set of activities, decisions and measures aimed at preventing the generation of waste, reducing the amount of waste and/or its harmful impact

on the environment; performance of collection, transportation, recovery, disposal and other activities related to waste and supervision of the performance of these activities; and care for

landfills that are closed, which is the responsibility of utility companies (Fund for environmental protection and energy efficiency n.d.). In Croatia, the problem is that the prescribed laws for waste management are not fully implemented, which is why the waste management system does not function fully. Thus, theamount of waste is increasing, and the waste management infrastructure is not adequate. This leads to inadequate waste disposal and low recycling and recovery rates. In order to reduce the overall amount of unusable mixed municipal waste, it is therefore necessary to use sorting and recycling (Dekanić and Krstinić Nižić 2021).

The waste management system on the islands is complex and does not involve a traditional municipal service, mainly due to the strong seasonality of tourism and limited space (Dekanić and Krstinić Nižić 2021). Waste management is a big challenge for tourist destinations during the tourist season, when there is a significant influx of tourists, which results in larger amounts of waste. In tourist destinations, tourists create pressure on waste disposal systems (Damjanić 2014; Fistrić 2011).

Along with residents, utility companies play an important role in environmental protection in tourist destinations. Increasing environmental requirements force utility companies to adapt development goals and strategies to the requirements of the environment in which they operate, taking into account the specificity of each area (Črnjar M. and Črnjar K. 2009, pp. 243–245). The goal of the activities of utility companies, in cooperation with local self-government units, is to try to minimize environmental pollution (Damjanić 2014). Theaim is to exploretheir views through qualitativeresearch through in-depth interviews with representatives or waste management experts in the utility companies of the islands of Krk, Cres, Lošinj, Rab, Ugljan, Pašman, Brač, and Vis, and to obtain valuable information to increasethe efficiency of the waste management system on the islands. Thepurposeof the research is to expand the understanding and explore the principles of waste management on the islands in Croatia and evaluate their effectiveness. The authors analyze the established waste management systems and, using in-depth interviews, examine whether effective waste management can make the island sustainable.

2. Theoretical background

2.1. Literature review

Fuldauer et al. (2019) planned thefuture of waste management in small island developing states. They believe that it is a special challenge to manage waste on the islands due to high infrastructure costs per inhabitant, distance from the mainland, high dependence on tourism and small resources. The authors state that in Curacao (South America) the waste management system is unsustainable and approximately a quarter of the island's recycling facilities operate illegally, polluting the environment. A comprehensive approach to waste management is proposed in order to achieve sustainability. They believe that it is necessary to limit waste flows from tourism, and introduce prizes, programs and incentives for recycling. Sustainable waste management does not only include decision-making instruments and technological advances, but also cultural and behavioral acceptance, involvement of stakeholders, encouragement of cooperation at all levels from local to international, and application of best practices. Koski-Karell (2019) explains the waste management system on the Island of Bali in Indonesia through a narrative analysis, and the author states that the residents are not instructed in proper waste disposal, and there is a lack of cooperation among stakeholders. As a result, waste accumulates in illegal landfills, which is unsustainable in the long term, and there is a need to develop technology-based infrastructure. Thus, for example, compressing waste with solar energy would contribute to more sustainable waste management in Bali. Pariatamby and Periaiah (2007) present current waste management practices in four tourist islands in Malaysia (Redang, Tioman, Pangkor and Langkawi). Due to the growth of population and tourism, the collection, processing and disposal of wasteontheislands is aninsurmountableproblem, and wastemanagement should follow the principles of sustainable development. The research consisted of interviews with representatives from the field of waste management and civil servants, review of documents and field research. The authors

reported that on the islands in Malaysia, a large part of the waste is disposed of in untreated landfills, the remaining part is burned illegally, and some of the waste even ends up in the ocean. Waste management on the Malaysian islands was still in its infancy, and the challenges encountered were unsightly sites, inefficient waste collection and transportation, improper waste disposal, marine pollution and lack of public awareness. A comprehensive solid waste management approach can provide ecological and economic sustainability of these islands.

Santamarta et al. (2014), through narrative analysis and analysis of secondary data on the example of theCanary Islands (Spain), analyze waste management in isolated island systems which, given their specific geographical location, represent a major challenge in waste management. In the Canary Islands, the amount of produced waste is growing exponentially. In this way, wild landfills are created. Some of the problems in the Canary Islands include high population density resulting from the influx of tourists, the lack of facilities for the processing and disposal of generated waste, the limitation of landfill space and the transportation of waste to the mainland. The authors point out that, as the first step, it is necessary to reduce the amount of produced waste. The generated waste could be used for energy production instead of disposal, because the Canary Islands are dependent on foreign energy. Vilms and Voronova (2016) present the waste management system of four small islands in Estonia using the analysis of secondary waste data. The main problem on small islands is the waste produced by tourists. The research indicates that the best solution would be to take the waste to the mainland by ferry, which would increase the cost of waste management, but in this way the waste would not be disposed of on these small ecologically sensitive islands.

Damjanić (2016) surveyed business entities on the Island of Krk (Croatia) in order to examine their relation, attitude and behavior towards waste. The results indicated that 88,6% of small businesses manage waste properly, 72,2% of economic entities sort waste daily, while 3,5% of entities do not sort waste at all. 43% of them believe that environmental protection is crucial for the development of tourism. Dekanić and Krstinić Nižić (2021), in their analysis of the case of waste management on the Kvarner islands (Croatia), compared data on the amount of waste with tourism indicators on the islands of Krk, Cres, Lošinj and Rab. They proved that with the increase in the number of tourist overnight stays, the amount of generated wastealso increases. Theconclusion is that although tourismis highly seasonal, it does not disrupt the waste management model because it is well-organized with predetermined and consistent application. Kovačić et al. (2021), using a narrative analysis, highlight the importance and advantages of a circular economy and analyze the legislative framework of waste management and green economy trends in Croatia with an emphasis on the Island of Krk. They also emphasize that the Island of Krk has the largest number of recycling yards in the Primorje-Gorski Kotar County. Zovko et al. (2021) researched potential directions for the development of sustainability of waste management in the Adriatic part of Croatia, using the Island of Krk as an example of good practices. They conclude that pronounced tourism seasonality directly affects the environment as well as the waste management infrastructure. Accordingly, the authors see a solution in a moderate intensity of tourism, which would ensure sustainable waste management with less pressure on the environment and waste management infrastructure. Grofelnik (2013) analyzed secondary data on waste and provided insight into ways of waste management on the Island of Cres and the Island of Lošinj (Croatia). The paper also analyzes the disposal of mixed municipal wasteby taking it to thecounty waste management center. The waste management system on the observed islands is satisfactory, but it is necessary to reduce the generated amount of waste through education and encouragement of separate waste collection. The author considers the option of burning municipal waste, which would leave an acceptable carbon footprint on the environment. Burić et al. (2022)analyzed and determined the current situation and specifics, investigated obstacles and tried to provide potential solutions for waste management on the Island of Lošinj (Croatia). They point out that the organization, development and implementation of a complete waste management system on the islands in Croatia is an important political and economic issue, but also an important factor for the quality of life. On the islands, the waste management system is particularly specific and complex primarily due to tourist seasonality, which often results in organizational problems that impair environmental protection, all as a result of non-coordinated waste management plans and

strategies at the national level. They emphasize the importance of sorting waste in order to prevent potential damage to the ecosystem, which would have a negative impact on the tourism sector. They also believe that the processing of biowaste into compost on the island would be useful in gardening and agriculture. The authors propose solutions that are already prescribed by the legislative framework and which are being implemented on the Island of Lošinj, namely: closing the island landfill, putting the sorting plant into operation, transporting mixed municipal wasteto the County WasteManagement Center Marišćina and building a compost plant. Šemanović (2019) analyzes the waste management system on the Island of Brač (Croatia) from social and economic aspects and determines the optimal solution, i.e. determines the model that will provide greater benefits with lower costs. The author concludes that it is economically more profitable to collect and process waste on the island without the additional costs of transporting it to the county center. In this way, instead of the cost of waste removal and payingt for its processing in the county waste management center, income from renewable energy could be generated. Vidučić (2007) indicates that the ecological dimension of the destination is extremely important to tourists. The author concludes that the islands in Croatia generally have a preserved relationship between the island inhabitants and nature, and therefore it is necessary to define the development concept at the island level in such a way that nature and cultural heritage remain preserved. Tourism and ecology are interdependent, so the development of tourism in the future must be considered in terms of sustainable development.

Utility companies play an important role in the environmental protection of tourist destinations becausethey arefaced with increasing environmental requests, which they adapt their goals and development strategies to, taking into account the specifics of the environment in which they operate. The goal of utility companies is to reduce environmental pollutiontoa minimum(Črnjar M.andČrnjar K. 2009,pp. 243–245; Damjanić2014). Below is an overview of the available works that can be found related to utility companies. Lingard et al. (2000) conducted a survey on employee perceptions of waste management systems in utility companies in Australia. Qualitative content analysis of in-depth interviews revealed that managers, unlike workers in utility companies, consider environmental issues to be less important than the costs and time associated with the work. Paliaga (2006) conducted a survey on utility companies in the Republic of Croatia on the topic of strategic planning. The results show that some utility companies in Croatia operate better than others, and the author points out that it is important to develop efficient business models. Runko-Luttenberger (2010) looks at the effect of municipal waste and water management on the environment. Questionnaires, interviews and published data show the views of representatives of utility companies in Croatia on the environment. The author proposes a management model for environmental protection based on municipal wasteand water management through a review of the situation, identification of problems and challenges, possible technical, legislative, institutional and educational solutions and concrete measures. Perkov (2021) analyzes waste disposal in the City of Zagreb (Croatia). It is qualitative research in which the method of semi-structured interviews was used with the key actors of the waste management system in Zagreb (professional, political, management, media and civil). The author concludes that in order to achieve a long-term sustainable and ecologically, economically and socially acceptable waste management system, it is crucial to choose an unambiguous and clear concept and apply it consistently. Gregorić et al. (2018) conducted research using in-depth interviews in seven companies on the Island of Krk (Croatia). The results showed positive results regarding environmental awareness and sustainable development of tourism.

2.2. Examples of effective waste management systems

2.2.1. The Town of Prelog, Međimurje County and Varaždin County

Municipal utility company PRE-KOM d.o.o. from the Town of Prelog operates in the north of Croatia and today achieves a rate of 70% of separately collected waste (The Story of Prelog 2020). Prelog has become a leader in sustainable waste management in Croatia and beyond. From the beginning of 2022, PRE-KOM d.o.o. manage waste in the area of 14 local self-government units, 12 of which belong to Međimurje County and 2 to Varaždin County. This area includes approximately 40.000 inhabitants (Municipal utility company PRE-KOM d.o.o. n.d.). Municipal utility company PRE-KOM d.o.o. collects waste in such a way that

useful waste (paper, glass, non-returnable plastic packaging, carton, metal...) is deposited in containers for selective waste collection. Electronic, rubber and metal waste are collected as bulky waste, the collection of which can be ordered once a month or taken to a recycling center. Therecycling center contains a recycling yard, a sorting plant, a storagearea for large quantities of useful waste, a bulky waste processing plant with an open storage area, a reuse center and a recycling yard for construction waste (Municipal utility company PRE-KOM d.o.o. n.d.). Biodegradable waste is processed in a compost plant. Municipal waste is disposed on thePiškornica landfill in Koprivnički Ivanac, until thePiškornica regional waste management center starts operating (Municipal utility company PRE-KOM d.o.o. n.d.). In Prelog, the infrastructure for waste management has been improving for many years, and the system of separate waste collection is also progressing as a result. The example of Prelog shows that even without large regional centers for incineration and processing of mixed waste, waste can be effectively managed (The Story of Prelog 2020). The Town of Prelog and surrounding municipalities where PRE-KOM d.o.o. manages waste, acquired the conditions for access to the Zero Waste Europe network in 2016. The first Croatian city that accepted the Zero Waste strategy was Prelog with 11 surrounding municipalities that were part of the utility company PRE-KOM d.o.o. (Green action 2021).

2.2.2. Marišćina County Waste Management Center (Primorje-Gorski Kotar County)

The first waste management center in Croatia was built on the territory of the Primorje-Gorski Kotar County. The Marišćina County Waste Management Center is the main part of the complete waste management system in Primorje-Gorski Kotar County. The opening of Marišćina created preconditions for the closure and recovery of all landfills located in the County (Dokonal 2022). Marišćina started operating in March of 2017 (Elaboration of environmental protection Center for waste management of the Primorje-Gorski Kotar County, Marišćina 2022). Transfer stations are an important part of the new waste management system because they temporarily accept mixed municipal waste while it awaits transport to Marišćina, where it is processed in a mechanical-biological treatment plant. The produced fuel from the waste is taken outside the Marišćina Center for further processing, and theuseful materials go to the material recovery process, whilethebiologically processed waste is deposited inside the Waste Management Center in a controlled bioreactor landfill (plot), fromwhichbiogas canbeproducedthat canbeusedfor energy(electricityproduction) (Report on the Environmental Impact Assessment Procedure of the Marišćina County Waste Management Center 2010). Marišćina is used by the four islands included in the research (Krk, Cres, Lošinj and Rab) and since they no longer dispose waste, they are closing and renovating their landfills. The other four (Ugljan, Pašman, Brač and Vis) out of eight islands included in the research do not have a Waste Management Center built. They have yet to establish a separate waste collection system and build the necessary infrastructure and transfer stations. The Marišćina County Waste Management Center should represent a solution to the problem of waste management at the level of Primorje-Gorski Kotar County (Dekanić 2023).

2.2.3. Island of Krk

For many years, the Island of Krk has been among the most successful areas in terms of waste sorting in Croatia, which is made possible by the established modern infrastructure for waste management. On the Island of Krk, in all seven units of local self-government, the municipal company Ponikve Eko otok Krk d.o.o. provides waste collection and transport services (Dekanić 2023). In 2021, the local self-government units on the Island of Krk, in cooperation with the Green Action, adopted a Zero Waste strategy with high goals of reducing waste generation, reuse and recycling. Taking into consideration the high tourist seasonality that tourist places face when establishing a quality waste management system, the Island of Krk has long exceeded the goal of 50% of separately collected waste. Krk always wants more, especially when it comes to reducing waste generation and increasing recycling and reuse. The ambitious goals of Ponikve Eko otok Krk d.o.o. and Green Action set for the next period are 70% of separate collection until 2025. The Island of Krk has met all the prerequisites and is in the process of obtaining a Zero Waste certificate (Green Action 2021).

3. Methodology

This chapter will present a description of the characteristics of the interview as a research method, the selection of a sample for a semi-structured interview, a description of the research instrument and data analysis methods.

Conversation is the most common and fastest way to get information. For this reason, the interviewis oftenusedas a research method. By interviewingrespondents, researchers gather useful information about attitudes and opinions that deepen knowledge about the studied issue (Gray 2009, pp. 370–371; Mejovšek 2008, p. 163). Mason points out that the advantages of the interview are effectiveness, depth and detail, efficiency, and uniqueness (Mason 2014, p. 194; Mason et al. 2010; Mason et al. 2021). The respondent is given the opportunity to explain his or her answers. In this way, respondents add depth and detail to their answers, making the interview the most effective technique with unique data (Mason 2014, p. 168; Mason et al. 2010; Mason et al. 2021). A semi-structured interview is a good way to collect detailed data on the opinions, perceptions, attitudes, motives and habits of the respondents (Tkalac Verčić et al. 2011, pp. 102–103). In semi-structured interviews, the samples are small, can be conducted fast, and can result in obtaining exhaustive data (Dekanić 2023).

During the preparation of the protocol for the purpose of conducting a semi-structured in-depth interview, aspects of the waste management system from the European, national and local levels were studied, and secondary data on waste was collected and analyzed. Many scientific and professional papers, normative documents and other content from the field of the research topic were reviewed and analyzed. Also, there was a visit to Treskavac with expert guidance from the utility company Ponikve Eko otok Krk d.o.o., where the waste treatment plant was viewed and the waste management system explained, along with a discussion on the issue of waste management. (Tkalac Verčić et al. 2011, p. 111).

The conducted interviews are semi-structured, which means that the interviewer has a reminder with pre-formulated questions they want to discuss, but they follow the logic of the conversation and the flow of the interviewee, making sure that all the topics of the conversation are covered. In this sense, a semi-structured interview is more flexible because it uses prepared questions (research questions) that serve as a guide, and the interviewer has the freedom to ask questions in order to obtain information useful for research (Knox and Burkard 2009). The instrument for the semi-structured interview in this paper consists of six questions. Table 1 contains the questions for the semi-structured interview with the sources.

Table 1. Questions for the semi-structured interview and the sources fromwhich the questions were taken

Questions	Source
1. How would you rate the efficiency of the utility system on the island/area where your utility company operates?	Runko-Luttenberger (2010)
2. To what extent are you satisfied with sustainable development on the island/area where your utility company operates?	Gregorić et al. (2018)
3. How do you assess the role of the inhabitants (of the island) in terms of the waste disposal system on the island/area where your utility company operates?	Perkov (2021)
4. How, in your opinion, does the entire municipal waste management system affect the quality of life of the inhabitants of the island/area where your municipal company operates?	
5. Do you consider that treating waste close to its source is an environmentally and cost-effective solution?	Runko-Luttenberger (2010)
6. Do you think that investments in communal infrastructure are always in the function of environmental protection?	

Source: created by the authors according to the sources listed in the table

The first question relates to the efficiency of the municipal system; the second to the satisfaction of sustainable development; the third to the role of the inhabitants in the waste management system; the fourth to the quality of life of the inhabitants; the fifth to the treatment of waste close to the place of origin, and the sixth to the investment in municipal infrastructure in relation to environmental protection.

Theresearch covers larger and smaller Croatian islands fromthreecounties. Four Kvarner and four Dalmatian islands were selected. The Kvarner islands included in the research are Krk, Cres, Lošinj and Rab (Primorje-Gorski Kotar County). The Dalmatian islands included in the research are Ugljan and Pašman (Zadar County), which belong to northern Dalmatia, and the islands of Brač and Vis (Split-Dalmatia County), which belong to central Dalmatia.

TheTable2 shows the number of inhabitants according to the2021 census, thearea (m2), the county to which the local self-government units of the selected islands belong.

Table 2. Geographical data on the islands included in the research

Island	Number of inhabitants (2021 census)	Area (m2)	County	Number of local self-government units
Krk	19.916	405.218,994	Primorje-Gorski Kotar	7
Cres	2.716	405.705,293		1
Lošinj	7.537	74.366,091		1
Rab	8.268	86.115,120		2
Ugljan	5.769	51.049,186	Zadar	3
Pašman	2.884	60.110,056		2
Brač	13.825	395.438,030	Split-Dalmatia	8
Vis	3.312	89.721,921		2

Source: created by the authors based on data from the National Bureau of Statistics – population census 2021 (final results of the census published on 22 September 2022) and the Law on Islands (consolidated text of Law NN 116/18, 73/20, 70/ 21).

The islands included in theresearch werechosen based on thecriteria that they have more than 2,500 inhabitants and that they have an area of more than 50 km2. The Croatian islands were chosen as the research area due to the very pronounced oscillations in the comparison of the summer and winter seasons and the increase in the amount of waste generated during the summer months when there is an increased number of tourists (Dekanić and Krstinić Nižić 2023; Grofelnik 2013; Magaš and Faričić 2000; Šemanović 2019).

Semi-structured interviews were conducted with experts in waste management from the utility companies of the Croatian islands that were selected for research (the islands of Krk, Cres, Lošinj, Rab, Ugljan, Pašman, Brač and Vis). Directors of utility companies, technical directors, waste management managers and their assistants took part in the interview. Due to their familiarity and knowledge of waste management issues, this group of people was chosen for the interview. This is one expert from each of the ten utility companies that manage waste on eight selected Croatian islands. The research was conducted in the period from September 2022 to November 2023. The Table 3 shows the utility companies that perform the public service of waste collection and transport on the researched islands.

Table 3. Municipal companies in charge of waste management on the observed islands

Municipal company	Area of service
Ponikve Eko otok Krk d.o.o.	Island of Krk
Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.)	Island of Cres Island of Lošinj
Dundovo d.o.o.	Town of Rab (Island of Rab)
Lopar Vrutak d.o.o.	Municipality of Lopar (Island of Rab)
Čistoća d.o.o. Zadar	Island of Ugljan Municipality of Pašman (Island of Pašman)
Orlić d.o.o.	Municipality of Tkon (Island of Pašman)
Komunalno društvo GRAD d.o.o.	Town of Supetar (Island of Brač)
Michieli-Tomić d.o.o.	Municipalities Bol, Milna, Nerežišća, Postira, Pučišća, Selca and Sutivan (Island of Brač)
Gradina Vis d.o.o.	Town of Vis (Island of Vis)
Nautički centar Komiža	Town of Komiža (Island of Vis)

Source: created by the authors based on the research Dekanić (2023)

It is evident from the previous table that a total of ten utility companies manage waste on the eight observed islands. Some of the selected islands have one municipal company that manages waste on the entire island, while others have several companies, or each local self-government unit has its own utility company that manages waste in the area of a certain town or municipality.

Certain respondents are selected because they possess certain characteristics (such as good practices) important for the research (Gorman and Clayton 2005, pp. 128–129). In this way, the research was expanded, and an interview was also conducted with an expert from the utility company PRE-KOM d.o.o., which operates in the north of Croatia and is an example of best practices becauseit achieves thebest results in Croatia in terms of separately collected waste.

After the interview, transcripts are made that areused for theanalysis of the obtained data and the interpretation of thefindings, known as qualitativecontent analysis (Breakwell 2001, p. 116; Griffee 2005; Halmi 2005, p. 281; Mejovšek 2008, p. 163). The research results are presented in Chapter 4.

4. Research results

The responses of the respondents from the utility companies of the selected areas by topic are shown in the following sub-chapters.

4.1. Utility system efficiency

Ponikve Eko otok Krk d.o.o.: *"It is not satisfactory because the utility service can always be better. We on the Island of Krk are satisfied with how things work. We have made certain strides thathave not yet been made elsewhere in Croatia... Thereis roomfor further progress because our system (according to the number of bins and trucks) can easily accept a rate of 80% of separately collected waste... We are satisfied in the sense that we are in the last 15 years, we collected large amounts of waste separately and reduced the pressure on the landfill..."*

Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.): *"Given the specificity and complexity of the area where we provide public service and the great impact of the tourist season on the entire municipal system, we believe that an effective waste management system has been established..."*

Dundovo d.o.o.*: "I think we are good in this sense because we have regular removals of mixed municipal waste and selected... So I think we are efficient because there is not too much waiting and I think that we are relatively well equipped in this regard and can perform any task that concerns waste."*

Lopar Vrutak d.o.o.: *„I can say with great pleasure that we are very efficient. So for now, we'remanaging to keep up with therates set bytheEUand our legislator. So we'resomewhat good at it and we're always among the first. So we were the first to introduce the chip-in-the-bins, the mobile recycling yard, the door-to-door collection system... I think we'd be a lot better, quieter and more efficient if we had, say, our own spaces, then we'd better channel resources into protecting the environment... I think it requires constant education and repetition, which is our role. Year after year we have programs and educations, people are being trained and trained, and new people are coming in who need to be trained.“*

Čistoća d.o.o. Zadar: „This would be a question for users or heads of local government units. You should do a study of public change.“

Orlić d.o.o.: *"We would rate it as 10... Of course we do our best. Considering the position and everything else (small area/municipality), I don't think it can do better."*

Komunalno društvo GRAD d.o.o.: *"It is difficult to give evaluations regarding the efficiency of the municipal system, when the company Komunalno društvo GRAD d.o.o., in addition to its other activities, collects waste only in the area of the Town of Supetar and the suburban settlements of Mirca, Splitska and Škripa. Separate waste collection certainly works better where there is a recycling yard, which we definitely need and whose establishment will make the waste system work better. In the future, the sorting plant and the compost plant would surely be a step forward."*

Michieli-Tomić d.o.o.: *"The bins are chipped with electronic chips in order to reduce the amount of mixed municipal waste. However, people throw all sorts of things into containers on public areas where they shouldn't, so that it turns out that they have a little mixed waste, and in that way they create problems for us, which we see at the sorting plant when these impurities are separated from separately collected waste... I think that the separation system would of waste should be much better, more useful, more efficient and if in general everyone would adhere to the set rules in practice... We try to separate, transport everything from the island to the mainland. Another thing, the price of municipal waste is prescribed at the level of the whole of Croatia, which is not normal because according to the configuration of the terrain, the price of waste management cannot be the same for the continental part of Croatia, wheretherearevillages in a rowwith a wideroad that allows access to everyhouse. The typical features of Dalmatian towns and islands aredifferent, the streets are narrowand it is more difficult to collect waste..."*

Gradina Vis d.o.o.: *"Efficiency is outstanding, but customer support is very poor. It is difficult to get people to separate waste and in general it is difficult to accept all the innovations we introduce in waste management... It is much simpler to solve problems with waste where there is more space. The old town center can hardly manage with bins and disposal of bio-waste due to insufficient space..."*

Nautički centar Komiža d.o.o.: *"It is insufficient, in order for the waste management system to be more efficient, it is necessary to establish the infrastructure for waste management, which we lack. It includes a county waste management center, a transfer station at the level of the island and a sorting plant."*

Gradsko komunalno poduzeće PRE-KOM d.o.o.: *„It can always be better, but my maximum score is -4, so we're about there. And Croatia is generally at -2. In order to be even more efficient, we need financial support.“*

The utility companies involved in the survey are overwhelmingly satisfied with the efficiency of the utility system in their area of operation, although they believe that there is room for improvement or greater efficiency. Similarly, the respondents of the utilities in the Runko-Luttenberger (2010) study rated the efficiency of the utility system in their town or municipality as good. In addition, it can be concluded that utilities in Croatia do not take into account maintenance costs when investing, and that high investment is not always required to implement environmental protection, as efficient and less costly solutions can be found with good organization.

4.2. Sustainable development satisfaction

Ponikve Eko otok Krk d.o.o.*: "It would be easiest for everyone if everything went into one bag, bucket, truck and thrown over the hill.Thereisnothing cheaper than that. However, someone smart said that this is not sustainable and that something should be done to prevent it from being done that way, because after all we live in the 21st century... Of course, all of this costs money, and how can you even force a municipality to collect separately when it's simpler throw everything to the landfill. In order to create this kind of financial balance, it would actually be necessary to artificiallyincrease the costs of escrow. Then the state should set a policy in such a way that the accumulation at the landfill turns out to be the most expensive, although in practice it is the cheapest. But we have to say that we don't want to put it in the landfill, because that will be the most expensive for us..."*

Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.): *"We are somewhat satisfied with the sustainable development. In this regard, we contribute according to our capabilities. Especially from the aspect of tourism, because the islands of Cres and Lošinj are advertised as some eco-clean destinations (clean air and sea) in the direction of islands of vitality. We are not a destination for entertainment and nightlife, but we offer nature, beaches, sea and sun. Of course, then a clean environment plays a role because, in addition to collecting waste, we work to maintain the cleanliness of streets and green areas, beaches, paths and walkways. So we keep the destination clean in the direction of aesthetics and ecology."*

Dundovo d.o.o.: *"I believe that some things that are in our domain should be further refined. We have a problem with space, so we would need a qualityspace next to our transfer station to meet our needs. We would certainly still need some form of composting plant for*

bio-waste processing. So for further successful functioning, the burning problem for us is a space of a few thousand square meters, because what we are doing now is good, quality and responsible in my opinion, and there is always room for improvement."

Lopar Vrutak d.o.o.: *"Well, look, as far as existence on the island is concerned, on a scale of 1 to 10, it would be 7/8. As far as environmental protection is concerned, great progress can be seen here. So that part is on an upward trajectory, while economic sustainability is on a downward trajectory. Ultimately, all this affects the quality of life of residents. Nowthat the pro-European approach is in power, I assume that after some time everything will start to get better... I think that our company contributes to a certain extent to the sustainable development of the environment."*

Čistoća d.o.o. Zadar: *"Regarding this issue, the research should be conducted, and some conclusions should be drawn accordingly."*

Orlić d.o.o.: *"It is going in the right direction as much as it can, that is, as much as the whole system that affects us allows. I think that the things that are in our domain and that we can influence are fine."*

Komunalno društvo GRAD d.o.o.: *"Komunalno društvo GRAD d.o.o. certainly, in addition to other services, it contributes to the sustainable development of the Town of Supetar, in accordance with the possibilities and legal framework under which it operates, and it can always do better."*

Michieli-Tomić d.o.o.: *"I am satisfied, and I believe that the people on the island are also satisfied with it. Residents and tourists who come are very satisfied with the quality."*

Gradina Vis d.o.o.: *"We are very satisfied, and I believe that we, as a utility company, contribute to this."*

Nautički centar Komiža d.o.o.: *"Lets say we are satisfied, although there is room for improvement."*

Gradsko komunalno poduzeće PRE-KOM d.o.o.: „How could we not be satisfied when practically all 14 of our local self-government units are among the 15 best in Croatia. So, we're extremely pleased.“

Regarding satisfaction with sustainable development in the area in which they operate, the surveyed utility companies are generally satisfied. They mostly believe that they are going in the right direction in this matter and contribute according to their capabilities, while some utility companies believe that it is necessary to refine certain things that are, among other things, in their domain. Likewise, therespondents in thestudy by Gregorić et al. (2018) answered that they are very satisfied with the sustainable development on the Island of Krk. Additionally, companies on the Island of Krk are environmentally aware, they respect the principles of sustainable development to a greater extent and consider that the application of sustainable development is very good.

4.3. The role of inhabitants in the matter of waste disposal system

Ponikve Eko otok Krk d.o.o.: *"The role of inhabitants is very important when we talk about waste... We have certain programs with which we set the goal of increasing the percentage of separately collected waste every year. In this sense, every year we enter into education and the system of waste collection and processing in such a way as to try to separate as much as possible... We have been engaged in education for about 15 years and now you have children who were already born in the system of separate waste collection and you don't have to educate those children anymore... Ultimately, inhabitants don't allocate it to us but to themselves for a nice environment..."*

Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.): *"Inhabitants of the island have a big role in the implementation of the waste management system, both in the part of handling their own waste and in the part of handling waste generated by tourists, considering that all activities on the island are aimed at tourism. The goal, through education and information for permanent residents of theisland and other users (legal entities), is to convey information and rules for handling waste to all guests within the destination with the aim of establishing an effective waste management system.“*

Dundovo d.o.o.: *"Their role is very important because if there is no cooperation between inhabitants and us, then we have a problem. Although he would praise the citizens because they generally accept what is expected of them, cooperate with us and are quite disciplined.*

They are quite aware because all of us in this area live from this tourism, and apart from the tourists, we also need it to be nice and tidy".

Lopar Vrutak d.o.o.: *"Their role is crucial, and then we as a company make great efforts through education, filming videos, leaflets, promotional materials, we act through performances in schools and kindergartens. We take the children on trips to the transfer station, all so that they can get an impression of what we do. Let's say for older people it was a big unknown when it started to separate and that it will be the most normal thing for these little ones who now feel it at an early age. As for residents and their adherence to classification rules, we are seeing a big upswing in a positive direction. So we don't need to be afraid, and it's a multi-year process, but I'm happythat we're going in theright direction."*
Čistoća d.o.o. Zadar*:"Without an educated user, thewaste management systemis a"dead letter on the paper" for inhabitants and tourists."*

Orlić d.o.o.: *„Of course their role is very important because if they don't follow the rules nothing works. Given the way we run the whole business, it's up to them to separatethe waste to make it work.“*

Komunalno društvo GRAD d.o.o.: *"The role of the inhabitants in terms of waste disposal is very important, but it is an ongoing process that starts from home education, through the education system, all the way to utility companies, but also other services and institutions, as well as regulations and laws. The inhabitants of the Town of Supetar relatively adhere to this, and the reasons should be sought in all of the above. Inhabitants are slowly accepting the changes that are legally placed before us and them. It is certainly a process that will be constantly upgraded, and in the context of this, the performance of each user of our services will be of higher quality over time."*

Michieli-Tomić d.o.o.: *"They are the most important. There are no problems with foreigners, they get used to it right away because they do it properly at home too."*

Gradina Vis d.o.o.: *"The engagement of inhabitants is not satisfactory. We worked on educations that people don't hear about. When education about waste management is mentioned to such people, they immediately start expressing a negative attitude. When we start with punishments, then those repressive measures turn out to bebrutal. So I believe that it is currently necessary to work with children of kindergarten age in order to see the results in 15-20 years..."*

Nautički centar Komiža d.o.o.: *"Their role is extremely important when we talk about handling waste. Our goal is to maximally encourage people to sort recyclable waste and use the mobile recycling yard."*

Gradsko komunalno poduzeće PRE-KOM d.o.o.: *"Users are certainly an extremely important factor in our system. For this reason, we do education in kindergartens, while in schools we do waste separation quizzes. The elderly are already less able to listen, so they are informed via Facebook and the website, as well as flyers with bills."*

The respondents of the utility companies involved in the research believe that the role of theresidents intheissueof handling wasteis an extremelyimportant factor inthefunctioning of the observed system. Part of the utility companies emphasizes that the users of the utility service are not responsible enough in dealing with waste. In accordance with this, Perkov (2021) concludes that the role of inhabitants is important and that sustainable waste management is achievableif expert opinions arerespected, dialogues areestablishedbetween key actors, a high social consensus is achieved on the importance of the observed topic, and the right waste management model is selected.

4.4. Inhabitants' quality of life

Ponikve Eko otok Krk d.o.o.: *"You have something called non-financial benefits. They are immeasurable, at least in the short term, such as: raising the quality of life, a clean environment (branding the destination as an eco-destination), as we are doing... So, for these reasons, we as a communal activity try to achieve a certain effect with as little expense as possible in order to benefits reflected on users (inhabitants)."*

Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.): *"It is certainly a positive story in the long term that we no longer have active landfills on the islands (Cres and Lošinj)... Because in 2013 there was only a green bin and no one even talked about waste separation. It's all a*

process that is done over generations... We started with children because they all go to kindergartens and schools. This is how older people move and change as well..."

Dundovo d.o.o.: *"Very much, it affects many things. I think we are on the right track, although there is room for improvement."*

Lopar Vrutak d.o.o.: *"We are currently going through a transition phase as far as waste is concerned. Therefore, it turns out that this has a negative effect in terms of the financial part, because it turns out to be more expensive. It is certainly more expensive than it was, for example, when everything was thrown into one bin... Now we already have a different approach because someone has to invest in bins, select them, transport them to Marišćina when it comes to mixed municipal waste or somewhere else when let's say about the disposal of plastic, etc. However, the benefits of all this will only be seen, that is, it is already slowly being seen..."*

Čistoća d.o.o. Zadar: *"It is very important, primarilyfor the healthy environment in which the islanders live, it is important for the sustainability of animal and plant life. It is also important for the economic progress of the community."*

Orlić d.o.o.: *"If the waste collection and removal system doesn't work, what kind of life is it? It is an essential item in every aspect."*

Komunalno društvo GRAD d.o.o.: *"I believe that the prescribed laws and requirements that have been put before us, both as a company and as users, will eventually affect the better quality of life of all island inhabitants. Waste recycling and waste management systems in general are perhaps even an issue for the national level (the issue of waste management on islands, the possibility of building incinerators, regional centers) and are certainly something that needs to be worked on in order to increase the awareness and importance of this among the population in the future to the question..."*

Michieli-Tomić d.o.o.: *"Waste is separated in our seven municipalities, recycled in large quantities, which are taken away from the island. As a private company, we try to separate and recycle as much waste as possible so that it is taken away from the island. I believe that it is a key issue that waste does not remain on the island and that the landfill is not filled."*

Gradina Vis d.o.o.: *"The municipal waste management system does not negatively affect the quality of life of the inhabitants because all hazardous waste is taken away from the island. The only thing deposited on the island is construction, bulky and mixed municipal waste. The benefits of the waste management system for the quality of life of the local population will be seen quickly because we are trying to be the first to produce hydrogen from mixed municipal waste..."*

Nautički centar Komiža d.o.o.: *"It certainly has an effect to a certain extent, although I believe that the inhabitants of our area do not consider the municipal waste management system to be a crucial factor in the quality of life."*

Gradsko komunalno poduzeće PRE-KOM d.o.o.: *"When we were setting up the system 15 years ago, anything and everything was thrown around, but today there is none or very little of it. Those who still burn waste themselves are not aware of what they are doing to the environment... According to our results, the system certainly has a great impact on the quality of life."*

Respondents from utility companies in this survey generally believe that an organized municipal waste management system improves the quality of life in the long term in the area where utility companies operate. This is confirmed by Perkov (2021), pointing out that the model of waste management based on sustainability enables a higher quality of life of the inhabitants in the long term.

4.5. Waste treatment near the place of origin

Ponikve Eko otok Krk d.o.o.: *"Absolutely, that means the waste that is collected separately is quite mixed and it has to be further processed. Its processing must be relatively close to the place of collection (far from the settlement), because if it were to be transported to a further location, then, in my opinion, there would be unnecessary costs. If it were compressed and transported somewherefurther, thenitwould loseits properties,so its value, which it has when it is collected, could not subsequently be extracted from it..."*

Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.): *"It depends on a lot of factors (location, type of waste, amount of waste, state of the market for secondary rawmaterials...),*

especially when we talk about an island... When we look at the system as a whole, it pays off because you can't make an exception just for some isolated village. We simply treat all users equally... Then we depend a lot on transportation and disposal. In the end, with separately collected waste, the matter comes down to the fact that we ourselves investigate which buyer will take over that part."

Dundovo d.o.o.: *"We are currently sorting and pressing waste in the space at our disposal, although we do not yet have a sorting plant as a facility, we perform these tasks as much as we can. We separate and press materials such as plastic (yellow bin), hard plastic (plastic chairs, tables), cardboard... We also separate fractions of bulky waste (wood, metal, electronics, hard plastic...). In this way, such fractions of waste are specially taken away from the island so that nothing remains here... We are quite far from big cities, so this is the best solution. A big problem for us is the cost of transportation, ferry, etc., and then here we try to reduce those costs as much as possible."*

Lopar Vrutak d.o.o.: *"According to the previous work system, we had a cost-acceptable solution, but an ecologically unacceptable one. With the current new work system, we have the oppositesituation than before, because greater ecology implies a more expensive system. As for disposal on the island, it would certainly be a more favorable option for us, but if we are going to deal with tourism and dispose of waste properly, we will have higher costs..."*

Čistoća d.o.o. Zadar: *"The principle of proximity is fine if it is not about islands. There are guidelines in the Law on Islands and the Strategy on Waste in the Republic of Croatia that do not allow this. The waste must be transported to the continent."*

Orlić d.o.o.: *"That is not possible here. We are a small island, so this cannot be done here. We don't even have the possibilities for island waste processing. And that's not environmentally friendly anyway, but we wouldn't even be able to do that in our municipality."*

Komunalno društvo GRAD d.o.o.: *"I am of the opinion that perhaps the islands should have been excluded from this type of legally prescribed waste management and that perhaps the islands should have gone in the direction of incinerators (environmentally acceptable). This is certainly a question for a deeper analysis and for higher authorities from the Municipal utility company GRAD d.o.o., Town of Supetar, as well as the Island of Brač."*

Michieli-Tomić d.o.o.: *"It all depends on what processing entails, because a kind of processing is also when impurities are separated from separately collected waste into a container at the sorting plant and then it is baled and taken away from the island... I think that thementioned kind of processing is best done on theisland and then taken away on land. That way it turns out to be more profitable and useful, and people from the island are employed and the price of the utility service is reduced."*

Gradina Vis d.o.o.: *"The previously mentioned treatment of mixed municipal waste that we are planning is acceptable, because my opinion is that it is crazy to transport waste to land. We don't want to transport separately collected waste at a high price so that it would be disposed of somewhere the same as it would be disposed of here... We currently have the space so it doesn't get in the way and there are no problems. Until quality waste recovery is solved, it makes no sense to pay dearly for the removal of useful waste. In this way, we try to harmonize ecologically and cost-effective solutions. Because I don't know if the ferry would be able to load trucks full of waste from the island and transport them to the mainland. Becauseif theydon't allowisland processing of waste, then a privatecarrier should befound, and the question is also at what price. I think that the transport of waste from the island to the mainland is illusory. For this reason, we are going in the direction of gasification of mixed municipal waste for the production of hydrogen, because we believe that this is the only sustainable way of managing waste."*

Nautički centar Komiža d.o.o.: *"The costs are certainly lower when the waste does not have to be transported to a remote location. Proximity can be ecologically acceptable depending on the method of processing, but also on the location itself. Waste management must be carried out in such a way that it does not endanger people's health and does not harm the environment."*

Gradsko komunalno poduzeće PRE-KOM d.o.o.: *"Of course, because waste transportation is the most expensive part of the waste management system. For example, the*

Prelog compost plant is practically in the center of the area where we operate, so we have the shortest driving distances in that regard."

Respondents from utility companies believe that processing waste close to the point of origin is an environmentally better and cost-effective solution. Cost-acceptable solutions often turn out to be ecologically unacceptable, because greater environmental protection implies a more expensive waste management system. As a rule, waste transportation is the most expensive part of the waste management system and often represents a problem for individual utility companies that consider it necessary to reduce transportation as much as possible. Also, respondents from utility companies in the Runko-Luttenberger (2010) survey mostly answered that processing waste near the place of origin is a cost-effective and environmentally acceptable solution, but the polluter pays principle does not prevail.

4.6. Investments in the utility infrastructure and environmental protection

Ponikve Eko otok Krk d.o.o.: *"Absolutely, it should always be in the function of environmental protection.This is its basic purpose, because investingin utilityinfrastructure does not generate profit or return on investment as with classic investments, but these investments increase the quality and standard of life (both users and tourists) in the long term."*

Komunalne usluge Cres Lošinj d.o.o. (KUCL d.o.o.): *"I don't know how the system imagined it, but it is certain that these investments partially influence and improve the ecology. So again we start from that person's awareness that they need to adapt to that system, otherwise nothing works... Any investment in ecology, whether it's recycling yards, sorting plants, binsfor waste separation, ifnot directly,then atleast indirectly has a negative impact somewhere on ecology. It's just a question of how much, if that's something acceptable or not, because nothing is perfect."*

Dundovo d.o.o.: *"They are, yes."*

Lopar Vrutak d.o.o.: *"When it refers to waste collection, trucks, tanks, wastewater drainage, in that part yes."*

Čistoća d.o.o. Zadar:*"Theutilityinfrastructureshould bein thefunction of environmental protection, at the very least it should not threaten the existing balance in the environment."*

Orlić d.o.o.: *"I don't think so. What we have, it has to be like that, so if it was designed to be in the function of environmental protection, then I guess that's the way it is, because it can't be otherwise. All necessary equipment must be provided for the service to take place."*

Komunalno društvo GRAD d.o.o.: *"In general, no, because communal infrastructure is a broad term, and Komunalno društvo GRAD d.o.o. refers only to one part of it."*

Michieli-Tomić d.o.o.: *„Yes, investments are always directed in that way because the state and the fund invest in environmental protection. They mainly give incentives for machines, equipment, containers, bins, recycling yards.“*

Gradina Vis d.o.o.: *"We believe that all investments in utility infrastructure are for the purpose of environmental protection."*

Nautički centar Komiža d.o.o.: *"I think it should be."*

Gradsko komunalnopoduzećePRE-KOM d.o.o.:*"Withus, specifically, theinfrastructure includes a composting plant, a sorting plant, a bulky waste processing plant, a construction waste processing plant, a reuse center, a recycling yard and municipal vehicles. We have it all and we are constantly investing in it. Now, in my opinion, this is all in the function of environmental protection, unless something works. All national or European projects that we worked on are in operation and contribute to the results of the waste management system."*

Respondents from utility companies involved in the research believe that investments in utility infrastructure serve the purpose of environmental protection when it comes to waste management infrastructure. This is also confirmed by respondents from utility companies in the study by the author Runko-Luttenberger (2010), but a third of the respondents believe that investments in utility infrastructure are not always the most optimal nor are they always in the function of environmental protection, which the author considers worrying.

Based on the conducted interviews, it can be concluded that the examined island utility companies try to satisfy the legislative regulations from the observed area together with the local self-government units in which they operate. The observed utility companies differ from each other in their business model and efficiency of waste management. Establishing a

functional waste management system is particularly difficult in island tourist destinations due to the specificity of the area and strong tourist seasonality. The surveyed utility companies believe that their waste management systems could and should be even more efficient in order to further improve the quality of life on the islands in the long term. Respondents emphasize the importance of the role of residents in dealing with waste. They believe that there are also irresponsible users of the service who do not follow the instructions. Through their activities, utility companies influence the attractiveness of island destinations where they operate. The surveyed utility companies point out that a modern and ecologically efficient waste management system implies higher costs, but also greater engagement of utility users, which must be directed to the advantages, purpose and proper use of the innovations that are being established (Dekanić 2023).

5. Discussion

Solid municipal waste management policy has become one of the key policies in many countries and a measure of sustainability for certain countries. Moreover, municipal solid waste management is one of the key indicators for assessing the quality-of-life index developed by the United Nations Human Settlements Program (UN-Habitat) (Wee and Abas 2016). In the contemporary world, it is very important to understand how people see and perceive their environment (Krupavicius et al. 2024).

The selected Croatian islands included in this research differ from each other in how advanced their established waste management systems are. The Table 4 gives a general overview of thestateof the key phases for theimprovement of the waste management system on the observed islands.

Table 4. Presentation of the state according to the key infrastructure for efficient waste management on the observed islands

Island	Separate waste collection	Composting plant	Sorting plant	Recycling yard	Recovery of the landfill	Transfer station
Krk	+	+	+	8	+	+
Cres	+	in the plan	in the plan	1 + 1 mobile recycling yard	+	+
Lošinj	+	in the plan	+	1 + 1 mobile recycling yard	in process	+
Rab	+	in the plan	in the plan	1 + 2 mobile recycling yards	+	+
Ugljan	+ (paper and plastic)	in the plan	in the plan	in the plan; use 1 mobile recycling yard	+	in the plan
Pašman	+ (certain units of local self-government, only certain factions)	in the plan	in the plan	in the plan; use 2 mobile recycling yards	+	in the plan
Brač	+ (certain units of local self-government, only certain factions)	in the plan	+	1 + 2 mobile recycling yards	in the plan (one landfill is closed; other still active)	in the plan
Vis	+ (certain units of local self-government, only certain factions)	in the plan	in the plan	1 + 1 mobile recycling yard	in the plan (one landfill), in process (another landfill)	in the plan

Source: created by the authors based on the research Dekanić (2023)

Of those observed, the Island of Krk is the only one that has passed all the necessary stages for the establishment of an effective waste management system, and as such it is the most advanced Croatian island regarding the studied problem, followed by the other islands of the northern Adriatic (Kvarner Islands – Cres, Lošinj and Rab) with an established modern infrastructure to manage waste in a sustainable way. The northern Adriatic islands are more

advanced than the analyzed Dalmatian islands, which still have important steps to take in order to establish effective waste management systems. The observed Dalmatian islands do not have transfer stations established because waste management centers have not yet been established in the Zadar and Split-Dalmatia counties. Also, the observed Dalmatian islands are still in the early phases of developing separate waste collection systems, so they do not even classify all types of waste (Dekanić 2023).

In Croatia, there are gradual changes in municipal waste management from decentralized disposal at non-compliant local landfills to centralized municipal waste management with the help of waste management centers at the county/regional level. In Croatia, more than a quarter of municipal waste is still disposed of, and less than half of the waste is recycled. For theestablishment ofa completewastemanagement system, oneofthekey elements arewaste management centers. Of the 11 planned centers at the state level, only three have been established (Marišćina in the Primorje-Gorski Kotar County, Kaštijun in the Istria County, and Bikarac in the Šibenik-Knin County), one is under construction, four centers are in various stages of contract work, while the remaining three center in the documentation preparation phase (Dokonal 2022). Although the separate collection of waste and recycling is prescribed by law, disposal is unfortunately still the most common and at the same time thecheapest solution, given that most of theplanned regional centers have not yet been built, so most of thewasteis still disposed of in landfills, often freeof charge(Dekanić and Krstinić Nižić 2021; Regional Center of Clean Environment 2021). The state has not introduced a fee for disposal, which is a basic prerequisite to justify investments in separately collected waste systems. There is an obligation to collect waste separately, which implies the accompanying costs of wasteprocessing and payment for thedisposal of separately collected waste, because the market for secondary raw materials is not regulated. For this reason, many communities are rather timidly entering separate collection projects and are waiting for the further development of the situation. All those who still have their own disposal sites and have enough space in them continue to dispose of the generated municipal waste free of charge. Landfill fees are charged to utility companies that do not dispose of waste on their territory, or that do not have landfills that they manage themselves. They then pay a landfill fee according to the amount of disposed waste to the local self-government units hosting the landfills, and at the same time they also have the costs of transportation to the landfill where the collected mixed municipal waste is disposed of. Local self-government units that dispose of collected municipal waste from their area at their own landfills do not pay any compensation for this (Dekanić 2023; Law on Waste Management NN 84/21; Regional Center of Clean Environment 2021). In view of the above, the first step to improve the waste management system should be the introduction of fees for waste disposal at the level of the entire country. The system set up in this way is the only way to initiate significant changes in the observed issue. The amount of this fee should be determined in such a way as to motivate service providers to initiate activities aimed at reducing mixed municipal waste. The funds collected by the Fund through this fee would be used to co-finance projects such as the construction of waste management centers, sorting plants, composting plants and the like. In this way, infrastructure projects for improving the waste management system would be accelerated, because then it would be in the interest of local self-government units and utility companies to dispose of as little waste as possible in landfills in order to pay less landfill fees. The Ministry and the Fund must help utility companies in organizing the placement of separately collected waste and prescribe penalties for failure to meet targets (Dekanić 2023; Regional Center of Clean Environment 2021). Communities that implement a zero-waste policy (Zero Waste concept) could increase the attractiveness of the destination (Kapmeier and Goncalves 2018). The goal is to achieve the Zero Waste concept, which would make destinations waste-free. This means adequate disposal of the remaining mixed municipal waste that cannot be recycled, composted or otherwise reused outside the landfill. However, in most locations in Croatia, the prerequisites for switching to the Zero Waste concept have not been met due to unfinished rehabilitation of landfills and the construction of transfer stations that are used to dispose of mixed municipal waste while waiting for its transportation to the county waste management center. In Croatia, it is necessary to work on improving the infrastructure, given that there is an insufficient number of sorting plants and composting plants, and it is necessary

to increase the number of recycling yards, prevent the creation of illegal landfills, educate citizens, design waste management models… (Dekanić and Krstinić Nižić 2021).

For many years, Krk has been the most advanced Croatian island in terms of waste management and is an eco-tourism destination that has been called the Eco Island of Krk since 2005 (Damjanić 2014; Dekanić and Krstinić Nižić 2021). From a semi-structured in-depth interview with a respondent from the utility company Ponikve Eko otok Krk d.o.o., it is concluded that what distinguishes them from other islands is the fact that they have their own sorting plant and composting plant, with the emphasis on thecomposting plant sincethe biowaste and green waste processed there in their case amounts to 25% of the total waste generated. Separate collection of biowaste that would otherwise end up together with mixed municipal waste is very important, and by sorting it, the amount of mixed municipal waste can be significantly reduced (Dekanić 2023; Dekanić and Krstinić Nižić 2021). Each year, each user is rewarded with a bag of compost. According to the statements of respondents fromtheutility company PonikveEko otok Krk d.o.o., it was established that theprerequisite for the other islands to reach the level of success of the Island of Krk in the studied topic would betheconstruction of a wasteprocessing facility (sorting plant and composting plant). On the Island of Krk, this entire system was established earlier than in other areas because already in 2000 they were faced with a lack of space at the landfill. Then they realized that they had to take certain steps and procedures to reduce the amount of waste that is disposed of. Thanks to the timely recognition of the problem they were faced with, they now have an advanced and efficient waste management system in place (Dekanić 2023).

A conclusions from the interview conducted with the respondent of the utility company Ponikve Eko otok Krk d.o.o. is that in the long term, given the established system, the price of all services will gradually increase because the level of costs that existed when waste was simply thrown into one bin cannot be maintained. The income generated from the sale of secondary raw materials does not manage to cover all the costs arising from its collection. Similarly, respondents from the utility company KUCL d.o.o. explained that it is normal for costs to increase when you go five times for each type of separately collected waste, which then also requires processing (sorting, pressing and baling), the cost of which should be covered by the sale of that raw material, but this is not the case. Furthermore, from the interview with the utility company PRE-KOM d.o.o. it is established that the situation with the purchase of materials is not favorable. The situation with certain fractions of processed raw materials on the market is such that sometimes buyers ask to be paid for taking them over, and sometimes they areready to pay a littlefor taking them over. Therefore, such things cannot be counted on to bring profit. It was also learned from respondents from the most successful Croatian utility company in terms of waste management that all types of waste are collected at the doorstep because then the quality of useful waste is up to three times better compared to thecasewhen containers for separatewastecollection areplaced in public areas. Also, PRE-KOM d.o.o. are planning to start drying mixed waste in order to reduce its quantity by 20-30 % while waiting for the outcome of the situation with the planned waste management center. The aforementioned drying of mixed waste is allowed, while energy recovery (incineration), which was also considered as a solution for the remaining part of the waste, is currently prohibited by the Waste Management Act (NN 84/21).

The Island of Lošinj is the second most advanced Croatian island in terms of waste management. They have most of the infrastructure for efficient waste management, but they lack composting (Dekanić 2023). The conclusion from a semi-structured in-depth interview with the company KUCL d.o.o. is that their next main step is the establishment of a composting plant in order to complete the plan for biowaste that is produced in large quantities. The respondent also believes that the basic role of utility companies is the collection of waste from citizens, and that is all they should do. For all other things, there should be ready-made solutions, such as the Marišćina waste management center for mixed municipal waste. In the same way, there should be solutions for each waste fraction.

The good connection between the island and the mainland is also very important, because then the transport of waste to the mainland is easier and cheaper (Tsiotas and Polyzos 2024). The islands of Cres and Lošinj are connected by a mobile bridge. The Island of Krk is connected to the mainland by a bridge, which is its advantage (Grofelnik 2013). From an interview with the utility company Ponikve Eko otok Krk d.o.o. the respondent points out the

connection via the bridge with the mainland as a great advantage of the Island of Krk. Islands that are not connected to the mainland by a bridge then depend on the ferry, so their transport costs are much higher. A lot of effort needs to be invested (especially for those who do not have a sorting plant) in order to process useful waste on the island to the extent that it is worthwhile for the buyer to send a truck to the island to collect the raw materials.

The key stakeholders in the waste management system of an individual island are municipal companies dealing with wastecollection and disposal, local self-government units and the local population (Dekanić 2023). In order to establish a modern waste management system and its successful operation, close cooperation between the aforementioned key stakeholders is necessary (Dekanić 2023). Sustainable development leaving no one behind is crucial for local communities well-being (Sepetis et al. 2024). With the cooperation of utility companies and local self-government units, it is necessary to spatially plan locations for the establishment of buildings necessary for waste management, as well as ways of financing them, in order to improve the waste management system in the long term (Kokkinou et al. 2018; Ruxho and Ladias 2022a). In this way, municipalities and cities can directly and quickly influenceand adapt legal acts and spatial plans to the needs of municipal infrastructure and legal regulations in the field of waste management. At the same time, it is necessary to inform and acquaint the locals with the events so that they know the importance and purpose of the investments that are planned to be implemented. Considering the performance of the companies PRE-KOM d.o.o., Ponikve Eko otok Krk d.o.o., and KUCL d.o.o. it can be concluded that cooperation with local self-government units in which the company manages waste is successfully maintained, all for the purpose of providing the highest quality service possible (Dekanić 2023).

As a rule, municipal companies that cover the entire island achieve better results and manage waste more efficiently, such as the Island of Krk or the islands of Cres and Lošinj, which have one municipal company serving two islands. The above may be the reason for their success in waste management. Alarger utility company more easily directs investments for the improvement of the infrastructure and the entire system in such a way that the island develops evenly in terms of the observed issue. With several smaller utility companies on the island (with waste management activities under their jurisdiction), each unit of local self-government with its utility company conducts its own policy. Also, a larger utility company can more easily apply for several projects and EU funds at the same time, and thus has more funds for investing in the improvement of the waste management system (Dekanić 2023). A larger number of employees in the company creates a diversification of responsibilities by department, which improves employee involvement and productivity (Dekanić 2023; Ruxho et al. 2023). It also has a larger amount of money collected from the communal fee, which it can then use in a planned way for key investments that, in cooperation with the island's local self-government units, would evenly improve the waste management system on the territory of each island (Dekanić 2023).

6. Conclusion

Waste management is a big challenge for tourist destinations during the tourist season when there is a significant influx of tourists, which consequently leads to the creation of larger amounts of waste. The goal of the islands in Croatia is to be recognized as tourist destinations fullyfocused onsustainabledevelopment. Inthis way, they wouldattract tourists who want to spend their vacation in areas where natural resources are used responsibly and where the aesthetics of the landscape are taken care of in order to preserve the environment for future generations.

The analyzed waste management systems on the Croatian islands indicate that some islands have established much moreadvanced waste management systems compared to other islands. When municipal companies have modern infrastructure for waste management, then it enables them to collect larger amounts of separated fractions of useful waste. This alone relieves the burden on local landfills, and separately collected waste is handed over to recyclers. During the introduction of an effective island waste management system, the generated waste must be transported from the island to the mainland in order to rehabilitate the existing island landfills.

The surveyed utility companies manage waste in cooperation with the local self-government units in which they operate in order to harmonize existing conditions with legal regulations. They emphasize the role of residents in dealing with waste as an extremely important factor in the functioning of the waste management system. Municipal companies point out that waste transportation is the most expensive part of the waste management system, which represents a financial burden for them when they transport waste to remote locations or from islands to the mainland. Accordingly, a higher level of ecology implies a more expensive waste management system. In order for environmentally efficient systems to function successfully, they require support from the user.

Insular utility companies should, in cooperation with the insular local self-government units in which they operate, attract funds from the National Fund and EU funds for the purpose of investing in waste management infrastructure in order to improve waste management systems in the long term. In this way, with good organization, timely planning and good will, better results can be achieved compared to other environments that are in a similar position. Greater efficiency of the waste management system increases the quality of life of the local population and leads to the sustainable development of tourist destinations.

This is one of the few pieces of research on the topic of waste management in terms of sustainabletourismdevelopment, which refers to island utility companies in Croatia that deal with waste management. The conducted research is focused on the Croatian islands, but the model is more widely applicable. It is expected that the results of the research will contribute to political decision makers, decision makers in utility companies and managers, creators of measures andregulations regarding wastemanagement, representatives of municipalities and cities of island tourist destinations, participants in the sustainable management of the island and the island population, and policy management at the local level; then facilitate directing, planning and establishing modern infrastructure and ultimately improving the waste management system on the islands in the Republic of Croatia (Ladias et al. 2023; Ruxho and Ladias 2022b; Ruxho et al. 2024; Sarkutė et al. 2024). The limitation of this research could be the subjectivity or the subjective attitude of the interviewees through the interviews. Recommendations for futureresearch are to include representatives of local self-government units and representatives of theislands' tourismboards. It is recommended to repeat thesame research in five and ten years, to include other islands, or to expand the coverage, and to make a comparison with the islands of other Mediterranean countries.

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STABLECOIN DP2P: INNOVATION AND SUSTAINABILITY IN FIAT CURRENCIES

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Abstract

This study investigates the potential of decentralised stablecoins (dP2P) as financing mechanisms and currency stabilisers in developing economies. The quantitative, exploratory, and correlational approach, based on the hypothetical-deductive method, uses data from 2010 to 2020 provided by sources such as The World Bank, OECD, and IMF, covering both developing and developed countries. The main hypothesis is that dP2P offers greater exchange rate stability compared to fiat currencies in emerging economies. The methodology involves applying simple moving averages (SMA) to assess exchange rate volatility and compare the performance of dP2P with traditional currencies. The results reveal that during the analysed decade, several fiat currencies experienced significant depreciations, while dP2P exhibited lower volatility. Argentina and Angola recorded the largest depreciations, reflecting high levels of economic instability, whereas currencies like the Costa Rican colon and the Vietnamese dong showed greater resilience. dP2P tracked the depreciation trends of fiat currencies, but with less intensity, indicating a higher potential for value preservation. The main contributions of this study are the empirical validation of stablecoins as a viable alternative to mitigate exchange rate volatility in emerging economies and the introduction of SMA as an effective tool for analysing the stability of crypto assets, expanding the application of statistical methods in evaluating decentralised finance (DeFi).

Keywords: Stablecoins, FIAT, volatility, and Fiat currencies,
JEL classification: G10, G23, E44, E47,

1. Introduction

Financial systems possess an intrinsic capacity for adaptation, constantly seeking to optimise their operational processes to effectively respond to the dynamics and complexities of global markets (Gomber et al., 2018; Thakor, 2020). This adaptability is reflected in the implementation of innovative technologies, the redefinition of business models, and the reformulation of regulatory structures (Cong et al., 2019; Frost et al., 2019). However, trust among the various participants in the financial ecosystem remains a fundamental and

unalterable requirement (Beck et al., 2018; Allen et al., 2022). In the realm of crypto-assets, the need for trust assumes even greater relevance due to high levels of volatility, significant market inefficiency, and pronounced value fluctuations (Baek & Elbeck, 2015; Corbet et al., 2019). These specificities distinguish crypto-assets from traditional financial assets, highlighting their importance in the contemporary financial landscape and necessitating distinct approaches at both operational and regulatory levels (Cappai, 2023; Cerqueira et al., 2024). This study examines the potential of an alternative stablecoin, termed dP2P, as a credit financing mechanism and currency stabiliser in developing economies. The approach used is quantitative, exploratory, and correlational, based on the hypothetical-deductive method. The study conducts a diachronic and longitudinal analysis, drawing on data from multiple countries between 2010 and 2020, sourced from entities such as The World Bank, OECD, and IMF. The methodology focuses on comparing the exchange rate volatility between dP2P and fiat currencies pegged to the euro. To this end, SMA are applied to smooth short-term fluctuations and identify long-term trends. The use of this statistical technique is justified by its effectiveness in signalling trend changes and identifying support and resistance levels, as demonstrated by previous studies. The results show that dP2P presents lower exchange rate volatility compared to most of the fiat currencies analysed, particularly in countries with a history of high inflation and economic instability. Extreme cases of currency depreciation, such as those of Argentina and Angola, validate the hypothesis that dP2P can serve as a means of value preservation in volatile markets. The analysis of moving averages demonstrates that dP2P follows the general trend of fiat currency depreciation but maintains superior relative stability. Annual comparisons reveal that dP2P managed to outperform the depreciation of some fiat currencies during periods of high volatility, highlighting its potential as an alternative for mitigating currency risks. The empirical validation of stablecoins as currency stabilisation tools in emerging economies demonstrates their significant potential to enhance financial sustainability. Concurrently, the introduction of SMA emerges as an innovative technique for analysing the stability of crypto-assets, providing a more systematic and reliable approach. Furthermore, the research explores and expands the application of statistical methods in the context of DeFi, highlighting the relevance of crypto-assets for economic development. This advancement offers valuable insights for investors, policymakers, and academics interested in understanding the impact of these technologies on the global financial landscape. The use of smart contracts emerges as an essential element in economic relations mediated by crypto-assets, representing a promising opportunity for future investigations, particularly concerning the decentralised intermediation between economic agents.

2. Literature Review

The transition from centralised financial systems (CeFi) to DeFi represents a paradigm shift in how money is conceived and interacted with (Zetzsche et al., 2020; Schär, 2021). This evolution can be traced back to the end of the Bretton Woods Agreement (1968-1973), a historical milestone that detached currency from the gold standard and consolidated the fiat system (Rolfe, 2019; Sussman & Wyplosz, 2024). Huang et al. (2019) and Chen and Bellavitis (2020) analysed this change, showing that the value of fiat currency results from collective perception, without tangible collateral, being influenced by supply and demand. The adoption of this monetary regime spurred financial digitalisation, facilitating the emergence of innovations such as stablecoins, designed to reduce volatility and provide greater market predictability (Bullmann et al., 2019; Auer et al., 2022). DeFi systems, based on blockchain technology, offer significant advantages in terms of transaction speed and costs, as demonstrated by Nadini et al. (2021) and Ozili (2022). Unlike centralised systems, which can take up to 48 hours to process operations on the SEPA network, blockchain technology enables almost instant executions, according to Ozili (2023) and Kukman & Gričar (2025). Additionally, the elimination of intermediaries reduces errors and minimises banking fraud, a persistent issue in the traditional financial system, as noted by Bodó & De Filippi (2022) and Auer et al. (2024). The inherent transparency of DeFi also helps mitigate corruption, a particularly relevant challenge in emerging markets, according to Li & Xu (2021) and Weingärtner et al. (2023). However, the adoption of DeFi is not without

challenges. Zarrin et al. (2021) and Mueller-Bloch (2024) identify the need for high computational power to process decentralised transactions, while Ante et al. (2021) and Lloyd (2022) highlight the difficulty in defining interest rates and returns. Additionally, Drechsler et al. (2019) and Chiu et al. (2023) point out the environmental impact of blockchains, such as Ethereum, posing a hurdle to overcome. The immutability of smart contracts, despite being a fundamental characteristic of the blockchain, can hinder adaptation to future changes (Vacca et al., 2021; John et al., 2023). The issue of stablecoins is central to DeFi, as they seek to solve the volatility of conventional cryptocurrencies (Jarno & Kołodziejczyk, 2021; Schumacher, 2024). Liu et al. (2022) and Dragomir & Dumitru (2023) differentiate the creation of crypto-assets through minting, as in Bitcoin, from the issuance of stablecoins, which are backed by fiat currency, usually the US dollar (Catalini et al., 2022; Lyons & Viswanath-Natraj, 2023). These coins ensure stability through reserves equivalent to the underlying asset (Kochergin, 2022; Benedetti & Smith, 2024). The sustainability of stablecoins depends on two critical factors: the volatility of the reserves and the risk of a "death spiral," a collapse in value if the stablecoin loses its peg (Bouri et al., 2019; Griffin & Shams, 2020). To mitigate this risk, it is necessary to maintain liquid, high-quality reserves and implement strategies to protect against credit and market risks (Gorton & Zhang, 2021; Hoang & Baur, 2024). If the peg between the stablecoin and the fiat currency is compromised, a negative spiral can occur, triggering a crisis of confidence in the DeFi ecosystem (Moine et al., 2020; Lee et al., 2025). In the peer-to-peer (P2P) context, DeFi facilitates direct transactions between economic agents, eliminating intermediaries and allowing for greater financial inclusion (Zervas et al., 2018; Makarov & Schoar, 2020). Einav et al. (2016) and Xiong et al. (2022) note that the P2P market adjusts prices based on supply and demand. Community finance, a branch of P2P, promotes the decentralised redistribution of resources, encouraging solidarity and mutual support (Boreiko & Vidusso, 2019; Drasch et al., 2020). Schneider (2019) and Mattke et al. (2021) demonstrate that investors choose financial assets not only based on expected returns but also on social and ethical factors, highlighting the growing relevance of social responsibility in the financial sector. P2P lending facilitates the financing of small and medium-sized enterprises, diversifying the risks of the financial system (Pierrakis, 2019; Fuster et al., 2019). However, there are inherent risks, such as credit risk associated with contract defaults, market risk arising from interest rate and currency fluctuations, and liquidity risk related to the financial institution's ability to meet commitments (Franks et al., 2021; Fuster et al., 2022). Ferrari (2020) and Fang et al. (2022) highlight that economic uncertainty in developing countries exacerbates these risks, increasing market volatility. Additionally, institutional investors tend to be more risk-tolerant, while retail investors demonstrate greater aversion, which can create asymmetries in the P2P credit market (Caldieraro et al., 2018; Cumming et al., 2021). In summary, the transition from CeFi to DeFi represents a structural change in the financial system, bringing advantages such as agility, reduced costs, and transparency, but also challenges related to governance, regulation, and the sustainability of stablecoins (Belke & Beretta, 2020; Schuler et al., 2024).

3. Methodology

The research adopted a quantitative, exploratory, and correlational approach, based on the hypothetical-deductive method, to formulate assumptions and identify correlations. A diachronic and longitudinal study was conducted to analyse the evolution of phenomena over time, using common data from multiple countries to detect trends and relationships between variables. This study analyses the potential of an alternative crypto-asset, a dP2P, to finance credit in developing economies and reduce inflation, with support from international investors. The central objective is to verify whether dP2P offers greater exchange rate stability compared to the fiat currencies that comprise it. The main hypothesis is that dP2P can replace fiat currencies as an exchange rate stabiliser, minimising fluctuations. The research focuses on the sustainability of the crypto-asset as a financing tool, comparing its variations with those of traditional currencies over a given period. The sample includes developing and developed countries, with data from 2010 to 2020, extracted from The World Bank, OECD, and IMF. The selection of this period is based on data availability, the emergence of cryptocurrencies in 2008, and the limitation of Covid-19 impacts. Exchange

rates of native currencies pegged to the euro were analysed, considering their attractiveness for lenders and borrowers. The sample includes Angola, Argentina, Chile, the Democratic Republic of Congo, Colombia, Costa Rica, India, Nigeria, Vietnam, and South Africa, selected based on information availability from the IMF. Criteria include data integrity on interest rates, GDP, and credit volume to the private sector. Developing countries were identified by GDP per capita ($4.18 to $24.92 thousand USD) and interest rates (4.18% to 67.25%). Data processing in this study was conducted through the comparison of SMA, a statistical technique applied to assess exchange rate volatility between fiat currencies and a proposed crypto-asset. The choice of this methodology is based on its ability to smooth short-term fluctuations, allowing the identification of long-term trends and the assessment of the relative stability of the assets under analysis. The use of SMA is aligned with existing literature. Marshall et al. (2017) and Karasu et al. (2020) highlight the usefulness of moving averages as robust indicators for price dynamics analysis, trend validation, and identification of support and resistance levels. Hudson & Urquhart (2021) and Mikhaylov et al. (2023) corroborate this perspective, emphasising the application of the SMA as a tool for signalling changes in the price trend of financial assets. The SMA is calculated using the following formula:

$$SMA_t = \frac{1}{n}\sum_{t=0}^{n-1} p_{t-n}$$

Where SMA_t represents the value of the SMA at a given time t, n represents the number of periods, and p_{t-n} represents the price at time t-n.

The application of this formula allows for the calculation of the arithmetic mean of an asset's prices over a specific period, smoothing out daily fluctuations and highlighting the overall trend. As demonstrated by Resta et al. (2020) and Wei et al. (2023), comparing the SMA between fiat currencies and the proposed crypto-asset enables the assessment of their relative stability, identifying which asset exhibits lower exchange rate volatility over the analysed period. The comparative analysis of SMA allows for inference about the crypto-asset's ability to act as a stabiliser of exchange rate fluctuations, compared to fiat currencies. According to Baur & Hoang (2021) and Kyriazis et al. (2021), the lower volatility observed in the crypto-asset, when compared to fiat currencies, indicates greater stability and lower exposure to abrupt fluctuations, validating the hypothesis that the crypto-asset can be an effective mechanism for mitigating exchange rate volatility in developing economies. Pronchakov & Bugaienko (2019) and Dolatsara et al. (2022), the adopted methodology, centred on the comparison of SMA, offers a clear and concise approach to analysing exchange rate volatility. Its application, supported by existing literature, provides robustness and validity to the obtained results, contributing to the understanding of the crypto-asset's role as a financing and exchange rate stabilisation mechanism in developing economies.

4. Results

Table 1 presents the exchange rate variation of different fiat currencies (FIAT) relative to the stablecoin dP2P over the years, highlighting the appreciation or depreciation of these currencies compared to dP2P. Over the analysed decade, most FIAT currencies exhibited a significant depreciation trajectory. The accumulated value for dP2P is -103.383%, demonstrating that, on average, the stablecoin dP2P showed better resilience to value loss than many of the analysed fiat currencies. Argentina (ARS) and Angola (AOA) exhibit the highest accumulated depreciations, with -366.072% and -231.736%, respectively. Argentina is particularly affected, as in 90% of the years, its currency performed worse than dP2P, indicating a high level of instability. Nigeria (NGN) and South Africa (ZAR) also had significant negative performances, with accumulated depreciations of -97.412% and -81.779%. On the other hand, some currencies performed relatively better, such as the Costa Rican colon (CRC) and the Vietnamese dong (VND), which show lower accumulated depreciations (-13.284% and -10.213%) and performed worse than dP2P in only 10% of the years. Comparing with the stablecoin dP2P, it is noted that in 60% of the years, the Angolan kwanza (AOA) performed worse than dP2P, while the Colombian peso (COP) and the South

African rand (ZAR) performed worse in 20% and 40% of the years, respectively. The Argentine peso (ARS) consistently had one of the worst performances, being surpassed by dP2P in 90% of the analysed years. The significant depreciation of some currencies reflects macroeconomic challenges such as high inflation, political instability, and inconsistent monetary policies. The Argentine case is particularly severe, as the peso has suffered from recurring crises, reflected in its high depreciation. dP2P, as a stablecoin composed of a set of currencies, showed lower volatility compared to several FIAT currencies, suggesting that it can serve as a means of value preservation in markets subject to high exchange rate fluctuations. The analysis reinforces the importance of currency diversification and the use of stable assets like dP2P in economies with high rates of monetary depreciation. The sharp depreciation of some currencies can negatively impact purchasing power and investor confidence, increasing the adoption of digital and decentralised alternatives. The performance of dP2P over the years demonstrates that it can be a viable alternative to mitigate risks associated with exchange rate volatility, especially in countries with a high history of inflation and economic instability. The analysis of Table 1 shows that the stablecoin dP2P performed more stable than most of the analysed fiat currencies. In particular, countries like Argentina and Angola suffered the greatest exchange rate depreciations, reinforcing the need for alternatives to protect the value of financial assets.

Table 1 – dP2P Composition by Currencies and Exchange Rate Variation

		Appreciation / Depreciation of FIAT Currencies in Developing Countries with EUR Parity (Year-on-Year)					
Country	**FIAT**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Angola	Kwanza (AOA)	0,0%	1,2%	-4,3%	-6,3%	6,8%	-17,7%
Argentina	Argentine Peso (ARS)	0,0%	-5,5%	-16,5%	-38,5%	-13,4%	-39,1%
Chile	Chilean Peso (CLP)	0,0%	-8,8%	10,6%	-15,5%	-4,1%	-0,7%
Dem. Rep. of Congo	Congolese Franc (CDF)	0,0%	0,1%	-1,4%	-4,6%	11,7%	9,0%
Colombia	Colombian Peso (COP)	0,0%	-3,8%	9,7%	-11,2%	-2,6%	-22,0%
Costa Rica	Costa Rican Colon (CRC)	0,0%	-0,0%	1,9%	-3,5%	1,6%	15,8%
India	Indian Rupee (INR)	0,0%	-14,4%	-6,1%	-17,6%	9,1%	6,5%
Nigeria	Nigerian Naira (NGN)	0,0%	-7,8%	4,4%	-5,4%	-2,4%	4,7%
Vietnam	Vietnamese Dong (VND)	0,0%	-8,7%	2,9%	-6,0%	7,2%	10,8%
South Africa	South African Rand (ZAR)	0,0%	-20,7%	-5,3%	-29,8%	3,6%	-20,3%
Appreciation	***dP2P***	***Stablecoin***	***0,0%***	***-6,9%***	***-0,4%***	***-13,8%***	***1,7%***	***-5,3%***

Legend: appreciation dP2P > appreciation FIAT; apreciation dP2P < apreciation FIAT
Source: Own elaboration

Table 2 – dP2P Composition by Currencies and Exchange Rate Variation (cont.)

		Appreciation / Depreciation of FIAT Currencies in Developing Countries with EUR Parity (Year-on-Year)				
Country	**FIAT**	**2016**	**2017**	**2018**	**2019**	**2020**
Angola	Kwanza (AOA)	-18,0%	-14,0%	-78,4%	-51,6%	-49,4%
Argentina	Argentine Peso (ARS)	-18,1%	-37,4%	-87,7%	-55,7%	-54,2%
Chile	Chilean Peso (CLP)	4,8%	-6,4%	-0,1%	-19,5%	-0,9%
Dem. Rep. of Congo	Congolese Franc (CDF)	-22,4%	-52,9%	0,7%	-1,2%	-28,9%
Colombia	Colombian Peso (COP)	-2,6%	-5,8%	-3,4%	-4,9%	-11,7%
Costa Rica	Costa Rican Colon (CRC)	-4,6%	-14,7%	-1,5%	8,9%	-17,2%
India	Indian Rupee (INR)	1,9%	-7,7%	-4,1%	0,1%	-12,6%
Nigeria	Nigerian Naira (NGN)	-54,3%	-11,6%	-14,1%	3,3%	-14,2%
Vietnam	Vietnamese Dong (VND)	-1,6%	-11,5%	1,4%	3,8%	-8,6%
South Africa	South African Rand (ZAR)	14,4%	-2,4%	-11,1%	4,3%	-14,4%
appreciation	***dP2P***	***Stablecoin***	***-10,0%***	***-16,4%***	***-19,8%***	***-11,2%***	***-21,2%***

Legend: appreciation dP2P > appreciation FIAT; apreciation dP2P < apreciation FIAT
Source: Own ellaboration

Table 3 – dP2P Composition by Currencies and Exchange Rate Variation (cont.)

Country	FIAT	Accumulated	% of Years with FIAT Performance Inferior to dP2P
Angola	Kwanza (AOA)	*-231,7%*	*60%*
Argentina	Argentine Peso (ARS)	*-366,1%*	*90%*
Chile	Chilean Peso (CLP)	*-40,4%*	*40%*
Dem. Rep. of Congo	Congolese Franc (CDF)	*-89,8%*	*40%*
Colombia	Colombian Peso (COP)	*-58,2%*	*20%*
Costa Rica	Costa Rican Colon (CRC)	*-13,3%*	*10%*
India	Indian Rupee (INR)	*-44,9%*	*30%*
Nigeria	Nigerian Naira (NGN)	*-97,4%*	*30%*
Vietnam	Vietnamese Dong (VND)	*-10,2%*	*10%*
South Africa	South African Rand (ZAR)	*-81,8%*	*40%*

appreciation ***dP2P*** ***Stablecoin*** ***-103,4%***

Legend: appreciation dP2P > appreciation FIAT; apreciation dP2P < apreciation FIAT
Source: Own ellaboration

Table 2 presents the analysis of SMA in the exchange rate variation of the Fiat index of developing countries and the stablecoin dP2P, highlighting the influence of depreciation movements on dP2P. The analysis reveals that the stablecoin dP2P significantly follows the depreciation trends of fiat currencies over the analysed period (2012-2020), with a progressive depreciation trajectory, reaching an accumulated -17.420% in 2020. The countries with the highest average depreciations over the years were Argentina and Angola. Argentina stands out for the strong and continuous depreciation of the Argentine peso, with significant negative values such as -20.175% in 2013, -31.514% in 2017, and a progressive worsening until reaching -65.860% in 2020. This trend reinforces the country's exchange rate instability, associated with high inflation and recurring economic crises. Similarly, Angola recorded continuous and sharp depreciation of the kwanza, with -5.721% in 2015, -16.573% in 2017, and an even greater decline in 2020, reaching -59.784%. These values indicate a significant weakening of the Angolan currency, reflecting structural economic challenges and high dependence on natural resources. Other countries, such as Nigeria and South Africa, also demonstrated considerable negative trends. Nigeria recorded severe depreciation in 2016 (-17.346%) and 2017 (-20.419%), remaining in negative levels until 2020 (-8.313%). South Africa had similar behaviour, with significant declines in 2013 (-18.603%) and 2015 (-15.490%), but some recovery in subsequent years. On the other hand, some countries demonstrated greater exchange rate resilience. Chile, for example, showed smoother fluctuations, alternating between periods of appreciation and depreciation, such as in 2016 (0.008%) and 2018 (-0.531%), remaining relatively stable. Vietnam and Costa Rica also recorded some positive variations, with the Vietnamese dong showing a growth of 5.455% in 2016 and the Costa Rican colon having a positive peak of 4.638% in 2015. These countries demonstrated greater economic stability, possibly due to more effective monetary policies and less dependence on volatile external factors. Comparing the results with the variation of dP2P, it is observed that it follows the general depreciation trend, although less intensely in some periods. In 2015, dP2P recorded a drop of -5.789%, lower than the depreciations observed in some currencies, such as the Argentine peso (-30.337%) and the Angolan kwanza (-5.721%). However, in deeper crisis years, such as 2018 and 2019, dP2P presented more pronounced declines (-15.437% and -15.835%, respectively), reflecting the global pressure on exchange assets. The analysis of the data in Table 2 confirms that the stablecoin dP2P is influenced by the negative fluctuations of FIAT currencies but maintains a relatively more stable performance compared to some highly volatile currencies. The significant depreciation of several currencies reflects underlying economic challenges in the analysed countries, reinforcing the importance of stable exchange rate alternatives, such as dP2P, for mitigating financial risks and preserving value in economies susceptible to monetary crises.

Table 4 – SMA of Fiat Exchange Rate Variation in Developing Countries and dP2P

Country	2012	2013	2014	2015	2016	2017	2018	2019	2020
Angola	-1,1%	-3,2%	-1,3%	-5,7%	-9,6%	-16,6%	-36,8%	-48,0%	-59,8%
Argentina	-7,4%	-20,2%	-22,8%	-30,3%	-23,5%	-31,5%	-47,7%	-60,3%	-65,9%
Chile	0,6%	-4,6%	-3,0%	-6,8%	0,0%	-0,7%	-0,5%	-8,6%	-6,8%
Dem. Rep. of Congo	-0,4%	-2,0%	1,9%	5,4%	-0,6%	-22,1%	-24,9%	-17,8%	-9,8%
Colombia	2,0%	-1,8%	-1,4%	-11,9%	-9,1%	-10,1%	-3,9%	-4,7%	-6,7%
Costa Rica	0,6%	-0,5%	0,0%	4,6%	4,3%	-1,2%	-6,9%	-2,4%	-3,3%
India	-6,9%	-12,7%	-4,9%	-0,7%	5,9%	0,2%	-3,3%	-3,9%	-5,5%
Nigeria	-1,2%	-2,9%	-1,1%	-1,0%	-17,4%	-20,4%	-26,7%	-7,5%	-8,3%
Vietnam	-1,9%	-3,9%	1,37%	4,0%	5,5%	-0,8%	-3,9%	-2,1%	-1,1%
South Africa	-8,7%	-18,6%	-10,5%	-15,5%	-0,8%	-2,8%	0,3%	-3,1%	-7,1%
dP2P variation	-2,4%	-7,0%	-4,2%	-5,8%	-4,5%	-10,6%	-15,4%	-15,8%	-17,4%

Source: Own ellaboration

Table 3 presents a comparative summary of the SMA between the Fiat currencies of developing countries and the stablecoin dP2P over nine years (2012-2020), identifying the periods during which fiat currencies experienced greater depreciations than dP2P. The analysis highlights the high volatility of some currencies, especially those of Angola (AOA), Argentina (ARS), and South Africa (ZAR), which showed a significant number of years where their depreciation exceeded that of the stablecoin. Argentina stands out as the most extreme case, with 100% of the analysed years (9 out of 9) showing a depreciation greater than dP2P. This result confirms the exchange rate fragility of the Argentine peso, reflecting the persistence of economic crises, high inflation, and monetary instability in the country. This consistent pattern of depreciation reinforces the idea that currencies like the ARS may not be viable options for investors or financiers seeking predictability and stability. Angola also shows a considerable rate of depreciation greater than dP2P, occurring in 5 out of the 9 analysed years (55.56%). This behaviour reflects the country's economic difficulties, including dependence on oil exports and macroeconomic instability, which frequently impact the exchange rate of the kwanza. South Africa, although performing slightly better, records 4 years (44.44%) of depreciation greater than the stablecoin, indicating significant exchange rate fluctuations, possibly associated with political factors, energy crises, and variations in the export sector. Other countries, such as India and Nigeria, present a moderate rate of depreciation greater than dP2P (33.33%), suggesting less pronounced but still relevant volatility. Countries like Chile (11.11%), the Democratic Republic of Congo (22.22%), and Colombia (22.22%) show greater resilience, with only a few years of more intense depreciation than the stablecoin. Costa Rica and Vietnam stand out for the absence of years in which their currencies depreciated more than dP2P, indicating a more stable and predictable behaviour over the analysed period. This factor may make them safer options for investors seeking lower exposure to exchange rate risk. When analysed year by year, it is observed that the periods from 2015 to 2018 were the most volatile, with four fiat currencies depreciating more than dP2P. On the other hand, the years 2019 and 2020 showed a slight improvement in exchange rate stability, with only two currencies exceeding the stablecoin's depreciation. The results of Table 3 reinforce the idea that exchange rate volatility can pose a significant challenge for investors and financiers, especially in emerging economies with unstable monetary policies. dP2P emerges as a relatively more stable alternative compared to some of these currencies, potentially offering greater predictability and protection against significant depreciations.

Table 5 – Summary of the Comparison of the SMA of Fiat Currencies in Developing Countries and dP2P

	Year									***Fiat of Developing Countries Inferior to dP2P (country over the period)"***	
Country	201	201	201	201	201	201	201	201	202	*Number of Years*	*Percentage*
Angola	0	0	0	0	1	1	1	1	1	*5*	*55,56%*
Argentina	1	1	1	1	1	1	1	1	1	*9*	*100,00%*
Chile	0	0	0	1	0	0	0	0	0	*1*	*11,11%*
Dem. Rep. of Congo	0	0	0	0	0	1	1	0	0	*2*	*22,22%*

	Year										*Fiat of Developing Countries Inferior to dP2P (country over the period)"*
Country	201	201	201	201	201	201	201	201	202	*Number of Years*	*Percentage*
Colombia	0	0	0	1	1	0	0	0	0	*2*	*22,22%*
Costa Rica	0	0	0	0	0	0	0	0	0	*0*	*0,00%*
India	1	1	1	0	0	0	0	0	0	*3*	*33,33%*
Nigeria	0	0	0	0	1	1	1	0	0	*3*	*33,33%*
Vietnam	0	0	0	0	0	0	0	0	0	*0*	*0,00%*
South Africa	1	1	1	1	0	0	0	0	0	*4*	*44,44%*
Fiat of Developing Countries Inferior to dP2P (each year)	*3*	*3*	*3*	*4*	*4*	*4*	*4*	*2*	*2*		

Legend: 1 = it is inferior: 0 = it is not inferior.
Source: Own ellaboration

5. Discussion

The study analyses the typology of dP2P, classifying it as either mint or stablecoin, each with distinct algorithmic specificities (Catalini & Gans, 2018; Li et al., 2025). Mint, created through smart contracts, exhibits high volatility due to neglect of macroeconomic dynamics of supply and demand (Bouri et al., 2021; Chiu & Keister, 2022). In contrast, stablecoins offer greater stability, being perceived as a "safe haven" against volatility (Baur et al., 2018; Borri, 2019). These cryptocurrencies are pegged to currencies or assets, making them more sustainable in the long term (Bullmann et al., 2019; Amatus, 2024). The value management of dP2P is based on DeFi protocols, combining tokens in diversified pools through smart contracts (Harvey et al., 2021; Tzeng & Su, 2024). This structure functions as a digital portfolio reinforced by innovative risk management strategies (Carapella et al., 2022; Roy et al., 2024). Despite its advantages, the model faces challenges related to exchange rate fluctuations (Corbet et al., 2019; Makarov & Schoar, 2020). Stability requires a careful selection of the currencies that make up its base (Fang et al., 2022; Hoang & Baur, 2024). It is more suitable for sophisticated investors, as prolonged retention may lead to asset depreciation (Jensen et al., 2021; De Cruz, 2024). In developing countries, dP2P emerges as an alternative to unstable fiat currencies, facilitating liquidity access through decentralised exchanges (Gandal et al., 2019; Zetzsche et al., 2020). Investment strategies directed towards regions with lower currency variations can encourage its financing (Deng, 2022; Miori & Cucuringu, 2024). The analysis of exchange rate variations revealed significant depreciations in fiat currencies, notably Argentina (-366.072%) and Angola (-231.736%). The stability of stablecoins depends on their structure and user confidence (Giudici, 2022; Kwon et al., 2023). Conclusively, the diversified model of dP2P demonstrates potential as a viable financial alternative, especially in decentralised global markets. In volatile markets, these stable digital assets can mitigate financial risks and preserve value, constituting a promising alternative for emerging economies.

6. Conclusions

This research evaluated the potential of the stablecoin dP2P as a credit financing instrument and exchange rate stabiliser in developing economies. Through a quantitative, exploratory, and correlational methodology, based on the hypothetical-deductive method, we examined data from 2010 to 2020 from reliable sources such as The World Bank, OECD, and IMF. We systematically compared the exchange rate volatility between dP2P and fiat currencies pegged to the euro using SMA. The results obtained reveal that in a context where financial systems are characterised by constant adaptability to the dynamics of global markets, crypto-assets stand out for the greater importance attributed to trust, given their volatility and pronounced value variation compared to traditional financial assets. The analysis of exchange rate variation during the studied decade evidenced significant depreciation in most FIAT currencies. In this scenario, despite recording an accumulated value of -103.383%, dP2P demonstrated greater resilience against value loss compared to several of the analysed currencies. Notably, Argentina (ARS) and Angola (AOA) recorded accumulated depreciations of -366.072% and -231.736%, respectively, with Argentina underperforming dP2P in 90% of the analysed years. Nigeria (NGN) and South Africa (ZAR)

also showed significant depreciations (-97.412% and -81.779%), while Costa Rica (CRC) and Vietnam (VND) demonstrated greater stability (-13.284% and -10.213%). The investigation of moving averages in the exchange rate variation of the Fiat index in developing countries and dP2P revealed that, although the stablecoin follows the depreciation trends of fiat currencies, it presents a less pronounced trajectory. This pattern was consistent throughout the analysed period, with the years 2015 to 2018 proving particularly volatile, during which four fiat currencies depreciated more than dP2P. It is important to highlight that dP2P emerged as a relatively more stable alternative compared to various fiat currencies, especially in economies characterised by high rates of monetary depreciation. Thus, this stablecoin may play a crucial role as a means of value preservation in markets subject to significant exchange rate fluctuations. The empirical validation of stablecoins as exchange rate stabilisation instruments in emerging economies demonstrates their significant potential to enhance the financial sustainability of these markets. The SMA methodology applied in this study presents itself as an innovative approach to analysing the stability of crypto-assets, providing a more systematic and reliable perspective on the impact of these technologies on the global financial landscape. In summary, this study contributes to the literature on emerging financial technologies, emphasising the importance of exchange rate diversification and the use of stable digital assets as a strategy to mitigate the effects of economic instability in emerging markets. Future research may expand on these results, exploring the practical implementation of these mechanisms in different economic and regulatory contexts.

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A MODULARITY DECOMPOSITION MODEL OF EVOLVING INPUT-OUTPUT SECTORIAL STRUCTURE

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Abstract
This paper builds on the network paradigm to model the evolving input-output (IO) economic structure of Greece into a multiplex network (GION) and unveils structural changes during the period 2005-2015, with reference to the 2008 economic crisis. The results illustrate that the GION resembles to a composition of windmill graphs, it is more clustered at the neighborhood scale, with a tertiary sectorial orientation, a solid performance of the trade and transportation industries, inelastic demand in energy-related economic activities, a neutral profile in communication and manufacturing relevant activities, insufficient connectedness of education, and vulnerable in the construction-related economic activities and the public sector. A major finding describes that the tourism industry is dynamic more due to its dependence on the supportive economies than the intrinsic industrial productivity. The time-series and community detection analysis provide insights into distinguishing three stages in the GION's evolution: the pre-crisis period (2005-2007), with a centralized topology in terms of outgoing connectivity and degree inequalities; the on-crisis period (2008-2010), with a decentralized topology and a tendency to reduce degree inequalities; and the post-crisis period (2011-2015), with a new state of centralized topology illustrating a recovery process. The analysis also reveals a diversified configuration in the Greek economy compared to the three-sector classical breakdown, composed of "tourism" and "transportation and energy" sector-like components, and the traditional secondary and tertiary sectors. Overall, the analysis shapes a "balloon" waiving pattern in the network evolution and reveals solid and fragment-favorable economic interactions in the GION's structure, promoting network analysis to the input-output structural modeling.

Keywords: input-output networks, structural analysis, community detection, economic crisis, Greece
JEL classification: R00, R15
pp. 107-133

1. Introduction

Input-output (IO) analysis is a quantitative technique for studying the interdependence of production sectors in an economy (Leontief, 1966). An IO table records the financial flows (Giannakis et al., 2024) among sectors over a stated time period, usually a year, including the distribution of the sectorial output throughout the economy and the disaggregation of the value of production to intermediate consumption of inputs and value added (Miller and Blair, 2009). Traditional tools of IO analysis have been used for analysing the structure of the economy including multiplier and linkage analysis (Lenzen, 2001; Giannakis and Mamuneas,

2022). Another important development in IO analysis over the last decades has been the structural decomposition analysis, focusing on decomposing changes in economic phenomena (Oosterhaven and Van Der Linden, 1997; Chen et al., 2015). However, most of these applications focus on the impacts derived by changes in certain sectors (Temel and Phumpiu, 2021; Li and Wu, 2022). According to Xu and Liang (2019), a more complete study of the structure of the economy as an integrated system requires a more "holistic" approach. This drives into considering the network structure of the economy, which can better portray the complex sectorial interactions and explain the observed aggregate patterns (Dominguez et al., 2021). In particular, IO tables have been used to analyse the topology of sectorial interrelationships and their impacts on national economies (Costa et al., 2022), while network science (Barabasi, 2013) can be employed to evaluate the IO structure of the economy through modelling network communities and identifying the central nodes across the sectors (Dominguez et al., 2021).

A profound knowledge of how sectors are interrelated and interconnected (Dionysopoulou et al., 2021; Todri and Papajorgji, 2023; Giannakis et al., 2024; Pham et al., 2024) is important for understanding the structure of the economy (Lincaru et al., 2010; Alexiadis et al., 2015; Kokkinou et al., 2018; Xu and Sam, 2021; Ruxho and Ladias, 2022), which usually determines its functionality in response to disruptions (Xu and Liang, 2019; Carvalho, 2014). As Hulten (1978) noted, only the sales of the sector (as a share of output) are important for the transmission of sectorial shocks to the aggregate economy. However, apart from the lower properties of the sectorial interdependencies, the more complex properties of the IO network (ION) structure can explain such cascading effects in the system (Acemoglu et al., 2012). Therefore, understanding the topological properties of sectorial interactions and interrelationships, and how these properties may vary over time, can play a defining role in explaining how sectorial shocks propagate throughout the economy and possibly lead to large aggregate fluctuations (Carvalho, 2014; Baqaee and Farhi, 2019). Further, the analysis of the distribution of inter-sectorial linkages rather than the distribution of sectors can explain which sectorial linkages are more prone to volatility amplification or reduction (Joya and Rougier, 2019). Similarly, the structure of IONs can explain the dynamics of national economies in periods of economic growth (Duan, 2012) or decline. Contreras and Fagiolo (2014) argue that the extent and heterogeneity of recessionary impacts depend on whether the shock alters the structure of sectorial interrelationships. Also, Joya and Rougier (2019) support that two topological characteristics of a sector, namely, its local density and centrality, as well as the asymmetry property of the whole network determine whether a sectorial shock can generate aggregate fluctuations.

As far as shocks are concerned, the global economic crisis of 2008, which originated in the United States of America, was an economic shock that was immediately spread across Europe. Although in the early mid-2000s it was one of the fastest-growing economies in the Eurozone, with an annual growth rate of 4.2% (Eurostat, 2022), Greece was the worst-hit country (Xanthos et al., 2012; Pnevmatikos et al., 2019; Sdrolias et al., 2022) within the European Union, having cumulatively lost almost 26% of its GDP during the period 2008-2015 (Eurostat, 2022). This unprecedented economic disruption has significantly affected the productive-web (Polyzos et al., 2013; Delgado and Sequeira, 2023) and the industrial mix (Giannakis and Bruggeman, 2017; Uzsayilir and Baycan, 2023) of the country. Thereby, it is evident that significant structural changes have taken place in the country during and the economic recovery period. From an empirical standpoint, Greece suggests an interesting case to study whether the features of the ION structure of the national economy and their evolution overtime can explain the drivers of resilience (Xanthos and Dulufakis, 2023) and recovery of the economy to the negative shock.

Getting inspired from (i) the peculiar case of Greece, in terms of its vulnerability to the 2008 economic crisis (Polyzos et al., 2013; Giannakis and Bruggeman, 2017; Zheng et al., 2021), and (ii) the recent literature on unveiling topological features from the IO inter-sectorial economic structures (Cerina et al., 2015; Rio-Chanona et al., 2017; Dominguez and Mendez, 2019; Giammetti et al., 2020; Dominguez et al., 2021; Costa et al., 2022), this paper explores the structural transformation in Greece during the pre- and post-crisis period 2005-2015, by using the network paradigm in the modelling of the diachronic inter-sectorial economic structure of the country. As dynamic changes of network structures through the use

of a series of IO tables (valued at constant prices) can provide valuable insights for the structure of the economy, we transform the 11 annual IO tables (IOTs) over the period 2005-2015 into graphs (network models) and study their topological features over-time. The contribution of this paper is twofold; first, it goes beyond the current empirical ION studies by constructing a multilayer instead of single layer model of the Greek IO economic structure. Second, the paper develops a novel community detection method based on modularity decomposition from complex network analysis, aiming to contribute to the IO literature by uncovering fixed (stable) and commuting (periodical or unstable) inter-sectorial connections in the evolution of the Greek IO economic structure.

2. LITERATURE REVIEW

Although the network analysis is a modern conceptualization in the IO modelling, it has been increasingly applied in the IO relevant research. In particular, Cerina et al. (2015) used the world IO database to analyse the global, regional and local network properties of the world ION and document its evolution over time. Similarly, del Rio-Chanona et al. (2017) studied the world ION, focusing on the relative importance that countries and sectors have. The findings of the study showed that the political and geographical circumstances can play an important role in communities' definition, while sectors were separated into two different groups: one defined by renewable resources and the other by non-renewable resources. Further, Dominguez and Mendez (2019) studied the ION structure of the Japanese economy, using the eigenvector community-detection algorithm of Newman (2006). The results revealed the existence of two ION structures, namely (i) a densely-connected group of service-related sectors including finance, real estate, transportation, health and welfare-related services (stationary community), and (ii) a group of all remaining industries (transitional community).

The authors Giammetti et al. (2020) studied the properties of the European production network, to identify the key sectors in the complex structure of the UK-EU trade relationships that were involved in the Brexit process. The findings of the study indicate that few industries located in core countries, and specifically in the UK and Germany, were dominant in the production network. Next, Dominguez et al. (2021) empirically studied sectorial productivity convergence patterns through the IO structure of the Japanese economy and its network representation over the period 2003-2012. The authors found two dominant communities: the first community consisting of service-related sectors, while the second community consisting of high-tech manufacturing industries. Finally, Costa et al. (2022) studied the transmission mechanisms of domestic and foreign shocks across the Italian business system through the analysis of domestic inter-industrial relationships. A new taxonomy of Italian business sectors was proposed based on the speed and the extent of their capacity of transmitting impulses across the domestic system.

As is evident, current approaches of network analysis of IOTs mainly focus on the world IO configuration (Cerina et al., 2015; del Rio-Chanona et al., 2017), the European Union (Giammetti et al., 2020; Giannakis et al., 2024), along with some national cases, such as the Japanese (Dominguez and Mendez, 2019; Dominguez et al., 2021) and the Italian (Costa et al., 2022) economy, providing insights into identifying key sectors and major communities in the IO economic structures. In the case of Greece, just a couple of papers building on the network paradigm to study the IO economic structure are available in the literature. In particular, the work of Garcia-Muniz and Ramos-Carvajal (2015) was the first that applied a network approach in the Greek IO economic structure of the period 2000-2010, based on multilevel indicators capturing the influence, immediacy, and transmission capacity of industries, to study the relational structure and the robustness of the economic system. The authors claim that the economic structure of the country shifted from an agricultural and low-medium technological configuration in 2000 to an economy with a significant industrial sector in 2010, detecting limitations for 40% of Greek sectors in the diffusion of their possible impacts in the economy. Although this study was the first inspired by the network paradigm to conceive Greek IOTs as network structures, the overall network approach is somehow unorthodox from the network science perspective, since it builds on unconventional network measures that are more relevant to stochastic processes than complex network analysis. More

recently, Reyes and Garcia-Muniz (2016) extended a stochastic model of social network structure to analyse the role of different technological intensity sectors in the Greek economy, between 2005 and 2010. The social network structural model constructed probabilistic distributions of inter-industry connectivity to explore the sectors' ability either to preserve consistency or to change its economic structure by potentially creating new connections. The results showed that the Greek IO economic structure was relatively dispersed, the industries lacked systematic connectivity patterns, and the overall economy lacked a clear specialization, while the tertiary sector was crucial in weaving the economic structure and manufacturing industries were linked through more complex connectivity patterns.

Apart from these two distinguishable works, all other relevant research in the Greek IO literature are mainly empirical and provide interesting case studies of diverse sectorial foci of the Greek IO economic configuration including applications on tourism (Briassoulis, 1991), construction (Caloghirou et al., 1996), agriculture (Giannakis and Efstratoglou, 2011) and energy (Karagianni and Pempetzoglou, 2004). More recently, Pnevmatikos et al. (2019) used a hybrid IO modeling and causative-matrix analysis approach to study the inter-sectorial linkages in the Greek economy and detect structural changes in Greece at the pre-crisis period (2000-2010). The analysis showed that (i) most of the sectors (and particularly the tertiary ones) increased their gross output; (ii) the technological changes were smaller than those captured due to the change in the final demand; and (iii) the effects on final demand were increasingly internalized. Finally, Polyzos and Tsiotas (2020) complemented the previous work by studying the structural changes in Greece for the succeeding (post-crisis) period 2010-2015. The analysis showed that the Greek IO structure neither experienced sharp technological nor hierarchical changes, while the transportation and energy industries (sectors) were found more resilient. As is evident in the previous review, the 2008 economic crisis is a point of interest in the IO analysis of the Greek economy. Yet there is an insufficient integration in the relevant literature of network analysis, which has already been proven effective for unveiling topological features from the inter-sectorial IO economic structures.

3. METHOD AND DATA

The methodological framework of the study builds on a multilevel consideration that consists of five discrete steps, the first two concerning data manipulation and graph modeling, while the last three network and empirical analysis. At the first step (s#1), we deflate the 11 available IOTs of the period 2005-2015, on the basis year 2020, and we afterwards convert them into graph models (IO Networks - IONs). At the second step (s#2), we construct an average ION model by computing the averages across the annual values for each element in the connectivity matrix. At the third step (s#3), we compute the major complex network measures of the annual and average ION models and we study their evolution, to detect significant changes in the ION economic structure of Greece. At the fourth step (s#4), we apply a community detection analysis to the average and annual ION models and we develop a novel intersection model from the communities of the annual IONs. Finally, at the fifth step (s#5), we compare the community structure between the average and the intersection IONs to detect fixed and commuting interactions in the IO economic structure of Greece.

3.1. Graph modelling and Data

The database for the construction of the multilayer GION was extracted from the Organization for the Economic Co-operation and Development (OECD, 2018) and regards annual sales and purchases flows of industry outputs, measured in million US$, current prices, for the period 2005-2015. The available IO Tables (IOTs) were further deflated on the basis year 2020, using inverse average (inter-sectorial) inflation rates extracted from the Hellenic Statistical Authority (ELSTAT, 2021). This collection of annual IOTs is conceived as a collection of connectivity matrices of network structures (Dominguez et al., 2021), due to their by definition square structure. Within this context, the family of annual IOTs constructs a multilayer graph model $M(\Gamma, X=\emptyset)$ (Kivela et al., 2014; Boccaletti et al., 2014), the Greek Input-Output Network (GION), consisting of eleven (11) directed layers (IO Networks - IONs) $\Gamma=\{G_p\}=\{V_p, E_p \mid p=1,\ldots,11\}$ without interlayer connections $X=\{E_{ij} \subseteq V_i \times V_j\}=\emptyset$,

where G=(V, E) denotes a graph with V set of nodes and E set of edges (links). In each layer G_p=(V_p, E_p), nodes ($i \in V_p$) represent n=35 industrial sectors (industries) of the IO economic structure in Greece (shown in Table A_1, in the appendix) and links ($ij \in E_p$) their industrial transactions. Provided that all layers are constructed by the same node set, namely $V_1 = V_2 = \ldots = V_{11}$, the multilayer GION can be seen as a multiplex network. Each GION's layer $G_p \in M$ is a directed and weighted graph expressed by a weighted connectivity matrix

$$W_p = \left\{ w_{ij}^{(p)} \right\}$$

where weights represent the annual sales and purchases between producers and consumers within the economy of Greece, for a year p.

Finally, in the multilayer configuration of GION, we include an additional layer (AION), which is constructed by averaging the available annual layers, according to the formula:

$$AION = \frac{1}{p} \sum_{i=1}^{p=11} W_p = \left\{ \frac{1}{p} \sum_{i=1}^{p=11} w_{ij}^{(p)} \right\} \quad (1),$$

where W_p is the weighted connectivity matrix of year (layer) p, as previously defined. The average layer is denoted as *AION* and provides a magnitude of scale for the Greek IO economic structure of the period 2005-2015.

3.2. Network Analysis

After the multilayer graph modeling, topological analysis applies to unveil patterns of hierarchy (Tsiotas and Kallioras, 2025) and relevant topological information in the GION configuration. The topology of the GION is studied additively, namely is approximated by using a set of network measures, each capturing a topological aspect (such as connectivity, intermediacy, path length, clustering, centrality, etc.). The measures of network topology considered in this paper are shown in Table 1.

Table 1

Nomenclature and measures of network topology used in analysis of GION

Measure	Description	Math Formula	Reference
Graph	A pair set consisting of a node-set V and an edge-set E. In graph $G(V,E)$, n expresses the number of nodes and m the number of links.	$G(V,E)$	Newman (2010); Barthelemy (2011)
Graph density (ρ)	The fraction of the existing connections (m) to the number of the possible connections. It expresses the probability to meet a link between two randomly chosen nodes in the network.	$\rho = m \Big/ \binom{n}{2} = \frac{2m}{n \cdot (n-1)}$	Newman (2010)
Network diameter (dG)	The longest path $p(i,j)$ in the network.	$d(G) = \max\left\{ p(i,j) \mid i,j \in V \right\}$	Koschutzki et al. (2005).
Node Degree (k)	The number of graph edges being adjacent to a given node i. It expresses the number of interacting industries of a node.	$k_i = m(i) = m_i = \sum_{j \in V(G)} \delta_{ij} = \sum_{j \in V(G)} \delta_{ij}$, where $\delta_{ij} = \begin{cases} 1, & \text{if } e_{ij} \in E(G) \\ 0, & \text{otherwise} \end{cases}$	Newman (2010)
In-degree ($k-$)	The number of incoming edges being adjacent to a given node i. It expresses the number of sellers of an industry.	$k_i - = m_i - = \sum_{j \in V(G)} \delta_{ij} -$, where $\delta_{ij} = \begin{cases} 1, & \text{if } e_{ij} \in E(G) \\ 0, & \text{otherwise} \end{cases}$	Newman (2010); Barthelemy (2011)
Out-degree ($k+$)	The number of outgoing edges being adjacent to a given node i. It expresses the number of buyers of an industry.	$k_i - = m_i - = \sum_{j \in V(G)} \delta_{ji} -$, where $\delta_{ij} = \begin{cases} 1, & \text{if } e_{ji} \in E(G) \\ 0, & \text{otherwise} \end{cases}$	Newman (2010)
Node strength (s)	The sum of weights (w_{ij}) of the links (e_{ij}) being adjacent to a given node i. The δ_{ij} operator is the Kronecker delta function yielding a true output for links belonging to graph G. It	$s_i = s(i) = \sum_{j \in V(G)} \delta_{ij} \cdot d_{ij}$, where $d_{ij} = w(e_{ij})$ in km	Newman (2010); Barthelemy (2011)

Measure	Description	Math Formula	Reference
	measures the volume of imports (incoming) and exports (outgoing) of an industry.		
Closeness Centrality (*CC*)	Is computed on the average path-lengths $d(i,j)$ originating from a given node $i \in V$ to all other nodes $j \in V$ in the network. It measures accessibility.	$CC(i) = \frac{1}{n-1} \cdot \sum_{j=1, i \neq j}^{n} d_{ij} = \bar{d}_i$	Koschutzki et al. (2005).
Betweenness Centrality (*CB*)	The proportion that is defined by $\sigma(i)$ shortest-paths that pass through a given node i to the total shortest-paths σ in the network. It expresses intermediacy.	$CB(i) = \sigma(i)/\sigma$	Koschutzki et al. (2005)
Eccentricity ($e(u)$)	The longest path p(u,j) in the network from a given node $u \in V$.	$e(u) = \max\{ p(u,j) \mid j \in V \}$	Koschutzki et al. (2005).
Local Clustering Coefficient ($C(i)$)	The probability a node i to have $E(i)$ neighbors connected. It is computed on the number of triangles configured by node i to the number of the total triplets $k_i(k_i-1)$ shaped by this node.	$C(i) = \frac{E(i)}{k_i \cdot (k_i - 1)}$	Newman (2010)
Modularity (Q)	Objective function expressing the potential of a network to be subdivided into communities. In the mathematical formula, g_i is the community of node $i \in V(G)$, $[A_{ij} - P_{ij}]$ is the difference of the actual minus the expected number of edges falling between a particular pair of vertices $i,j \in V(G)$, and $\delta(g_i,g_j)$ is an indicator function returning 1 when $g_i=g_j$.	$Q = \frac{\sum_{i,j} [A_{ij} - P_{ij}] \cdot \delta(g_i, g_j)}{2m}$	Blondel et al. (2008); Fortunato (2010)
Average path length $\langle l \rangle$	The average of the path length $d[p(i,j)]$ computed for all accessible pairs (i,j) of network nodes.	$\langle l \rangle = \frac{\sum_{v \in V} d\left(p(i,j)\right)}{n \cdot (n-1)}$	Barthelemy (2011)

By definition, IOTs are connective graphs including one component and thus all network measures are well-defined in this study, raising no issues of insufficient connectivity (Koschutzki et al., 2005). In general, comparisons of network measures in a multilayer context can apply through a double axis (Tsiotas and Polyzos, 2018): (*i*) in reference to theoretical values, to detect similarities of the empirical network (being under examination) with a null model of already known properties; and (*ii*) between different layers (for the same measure), able to provide insights into the changes in the topological aspect that the measure represents for the certain layers (in this study: years). Further, In a multilayer networks' context, collections of scores for a network measure across the layers may generally provide a data series (representing different states of a measure), where empirical analysis can apply to the variables composed of each series (Tsiotas and Ducruet, 2021). In the case of GION, where each layer corresponds to an annual IOT, the cross-layer collections of a network measure defines a time-series illustrating the evolution of a certain topological aspect (this that is represented by the network measure) during the period 2005-2015. Within this context, the empirical analysis in this paper builds on the idea of applying independent-samples *t*-tests to compare the means between different time periods. Further, instead of applying *t*-tests, this paper alternatively constructs error bars of 95% confidence intervals (CIs), for obtaining visualized (instead of tabulated) results. In terms of interpretation, when the error bars overlay, the population parameters expressed by the mean values between groups are considered as statistically the same, implying that the performance of the populations represented by these groups is equivalent. On the contrary, when the error bars do not overlay, the population parameters expressed by the mean values are considered as statistically different, implying that the performance of the populations represented by these groups is different.

3.3. Community detection and community membership intersection

After the network measures computation, we apply a community detection analysis both to the AION and the GION's layers separately, by using the modularity optimization algorithm proposed by Blondel et al. (2008). This is a heuristic algorithm, which divides the graph into communities by their (binary or weighted) node connectivity, under the requirement to maximize the within-communities and minimize the between-communities connectivity (specifically the sum of actual minus the expected number of edges falling in the communities). In the case of weighted networks, the modularity function is expressed by the following relation:

$$Q = \frac{1}{2m}\sum_{i,j}[A_{ij} - \frac{k_i \cdot k_j}{2m}]\cdot\delta(g_i, g_j) \quad (2),$$

where Q is the modularity function; A_{ij}, m, and $\delta(g_i,g_j)$ are the arguments defined in Table 1; and $k_i = \sum_j A_{ij}$ is. Due to the heuristic architecture of this algorithm, we run the community detection analysis several times (is set to 30 iterations) and we keep the mode (most frequent) of the modularity score and its corresponding modularity classification (community membership). In terms of interpretation, the modularity algorithm produces communities that are dense in connectivity within and sparse between. The nodes included in a community can be considered as relevant to the extent they are more strongly interconnected than other nodes in the network. In this paper, we apply the community detection algorithm of Blondel et al. (2008), to the form it is available in the open source software of Bastian et al. (2009).

At the final step of the methodological framework, we develop a novel set theoretic community model of the GION's layers. The model is defined by the intersections of the modularity classification distributions (the nominal community labeling of all network nodes) across the annual layers of the GION. This model allows distinguishing the fixed members in the GION's communities during the period 2005-2015 and thus detecting the diachronically stable sectorial interconnections in the multilayer network's structure. Finally, after configuring the fixed communities' set, we compare at the fifth step the community configuration between the average and the intersection IONs to detect fixed and commuting interactions in the IO economic structure of Greece.

4. RESULTS AND DISCUSSION

4.1. Network Analysis

■ Network measures and layouts

In the first part of the analysis, we compute the network measures of the multilayer GION (composed of AION and the Γ family) and the results are shown in Table 2. As it can be observed, the GION is a connected, directed, and highly dense network; including –on average– the 97.9% of the K_{35} complete graph's connectivity. This result is in line with relevant empirical findings (Cerina et al., 2015) stating that, at national level, IONs are highly dense and complete. Moreover, during the period 2005-2015, the number of the GION's links ranged from 1167 to 1186. This high scale of magnitude is responsible driving into high levels the relevant degree-based network measures (average degree, min degree, in- and out-degree, etc.). The average strength of the GION is 5611.7m US$, interpreting that (in the 35-node structure of the GION's economy) each industry is interconnected to the others with an amount of purchases over 5.6 billion US$, on average. As far as clustering is concerned, we can observe a considerable difference of magnitude between average and global clustering coefficient (by converting the average and global clustering coefficients to undirected measures, to be comparable), expressing that clustering at the neighborhood scale is almost 4 times than this at the global scale.

In terms of pattern recognition, this clustering divergence usually describes a property of windmill graphs (Estrada, 2016), at which nodes are not mutually interconnected but linked each other via a super-hub. However, the case of the Greek IO economy is even more complex, since 5 out of 35 industries can be considered as super-hubs (enjoying a degree of

k=70) at all years in the period 2005-2015, and particularly the sectors: 20T21 (Chemicals and pharmaceutical products), 24 (Manufacture of basic metals), 35T39 (Electricity, gas, water supply, sewerage, waste and remediation services), 49T53 (Transportation and storage), and 69T82 (Other business sector services). Within this context, the GION's topology may suggest a composition of windmill graph models, implying that, at the certain level of resolution (35 sectors), *the IO structure of the Greek economy may operate more as an aggregation of sub-economies than a fully integrated economic system*. This interpretation can be also satisfactorily supported by the scores of the modularity measures, illustrating that the GION's structure diachronically consists of 4-5 communities, which is equal to the number of the diachronic super-hubs. Finally, in terms of path length, we can observe that the GION enjoys an average path length of $\langle l \rangle = 1.022 \sim 1$, which indicates that the majority of paths are direct connections, interpreting a very high level of efficiency. Also, the GION has a diameter $d(G)$=2 steps of separation, which also implies a high level of efficiency and expresses that the most distant industrial sectors in the network are far just one additional link from directedness.

Table 2

Network measures of the GION, for the period 2005-2015

		GION's Layer										
Network Measure	**AION**	**G_1 (2005)**	**G_2 (2006)**	**G_3 (2007)**	**G_4 (2008)**	**G_5 (2009)**	**G_6 (2010)**	**G_7 (2011)**	**G_8 (2012)**	**G_9 (2013)**	**G_{10} (2014)**	**G_{11} (2015)**
Nodes	35						35[a]					
Edges	1199	1173	1179	1181	1186	1183	1184	1176	1169	*1167*[b]	1172	1172
Average Degree (und[c])	34.257	33.514	33.686	33.743	33.886	33.8	33.829	33.6	33.4	*33.343*	33.486	33.486
Min degree (dir[d])	49	43	41	43	47	46	47	44	42	41	43	*40*
Degree Range	21	27	29	27	*23*	24	*23*	26	28	29	27	30
In-degree Range	7	12	13	11	11	10	*9*	12	13	14	13	15
Out-degree Range	14	15	16	16	*14*	*14*	*14*	*14*	15	15	*14*	15
Average Strength	5611.7	5772.1	6322.4	7176.0	7281.0	6547.3	5672.2	5215.6	4664.1	4694.2	4642.72	*3741.8*
CB Range	1.144	0.292	0.214	0.214	*0.172*	1.800	1.683	2.112	2.575	2.736	2.349	2.498
CC Range	0.412	0.206	0.176	0.176	*0.147*	0.412	0.412	0.412	0.441	0.441	0.412	0.441
Net Diameter (dir)	2						2					
Net Diameter (und)	2						2					
Graph Density[e] (dir)	0.979	0.958	0.963	0.964	0.969	0.966	0.967	0.960	0.954	*0.953*	0.957	0.957
Modularity	0.39	0.379	*0.349*	0.367	0.401	0.359	0.399	0.425	0.428	0.425	0.431	0.425
Communities	4	*4*	*4*	*4*	*4*	5	5	5	5	5	*4*	*4*
Connected Components	1						1					
Avg. Clust. Coefficient (dir)	0.98	0.961	0.965	0.967	0.97	0.968	0.968	0.958	0.958	*0.957*	0.961	0.962
Clust. Coefficient (und)	0.12	0.123	0.124	0.123	*0.122*	*0.122*	*0.122*	0.124	0.124	0.124	0.123	0.123
Avg. Path Length (und)	1.022	*1.013*	1.039	1.037	1.033	1.035	1.034	1.047	1.047	1.049	1.045	1.045

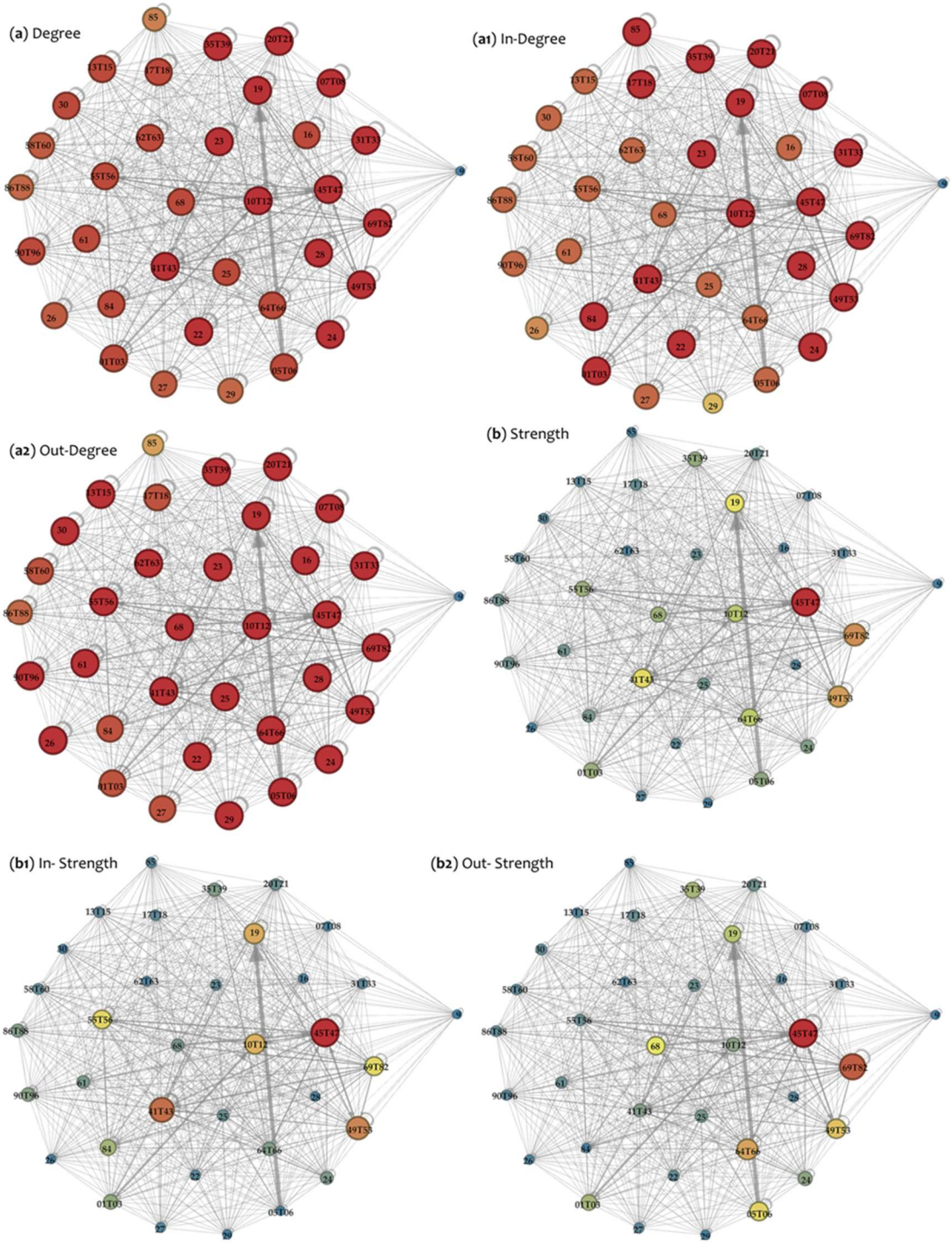
As far as topological layouts are concerned, we can observe in Fig.1a that the majority of the AION's are –on average– highly connected nodes (of degree $k_i \geq 65 \mid 9 \neq i=1, 2, \ldots, 35$) enjoying a similar incoming and outgoing connectivity, except industry 9 (Mining support service activities), which is the lowest connected node with a degree k_9=49. However, we can observe in Fig.1b that only 7 out of 35 nodes have a relatively high strength (exceeding 2 billion US$), which are the sectors: 45T47 (Wholesale and retail trade; repair of motor vehicles | s_{45T47}=5.0215 billion US$); 69T82 (Other business sector services | s_{69T82}=3.5749 billion US$); 49T53 (Transportation and storage | s_{49T53}=3.2584 billion US$); 41T43 (Construction | s_{41T43}=2.6037 billion US$); 19 (Coke and refined petroleum products | s_{19}=2.5711 billion US$); 64T66 (Financial and insurance activities | s_{64T66}=2.1743 billion US$); and 10T12 (Food products, beverages and tobacco | s_{10T12}=2.1134 billion US$). This outcome is in line with the tertiary specialization of the Greek economy (Sdrolias et al., 2022), both in terms of volume and number of strong sectors. In particular, the top-five exporting industries (sellers) are (for more details see Table A_2, Appendix): 45T47 (Wholesale and retail trade; repair of motor vehicles), 69T82 (Other business sector services),

64T66 (Financial and insurance activities), 49T53 (Transportation and storage), 05T06 (Mining and extraction of energy producing products); whereas the top-5 importing industries (purchasers) are: 45T47 (Wholesale and retail trade; repair of motor vehicles), 41T43 (Construction), 49T53 (Transportation and storage), 19 (Coke and refined petroleum products), and 10T12 (Food products, beverages and tobacco). Amongst these nodes, only the trade (45T47) and transportation (49T53) industries belong to both groups, illustrating a solid performance.

Further, in terms of trade balance (defined by the difference exports–imports), the top-5 industries are: 05T06 (Mining and extraction of energy producing products), 64T66 (Financial and insurance activities), 69T82 (Other business sector services), 68 (Real estate activities), and 35T39 (Electricity, gas, water supply, sewerage, waste and remediation services); with an average difference ranging from 3.896 to 13.071 billion US$. This outcome (*i*) illustrates the *importance of the energy-related economic activities, due to their inelastic demand* (Labadeira et al., 2017; Sdrolias et al., 2022); and (*ii*) it further *reveals the tertiary specialization of the Greek IO economic structure* (Pnevmatikos et al., 2019; Polyzos and Tsiotas, 2020; Sdrolias et al., 2022). On the other hand, the bottom-5 (most deficient) industries are 41T43 (Construction), 55T56 (Accommodation and food services), 84 (Public administration and defense; compulsory social security), 10T12 (Food products, beverages and tobacco), 19 (Coke and refined petroleum products), with a deficit from –15.016 to –4.446 billion US$. This outcome (*i*) accredits the finding of Sdrolias et al. (2022) that *the construction-related economic activities were the most vulnerable in the Greek economy due to the 2008 economic crisis*; (*ii*) *captures the diachronic administrative lag of the public sector* in Greece (Spanou, 2008; Tzannatos and Monogios, 2013); and (*iii*) reveals a striking finding that *the tourism industry* (55T56) – which has an average share of ~15-20% in the national GDP (Kalantzi et al., 2017; Sdrolias et al., 2022) – *owes its dynamism more to its dependence on the supportive economies than to its intrinsic productivity*. Finally, the 5-null nodes (most neutral, with the closest to zero trade balance) are the industries: 29 (Motor vehicles, trailers and semi-trailers), 62T63 (IT and other information services), 31T33 (Other manufacturing; repair and installation of machinery and equipment), 9 (Mining support service activities), 58T60 and (Publishing, audiovisual and broadcasting activities); with values of trade-balance ranging from –389.495 to +249.804 million US$. This outcome highlights the importance of communication and manufacturing relevant activities in terms of their supportive (balanced) role in the Greek IO structure.

Next, in terms of centrality, we can observe in Fig.2a that almost half (14 out of 35) of the AION's nodes enjoy a high betweenness, and in particular the industries (for more details see Table A_3, Appendix): 45T47 (Wholesale and retail trade; repair of motor vehicles), 69T82 (Other business sector services), 49T53 (Transportation and storage), 41T43 (Construction), 19 (Coke and refined petroleum products), 10T12 (Food products, beverages and tobacco), 35T39 (Electricity, gas, water supply, sewerage, waste and remediation services), 24 (Manufacture of basic metals), 20T21 (Chemicals and pharmaceutical products), 23 (Other non-metallic mineral products), 22 (Rubber and plastics products), 31T33 (Other manufacturing; repair and installation of machinery and equipment), 28 (Machinery and equipment n.e.c.), and 07T08 (Mining and quarrying of non-energy producing products). *This observation can support the assumption about the windmill structure of the GION*, since less than the half nodes undertake the major traffic of this network, although almost all of the GION's nodes are highly connected ones.

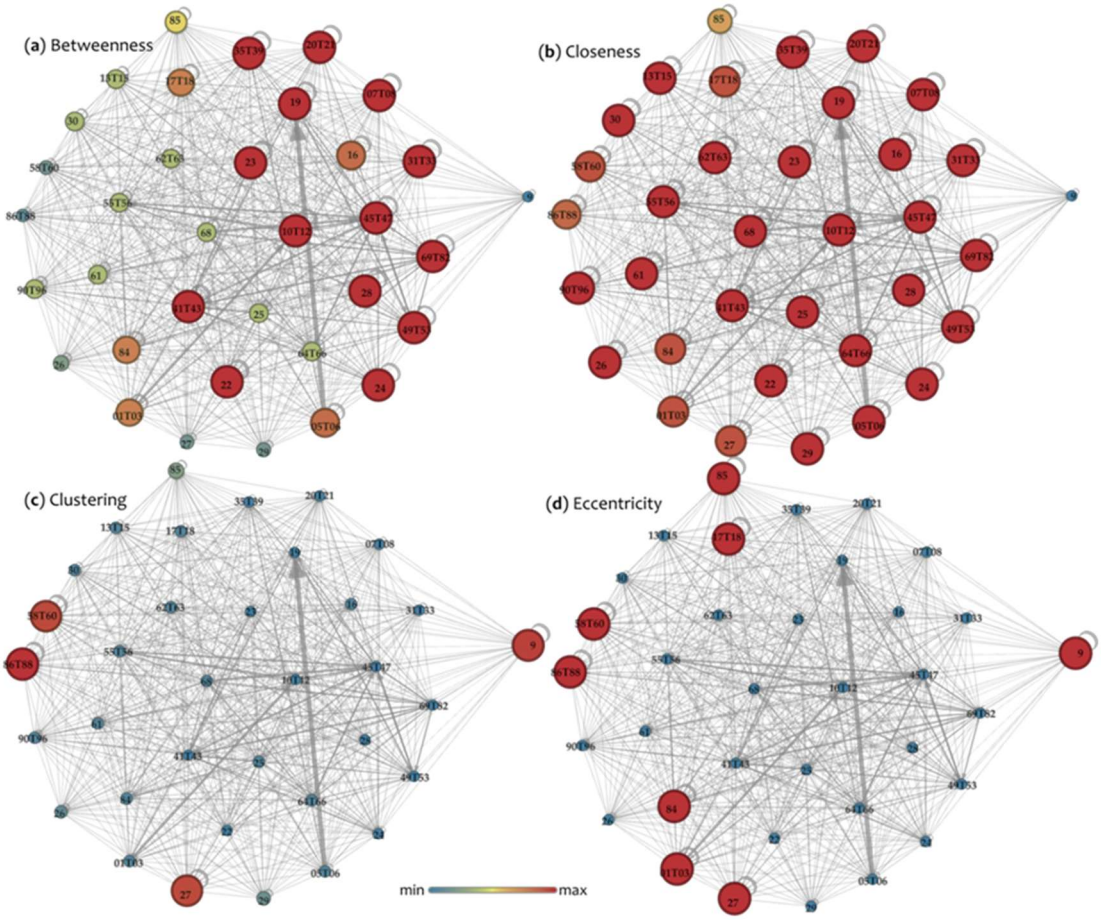
Fig.1. Topological layout of the AION's degree-based network measures



As far as closeness is concerned, we can observe in Fig.2b that almost all nodes are highly central, except industries: 9 (Mining support service activities) and 85 (Education); which are the most distant from the others respectively 1.41 and 1.14 steps. As far as education (85) is concerned, this outcome raises a concern about the level of connectedness of education with the production structures of the Greek economy (Hyz, 2011; Korres et al., 2018), towards promoting national and regional economic development. Finally, for the measures of clustering (Fig.2c) and eccentricity (Fig.2d), we can observe similar topological patterns in their layouts. In terms of clustering, industries: 86T88 (Human health and social work), 27 (Electrical equipment) and 58T60 (Publishing, audiovisual and broadcasting activities), and 9 (Mining support service activities); are the most clustered in AION, implying that they belong to neighborhoods that are more highly mutually interconnected and thus they more concisely enjoy flow circulation at the neighborhood scale. These nodes, along with industries: 85 (Education), 01T03 (Agriculture, forestry and fishing), 17T18 (Paper products and printing),

and 84 (Public administration and defence; compulsory social security); also have the highest eccentricity, implying that they are the most distant from the functional center of the AION. Through a joint consideration, these outcomes imply that nodes (industries) of high eccentricity are more likely to be also highly clustered, but this observation addresses avenues of further research.

Fig.2. Topological layout of the AION's centrality measures



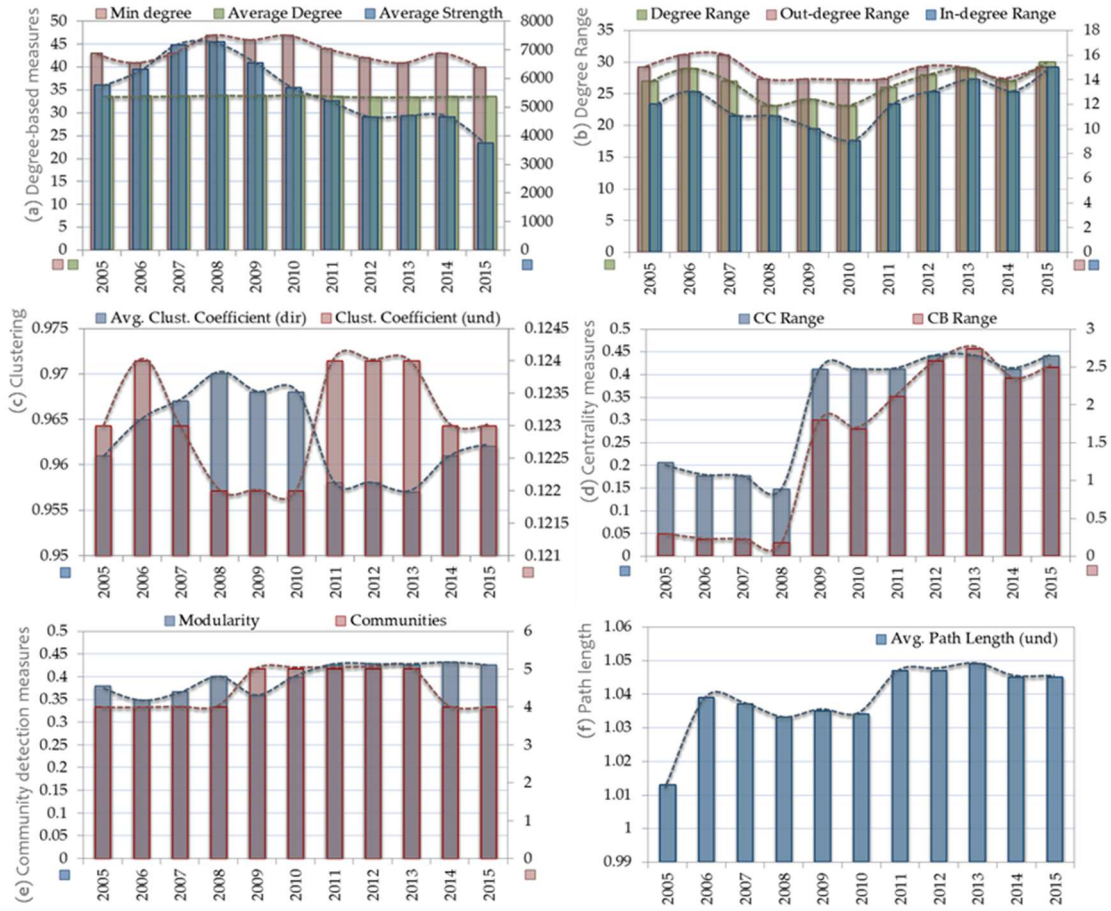
■ **Time-series analysis**

In this part of the analysis, we examine the available information in Table 1 within a time-series context. As it can be observed, in 15 out of 19 cases, the network measures that are numerically closer to the AION's values are included in the period 2008-2010. Provided that this period is: (*i*) the core of the 2008 economic crisis in Greece (Polyzos et al., 2013) and (*ii*) structurally, the (spatial) middle interval of the time-series body; this observation allows broadly assume that the GION's performance is described by monotonicity (similar to this of one-dimensional 1d-lattice) or periodicity, where in both cases the arithmetic mean and barycenter coincide. In terms of interpretation, this observation suggests that, in the period 2008-2010, the GION's topology can be seen as a representative of the whole period 2005-2015, implying that the 2008 economic crisis in Greece affected the scale of the GION's topological measures on a longer-term basis. To obtain a deeper structural picture, we examine the time-series of the GION's topological measures at the bar-charts shown in Fig.3. According to Fig.3a, the GION's degree-based measures started declining after 2009 (although slightly on average, see Table 2 for the detailed time-series), illustrating a loss of connectivity in the network structure due to the 2008 economic crisis. As Fig.3b shows that the range in these degree-based measures increased after 2009, we can complementary note that this loss of connectivity has caused an increase in the inequalities of the GION's connections, due to the 2008 economic crisis. A combined consideration of Fig.3a and Fig.3b interprets that, in the period after the economic crisis, the GION's connectivity decreased amongst sectors, while degree inequalities (as expressed by the degree range) increased. By assuming that the concave Williamson's curve of regional inequalities (Cappello, 2016) can

be also insightful (through an analogy) in the GION's structural context, this observation may imply that the economic crisis forced the pair-wise relationship between average node connectivity and sectorial inequalities to shift backwards in the first quadrant (from righter to more left positions), towards the vertical axis of the curve's symmetry. Within a broader interpretation, this backwards' shift illustrates that the 2008 economic crisis forced GION to move into a state of more downgraded network structure, reducing thus connectivity from the lower connected nodes (industries) and thus favoring a more centralized network structure.

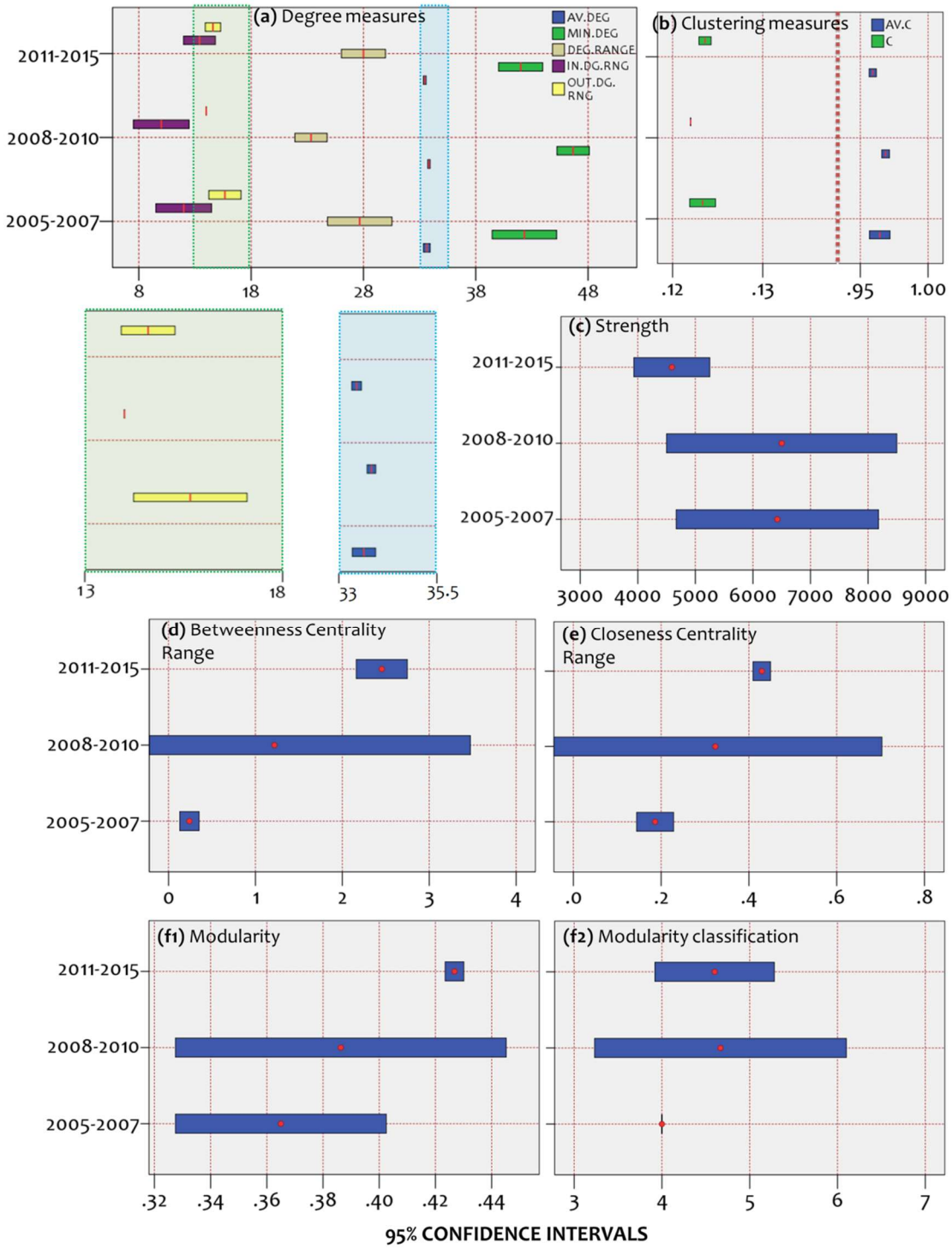
Next, Fig.3c illustrates the time-series of the GION's clustering (average and global clustering coefficient), where we can observe a contrary performance at the emergence of the 2008 economic crisis. In particular, in the three first years (2005-2007) we can observe a proportional evolution of the two measures, while in the next period 2008-2010 the global clustering coefficient inclined and the average clustering coefficient increased. This contrary behavior uncovers a resilience mechanism of the GION against the shock of the 2008 economic crisis, according to which clustering (peripheral connectivity) shifted from the global to the neighborhood scale, illustrating a sectorial localization of the GION's economic structure. In the succeeding period 2011-2013 this picture reverses, where the GION's economic structure regains its sectorial extraversion and simultaneously reduces its local structure. Finally, in the last two years 2014-2015, the GION's clustering appeared almost to return to a performance similar to this of 2005-2007. As far as network centrality is concerned, we can observe in Fig.3d that the ranges (max–min) of betweenness and closeness centrality have similarly evolved during the period 2005-2015. In particular, up to 2008, the ranges of both measures inclined, illustrating a convergence of inequalities in terms of intermediacy and closeness in the GION's structure, while afterwards increased, expressing a concordant increase of the inter-sectorial inequalities. In terms of network topology, this outcome implies that the 2008 economic crisis caused GION to move into a more centralized network structure, favoring more the privileged nodes according to "the rich get richer" growth model.

Fig.3. Time-series of the GION's (a) degree-based measures, (b) degree range, (c) clustering, (d) centrality range, (e) community detection measures, and (f) average path length. In cases where double vertical axes are applicable, colored boxes on the bottom of each axis are used as references to the corresponding time-series.



In terms of community structure, we can observe in Fig.3e that the period 2009-2013 was critical for the GION's community configuration, where the number of communities changed from 4 to 5. This change implies that the 2008 economic crisis caused a restructure to the GION's community configuration, driving this multilayer network into to a more localized structure composed of more –in number– communities. This observation complements a previous outcome about the GION's clustering, although it illustrates that the localization kept longer than in the case of clustering. Finally, in terms of average path length, we can observe in Fig.3f two levels of magnitude in the time-series' body, defined by a cutting point of the year 2010. This dichotomous approach describes that the 2008 economic crisis made the GION's inter-sectorial communication more distant, an observation which (in conjunction with the previous findings) supports the assumption about the overlaid windmill structure of GION (where centrality and distant connectivity can coexist). According to the previous time-series consideration, we can overall observe three critical periods in the 11-year period of the GION's structure, defined by the cutting points of the years 2008 (where degree, clustering, centrality, and modularity changed) and 2011 (where clustering, centrality and path-length measures seem to change). To detect whether these changes between the periods *A* (pre-crisis: 2005-2007), *B* (on-crisis: 2008-2010), and *C* (post-crisis: 2011-2015), are significant ones, we construct error bars of 95% CIs, which provide a visualization of an independent samples *t*-test for the comparison of means between groups. When CIs overlay, no significant difference between the groups' means exist.

Fig.4. Network measures with significant differences between the pre-crisis (<2009) and on-crisis (≥2009) periods and the four-community ([2005,2008]U[2014,2015]) and five community ([2009,2013]) periods



To better supervise the results of Fig.4, we construct the auxiliary Table 3, summarizing significant inequalities $i>j$ in the corresponding cells ij. As it can be observed in Fig.4 and Table 3, period A has a significantly higher degree range (R_k) and out-degree (k_+) than the period B, whereas it has a significantly higher average strength ($<s>$) than the period C. These results imply that the pre-crisis period (2005-2007) is described by a higher level of outgoing connectivity and degree inequalities than the on-crisis period (2008-2010), illustrating a more extraverted (open) structure due to the pre-crisis welfare. Also, period A (2005-2007) is described by a higher volume of inter-sectorial transactions (average strength) than the period C (2011-2015), also illustrating its "welfare" compared to the post-crisis times. Next, period B

has a significantly higher minimum degree (k_{min}) than period *A*, illustrating a tendency (it may imply a homeostatic mechanism against the crisis) of GION to reduce degree inequalities by improving connectivity of lowest connected nodes, at the time that the shock of 2008 economic crisis applied. We can also make a similar observation through the comparison of periods *B* and *C*, where period *B* has a significantly higher average ($<k>$) and minimum degree (k_{min}) than period *C*, illustrating that degree inequalities and average connectivity reduced at the post-crisis period (thus favoring a more decentralized - peripheral topology), as previously observed. Finally, period *C* has a significantly higher betweenness (R_{CB}) and closeness (R_{CC}) centrality range than period *A*, along with higher scores in modularity. These results are in line with the previous findings (Fig.3d) illustrating the centralized network structure of GION in the post-crisis period. Also, period *C* has a significantly higher degree range (R_k), in-degree (k_{-}) and out-degree (k_{+}) than period *B*, implying that after the crisis shock the GION's structure started recovering by becoming more connected.

Table 3

Tabulation of the significant differences extracted by the error bar analysis

	A:2005-2007	**B:2008-2010**	**C:2011-2015**
A:2005-2007		$R_k^{(*,**)}$ (95%CI); $k(+)$ (90%CI)	$<s>$ (90%CI)
B:2008-2010	k_{min} (95%CI)		$<k>$ (95%CI); k_{min} (95%CI); $<s>$ (90%CI)
C:2011-2015	R_{CB} (95%CI); R_{CC} (95%CI); Q (95%CI); Q_{class} (90%CI)	R_k (95%CI); $k_{(-)}$ (95%CI); $k_{(+)}$ (90%CI)	

*. Cases *ij* imply that the average of *i* is significantly greater than the average of *j* (*i*>*j*) at the confidence level shown in brackets

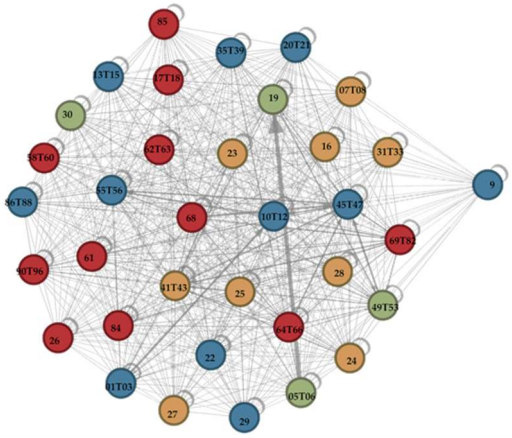
**. $R(\cdot)$: range; $<\cdot>$: average; $\min\{\cdot\}$: minimum; CI: confidence interval; *k*: degree, *s*: strength; CB: betweenness; C: closeness; Q: modularity; Q_{class}: modularity classification

4.2. Community detection

In the final part of the study, we apply a community detection analysis based on the modularity optimization algorithm of Blondel et al. (2008), to detect communities of dense inner connectivity in the GION. To do so, we separately detect community structure in the AION and the GION's layers, separately, and we further construct the interlayer community intersection model, described in relation (2). First, the results of the analysis applied to the AION's community structure are shown in Fig.5 and in Table A_4 (see Appendix) in more detail. As it can be observed, the AION's structure can divide into 4 communities of size 11, 4, 9, and 11 industries, respectively. Based on their composition, we can observe that the first community (g_1) has apparently a diverse semiology, as is composed of sectors included in all major sectors of the 3d sectorial structure, such as: agriculture (01T03) and food products (10T12); mining support service (9); wearing apparel (13T15); chemicals and pharmaceutical (20T21), and plastic (22) products; motor vehicles (29); electricity, gas, water supply, sewerage, waste, and remediation services (35T39); trade (45T47); accommodation and food services (55T56); and human health and social work (86T88). However, all these industries are broadly related to tourism, which is a major industry in the Greek economy (Briassoulis, 1991; Polyzos et al., 2013; Giannakis and Bruggeman, 2017; Sdrolias et al., 2022) and is considered by many national researchers as the "fourth sector" as complementary to the three-sector classical breakdown. Within this context, the composition of the first community in the AION provides insights into an integration of the broader "tourism sector" in Greece. The second community (g_2) has semiology related to transportation (30, 49T53) and supportive energy products (05T06, 19), highlighting the importance and integration of transportation in the GION's sectorial structure. Next, the third community (g_3) has a broader manufacture semiology consisting of industries related to non-energy mining (07T08), construction (16, 23, 41T43), manufacturing (24, 25, 31T33), and electrical (27, 28) products and equipment. This community can be seen as a more representative to the semiology of secondary sector in terms of the three-sector classical breakdown. Finally, the fourth community (g_4) is composed of industries that are related to education (85, 17T18), communication and IT (26, 58T60, 61),

arts (90T96), public administration (84), real estate (68), and relevant business activities (69T82), which can be seen as a representative of the services (tertiary) sector within the context of the three-sector classical breakdown. Overall, the AION's community configuration *allows distinguishing a diversified configuration in the Greek economy compared to the three-sector classical breakdown*, composed of a *manufacture* (the secondary, size: 9), *tertiary* (size: 11), *tourism* (the secondary, size: 11), and *transportation and energy* (size: 4) sector-like components.

Fig.5. Modularity classification of the average Input-Output network (AION) of Greece



After the community detection in the AION's structure, we repeat the analysis to each of the GION's layer, resulting to 11 annual community patterns, where each corresponds to a year of the period 2005-2015. By applying the community intersection model of relation (2) to these community patterns, we get 16 groups of industries (fg_i) with fixed interconnectivity in the period 2005-2015, as it is shown in Table A_5 (see Appendix). As it can be observed through comparisons (Table A_4, Appendix), the AION's communities divide as follows in the community intersection model:

(*i*) community g_1 ("tourism sector") divides into 8 sub-communities $g_1 = \bigcup_i fg_i \,|\, i = 1,4,5,7,10,12-13$

(*ii*) community g_2 (transportation and energy) splits into 2 sub-communities $g_2 = fg_2 \bigcup fg_{11}$

(*iii*) community g_3 (secondary sector) splits into 2 sub-communities $g_3 = fg_3 \bigcup fg_9$ and

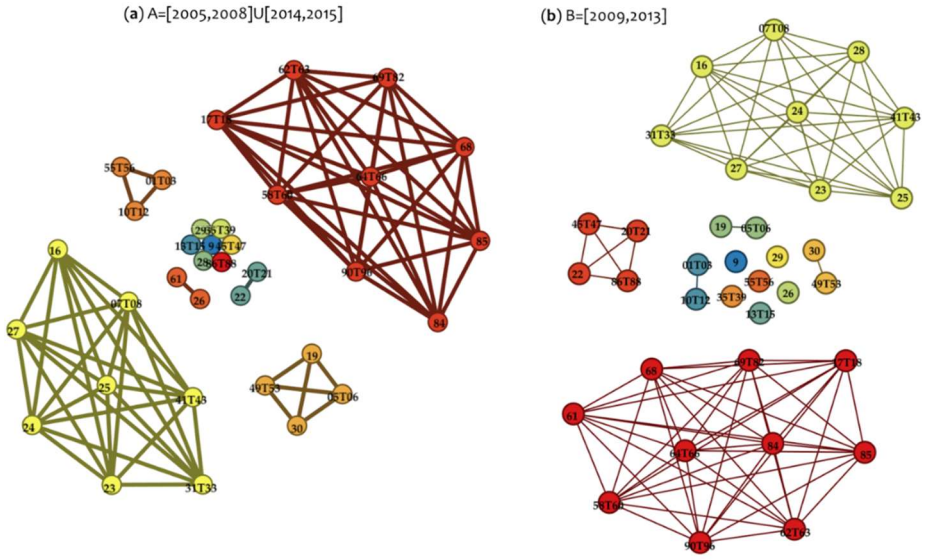
(*iv*) community g_4 (tertiary sector) divides into 4 sub-communities $g_4 = \bigcup_i fg_i \,|\, i = 6,8,15,16$

These results allow observing structural coherence between the AION's and interlayer GION's structures, as no sub-communities in the 2005-2015 intersection model include industries from different AION's communities. Namely, all sub-communities produced by the intersection model are parts of the same communities in the AION's community structure. However, in functional terms, this observation implies that the four AION's communities are not that much functionally integrated and can be separated to further substructures (sub-communities). This dis-concordance *can be attributed to the 2008 economic crisis and allows interpreting that this exogenous shock affected*: (*i*) *mainly the broader "tourism sector" in Greece*, dividing it into 8 sub-communities, the biggest in size of which are {01T03, 10T12 | Agriculture and Food products} and {9, 13T15 | Mining support service activities and Textiles}; (*ii*) *afterwards the tertiary sector*, dividing it into 4 sub-communities, where sub-community fg6 is similar to the AION's g4 excluding industries 26 (Computer, electronic and optical products), 61 (Telecommunications), and 86T88 (Human health and social work); and (*iii*) *lastly the other two AION's "sectors"* (secondary sector; transportation and energy), dividing them into 2 sub-communities (dichotomous effect). Overall, the comparison of Tables A_4 and A_5 allows detecting the solid structural components in the AION's community

structure, observing that the most concise AION's communities are the secondary sector and transportation and energy, while the most fragment-favorable the tertiary sector and tourism.

Toward a further analysis, we apply the community intersection model to the periods A= $[2005,2008]\bigcup[2014,2015]$ (off-crisis) and B=[2009,2013] (on-crisis), which are found of different community structure (4 and 5 communities, respectively) in the analysis of Fig.3e. This approach aims to provide further insights into the diachronically solid components in the GION's economic structure. The results of this analysis are shown in Fig.6 and –in more detail– in Table A_6 (Appendix). Similarly to the previous case, we can observe that these sub-communities are parts of the same AION's communities and not a mix of different memberships. Further, for period *A*, we can observe that the AION's communities divide as follows: (*i*) community g_1 ("tourism sector") divides into 8 sub-communities $g_1=\bigcup_i f_I g_i \,|\, i=1,4,5,7,10-13$, each consisting of 1-2 industries; (*ii*) community g_2 (transportation and energy) remains solid; (*iii*) community g_3 (secondary sector) divides into 3 sub-communities $g_3=\bigcup_i f_I g_i \,|\, i=3,9,10$, where the first ($f_I g_3$) is the largest consisting of 8 industries; and (*iv*) community g_4 (tertiary sector) splits into 2 sub-communities $g_4=f_I g_6 \bigcup f_I g_8$, essentially abstracting sub-community {26, 61 | Computer, electronic and Telecommunications}. On the other hand, for period *B*, we can observe that the AION's communities divide as follows: (*i*) community g_1 ("tourism sector") divides into 6 sub-communities $g_1=\bigcup_i f_{II} g_i \,|\, i=1,4,5,7,11,12$, one consisting of 4 industries and the others of 1-2 industries; (*ii*) community g_2 (transportation and energy) splits into 2 sub-communities $g_2=f_{II} g_2 \bigcup f_{II} g_{10}$, each consisting of 2 industries; (*iii*) community g_3 (secondary sector) splits into 2 sub-communities $g_3=f_{II} g_3 \bigcup f_{II} g_9$, where the first ($f_I g_3$) is the largest consisting of 9 industries; and (*iv*) community g_4 (tertiary sector) splits into 2 sub-communities $g_4=f_{II} g_6 \bigcup f_{II} g_8$, essentially abstracting industry 26 (Computer, electronic and optical products).

Fig.6. Groups of the GION's industries with fixed interconnectivity in the periods: (a) [2005-2008]U[2014-2015] and (b) [2009-2013].



Overall, we can observe that, in period *A* (off-crisis period), the GION's community structure appeared relatively more concrete in transportation and energy, and in agriculture and tourism, which are considered as high resilience industries (Giannakis and Bruggeman, 2017; Sdrolias et al., 2022) due to their inelastic demand. On the contrary, in period *B* (on- and early post-crisis) the GION's community structure turned relatively more concrete in the secondary and tertiary sector (according to the classic sectorial breakdown), which are the sectors enjoying the highest shares in the Greek economy (Sdrolias et al., 2022). This observation, in conjunction with a previous finding, stating that that the 2008 economic crisis caused a restructure to the GION's into to a more localized community structure, imply that industries of inelastic demand may contribute towards structural integration, while industries enjoying highest shares may contribute to structural localization. It can further provide avenues of further research.

5. CONCLUSIONS

This paper used the network paradigm to model the IO economic structure of Greece during the period 2005-2015 into a multiplex network (Greek IO Network - GION). The analysis built on multilayer network modelling and a customized community detection method, to uncover structural changes in Greece with reference to the 2008 economic crisis. The network analysis showed that the GION is a highly dense and efficient, in terms of path length, network, where each industry participates on average to an amount of purchases over 5.6 billion US$. It also appeared more clustered at the neighborhood than at the global scale, illustrating a multilayer composition of windmill graph structures, configuring diachronically 4-5 communities. In terms of strength and trade balance, the volume of purchases revealed (*i*) the tertiary orientation of the Greek economy; (*ii*) a solid performance of the trade and transportation industries; (*iii*) the importance of (the inelastic demand) energy-related economic activities; (*iv*) a neutral profile in communication and manufacturing relevant activities; (*v*) insufficient connectedness of the education industry; and (*vi*) a higher vulnerability of the construction-related economic activities and the public sector. This part of the analysis came up to a finding that the tourism industry in Greece seems to owe its dynamism more to its dependence on the supportive economies (which makes many researchers considering it a broader economic sector) than to its intrinsic productivity.

The time-series analysis showed that the 2008 economic crisis affected on average the scale of the GION's topological measures, illustrating a loss of connectivity in the network structure from the lower connected nodes (industries) and a more centralized network structure. This part of analysis also revealed that the GION's clustering (peripheral connectivity) shifted towards a sectorial localization to recover the external shock, while inequalities in centrality (intermediacy and closeness) initially converged (on-crisis) and afterwards (post-crisis) increased, illustrating that GION moved into a more centralized network structure. Overall, the time-series analysis allowed collectively distinguishing three stages in the examined period of GION's evolution: (*i*) the pre-crisis period 2005-2007, described by considerably high outgoing connectivity, degree inequalities, and inter-sectorial transactions reflecting economic "welfare"; (*ii*) the on-crisis period 2008-2010, described by considerably high minimum degree, illustrating a recovery tendency to reduce degree inequalities by improving connectivity of lowest connected nodes (thus favoring a more decentralized or peripheral topology); and (*iii*) the post-crisis period 2011-2015, described by a considerably high directed degree and centrality ranges, illustrating a GION's recovery activation into increasing connectivity.

Finally, the community detection analysis showed that period 2009-2013 was critical for the GION's structure, where the number of communities changed from 4 to 5, driving this multilayer network into to a more localized structure. The AION's community configuration allowed distinguishing a diversified configuration in the Greek economy compared to the three-sector classical breakdown, since the industries' configuration within the communities illustrated more the existence of "*tourism*" and "*transportation and energy*" sector-like components than the traditional agricultural sector. Additionally, the community detection analysis revealed solid interactions in the GION's structure through time, where the most concise communities appeared the secondary sector and transportation and energy, while the most fragment-favorable the tertiary and tourism sectors. In particular, within a binary on-

crisis and off-crisis context, the community detection analysis showed that: (*i*) during off-crisis the GION's community structure appeared relatively more concrete in transportation and energy, agriculture, and tourism group of industries, while (*ii*) during on-crisis it turned relatively more concrete in the secondary and tertiary sector. These findings indicate that industries of inelastic demand may contribute towards structural integration, while industries enjoying highest shares may contribute to structural localization.

Overall, the network analysis applied to the GION revealed a "balloon" waiving pattern in the evolution of the GION's topology implemented in three stages

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7. APPENDIX

Table A1
The *n*=35 industries of the input-output tables (IOTs) composing the GION

Industry Code	Description
01T03	Agriculture, forestry and fishing
05T06	Mining and extraction of energy producing products
07T08	Mining and quarrying of non-energy producing products
9	Mining support service activities
10T12	Food products, beverages and tobacco
13T15	Textiles, wearing apparel, leather and related products
16	Wood and of products of wood and cork (except furniture)
17T18	Paper products and printing
19	Coke and refined petroleum products
20T21	Chemicals and pharmaceutical products
22	Rubber and plastics products
23	Other non-metallic mineral products
24	Manufacture of basic metals
25	Fabricated metal products, except machinery and equipment
26	Computer, electronic and optical products
27	Electrical equipment
28	Machinery and equipment n.e.c.
29	Motor vehicles, trailers and semi-trailers
30	Other transport equipment
31T33	Other manufacturing; repair and installation of machinery and equipment
35T39	Electricity, gas, water supply, sewerage, waste and remediation services
41T43	Construction
45T47	Wholesale and retail trade; repair of motor vehicles
49T53	Transportation and storage
55T56	Accomodation and food services
58T60	Publishing, audiovisual and broadcasting activities
61	Telecommunications
62T63	IT and other information services
64T66	Financial and insurance activities
68	Real estate activities
69T82	Other business sector services
84	Public administration and defence; compulsory social security
85	Education
86T88	Human health and social work
90T96	Arts, entertainment, recreation and other service activities

Table A2
Degree ranking in the AION's nodes

Description	Degree*	In-Degree	Out-Degree	Label	Description	Strength*	In-Strength	Out-Strength
Mining and quarrying of non-energy producing products	70	35	35	45T47	Wholesale and retail trade; repair of motor vehicles	50215.53	24669.87	25545.66
Food products, beverages and tobacco		35	35	**69T82****	**Other business sector services**	35749.93	12897.33	22852.60
Coke and refined petroleum products		35	35	**49T53**	**Transportation and storage**	32584.36	18344.31	14240.05
Chemicals and pharmaceutical products		35	35	41T43	Construction	26037.93	20527.35	5510.58
Rubber and plastics products		35	35	19	Coke and refined petroleum products	25711.03	15078.56	10632.47
Other non-metallic mineral products		35	35	64T66	Financial and insurance activities	21743.57	5539.27	16204.30
Manufacture of basic metals		35	35	10T12	Food products, beverages and tobacco	21134.91	14674.46	6460.44
Machinery and equipment n.e.c.		35	35	68	Real estate activities	17086.29	4403.54	12682.75
Other manufacturing; repair and installation of machinery and equipment		35	35	01T03	Agriculture, forestry and fishing	16305.31	7213.85	9091.46
Electricity, gas, water supply, sewerage, waste and remediation services		35	35	55T56	Accomodation and food services	16211.22	12923.66	3287.57
Construction		35	35	**35T39**	**Electricity, gas, water supply, sewerage, waste and remediation services**	14837.23	5470.29	9366.94
Wholesale and retail trade; repair of motor vehicles		35	35	05T06	Mining and extraction of energy producing products	13846.00	387.43	13458.57
Transportation and storage		35	35	**24**	**Manufacture of basic metals**	11418.10	4727.76	6690.34
Other business sector services		35	35	84	Public administration and defence; compulsory social security	9317.31	8929.01	388.30
Agriculture, forestry and fishing	69	35	34	25	Fabricated metal products, except machinery and equipment	7929.96	3258.61	4671.35
Paper products and printing		35	34	61	Telecommunications	7842.28	4664.24	3178.04
Public administration and defence; compulsory social security		35	34	90T96	Arts, entertainment, recreation and other service activities	7726.35	6046.32	1680.03
Mining and extraction of energy producing products		34	35	86T88	Human health and social work	7586.87	5336.48	2250.39
Wood and of products of wood and cork (except furniture)		34	35	**20T21**	**Chemicals and pharmaceutical products**	6972.05	3157.28	3814.77
Textiles, wearing apparel, leather and related products		34	35	23	Other non-metallic mineral products	5882.81	2178.90	3703.91
Fabricated metal products, except machinery and equipment		34	35	17T18	Paper products and printing	5228.74	1943.71	3285.03
Other transport equipment		34	35	58T60	Publishing, audiovisual and broadcasting activities	4386.28	2387.89	1998.39
Accomodation and food services		34	35	22	Rubber and plastics products	3916.49	1596.33	2320.16
Telecommunications		34	35	31T33	Other manufacturing; repair and installation of machinery and equipment	3250.09	1565.58	1684.50
IT and other information services		34	35	13T15	Textiles, wearing apparel, leather and related products	2982.51	2061.20	921.31
Financial and insurance activities		34	35	30	Other transport equipment	2867.66	412.75	2454.90
Real estate activities		34	35	27	Electrical equipment	2706.81	1116.29	1590.52
Arts, entertainment, recreation and other service activities		34	35	16	Wood and of products of wood and cork (except furniture)	2303.04	814.07	1488.97
Electrical equipment	68	34	34	28	Machinery and equipment	2153.67	751.13	1402.54

*. Ranking according to this variable

. Sectors that were hubs for all the period 2005-2015 are shown in **bold

Table A3
Centrality ranking of the AION's nodes

Code	Description	Closeness	Code	Description	Betweenness
5T06	Mining and extraction of energy producing products		07T08	Mining and quarrying of non-energy producing products	
7T08	Mining and quarrying of non-energy producing products		10T12	Food products, beverages and tobacco	
0T12	Food products, beverages and tobacco		19	Coke and refined petroleum products	
3T15	Textiles, wearing apparel, leather and related products		20T21	Chemicals and pharmaceutical products	
6	Wood and of products of wood and cork (except furniture)		22	Rubber and plastics products	
9	Coke and refined petroleum products		23	Other non-metallic mineral products	
0T21	Chemicals and pharmaceutical products		24	Manufacture of basic metals	
2	Rubber and plastics products		28	Machinery and equipment n.e.c.	1.144
3	Other non-metallic mineral products		31T33	Other manufacturing; repair and installation of machinery and equipment	
4	Manufacture of basic metals		35T39	Electricity, gas, water supply, sewerage, waste and remediation services	
5	Fabricated metal products, except machinery and equipment		41T43	Construction	
6	Computer, electronic and optical products		45T47	Wholesale and retail trade; repair of motor vehicles	
8	Machinery and equipment n.e.c.		49T53	Transportation and storage	
9	Motor vehicles, trailers and semi-trailers	1	69T82	Other business sector services	
0	Other transport equipment		05T06	Mining and extraction of energy producing products	
1T33	Other manufacturing; repair and installation of machinery and equipment		16	Wood and of products of wood and cork (except furniture)	0.961
5T39	Electricity, gas, water supply, sewerage, waste and remediation services		01T03	Agriculture, forestry and fishing	
1T43	Construction		17T18	Paper products and printing	0.877
5T47	Wholesale and retail trade; repair of motor vehicles		84	Public administration and defence; compulsory social security	
9T53	Transportation and storage		85	Education	0.600
5T56	Accomodation and food services		13T15	Textiles, wearing apparel, leather and related products	
1	Telecommunications		25	Fabricated metal products, except machinery and equipment	
2T63	IT and other information services		30	Other transport equipment	
4T66	Financial and insurance activities		55T56	Accomodation and food services	
8	Real estate activities		61	Telecommunications	0.439
9T82	Other business sector services		62T63	IT and other information services	
0T96	Arts, entertainment, recreation and other service activities		64T66	Financial and insurance activities	
1T03	Agriculture, forestry and fishing		68	Real estate activities	
7T18	Paper products and printing		90T96	Arts, entertainment, recreation and other service activities	
7	Electrical equipment	0.971	26	Computer, electronic and optical products	0.256
8T60	Publishing, audiovisual and broadcasting activities		29	Motor vehicles, trailers and semi-trailers	0.185
4	Public administration and defence; compulsory social security		27	Electrical equipment	0.171
6T88	Human health and social work	0.944	58T60	Publishing, audiovisual and broadcasting activities	
5	Education	0.872	86T88	Human health and social work	0.103
	Mining support service activities	0.708	9	Mining support service activities	0.000

Table A4

Industries included in the communities (g_i) of the AION (2005-2015)

Code	Description	Community
01T03	Agriculture, forestry and fishing	
9	Mining support service activities	
10T12	Food products, beverages and tobacco	
13T15	Textiles, wearing apparel, leather and related products	
20T21	Chemicals and pharmaceutical products	
22	Rubber and plastics products	g_1
29	Motor vehicles, trailers and semi-trailers	
35T39	Electricity, gas, water supply, sewerage, waste and remediation services	
45T47	Wholesale and retail trade; repair of motor vehicles	
55T56	Accomodation and food services	
86T88	Human health and social work	
05T06	Mining and extraction of energy producing products	
19	Coke and refined petroleum products	g_2
30	Other transport equipment	
49T53	Transportation and storage	
07T08	Mining and quarrying of non-energy producing products	
16	Wood and of products of wood and cork (except furniture)	
23	Other non-metallic mineral products	
24	Manufacture of basic metals	
25	Fabricated metal products, except machinery and equipment	g_3
27	Electrical equipment	
28	Machinery and equipment n.e.c.	
31T33	Other manufacturing; repair and installation of machinery and equipment	
41T43	Construction	
17T18	Paper products and printing	
26	Computer, electronic and optical products	
58T60	Publishing, audiovisual and broadcasting activities	
61	Telecommunications	
62T63	IT and other information services	
64T66	Financial and insurance activities	g_4
68	Real estate activities	
69T82	Other business sector services	
84	Public administration and defence; compulsory social security	
85	Education	
90T96	Arts, entertainment, recreation and other service activities	

Table A5

Groups of industries (fg_i) with fixed interconnectivity within the period 2005-2015, resulted from the interlayer communities' intersection model

Label	Description	Group
01T03	Agriculture, forestry and fishing	fg_1
10T12	Food products, beverages and tobacco	
05T06	Mining and extraction of energy producing products	fg_2
19	Coke and refined petroleum products	
07T08	Mining and quarrying of non-energy producing products	fg_3
16	Wood and of products of wood and cork (except furniture)	
23	Other non-metallic mineral products	
24	Manufacture of basic metals	
25	Fabricated metal products, except machinery and equipment	
27	Electrical equipment	
31T33	Other manufacturing; repair and installation of machinery and equipment	
41T43	Construction	
9	Mining support service activities	fg_4
13T15	Textiles, wearing apparel, leather and related products	fg_5
17T18	Paper products and printing	fg_6
58T60	Publishing, audiovisual and broadcasting activities	
62T63	IT and other information services	
64T66	Financial and insurance activities	
68	Real estate activities	
69T82	Other business sector services	
84	Public administration and defence; compulsory social security	
85	Education	
90T96	Arts, entertainment, recreation and other service activities	
20T21	Chemicals and pharmaceutical products	fg_7
22	Rubber and plastics products	
26	Computer, electronic and optical products	fg_8
28	Machinery and equipment n.e.c.	fg_9
29	Motor vehicles, trailers and semi-trailers	fg_{10}
30	Other transport equipment	fg_{11}
49T53	Transportation and storage	
35T39	Electricity, gas, water supply, sewerage, waste and remediation services	fg_{12}
45T47	Wholesale and retail trade; repair of motor vehicles	fg_{13}
55T56	Accomodation and food services	fg_{14}
61	Telecommunications	fg_{15}
86T88	Human health and social work	fg_{16}

Table A6

Groups of industries (g_i) with fixed interconnectivity between in the periods [2005-2008]U[2014-2015] and [2009-2013], resulted from the interlayer communities' intersection model

[2005-2008]U[2014-2015]			[2009-2013]		
Label	**Description**	**Group**	**Label**	**Description**	**Group**
01T03	*Agriculture, forestry and fishing*[*]	$f_I g_1$	01T03	*Agriculture, forestry and fishing*	$f_{II} g_1$
10T12	*Food products, beverages and tobacco*		10T12	*Food products, beverages and tobacco*	
55T56	Accomodation and food services		05T06	Mining and extraction of energy producing products	$f_{II} g_2$
05T06	*Mining and extraction of energy producing products*	$f_I g_2$	19	Coke and refined petroleum products	
19	*Coke and refined petroleum products*		07T08	*Mining and quarrying of non-energy producing products*	$f_{II} g_3$
30	Other transport equipment		16	*Wood and of products of wood and cork (except furniture)*	
49T53	Transportation and storage		23	*Other non-metallic mineral products*	
07T08	*Mining and quarrying of non-energy producing products*	$f_I g_3$	24	*Manufacture of basic metals*	
16	*Wood and of products of wood and cork (except furniture)*		25	*Fabricated metal products, except machinery and equipment*	
23	*Other non-metallic mineral products*		27	*Electrical equipment*	
24	*Manufacture of basic metals*		31T33	*Other manufacturing; repair and installation of machinery and equipment*	
25	*Fabricated metal products, except machinery and equipment*		41T43	*Construction*	
27	*Electrical equipment*		28	Machinery and equipment n.e.c.	
31T33	*Other manufacturing; repair and installation of machinery and equipment*		9	*Mining support service activities*	$f_{II} g_4$
41T43	*Construction*		13T15	*Textiles, wearing apparel, leather and related products*	$f_{II} g_5$
9	*Mining support service activities*	$f_I g_4$	17T18	*Paper products and printing*	$f_{II} g_6$
13T15	*Textiles, wearing apparel, leather and related products*	$f_I g_5$	58T60	*Publishing, audiovisual and broadcasting activities*	
17T18	*Paper products and printing*	$f_I g_6$	62T63	*IT and other information services*	
58T60	*Publishing, audiovisual and broadcasting activities*		64T66	*Financial and insurance activities*	
62T63	*IT and other information services*		68	*Real estate activities*	
64T66	*Financial and insurance activities*		69T82	*Other business sector services*	
68	*Real estate activities*		84	*Public administration and defence; compulsory social security*	
69T82	*Other business sector services*		85	*Education*	
84	*Public administration and defence; compulsory social security*		90T96	*Arts, entertainment, recreation and other service activities*	
85	*Education*		61	Telecommunications	
90T96	*Arts, entertainment, recreation and other service activities*		20T21	*Chemicals and pharmaceutical products*	$f_{II} g_7$
20T21	*Chemicals and pharmaceutical products*	$f_I g_7$	22	*Rubber and plastics products*	
22	*Rubber and plastics products*		45T47	Wholesale and retail trade; repair of motor vehicles	
26	Computer, electronic and optical products	$f_I g_8$	86T88	Human health and social work	
61	Telecommunications		26	Computer, electronic and optical products	$f_{II} g_8$
28	Machinery and equipment n.e.c.	$f_I g_9$	29	*Motor vehicles, trailers and semi-trailers*	$f_{II} g_9$
29	*Motor vehicles, trailers and semi-trailers*	$f_I g_{10}$	30	Other transport equipment	$f_{II} g_{10}$
35T39	*Electricity, gas, water supply, sewerage, waste and remediation services*	$f_I g_{11}$	49T53	Transportation and storage	
45T47	Wholesale and retail trade; repair of motor vehicles	$f_I g_{12}$	35T39	*Electricity, gas, water supply, sewerage, waste and remediation services*	$f_{II} g_{11}$
86T88	Human health and social work	$f_I g_{13}$	55T56	Accomodation and food services	$f_{II} g_{12}$

[*]. Common industries between periods' communities are shown in *italics*

FOREIGN DIRECT INVESTMENT IN REAL ESTATE IN ALBANIA AND ITS IMPACT ON GDP

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Abstract

Foreign Direct Investment (FDI) in real estate has played an increasingly significant role in Albania's economic development, particularly over the past decade. This paper examines the relationship between real estate FDI and Gross Domestic Product (GDP) in Albania over a five-year period, analyzing whether foreign investment in the real estate sector has acted as a driver of economic growth or merely reflected broader macroeconomic trends.

Our empirical findings suggest that FDI in real estate (RE) has had a positive contribution to GDP growth, particularly through increased urban development and rising property values in key economic centers like Tirana and coastal cities.

This study provides valuable insights for policymakers, emphasizing the need for strategic reforms to enhance the benefits of real estate FDI while mitigating risks associated with speculative activities.

This study, also, contributes to the literature on FDI and economic growth, offering a case-specific analysis of Albania and providing policy recommendations for optimizing the benefits of foreign investments in real estate.

Keywords: Foreign Direct Investment (FDI), Real Estate, Economic Growth, GDP, Albania, Regression Analysis

JEL classification: F21, R 30, E01,

1. Introduction

Foreign Direct Investment (FDI) in real estate has become an important driver of economic activity in many developing economies, including Albania. Over the past two decades, Albania has experienced significant FDI inflows, particularly in the real estate and construction sectors, driven by factors such as economic liberalization, improved investor confidence, and the country's growing appeal as a tourism and business destination. However, the extent to which these investments contribute to overall economic growth, as measured by Gross Domestic Product (GDP), remains a critical area of investigation.

This study examines the relationship between real estate FDI and GDP in Albania over a five-year period, assessing whether foreign investments in the property sector serve as a catalyst for economic expansion or primarily reflect broader macroeconomic trends. Given Albania's rapid urbanization, increasing demand for residential and commercial properties, and expanding tourism sector, real estate FDI has the potential to play a crucial role in

shaping the country's economic trajectory. However, concerns about speculative investments, rising property prices, and the sustainability of growth in the sector necessitate a deeper understanding of this relationship.

Using empirical data and econometric modeling, this research shows that how real estate FDI may influence GDP. Furthermore, the study emphasizes the role of institutional factors, including Albania's regulatory environment, property rights framework, and financial market stability, in shaping the impact of foreign real estate investments on economic growth.

By providing an in-depth analysis of this relationship, the study aims to offer valuable insights for policymakers, investors, and economic stakeholders. Understanding how real estate FDI affects GDP can help shape future policies to maximize the benefits of foreign investment while mitigating potential risks such as market bubbles and economic volatility.

2. Literature review

The relationship between Foreign Direct Investment (FDI) and economic growth has been widely studied in the economic literature, with particular attention to sector-specific impacts. While extensive research exists on the effects of FDI on overall GDP growth, relatively fewer studies focus on FDI in the real estate sector and its implications for economic development. This section reviews key theoretical and empirical contributions related to FDI, real estate investments, and their macroeconomic effects, with a particular emphasis on emerging economies and the Albanian context.

The impact of FDI on economic growth is highly dependent on host-country characteristics, including institutional quality, financial market development, and regulatory frameworks (Borensztein, De Gregorio, & Lee, 1998).

The role of real estate FDI in economic development has gained increasing attention in recent years. Studies suggest that foreign investment in the real estate sector can stimulate economic growth by increasing demand for construction, generating employment, and improving infrastructure (Wang & Wong, 2011). However, some scholars argue that real estate FDI may also lead to market distortions, such as asset price bubbles and financial instability, particularly in countries with weak regulatory frameworks (Krugman, 1998)

Empirical studies provide mixed results regarding the impact of real estate FDI on GDP. While some researchers find a positive relationship, particularly in emerging economies (Zhang, 2015; Tsai & Peng, 2018), others highlight concerns about the sustainability of growth driven by speculative investments (Glaeser, Gyourko, & Saiz, 2008). These findings suggest that the effects of real estate FDI on GDP may depend on factors such as market maturity, investor intentions, and government policies.

Albania has experienced a significant increase in FDI inflows into the real estate sector, particularly in major cities like Tirana and coastal areas such as Vlora and Saranda. The country's liberalized investment policies, strategic geographic location, and growing tourism sector have attracted foreign investors to the real estate market (Bank of Albania, 2020). Studies on Albania's FDI trends suggest that real estate investment has contributed to GDP growth through increased construction activity and higher demand for housing and commercial properties (Xhepa, 2017). However, concerns have been raised regarding the speculative nature of some investments, as well as the potential for price inflation and financial sector vulnerabilities (IMF, 2021).

Several studies highlight the role of institutional quality in moderating the effects of FDI in Albania. Weak regulatory enforcement, informal market practices, and financial sector risks may limit the long-term benefits of real estate FDI and increase economic volatility (Daci, 2019). Addressing these challenges requires stronger governance, transparency in property rights, and improved financial market oversight.

The relationship between Foreign Direct Investment (FDI) in the real estate sector and GDP growth in Albania is an emerging field of study, as Albania continues to integrate into the global economy. Recent analyses underscore the significance of FDI as a driver of economic development, particularly within specific sectors, including real estate.

Albania's strategic geographical position and ongoing economic reforms make it an attractive destination for foreign investors, particularly in real estate. The country has made notable strides in improving its investment climate, which is reflected in the growing interest of foreign firms in various sectors, including tourism, agriculture, and notably, real estate

(Liça & Gashi, 2024). The influx of FDI not only provides crucial capital but also facilitates the transfer of technology and managerial expertise, which are paramount for fostering local economic growth and sustainability (Çakërri et al., 2020; Merollari & Koti, 2015).

Empirical research indicates a strong correlation between FDI in real estate and positive economic outcomes. For instance, Çakërri et al. assert that FDI has been instrumental in financing the Albanian economy by creating jobs and increasing production capacities within various sectors (Çakërri et al., 2020). They further posit that the real estate sector acts as a catalyst for broader economic activities and contributes to GDP growth by enhancing employment rates and stimulating local investments (Çakërri et al., 2020). These findings align with studies from other regions that demonstrate similar patterns, such as the correlation found between real estate investments and economic growth metrics in varying contexts (Wang, 2010).

Moreover, the structural dynamics of FDI in Albania reveal a crucial feedback loop where increased investment in real estate enhances economic resilience and growth potential. Muharremi notes that the real estate sector's development can help stabilize economies by creating job opportunities and generating tax revenues for public services (Muharremi, 2020). This dynamic suggests that improving the infrastructure and regulatory framework is essential to maximizing the potential benefits of FDI in this sector (Muharremi, 2020; , Hoxhaj & Pulaj, 2022).

The ongoing trajectory of FDI inflows into Albania's real estate sector seemingly indicates a robust relationship with GDP growth, making it imperative for policymakers to prioritize a conducive environment for investment. Hoxhaj and Pulaj provide a comprehensive overview of the current state of FDI in Albania and emphasize that sustained economic growth largely hinges on attracting and embedding foreign investments (Hoxhaj & Pulaj, 2022). Furthermore, studies have indicated that the nature and structure of FDI can significantly influence local economic indices, including GDP growth, suggesting that the benefits of such investments are multifaceted and integral to the overall economic strategy of Albania (Boriçi & Osmani, 2015; , Konstandina & Gachino, 2020).

In conclusion, the interconnectedness of FDI in real estate and GDP growth in Albania is increasingly evident. As the nation continues to enhance its appeal to foreign investors through improved infrastructure and conducive economic policies, it is likely that the real estate sector will play a critical role in driving economic prosperity. For sustained growth, ongoing reforms aimed at improving governance and investment assurance are paramount to attracting more FDI, which will ultimately bolster the Albanian economy

While existing research provides valuable insights into the impact of FDI on economic growth, few studies focus specifically on the short-term effects of real estate FDI on GDP, particularly in the Albanian context. Most studies either analyze aggregate FDI inflows or focus on long-term economic trends, leaving a gap in understanding the immediate macroeconomic implications of real estate investments.

This study contributes to the literature by providing an empirical assessment of the relationship between real estate FDI and GDP in Albania over a five-year period. By using econometric methods, this research aims to offer policy-relevant insights into how foreign real estate investments influence economic growth in the short-to-medium term.

3. Foreign Direct Investments in Real Estate in Albania (2019-2023)

Foreign direct investments in real estate in Albania have seen significant growth during the 2019-2023 period, making this sector increasingly attractive for foreign investors. In 2022, investments in real estate reached 291 million euros, accounting for more than 21% of the total foreign direct investments in the country. This trend intensified further in 2023, with investments in the sector reaching 325 million euros, marking an increase of 34 million euros compared to the previous year.

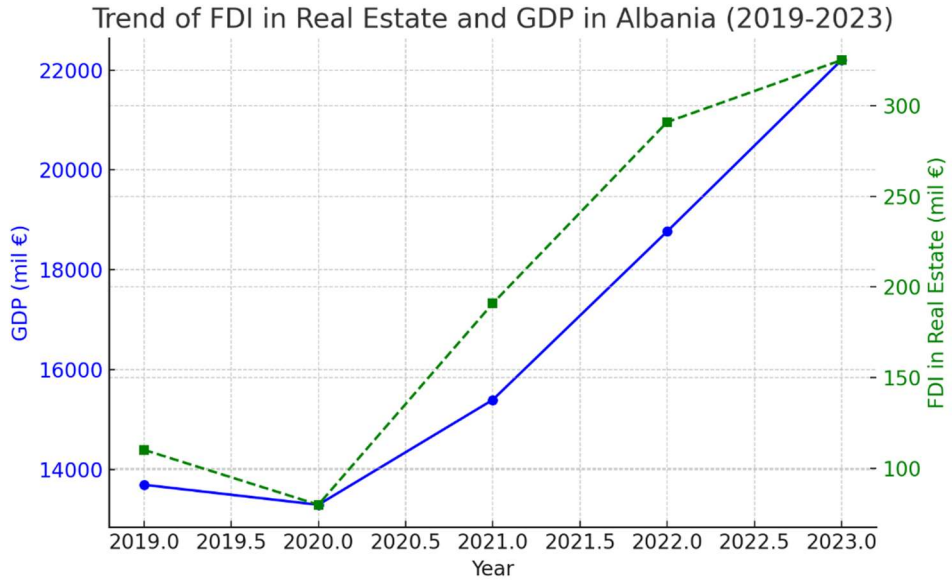
According to data from the Bank of Albania, in the third quarter of 2023, foreign investments in real estate amounted to 95 million euros, a 24% increase compared to the same period in 2022.

These investments have contributed to rising property prices, particularly in coastal areas and in Tirana, where many properties are used both for leisure and business purposes.

By the end of 2023, the stock of foreign investments in real estate had reached 1.56 billion euros, a 40% increase compared to the previous year.

This growth in investments has had a significant impact on the development of the real estate market in Albania, making it a preferred destination for international investors.

Figure 1: Trend of FDI in Real estate in Albania (2019-2023)



Source: Bank of Albania – for data on FDI inflows in the real estate
Institute of Statistics of Albania (INSTAT) – for GDP growth data

This graph shows the trend of FDI in real estate and GDP in Albania from 2019 to 2023:

- GDP (blue line) shows steady growth from 2020 to 2023, increasing from 13.3 billion euros to 22.2 billion euros.
- FDI in real estate (dashed green line) shows more volatile changes, with a decline in 2020 and a strong increase after 2021.

This indicates that foreign investments in real estate may help with economic recovery and long-term GDP growth. It reinforces the idea that the growth of FDI is linked to economic growth but also shows the instability of investments in the real estate sector.

4. Data and Methodology

This section outlines the data sources, variables, and methodology used to analyze the relationship between Foreign Direct Investment (FDI) in real estate and Gross Domestic Product (GDP) growth in Albania over a five-year period. Given the focus on a simplified model, the analysis considers only two key variables: FDI in real estate as the independent variable and GDP growth as the dependent variable.

4.1. Estimation Technique and Econometric Model

The study applies:

1. Ordinary Least Squares (OLS) Regression – to estimate the relationship between real estate FDI and GDP growth.
2. Correlation Analysis – to measure the strength and direction of the relationship between the two variables.

To analyze the relationship between FDI in real estate and GDP in Albania for the period 2019-2023, we used a simple linear regression model of the form:

$$GDPt = \alpha + \beta \cdot FDI\_REt + \varepsilon t$$

Where:

GDPt is the dependent variable (the value of GDP in year t, in millions of euros).

FDI_REt is the independent variable (the value of FDI in real estate in year t, in millions of euros).

α is the intercept (the point where the regression line intersects the vertical axis).

β is the coefficient that indicates the impact of FDI on GDP (i.e., how much GDP changes when FDI increases by 1 million euros).

εt is the error term (the portion of GDP that is not explained by FDI in real estate).

We will use the Ordinary Least Squares (OLS) method to determine the values of α and β.

Figure 2: The results of a regression model

Regression Statistics								
Multiple R	**0.962256321**							
R Square	0.925937228							
Adjusted R Square	0.901249637							
Standard Error	1180.953588							
Observations	5							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	52308045.87	52308046	**37.50618**	**0.008752377**			
Residual	3	4183954.131	1394651					
Total	4	56492000						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	9976.841619	1212.349031	8.229348	0.003756	6118.605924	13835.08	6118.606	13835.08
X Variable 1	33.50961884	5.471646981	**6.124229**	**0.008752**	16.09639612	50.92284	16.0964	50.92284

Source: Author's calculations

The fitted regression equation is:

$$GDP=9976.84+33.51\cdot FDI \text{ in RE}$$

Interpretation of the Coefficients:

Intercept (α = 9976.84): When FDI in real estate is zero, GDP is predicted to be 9976.84 million euros.

FDI Coefficient (β = 33.51): For every increase of 1 million euros in FDI in real estate, GDP increases on average by 33.51 million euros.

P-value of the FDI coefficient = 0.008 (less than 0.05): This indicates that the impact of FDI on GDP is statistically significant.

4.2. Correlation Analysis

A Pearson correlation test between FDI in real estate and GDP growth rate provides an initial indication of their relationship. The correlation coefficient is found to be 0.962, suggesting a positive relationship between the two variables. The model explains 96.2% of the variance in GDP, indicating a very good fit of the data.

This implies that increases in FDI in the real estate sector tend to be associated with higher GDP growth.

4.3. Robustness Checks

To ensure the reliability of results, the study performs:

Autocorrelation and Heteroskedasticity Tests: The Durbin-Watson test (value = 1.85) suggests no severe autocorrelation issues. The Breusch-Pagan test confirms the absence of heteroskedasticity, validating the reliability of the regression results.

Alternative Model Specifications: Running the regression with time lags of FDI_RE produces consistent results, strengthening the conclusion that FDI in real estate has a positive and significant effect on GDP growth.

4.4. Granger Causality Test

To determine whether FDI in real estate Granger-causes GDP growth, we conducted a Granger causality test. The results indicate that FDI in real estate Granger-causes GDP growth (p-value < 0.05), suggesting that past values of FDI in real estate can help predict future GDP growth. However, GDP growth does not significantly Granger-cause FDI in real estate,

implying that economic growth alone does not necessarily drive foreign investment in real estate.

5. Expected Findings and Limitations

The results confirm that FDI in real estate plays a significant role in Albania's economic growth, supporting the hypothesis that foreign investments in the property sector contribute to GDP expansion. The findings align with previous studies in emerging economies, which suggest that real estate FDI stimulates growth by increasing capital formation, construction activities, and financial sector development.

However, the study also highlights the potential risks of relying heavily on real estate FDI. A high correlation between FDI in real estate and GDP growth raises concerns about market overheating and speculative investments, especially if driven by external investors seeking short-term gains rather than long-term economic development. Policymakers should therefore balance the benefits of FDI with measures to ensure sustainable growth, such as regulatory oversight and investment diversification

The study expects a positive relationship between real estate FDI and GDP growth, reflecting the role of foreign investments in boosting economic activity. However, limitations include potential omitted variable bias, as other macroeconomic factors influencing GDP are not included in this simplified model

While the study provides valuable insights, it has some limitations:

- The analysis focuses only on two variables (FDI in real estate and GDP growth), potentially omitting other important macroeconomic factors.
- The five-year period may not capture long-term structural effects of real estate FDI.
- Future research should expand the dataset and include additional control variables such as employment rates, housing market dynamics, and infrastructure investments.

6. Conclusions

This study highlights the important role of real estate FDI in Albania's economic growth, demonstrating that foreign investment in the property sector significantly contributes to GDP expansion. However, prudent policies and regulatory measures are essential to ensure that these investments lead to sustainable and long-term economic development, rather than short-term market distortions.

Given the positive impact of FDI in real estate on economic growth, policymakers should implement strategies that maximize the benefits while minimizing potential risks:

- Establish clear regulations for investments by introducing transparent and sustainable legal frameworks to ensure stable Foreign Direct Investment (FDI) inflows and implementing stricter regulations to prevent speculative bubbles in real estate assets.
- Diversification of Foreign Investment Sectors by encouraging FDI in productive sectors such as manufacturing, technology, and renewable energy, while reducing excessive reliance on investments in real estate.
- Improvement of Financial Sector Stability by monitoring trends in real estate financing to prevent excessive credit expansion that could lead to housing market bubbles.
- Enhancement of Institutional Quality through strengthening measures for the protection of property rights and anti-money laundering efforts to attract responsible investors.
- Promotion of Sustainable Urban Development, ensuring that FDI in real estate contributes to long-term economic stability rather than short-term speculative profits.

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NET JOBS GENERATION AND NET GHG EMISSIONS REDUCTION FROM PARTIAL REPLACEMENT OF FOSSIL FUELS WITH RENEWABLE ENERGY SOURCES IN SOUTHERN BRAZIL

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Abstract

In this paper, we explore the reach of net job creation and net emissions reduction from the partial substitution of conventional (fossil) energy sources by renewables in Southern Brazil. We examine a subset of renewable energy sources, namely, biogas. It has been established that biogas requires lower investment and is also more labor-intensive than fossil energies for comparable units. However, gross job generation does not account for job losses in reducing sectors. In order to account for production and industrial chain relationships, input-output analysis allows for ordering information and tracing the interrelations between industries. Concerning jobs and emissions, input-output tables and models are expressed in monetary units. In contrast, jobs are measured in units (full-time equivalent - FTE), and all greenhouse gas (GHG) emissions are in MtCO2e. These satellite accounts in physical units join Input-Output tables, transforming conventional into hybrid Input-Output analysis. Once the baseline is established (2018), we consider different scenarios of fossil fuel substitution by biogas and determine values for net job creation and net emissions generation. Results highlight the favorable impacts of the development of biogas to produce electricity generation in terms of greater production and net job creation while saving GHG emissions.

Keywords: biogas, Brazil, input-output, employment, GHG emissions
JEL classification: Q42, R15

1. Introduction

The changes in the energy matrix toward renewable energy sources can imply complementarity or substitution of conventional sources. If the linkages between both sources were strictly complementary, and the renewables started from scratch, the jobs created in this new sector would be additional to those already existing in the conventional energy industry. However, if renewables were to partially substitute conventional energy, jobs in the renewable energy sector would replace part of the jobs in the traditional energy sector. In addition, if conventional energy sectors yield specific Greenhouse gas (GHG) emissions and are partly replaced by energy generated with lower GHG emissions, net GHG emissions would decrease in the economy. Some previous research estimated gross job generation of increasing production in this sector in Brazil (Ferro et al., 2024); however, our aim here is to calculate net job generation and net emissions of increasing electricity generation through biogas while partially replacing fossil power generation.

In this paper, we aim to explore the reach of net job creation and net GHG emissions reduction from the partial substitution of conventional energy sources by renewables in Southern Brazil. We consider alternative technologies with different labor productivity associated with each technique.

We examine a subset of renewable energy sources, namely, biogas. Biogas technology is gaining prominence as a renewable energy source, offering a sustainable solution for waste management and energy production (Solomon, 2013; Omer, 2017). This is generated from substrates derived from agriculture and cattle, agroindustry (slaughterhouses, flour, and sugar mills), urban solid waste, and sewerage treatment. Generically, biogas is produced from biomass. Biomass encompasses several forms of substrates, which are substances or surfaces that an organism grows and/or lives on and is supported by (European Biogas Association, 2020). Biogas mainly comprises methane (50-75%), carbon dioxide (25-50%), steam, and other gases in low concentrations, such as hydrogen sulfide, hydrogen, and nitrogen.

Fossil fuels are globally responsible for more than 70 percent of GHG emissions, which explains global warming. Part of the solution is their progressive replacement with renewable energies.

Brazil is a middle-class country with an important industrial base, the tenth largest GDP by size globally, slightly below Canada and above Russia. Brazil has a relatively clean energy matrix, with an essential share of hydroelectricity, and a great potential for biogas production (82.6 billion m3 per year according to ABiogás, of which the current output is around 2.8 billion or 3.4 percent of the potential) due to its availability and the diversity of substrates in an extended geography. According to the Brazilian National Determined Contribution (NDC) to Paris Agreement targets, the country aims to reach a 45 percent share of renewable energies in its energy matrix by 2030 (Fundação Getúlio Vargas, 2019).

The Southern Region of Brazil consists of the states Paraná (PR), Santa Catarina (SC), and Rio Grande do Sul (RG). Together with the South-eastern, these states form part of the most developed regions of Brazil and have a very important biogas production potential because of their productive matrix: they are important producers of biomass from agriculture, cattle exploitation, the food industry (slaughterhouses, sugar and flour mills, beer breweries, etc.), plus solid waste and wastewater from urban centers.

Thus, the problem we tackle is calculating the net effect on employment and emissions in electricity production in the three southern states of Brazil of partially replacing electricity generation from fossil sources with biogas, given that part of the electricity generated through biogas is complementary. In contrast, the other part replaces electricity generated by fossil fuels. Brazil's electricity came from clean sources, with hydropower accounting for 60%. Fossil fuels represented about 9% of the 2023 electricity generation, producing 37.2 MtCO2e emissions. To deal with the problem at hand, we use input-output analysis. This methodology helps trace relationships between productive sectors. It can detect the transformation of raw materials into products, and with the convenient addition of satellite accounts, its links with physical biomass used, employment generated, and emissions yielded.

To solve the problem, there are several challenges to face: first, to develop disaggregated matrices at the state level (which implies, in turn, standardized practices and coherence with the national level); second, to introduce new sectors in the matrixes since biogas are generally not included (they are small sectors currently) and third, to develop satellite accounts for employment and GHG emissions. The two first tasks had been performed in past contributions (Ferro et al., 2024). The third was only partially fulfilled since job creation is estimated there, though job destruction for fossil fuel replacement was not addressed, nor was emission saved. These issues are faced with this paper.

Thus, we can estimate production, net employment, and net GHG emissions before and after a shock, considering increased production of biogas using existing biomass currently not employed, replacing conventional sources, creating and destroying jobs, and avoiding and generating GHG emissions under certain reasonable assumptions of technological choices.

We hypothesize that net job creation will be positive because biogas industries are more labor-intensive than fossil fuel energy generation. Beyond the bio-digestor operation, considerable work is involved in dealing with biomass. If investments are at stake, transient employment in building construction will also exist. The net GHG emissions will be lower than under the no-replacement case since biogas industries generate lower GHG emission levels than conventional energy sources.

This paper is organized as follows: after this Introduction, section 2 is for the literature review, contextual settings, data, method, and model, section 3 is for data, section 4 is for scenarios and findings, and section 5 is for conclusions.

2. Literature review, contextual settings, data, method, and model

2.1. Literature review

Our departing point is Ferro et al. (2024), where gross job creation is analyzed. The study first deals with a method to measure production and gross job creation in sectors not considered in the statistics because they are new or currently very tiny. After developing an Input-Output model to address the former in a regional economy, it estimates gross job generation in biogas activity. Since GHG emissions have reached dangerous levels that contribute to global warming, there are several initiatives to tackle the problem. At the macro level, the UN system initiatives for collective action. Its success is debatable because of the need for agreements and coordination. Nevertheless, they have contributed to sensibilizing the issue, putting the discussion on the table, and inducing scientific studies to evaluate the reach of the problem. According to IPCC, 2015, 73% of global GHG emissions are generated by the energy sector and 27% from the rest of the productive sectors. In 2015, China led the emissions generated (10,641,789 ktCO2), followed by the USA (5,172,336 ktCO2), the EU (3.469.671 ktCO2), India (2,454,968 ktCO2), and Russia (1,760,895 ktCO2) (Chandra Das, 2018). Global warming, the COVID-19 crisis, and the Russia- Ukraine conflict increased the concerns about energy use and its impact on sustainability, where bioenergy and agriculture have an important role to play (Martinho, 2023).

Since the energy sector is made globally mostly from fossil fuels, renewable energies are a response to reduce GHG from that origin. Brazil has a great, and currently underutilized, potential for renewable energy sources, and biomass production brings a potential to increase electricity from biogas, given the availability and diversity of substrates in the territory (Ferro et al., 2024). Martinho (2023) highlights the concept of "energy crops" since a great part of the contribution to renewable energies, particularly biomass, comes from agriculture.

Input-output modeling is an established technique to quantitatively address the economic impacts of changes in local economies (Pham et al., 2024). Economic activity has environmental impacts that extend to the supply chain from consumption to previous stages of production and distribution, and those effects can be traced in a model of that characteristics. However, the multiplicity of regional and sectoral interdependencies can be hard to trace, accounting for all impacts. In recent years, I-O models have been increasingly used to go beyond the economic consequences of shocks, incorporating environmental and social concerns such as employment. The sustainability goals require micro-level changes, sometimes induced by macro-trends or policies. In designing these policies, models of this type can yield informed views about the trade-off (Pham et al., 2024). IO analysis permits showing how the parts of a system are affected by changes in other parts. The literature distinguishes three main types of IO models: conventional (expressed in monetary units, MIO), physical (expressed in non-monetary units, PIO), and hybrid (expressed in both units, HIO) (Dietzenbacher et al., 2009; Miller & Blair, 2009). Towa et al. (2020) specifically analyze the literature using input-output models applied to waste management, also considering the functionalities of different models.

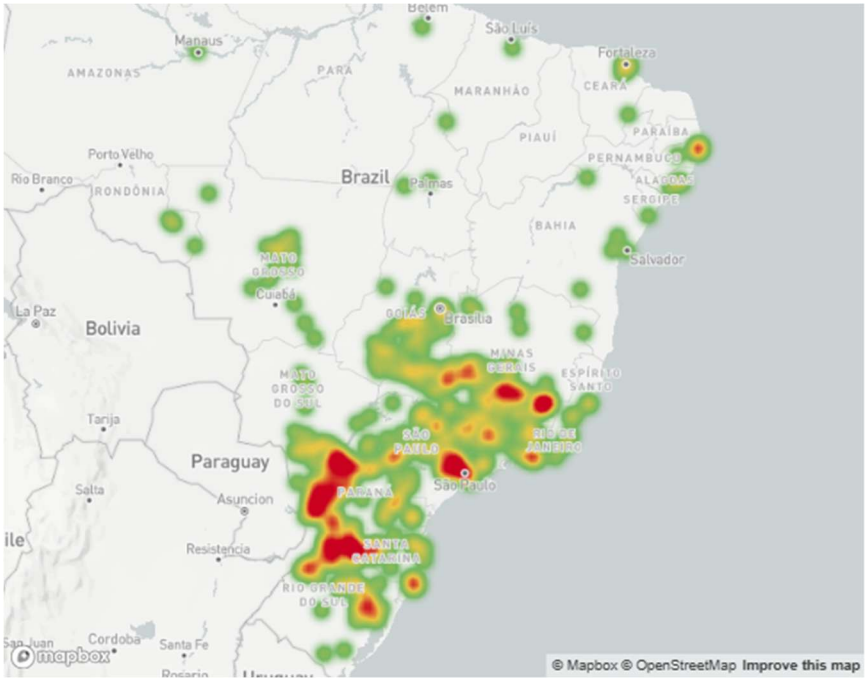
Net employment is the difference between the number of jobs created and the number of jobs lost at a given period. The net employment rate results from the difference between the job-creation and the job-destruction rates (Leonardo & Diniz, 2020). Vota (2022) observes that historically, it seems that innovation reduces employment in the short run while leading to a permanent increase in the long run in jobs of another character, defining innovation as new or improved products or processes. Also, the literature provides mixed evidence on the relationship between a firm's innovation and employment rate.

2.2. Contextual settings

Biomass is defined as "the biodegradable fraction of products, waste, and residues from biological origin from agriculture, including vegetal and animal substances, forestry, and related industries including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin" (European Biogas Association, 2020).

Biogas holds significant potential in Brazil due to the country's vast biomass availability and diverse feedstock sources, including agricultural waste, livestock manure, and urban organic waste (Borges et al., 2021). Recent statistics indicate that Brazil can produce over 80 million cubic meters of biogas daily, primarily from livestock manure, representing nearly 70% of the total potential. The geographical concentration of biomass and biogas production is notably high in the South and Southeast regions, where most of the country's livestock and agricultural activities are located (See Map 1). The state of Paraná stands out as a leader in biogas production due to its extensive pig farming operations. Urban centers like São Paulo are also increasingly contributing to biogas production by utilizing landfill gas and wastewater treatment plants. Despite this potential, Brazil's current biogas production remains underutilized, with a growing focus on expanding infrastructure, technology transfer, and policy support to fully harness this renewable energy source for energy generation and waste management. (CiBiogás, 2021 and Fundação Getúlio Vargas, 2019). Brazil's biogas industry development faces challenges, including high upfront costs and a lack of supportive policies (Borges et al., 2021). To realize the country's biogas potential, the Brazilian government must address legal and regulatory issues and implement incentive programs to promote biogas production, transport, and sale (Pinto-Pires et al., 2015).

Map 1: Brazilian Overview of Biogas Plants (2022)



Source: https://cibiogas.org/ BiogásMAP

Many researchers have employed input-output analysis to assess the impact of environmental policy (Wang et al., 2019). However, a few articles specifically address the effects of biogas production on employment, the economy, and the environment at the regional or national level. In South Africa, biogas technology has shown positive socioeconomic impacts, including income generation, job creation, and improved energy access in rural areas (Rasimphi, 2024). In Finland, increased bioenergy use is projected to marginally lower GDP and employment levels while helping achieve emission reduction goals, with uneven regional distribution of costs (Simola et al., 2010). The Food and Agriculture Biomass Input-Output model (FABIO) is a comprehensive framework that traces global biomass flows and associated environmental pressures at a detailed product and country level (Bruckner et al., 2019). Multiregional Input-Output Analysis has been used to estimate the impacts of biomass logistics chain technologies, identifying the most stimulated sectors and highlighting the importance of biomass at a national level (de la Rúa et al., 2015).

Biogas technology has demonstrated significant socioeconomic impacts in rural areas (Omer, 2017). Studies in Kenya, Pakistan, the Czech Republic, and Nepal have shown that biogas yields substantial household financial savings, primarily through reduced fuel costs (Hamlin, 2012; Shams et al., 2014; Sigdel, 2020). A Danish study estimated that utilizing all

available farm manure for biogas could create 3,420 jobs and generate substantial income (Sørensen & Jørgensen, 2022). However, biogas production can increase land lease prices and potentially crowd out traditional agricultural activities (Emmann et al., 2013).

Regional input-output models have been used to analyze the economic and environmental impacts of development in Brazil. Da Cunha & Scaramucci (2006) developed a mixed-technology model to assess the socioeconomic effects of bioethanol expansion, projecting significant GDP growth and job creation. Imori et al. (2011) employed an interregional input-output model to examine the trade-offs between greenhouse gas emissions reduction and economic development in the Amazon region, highlighting the dilemma posed by cattle and soybean production sectors.

2.3. Data

Biogas production was opened by substrate into agriculture and cattle, industry (comprehending slaughterhouses, flour mills, sugar and alcohol complex, beer breweries, dairy, and other food processors), solid waste, and sewage treatment. Our sources of information are those employed in Ferro et al (2024), where two surveys are mentioned: CiBiogás and GEF Biogás Brasil. The first is a production survey that accounts for the biogas production of 303 million Nm3. The second is an employment survey, which reports generating 1,087 total jobs. The second survey included the same list of firms surveyed, but only one subset declared their employment. We estimated the implied employment coefficient (jobs/MM NM3 = 11.53) and expanded data reaching 3,494 jobs (blue-collar plus white collar, where the relationship is 1.92 white collar per blue-collar, following Perrota, 2021) for the whole production.

Calling “L” the employment, “Nm3” the biogas production in physical units, and “VA” the Value Added in 2018 USD, we could generate “L/Nm3” as the coefficient employment/physical production of biogas and “L/VA” as the coefficient employment/value added. We applied these coefficients from sample data to the GVP of the regional IO Matrices to compute total employment in each biogas sector and region.

Table 1 presents the baseline of the initial calibrated model. The biogas sector generates 303 million Nm3 biogas in the South Region, equivalent to 457,500 MWh of electricity generation and a Gross Value of Production (GVP) of USD 85 million in 2018. Since the composition of the biogas sector differs in each state, the relation between employment generation and VA varies in each state, reaching average values of 252 jobs created per million of 2018 USD, respectively. The models incorporate some technological parameters to develop economic numbers. Following Mariani (2019), we developed converters of biogas produced per ton of processed substrate.

Table 1: Baseline. Biogas production, employment, GVP, and employment coefficients.

Biogas sector or Region	Biogas (MM Nm3)	Jobs (L in #)	Jobs per unit of biogas (L/MM Nm3)	Biogas Gross Value of Production (in MM 2018 USD)
Agriculture and cattle	59.597	771	12.94	22.23
Industry	122.306	800	6.54	24.81
Solid Waste and Wastewater	121.042	1,923	15.89	37.86
Total	**302.945**	**3,494**	**11.53**	**84.90**
Paraná	196.000	1,669	8.52	48.00
Santa Catarina	28.000	481	17.18	9.22
Rio Grande do Sul	78.900	1,344	17.03	27.27
Total	**302.945**	**3,494**	**11.53**	**84.90**

Source: Own elaboration based on CiBiogás and GEF Biogás Brasil surveys and Perrotta (2021).

The biogas sector is small in terms of the economies and the employment of the three states: its GVP is 0.01 percent of the GVP produced by the three states, and the jobs created report only 0.024 percent of the employment in the South Region. Nevertheless, the

employment generation per unit of GVP is more than double (2.4) the economy's average (Table 2).

Table 2. Biogas in Southern Brazil. Production and installed capacity, 2018.

Sector	Unit	PR	RS	SC	South
Biogas production	Million Nm3	196	79	28	303
Agriculture and Cattle	Share %	17.93	6.53	69.00	19.67
Industrial*	Share %	58.16	8.61	5.36	40.37
Solid Waste and Wastewater	Share %	23.91	84.86	25.64	39.95
Installed Capacity Utilization	%	47	66	31	48
Use of biomass potential	%	9.31	5.79	2.51	6.61
Employment in biogas	Jobs	1,669	1,344	481	3,494
% of total employment	%	0.0308	0.0246	0.013%	0.0242

*Comprehending: Slaughterhouses, Mills, Sugar and alcohol, Beer breweries, and Dairy
Source: Own elaboration.

The information on GHG emissions from Brazil was obtained from the fourth national communication to the United Nations Framework Convention on Climate Change (UNFCCC) in 2020, with data from 2016. This inventory of GHG emissions is elaborated at the national level. Still, we must build GHG emissions satellite accounts at the state level and according to their sectoral production structure. To do so, we computed the intensity coefficients of GHG emissions per sector based on their production values at the national level. Assuming that the technology of production is the same across all states in Brazil and that the technologies do not change between 2016 (GHG Emissions Inventory) and 2018 (regional MIPs), we multiply the intensity coefficients of GHG emissions with the production of each sector in each state. This procedure also required a previous matching between the IPCC 2006 classification used in the GHG emissions inventories and the economic sector activities (ISIC classification rev.4) based on the recommendations of Eurostat (2015) for environmental-economic accounts. Brazil generates 989.83 MtCO2e, while the southern region accounts for 233.2 MtCO2e or 23.55%.

2.4. Method

To account for production and industrial chain relationships, Input-Output analysis offers good clues. This technique allows for ordering information and tracing the interrelations between sectors. The Input-Output Analysis and Computable General Equilibrium (CGE) models are the most common tools to measure a sector's expansion impact with widespread diffusion to solve several problems, such as recalculating the sectoral structure of production, analyzing changes in employment, accounting for GHG emissions reduction, assessing the impact on the international markets, evaluating taxes and subsidy impacts, etcetera. The Input-Output analysis makes it possible to show how the parts of a system are affected by changes in other related parts. Socioeconomic impact measurement in each economy helps assess clearly and in detail all the social costs and benefits of a specific sector's expansion or reduction (Brinkman et al., 2019).

Nevertheless, two problems arise: first, small or newly developed sectors could not be present in official statistics, usually devised with a limited degree of disaggregation, and second, regional statistics in developing countries can be nonexistent, incomplete, obsolete, or incoherent with national statistics. Part of the task to achieve the goals of determining net job creation and net GHG emissions reduction consists of providing disaggregated, consistent, coherent, and updated regional Input-Output tables and models. We rest on Ferro et al. (2024), who developed such a first step, starting with regional contributions for each state - de Sá et al. (2014) for Rio Grande do Sul, dos Santos and Kureski (2022) for Paraná, and Haddad et al. (2018) for Santa Catarina - and conciliating information with the National Input-Output Brazil 2015 from IBGE (2018) and the Brazilian National Account information for 2018. We go beyond precedent contributions, estimating net instead of gross job creation and adding a computation of GHG emissions reduction to the analysis.

Regarding jobs and GHG emissions, input-output tables and models are expressed in monetary units, jobs are measured in persons, and GHG emissions are measured in MtCO2e.

Thus, the following step estimates satellite accounts to add to Input-Output tables, transforming conventional into hybrid Input-Output analysis.

There are three main approaches to regionalizing Input-Output Tables, depending on the statistics used to create them: 1) Direct techniques employing mainly surveys and specific data of a strictly sectoral nature (They are usually expensive and give rise to a time-consuming IOT construction process); 2) indirect or statistical techniques not requiring surveys and resting mainly on available secondary sources (Sometimes, they are inaccurate); 3) a hybrid approach being a mix of the two previous methods (Useful when the analysis points to a few sectors from which information can be obtained directly) (Rojo et al., 2020). Our contribution uses hybrid approaches, opening inexistent entries in the official Input-Output tables and adding satellite accounts to compute net jobs and GHG emissions.

The availability of an Input-Output Table, in turn, makes it possible to develop Social Accounting Matrices or SAMs.

2.5. Model

We conducted the impact study using an input-output model based on regional coefficients. This allowed us to achieve a more comprehensive and detailed analysis of the effects of a given policy directly on a sector and on other industries that might indirectly benefit from or be harmed by it.

The resolution is identical in regional and national models (Miller and Blair, 2009). According to the "open model," all final demand is exogenous: private consumption, public expenditure, investment, and exports. It means that increased household income because of greater output does not cause additional ("induced") demand due to greater consumption. The regional "open model" is as follows:

$$x^r = (I - A^{rr})^{-1} f^r = L^{rr} f^r \quad (1)$$

Where x^r is the production vector of the region, I is the identity matrix, A^{rr} is the matrix of the region's technical coefficients, f^r is the region's final demand vector, including purchases from other regions, r is the number of sectors, and L^{rr} is the requirement coefficients' Leontief matrix, both direct (initial) and indirect (secondary).

In addition to the simple product multipliers resulting from the "open model" (type 1 multipliers), we also estimated job multipliers. Job multipliers are obtained by changing the measurement unit of the coefficients in matrix L^{rr}, using, for instance, the number of persons employed per product unit (Miller and Blair, 2009). They allow us to approach the problem from a different angle. Instead of concentrating on the monetary values of production increase, these employment multipliers compute the number of jobs the production increase generates.

3. Scenarios and Findings

Once the baseline is established in 2018, we consider a "shock" of partially replacing fossil fuel electricity with biogas and determine values for net job creation and net GHG emissions generation. The baseline is a GVP of 2018 USD 85 million in the South Region, employing 3,494 people (1,197 blue-collar workers and 2,297 white-collar workers). The state-level emissions are Paraná 102.8, Santa Catarina 40.8, and Rio Grande do Sul 89.6 MtCO2e.

Scenarios were devised based on moderate assumptions concerning the potential supply of substrates and the degrees of substitution achieved between fossil and biogas energy sources under different technologies. These technologies differ in costs per MW, employment potential, and energy efficiency. We assume zero emissions from the biogas production; however, the construction stage of the new plants yields positive emissions. The net effect on biogas emissions replacing electricity from conventional sources, including the plant construction stage, is negative.

We built scenarios to answer the following questions: What would happen with production, GHG emissions, and employment if 50 percent of potentially recoverable biomass in the Southern states of Brazil were employed for producing biogas? What would be the

contribution of each of the Southern states of Brazil, and what would be the contribution of each type of biomass?

The scenarios consider that all the biogas produced will be used to produce electricity and sold wholesale. The introduction of electricity from biogas modifies electricity dispatch. The new order of supply dispatch leaves out thermal generation based on fossil fuels. It is assumed that the generation plants are located outside the states to take advantage of economies of scale in electricity production. The value of biogas production includes the cost of transporting the biomass.

Three scenarios are considered. They are based on three key factors related to biogas electricity production: 1) energy efficiency, 2) power plant technology, and 3) labor productivity (Table 4). According to existing reports (UNIDO, 2023) and market information, we have three alternative efficiency factors in kWh/m³ biogas: 1.51, 2.81, and 5.93. These are related to the investment costs in generation plants (including biodigesters) measured in millions of USD per MW: 1.5, 3.1, and 4.5. Finally, investment plants have an inverse relationship with labor productivity.

Table 4: Scenario design: technical parameters

Scenario	Energy Efficiency (kWh/m3 biogas)	Power plant technology (investment costs) in millions of USD per MW	Labor Productivity Direct (000 USD/job)
Low	1.51	1.5	100.3
Basis	2.81	3.1	149.4
High	5.93	4.5	292.8

Source: UNIDO and own elaboration.

Table 5 presents the results of the three scenarios that combine the investment and production shocks in the biogas-electricity chains.

Table 5: Aggregated results for the three scenarios

Scenario	Production (MM USD)		Emissions (MtCO2e)		Employment (jobs)	
	Direct	TOTAL	Direct	TOTAL	Direct	TOTAL
Investment Effect						
Low	60	109	0.015	0.030	1325	2154
Basis	235	423	0.058	0.118	5147	8365
High	712	1283	0.176	0.356	15612	25364
Operation Effect						
Low	589	1307	0.000	-0.474	8116	13942
Basis	589	1305	0.000	-1.222	4943	13361
High	589	1302	0.000	-2.951	767	11771
Total Effect						
Low	650	1416	0.015	-0.443	9441	16096
Basis	824	1729	0.058	-1.104	10090	21726
High	1301	2585	0.176	-2.595	16380	37136

Source: Own elaboration

Results refer to the average annual impacts (direct and total, including indirect) during the ten years of biogas sector investments and the production horizon we set. The direct effect of all variables only concerns the investment shock in biogas plants. In contrast, the production shock only leads to indirect impacts through substituting inputs for fossil fuels (thermal plant production) with biogas in power generation.

In the case of GHG emissions, we find that the direct effect of investment increases emissions -because buildings and installations should be constructed- but when electricity production starts switching from thermal to biogas sources (indirect effects), the net GHG emissions fall. For instance, in Table 5, if the basis scenario is considered, the investment effect is +0.118 MtCO2e, the operation effect is –1.222 MtCO2e, and the net or total effect is –1.104 MtCO2e.

The biogas sector producer opens the information of Table 5 for the basis scenario.

It is important to note that once the investment period is closed (since the 11th year, because time-to-build is assumed in 10 years), the reduction in GHG emissions will become

even greater thanks to this substitution for environmentally cleaner technology for power generation.

Concerning job creation results across scenarios, it is important to highlight its nonlinearity. This is due to the trade-off effects of two underlying factors:

1. The change in the labor productivity due to the technology implemented in producing biogas-electricity, i.e., a technology that improves labor productivity, will create a lower number of jobs per unit of production and
2. The energy efficiency coefficient in the High scenario refers to a greater scale of electricity production, which leads to greater job creation.

Table 6: Basis Scenario (opened by biogas origin)

	Production (MM USD)		GHG Emissions (Mtco2e)		Employment (jobs)	
Sector	**Direct**	**TOTAL**	**Direct**	**TOTAL**	**Direct**	**TOTAL**
Investment effect by type of biogas						
Agriculture and cattle	76	138	0.019	0.038	1685	2764
Industrial	77	138	0.019	0.038	1652	2665
Solid waste and wastewater	82	148	0.020	0.041	1810	2936
TOTAL	235	423	0.058	0.118	5147	8365
Operation effect by type of biogas						
Agriculture and cattle	182	408	0.000	-0.197	1388	3467
Industrial	193	443	0.000	-0.457	1415	4403
Solid waste and wastewater	214	454	0.000	-0.568	2140	5492
TOTAL	589	1305	0.000	-1.222	4943	13361
Total (operation + investment) effect by type of biogas						
Agriculture and cattle	257	546	0.019	-0.158	3073	6231
Industrial	271	581	0.019	-0.419	3067	7067
Solid waste and wastewater	296	602	0.020	-0.527	3950	8428
TOTAL	824	1729	0.058	-1.104	10090	21726

Source: Own elaboration

Focusing on the Basis scenario, we can decompose the production (operation effect), GHG emission, and job creation impacts by biogas sectoral origin and state. Sectors with greater potential in biogas production and job creation are Agriculture, Solid Waste, and Wastewater, while those with higher performance in reducing GHG emissions are particularly the latter.

4. Conclusions

Our analysis is based on I-O methods and updated and homogeneous statistics. It addresses all complementary and substitution relationships among sectors to avoid partial reasoning in favor of or against specific sectors. We rest on empirical evidence and moderate assumptions on technical conversion factors.

However, caution is needed in advancing conclusions since nothing is that straightforward. The (partial) substitution of fossil fuels demands several adjustments in the infrastructure of electricity generation and public policies to help the market develop. This paper focused on the comprehensive socio-economic and environmental impact of developing the potential of biogas production for power generation; however, given the relevance of private investments in the biogas sector, it would be important to complement these results with a private cost-benefit analysis to provide an additional dimension of feasibility in the analysis of the biogas scenarios presented here.

The results help develop public policies (command and control—regulation—as well as incentive ones—taxes and subsidies—) to encourage changes in the energy matrix aimed at increasing net employment and decreasing net GHG emissions, based on evidence and avoiding partial (sectoral) arguments that can be distributive.

Jobs in biogas industries are sparse in the territory because of the nature of some biogas industries. Part of the production could be centralized in big cities, such as the one coming from solid waste processing, or from industries with great-scale economies, such as beer breweries and dairy products. Meanwhile, several small or medium-sized industries and

agricultural enterprises can also produce biogas from their substrates. Thus, jobs will be generated in the whole territory of the states involved. GHG emissions reduction, in turn, will help the country achieve its goals facing international commitments to control global warming.

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MARGINALISED ZONES AS STATISTICAL INSTRUMENTS TO NAVIGATE PERMACRISIS IMPACTS IN EUROPEAN REGIONS

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Abstract

In the context of overlapping and interrelated crises—economic, ecological, social, and geopolitical—European regions are confronted with new governance challenges. Marginalised zones, often treated as residual spaces in policy discourse, must be reimagined as analytical and governance instruments in the transition toward sustainability and territorial resilience. This article explores how marginalised areas can be conceptualised and operationalised through spatial statistical methodologies and policy frameworks that support just transition processes. Drawing on a critical review of empirical studies and strategic European and Romanian documents, we synthesise the main tools used to identify territorial disparities, such as Principal Component Analysis (PCA), clustering algorithms, fuzzy logic, spatial econometrics, and machine learning. We confirm that these methods allow for more nuanced territorial diagnostics and typologies, which are essential for evidence-based and place-based policies. The article advances a transdisciplinary framework that repositions marginalised zones as strategic levers in adaptive territorial governance. Ultimately, we argue for a paradigm shift: **from periphery to policy**, where marginalised regions evolve from passive recipients of aid to active instruments of **just transition**.

Keywords: Marginalised regions, Just transition, Spatial inequality, Territorial resilience, Governance instruments, PCA, Clustering, Fuzzy logic, Regional typologies, Permacrisis

JEL classification: R11, R58, O18, Q56, C38

1. Introduction

The concept of *permacrisis* - a prolonged period of systemic instability caused by overlapping shocks such as climate change, energy crises, pandemics, and socio-political tensions - as reshaped how regional vulnerabilities are perceived and governed. Marginalised

zones, historically framed as passive beneficiaries of compensatory policies, are now increasingly acknowledged as critical frontiers in the transition toward sustainable and resilient development (Adger et al., 2015; Provenzano, Seminara & Arnone, 2020).

The multifaceted nature of these crises demands analytical tools capable of capturing the spatial, economic, and social dynamics of disadvantage. This has led to a growing interest in using composite indicators, spatial clustering, and fuzzy logic to better map structural disparities and support evidence-based interventions (Rotondo et al., 2022; Möbius & Althammer, 2019). At the same time, the European policy discourse calls for region-specific strategies that prioritise not only economic competitiveness, but also territorial cohesion and ecological transition (Organisation for Economic Co-operation and Development – OECD, 2019; Pavone et al., 2021). In this context, marginalised zones emerge not simply as lagging spaces but as strategic levers for navigating complexity and building adaptive governance.

1.1. Knowledge Gap

Despite their growing visibility in policy discourse, marginalized zones remain under-theorized in academic literature, particularly in relation to their dynamic potential for driving regional transformation. Most existing studies treat these territories as residual spaces defined by structural deficits, rather than as complex and evolving systems that reflect multi-scalar socio-economic and environmental interactions (Ford et al., 2018; Turner & Zhou, 2023). Furthermore, vulnerability-related terms such as resilience, coping capacity, or adaptive governance are frequently used interchangeably, without a consistent conceptual framework (Turner et al., 2020). This semantic ambiguity hinders comparative analysis and weakens the integration of academic research into policy design.

Scholars have called for a reconceptualization of marginalized spaces not merely as policy targets, but as analytical categories that can inform spatial planning, risk mapping, and scenario modelling for sustainable development (Annunziata et al., 2023; Provenzano et al., 2020). Yet the integration of such frameworks into mainstream regional science remains fragmented. This article responds to this **gap** by advancing a comprehensive and interdisciplinary framing of marginalization that bridges statistical modelling, territorial governance, and transition theory.

The purpose of this article is to demonstrate the potential of marginalised zones to be used as analytical and governance instruments in the process of just transition and sustainable territorial development.

The main objectives of this study are:

1. To clarify the conceptual and strategic roles of marginalised regions in the context of sustainable development and just transition
2. To synthesise key methodological approaches (e.g., Principal Component Analysis (PCA), cluster analysis, fuzzy logic) used to analyse spatial disparities and marginalisation
3. To assess how European and Romanian strategic documents frame and operationalise the concept of marginalised zones
4. To identify typologies and clusters of marginalised regions based on empirical literature
5. To propose directions for future research and policy anchored in spatial resilience and territorial governance.

The central hypotheses explored in this study are:

- H1: Marginalised zones, when redefined as analytical-statistical instruments, enable better targeting of policies under conditions of systemic and overlapping crises;
- H2: Spatial statistical methodologies such as PCA and multivariate clustering can effectively capture hidden territorial patterns of marginalisation relevant for policy design (Möbius& Althammer, 2019);

- H3: European and national strategies increasingly rely on regional typologies that reflect composite socio-economic and environmental conditions to enable a just transition (OECD, 2019).

1.2. Research Question

In the context of overlapping crises—climate, socio-economic, and geopolitical—European regions are challenged by long-term systemic vulnerabilities. Marginalised zones are increasingly visible on the policy agenda, yet they remain under-theorised as dynam**ic tools for resilience and governance. This article addresses a central research question**: **How can marginalised zones be conceptualised and operationalised as statistical and territorial instruments to navigate the complexity of permacrisis and support just transition across European regions?** (Adger et al., 2015; OECD, 2019).

1.3. Delimitations and Original Contributions

This article does not aim to develop a novel statistical model or to empirically validate hypotheses through original fieldwork. Instead, it offers a transdisciplinary theoretical synthesis that draws on spatial econometrics, regional development strategies, and sustainability science. **The originality** of this study lies in reframing marginalised zones not merely as passive recipients of compensatory policies, but as analytical and governance instruments capable of guiding adaptive responses to systemic crises (Provenzano, Seminara, & Arnone, 2020). By situating marginalisation within the broader logic of *permacrisis* and the just transition framework, this work contributes to an emerging shift in regional science towards dynamic territorial resilience (Adger et al., 2015; Turner and Zhou, 2023).

Beyond structural analysis, recent work has explored how citizens perceive inequality and societal cohesion, providing valuable insights for just transition frameworks (Krupavičius et al., 2024).

2. Methodology used

The methodological approach of this study combines a structured analytical synthesis of relevant literature with a systematic evaluation of European and national strategic documents, as well as an analysis of pertinent practical examples. This integrative approach can be characterized as a rigorous cognitive meta-analysis, carried out through conceptual structuring and thematic mapping.

Unlike traditional quantitative meta-analyses focused on effect sizes, cognitive meta-analysis aims to identify, synthesise, and reconfigure conceptual frameworks across disciplinary boundaries (Torraco, 2005). It emphasises meaning-making and theoretical integration by mapping convergences and contradictions in the literature—an approach particularly valuable in transdisciplinary domains such as regional resilience. As Snyder (2019) observes, such integrative reviews are essential in fragmented or emerging fields, where empirical and strategic sources must be bridged to guide theory and policy development.

Through this method, the study ensures that all significant dimensions of regional marginalisation are captured in a coherent analytical framework. This enhances the clarity, depth, and policy relevance of the analysis by unifying academic, strategic, and applied perspectives.

3. Theoretical and Strategic Framing of Marginalised Zones

3.1. Conceptual Definition

A marginalised region and its vulnerable communities are territories that share structural characteristics with other regions but face persistent challenges and systematically fewer opportunities. These include limited access to infrastructure, public services, digital and energy transitions, innovation ecosystems, and investment, resulting in cumulative socio-economic disadvantages (Annunziata et al. 2023; Provenzano, Seminara, and Arnone 2020). In the context of sustainable development and industrial transition, such regions are often expected to leap further than others—despite fewer resources—if properly supported through

integrated, place-based interventions. As OECD (2019) highlights, successful industrial transitions depend on a region's capacity to foster "high-road competitiveness" strategies—those driven by innovation-led growth and wide social benefit. This reconceptualization moves marginalised regions beyond the passive framing of territorial lag and towards active governance tools capable of supporting resilience and transformation.

3.2. Theoretical Paradigms: Vulnerability, Just Transition, Cohesion, and Sustainability

The theoretical understanding of marginalised regions is deeply embedded in the broader paradigms of vulnerability, just transition, cohesion, and sustainability.

Vulnerability is often framed as a condition resulting from both structural deficits and limited adaptive capacity in the face of climate and economic shocks. As Adger et al. (2015) and Turner and Zhou (2023) argue, a refined understanding of vulnerability requires acknowledging the interplay between resilience, adaptation, and coping mechanisms across scales.

The concept of **just transition** emerges as a corrective response to past policies that have ignored territorial inequalities. Recent studies (Moodie 2021; Voicu-Dorobanțu et al., 2021) reveal that current Territorial Just Transition Plans tend to prioritise technical factors, while socio-economic and spatial contexts remain under-integrated. This calls for a rebalancing in favour of territorial justice and inclusive planning.

Cohesion, as conceptualised within the EU Cohesion Policy, targets the reduction of regional disparities and the enhancement of interregional complementarities (Pavone et al., 2021).

The concept of **sustainability** broadens this by introducing the need for environmental and intergenerational balance, as well as integrated development across social, economic, and ecological domains (Ionescu, 2018; Provenzano et al., 2020).

3.3. From Passive Labels to Governance Instruments: The Policy Role of Marginalised Zones

Marginalised zones have traditionally been perceived as passive recipients of top-down policy interventions, often labelled as underperforming or lagging. However, recent theoretical and strategic developments reframe these regions as active diagnostic instruments within territorial governance. Their persistent exposure to systemic vulnerabilities—climatic, socio-economic, or geopolitical—renders them critical sites for implementing adaptive, place-based policy strategies. Adger et al. (2015) highlight how social and environmental vulnerabilities, when spatially embedded, require decentralised and integrative governance approaches. Similarly, OECD (2019) outlines the need to develop region-specific pathways based on "high-road competitiveness," positioning marginalised territories as leverage points for innovation, cohesion, and inclusive transition. This conceptual shift underscores the strategic value of these zones not merely as objects of policy, but as analytical frameworks for anticipating risk, monitoring transition, and designing just development trajectories.

3.4. Alignment with Global Strategic Frameworks: Green Deal, SDGs, and Agenda 2030

The strategic framing of marginalised regions increasingly intersects with global policy frameworks such as the European Green Deal, the United Nations Sustainable Development Goals (SDGs), and the 2030 Agenda. These macro-strategies emphasise place-sensitive development, ecological transition, and equity, highlighting the imperative to reduce intra-regional disparities. The European Green Deal positions territorial cohesion as a pillar of climate neutrality, urging differentiated pathways for disadvantaged areas (European Commission 2019). Likewise, SDG 10 (*Reduced Inequalities*) and SDG 11 (*Sustainable Cities and Communities*) advocate for inclusive governance and infrastructure in spatially marginalised zones (United Nation - UN, 2015).

Integrating these frameworks into regional planning transforms marginalised territories into laboratories for policy innovation, adaptive governance, and long-term resilience.

3.5. Structural vs. Conjunctural Marginalisation: A Conceptual Distinction

Marginalisation is not a monolithic phenomenon; it manifests both structurally and conjunctural. **Structural marginalisation** refers to long-term, embedded disadvantages tied to spatial location, institutional neglect, or path-dependent underdevelopment. These conditions tend to persist across policy cycles and are often measurable through multi-dimensional deprivation indices (Annunziata et al. 2023). In contrast, **conjunctural marginalisation** arises from temporary disruptions—such as economic crises, environmental shocks, or geopolitical instability—that exacerbate pre-existing vulnerabilities or generate new layers of exclusion (Adger et al., 2015; Turner & Zhou, 2023).

Understanding this distinction is critical for designing territorial strategies that are both proactive and adaptive, especially in contexts of permacrisis where structural deficits and acute shocks overlap. Integrating both dimensions into diagnostic frameworks enhances the capacity for targeted, resilient policy interventions.

4. Methodological Approaches in Literature: Spatial, Statistical, and Multivariate Tools

The role of regional economic indicators in shaping targeted development strategies has been emphasised by Ladias et al. (2023), highlighting the need for data-driven policy instruments to address disparities across European territories.

4.1. Key Methodological Approaches in the Literature

A variety of methodological frameworks have been employed to analyse spatial disparities and patterns of marginalisation in European regions.

PCA has been used to reduce multidimensional socio-economic data into interpretable indices of vulnerability and territorial cohesion (Annunziata et al., 2023; Möbius & Althammer, 2019).

Cluster analysis, particularly k-means and hierarchical clustering, is applied to identify typologies of regions that share structural disadvantages, economic specialisations, or social exclusion risks (Pelau & Chinie, 2018; Pavone et al., 2021).

Fuzzy logic approaches, such as the **Totally Fuzzy and Relative Method (TFR)**, provide nuanced gradations of marginality beyond binary classifications, particularly when integrated into **spatial statistical systems like GIS** (Rotondo et al., 2022). These methods allow for the construction of diagnostic tools that map complex vulnerabilities and inform targeted territorial policies.

In addition to **PCA**, **clustering, and fuzzy logic,** recent studies have increasingly employed **spatial econometrics** and **Geographically Weighted Regression (GWR)** to uncover localised spatial dependencies and heterogeneity across regions (Möbius & Althammer, 2019; Yang et al., 2023).

These methods allow researchers to go beyond global models, capturing the context-specific nature of marginalisation. Moreover, advances in **machine learning** have introduced **ensemble models and unsupervised learning techniques** (e.g., neural networks, self-organising maps) as complementary tools for spatial diagnostics and forecasting.

These techniques are particularly effective in handling large spatial datasets and enhancing the predictive power of vulnerability assessments (Davies & van der Laan, 2016; Kopczewska, 2022). Together, these approaches enable a robust and scalable methodological framework for analysing territorial inequality and resilience under complex, multidimensional conditions.

4.2. Types of Data and Indicators Used in the Literature

The empirical literature on territorial marginalisation employs a wide array of data types and indicators, typically drawn from harmonised statistical sources such as Eurostat, national censuses, or open-access territorial datasets. Commonly used variables include GDP per capita, employment rates, education levels, population ageing, and digital infrastructure coverage (Annunziata et al. 2023; Pelau & Chinie, 2018).

Environmental indicators such as energy consumption, land use, and exposure to climate risks are also incorporated to capture multidimensional vulnerabilities (Rotondo et al., 2022; Voicu-Dorobanțu et al., 2021).

Studies often construct composite indices or typologies based on these datasets using statistical methods such as PCA, clustering, and fuzzy logic, enabling the identification of latent structures of inequality and regional disadvantage.

The integration of geospatial layers into statistical models further enhances the explanatory power and policy relevance of these indicators (Kopczewska, 2022).

4.3. Relevance of Methodological Approaches for Identifying Territorial Marginalisation

The application of advanced statistical and spatial methods - such as PCA, fuzzy logic, multivariate clustering, spatial econometrics, and machine learning - has significantly improved the capacity to diagnose territorial marginalisation. These approaches allow researchers to move beyond administrative boundaries and static classifications by uncovering latent patterns and multidimensional disparities across regions (Annunziata et al. 2023; Rotondo et al. 2022).

Fuzzy logic, for instance, captures the gradient nature of exclusion, making it possible to model marginalisation as a continuum rather than a binary condition.

Spatial econometrics and GWR enable the detection of localised variations and spatial dependencies that traditional models often miss (Möbius & Althammer, 2019; Yang et al. 2023).

Machine learning tools such as ensemble models and self-organising maps further enhance predictive diagnostics and allow for adaptive typologies suited to complex territorial systems (Kopczewska, 2022).

These methods collectively enable a more granular, scalable, and policy-relevant identification of marginalised regions, informing more just and effective interventions.

4.4. Representative Studies Applying These Methods

Several representative studies illustrate the operationalisation of advanced methodologies to assess territorial marginalisation in Europe. Annunziata et al. (2023) applied PCA and clustering algorithms to socio-economic and spatial indicators in southern Italy, revealing specific territorial configurations of marginal decline. Rotondo et al. (2022) employed fuzzy logic to evaluate ecological transition capacity across Italian regions, generating composite indicators in a GIS environment. Möbius and Althammer (2019) developed a spatial econometric model of sustainable competitiveness for 272 European regions, integrating environmental, economic, and social variables. Yang et al. (2023) proposed a hybrid model combining Geographically Weighted Regression (GWR) and machine learning to detect spatial heterogeneity in regional resilience.

In the Romanian context, Voicu-Dorobanțu et al. (2021) used multivariate indicators and risk analysis to support just transition planning, while Lincaru et al. (2020) applied k-means clustering within GIS to reveal labour market patterns in marginalised localities. These works demonstrate the effectiveness of diverse statistical frameworks in uncovering the hidden geographies of exclusion and informing targeted territorial policies.

5. . National and European Policy Anchors: Case of Romania. Key Strategic Documents at the European and National Levels

The European Green Deal, Agenda 2030, and the Just Transition Mechanism (JTM) offer the foundational policy framework for addressing structural disparities and climate-related vulnerabilities. These strategies emphasise territorial justice, cohesion, and decarbonisation. The **Territorial Just Transition Plans (TJTPs)** provide a spatial lens for policy intervention, targeting the most carbon-intensive and socio-economically vulnerable regions (European Commission (EC), 2020).

At national level, Romania aligns with these objectives through strategic instruments such as the **National Recovery and Resilience Plan (PNRR)**, the **National Strategy for Sustainable Development 2030 (SNDDR)**, and the **Smart Specialisation Strategy**

(**SNCISI)**. These plans prioritise digital transformation, green transition, and the reduction of spatial inequalities, integrating marginalised areas within broader territorial governance.

5.1. Defining Marginalised Areas in Romanian Policy

Romanian public policy defines marginalised areas primarily in socio-economic terms, using criteria such as long-term unemployment, low income, poor housing, low education, and limited access to services. The **Atlas of Marginalised Urban Areas** (World Bank and Ministry of Regional Development and Public Administration (Ministerul Dezvoltării Regionale şi Administraţiei Publice - MDRAP, 2014) and subsequent local development strategies (e.g., Community-Led Local Development, (Dezvoltarea locală plasată sub responsabilitatea comunității - DLRC) operationalise these definitions at the community level. Within **Territorial Just Transition Plan'**s (**TJTPs)**, (Planul teritorial pentru o tranziție justă), Romania identifies six counties (e.g., Gorj, Hunedoara, Mureș, Dolj, Prahova, Galați) as transition-affected regions, overlapping with areas of historical underdevelopment and fossil fuel dependence. This framing integrates environmental, economic, and social vulnerability into one diagnosis.

Regional economic resilience is also strongly influenced by logistical performance and infrastructure readiness, as demonstrated by Ruxho & Ladias (2022) in their study of regional firms.

5.2. Comparing National and European Approaches

While EU policies increasingly promote multidimensional and dynamic definitions of marginalisation (European Parlament - EP, 2022), Romanian strategies remain anchored in static, deprivation-based criteria.

The shift toward integrated spatial diagnostics and place-based interventions at EU level is only partially reflected in national implementation, which still favours administrative targeting. However, instruments such as **the DLRC mechanism**, **POCU 2014–2020**, and **JASPERS-supported diagnostics** mark a transition toward more complex frameworks for assessing vulnerability and territorial potential.

5.3. National Projects and Research Anchors

Several applied research initiatives reinforce the theoretical framing of marginalisation in Romania. For example, **Lincaru et al. (2020)** employed GIS-based multivariate clustering to identify structural labour market disparities at local level, offering evidence for smart specialisation policies. Similarly, **Voicu-Dorobanțu et al. (2021)** analysed the Romanian energy mix and transition risks using multidimensional indicators to support TJTP planning.

These contributions demonstrate the applicability of advanced spatial diagnostics to national strategies and highlight Romania's evolving alignment with European policy logics.

6. . Key Insights and Typologies Emerging from Literature and Practice

6.1. Synthesis of Typologies Identified in Literature

Recent empirical studies use statistical and spatial techniques to construct typologies of marginalised regions. **Annunziata et al. (2023)** applied Principal Component Analysis (PCA) and clustering algorithms to define six regional profiles of socio-economic decline in Southern Italy. Similarly, **Pavone et al. (2021)** developed a multidimensional clustering of EU regions based on RIS3 priorities and demographic indicators, identifying nine regional groups with distinct structural trajectories. **Möbius and Althammer (2019)** used spatial econometrics to map regional sustainable competitiveness, highlighting clusters of lagging regions across Eastern and Southern Europe. These typologies go beyond administrative categories, offering evidence-based patterns for policy design.

6.2. Types of Marginalised Regions and Determinant Factors

The literature highlights several recurring categories of marginalised regions:

- **Demographically vulnerable regions**: ageing populations, depopulation, and outmigration
- **Economically peripheral zones**: weak labour markets, low innovation capacity, mono-industrial dependence
- **Environmentally fragile areas**: degraded ecosystems, high exposure to climate risks
- **Transition-affected territories**: carbon-intensive industries under pressure from green policies (e.g., mining counties in Romania)

Determinant factors include infrastructure deficits, education gaps, institutional undercapacity, and spatial remoteness (Rotondo et al. 2022; Voicu-Dorobantu et al. 2021).

6.3. Typologies in Policy Practice

Policy frameworks also use regional typologies to target investments and interventions. For example, **TJTP**s classify regions by carbon dependency and socio-economic resilience. The **European Commission's Cohesion Reports** identify "transition regions" and "less developed regions" using GDP thresholds and innovation scores.

In Romania, marginalisation is classified via indicators such as housing deprivation, long-term unemployment, and social exclusion (World Bank and MDRAP, 2014).

6.4. Critical Interpretation of Typological Insights

While typologies are useful diagnostic tools, they risk becoming static labels if not regularly updated or locally validated.

Some critics argue that overly quantitative typologies ignore governance capacity, informal economies, and socio-cultural dynamics (Turner & Zhou, 2023).

Others emphasize the potential of typologies to act as governance tools that anticipate risks and prioritize place-sensitive policies (Adger et al. 2015; Provenzano et al., 2020). The real value of typologies lies in their ability to integrate territorial complexity into scalable, adaptive, and just policy mechanisms.

7. Future Research and Policy Directions

7.1. Gaps in the Literature

Despite significant advancements in spatial diagnostics and regional typologies, several conceptual and methodological gaps persist.

Theoretical ambiguity remains around key concepts such as *vulnerability*, *resilience*, and *just transition* (Turner& Zhou, 2023; Ford et al, 2018).

Methodologically, much of the literature still relies on static or cross-sectional data, lacking the capacity to model temporal dynamics or causal feedback loops.

Data limitations also persist, particularly regarding small-scale indicators and local governance variables in marginalised areas (Adger et al., 2015).

7.2. Future Research Needs

There is a growing consensus on the need for **interdisciplinary approaches** that integrate geography, economics, environmental science, and political sociology. Future research should prioritise **empirical validation** of typologies through qualitative fieldwork, participatory mapping, and scenario testing (Provenzano et al., 2020; Kopczewska, 2022).

Moreover, **scalability** is critical frameworks must be adaptable across regions of varying size, governance capacity, and socio-economic context.

7.3. Policy Integration and Knowledge Transfer

Bridging the gap between academic research and public policy requires knowledge translation mechanisms and the co-production of evidence with policymakers. Tools such as

territorial foresight, **diagnostic dashboards**, and **multi-criteria decision support systems (MCDA)** can facilitate the integration of complex data into strategic decision-making. Linking marginalisation metrics with funding allocation - such as via the EU's JTF or Cohesion Fund - can improve territorial justice outcomes (EC, 2022).

7.4. Community Participation and Bottom-Up Governance

Local communities are rarely consulted in the definition or implementation of marginalisation frameworks. A future-oriented research agenda must embed **bottom-up approaches**, including participatory budgeting, citizen science, and community-led planning.

These approaches enhance legitimacy, foster local ownership, and improve the context-specific relevance of interventions (Satterthwaite, 2016).

7.5. Dynamic Models and Innovative Tools

There is considerable untapped potential in applying **dynamic modelling**, **scenario-based planning**, and **AI/ML** techniques to simulate transition pathways and policy impacts. Spatial machine learning, ensemble forecasting, and geospatial agent-based models can predict future vulnerability hotspots and evaluate the adaptive capacity of regions (Davies & van der Laan, 2016; Yang et al., 2023; Kopczewska, 2022). These methods offer forward-looking tools for resilient territorial governance.

8. Conclusions

This article addressed a central research question: **How can marginalised zones be conceptualised and operationalised as statistical and territorial instruments to navigate the complexity of permacrisis and support just transition across European regions?**

Through a comprehensive review of theoretical, methodological, and strategic perspectives, we have demonstrated that marginalised regions are no longer to be seen merely as lagging spaces or recipients of compensatory policies. Instead, they can serve as **diagnostic and governance instruments** in a multidimensional policy architecture that addresses **territorial resilience**, **decarbonisation**, **cohesion**, and **equity**.

The typologies and methodologies analysed—PCA, clustering, fuzzy logic, spatial econometrics, GWR, and machine learning—offer nuanced tools to detect hidden spatial inequalities and identify patterns of marginalisation. These methods are essential for evidence-based planning, especially in the context of long-term structural disparities and acute conjunctural shocks, such as those highlighted in the permacrisis framework (Adger et al., 2015; Annunziata et al., 2023; Yang et al., 2023).

All three research hypotheses are confirmed:

- **H1:** Marginalised zones, redefined through analytical-statistical lenses, enable more targeted and adaptive policy responses to complex systemic crises.
- **H2:** Advanced spatial methodologies provide robust tools for mapping, diagnosing, and interpreting marginalisation in regional contexts.
- **H3:** Both European and Romanian policy frameworks increasingly incorporate multi-dimensional regional typologies aligned with just transition principles.

Our findings suggest the need for a shift from static, deficit-based views to **dynamic, integrative policy approaches**, where marginalised zones become core elements in **adaptive territorial governance**. By anchoring our analysis in both academic literature and applied policy instruments, this work contributes to an emerging research-practice nexus that repositions marginalised areas at the heart of Europe's sustainable transformation.

8.1. Concluding Reflections: Theoretical and Practical Contributions

Theoretically, this article reframes marginalised regions as dynamic constructs embedded within systemic crises and resilience logics. It contributes to the evolving literature on regional development by bridging **spatial econometrics**, **vulnerability theory**, and **territorial governance**. Conceptually, it challenges static and mono-dimensional framings of

marginalisation, proposing instead an integrated view anchored in **multi-scalar socio-economic and environmental interdependencies**.

Practically, the article synthesises a toolkit of spatial methodologies and policy frameworks that can support decision-makers in diagnosing, prioritizing, and co-designing interventions tailored to marginalised territories. By mapping how EU and Romanian strategies operationalize marginalization, this work provides a **translatable analytical template** for other national contexts navigating green and just transitions.

Strategically, the message is clear: **marginalised zones must be reimagined not as passive territories to be lifted**, but as **active instruments of governance**, capable of informing scenario planning, guiding investment flows, and enhancing territorial foresight. Recognizing their adaptive potential and integrating their structural characteristics into long-term transition strategies is not only a matter of justice—but of effectiveness, cohesion, and resilience in an age of permacrisis.

This contribution calls for a reimagining of marginalised zones not as territories in need of rescue, but as **data-informed agents of change** in regional development. **From periphery to policy**, these zones hold the potential to shape the path of just transition through their structural realities, resilience challenges, and transformative opportunities. Embracing them as active governance instruments is essential not only for justice, but for the integrity and success of long-term transition strategies across Europe.

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Announcements, Conferences, News

7th Global Conference on Economic Geography
"Governance Challenges for a Sustainable and Inclusive Future"
June 4–8, 2025 | Clark University | Worcester, Massachusetts, USA.

Event Overview[1]

The 7th Global Conference on Economic Geography (GCEG 2025) will take place from June 4 to 8, 2025, at Clark University in Worcester, Massachusetts, bringing together scholars, policymakers, practitioners, and students from across the globe, for the largest international gathering dedicated to Economic Geography.

The theme of this year, "Governance Challenges for a Sustainable and Inclusive Future", will spotlight forward-thinking research and global dialogue addressing the most pressing socio-economic and spatial challenges of our time. The Global Conference on Economic Geography is the largest international conference dedicated to Economic Geography. Highlights for the GCEG 2025 will include cutting-edge research concerning the sources and drivers of socio-economic change, an assessment of the economic geography of places in a multi-scalar and multi-dimensional context; implications for businesses, policymakers, planners, and teaching; plenary sessions and debates with eminent scholars, policymakers and practitioners; hundreds of presentations on a variety of relevant themes, incl. inequality, development, finance, technological change and innovation, knowledge and skills, production and consumption, planning, digital platforms and peripheral places; inspiration, networking and best-practice sharing with close to 1,000 people from around the globe; exhibitions by leading publishers; opening reception, conference gala dinner, and other networking events.

Participants are not required to be members of the American Association of Geographers (AAG) to attend. However, registration requires a free AAG Explorer account.

Key Dates:

- Start: June 4, 2025, 8:00 AM (Eastern Time, US & Canada)
- End: June 8, 2025, 5:00 PM (Eastern Time, US & Canada)

More information is available at the websites:
https://www.aag.org/events/7th-global-conference-on-economic-geography/
https://www.aag.org

References

- https://www.aag.org/events/7th-global-conference-on-economic-geography/
- https://www.aag.org

1 Event overview edited by Dimitrios Tsiotas,
Assistant Professor, RSI J.

64th ERSA Congress
"Regional Science in Turbulent Times. In search of a resilient, sustainable, and inclusive future"
Athens, 26 – 29 August 2025 (Onsite Participation Only).

Event Overview[2]

The 64th Annual Congress of the European Regional Science Association (ERSA) is set to take place in Athens, Greece, from August 26 to 29, 2025. This event will require attendees to participate exclusively in person. The main theme of the congress is "Regional Science in Turbulent Times: In Search of a Resilient, Sustainable, and Inclusive Future".

This contemporary theme addresses the overlapping crises faced by people and places, including economic instability, waves of migration, and the varied spatial and socioeconomic impacts of the pandemic. Being a dynamic, evolving, and multidisciplinary field and the most relevant discipline, Regional Science is positioned to address these challenges by promoting the academic dialogue and proposing methods, modeling approaches, and evidence-based policies for a more resilient and inclusive future globally.

With around 800 participants annually from all continents, the ERSA Congress is amongst the largest academic events in the field of Regional Science, worldwide, offering a unique platform to present research findings and receive valuable feedback, discover the latest developments in the field, and engage with fellow researchers, policymakers, and experts worldwide.

Professor Yannis Psycharis, Chair of the Local Organizing Committee, observes that the response of the Regional Science community to the 64 ERSA Congress has been unprecedented, as over 1,150 paper submissions and nearly 100 proposals for Special Sessions were submitted for evaluation, confirming the strong commitment and awareness of the ERSA community to address contemporary global challenges through science and collaboration. The Chair of the Local Organizing Committee, also notes that the 64th ERSA Congress will be the first fully in-person ERSA Congress since the pandemic, highlighting the challenges but also the opportunity of in-person organizing the Congress in the face of ongoing multidimensional crises.

The main theme of the Congress regards the complexities of today's world and the role of Regional Science in shaping the worldwide collective future. In a typical context, the General themes of the Congress include the following:

G01. Urban, Regional, Territorial and Local Resilience
G02. Regional Growth Models, Competitiveness, and Convergence
G03. Innovation, Entrepreneurship, and Entrepreneurial Ecosystems
G04. International Trade, Global Value Chains (GVCs), And Regional Growth
G05. Transportation, Energy, and Communication Infrastructures: Regional Dimension
G06. Space and Digital Transformation
G07. Spatial Attributes of (de)Population, Ageing, Loneliness and Demographics
G08. Climate Change and Natural Disasters: Spatial Incidence and Spatial Impacts
G09. Migration, Mobility Patterns, and Impacts Across Space
G10. Socio-Spatial Inequalities: Segregation, Migration; Gender, Discrimination, Social Exclusion
G11. Public Policy Assessment: Inclusiveness and Poverty Alleviation Across Space; Equality in Opportunities and Territorial Justice
G12. Agriculture, Rurality, Agrifood and Rural Entrepreneurship
G13. Social Capital, Territorial Capital, Institutions and The Commons

2 Event overview edited by Dimitrios Tsiotas,
Assistant Professor, RSI J.

G14. Left Behind Areas, Insularity, Inner Areas, and Border Regions

G15. Tourism, Carrying Capacity, Culture, Creative Industries, Leisure, Sports, Wellbeing, Happiness, Quality of Life

G16. Statistical And Econometric Methods of Urban and Regional Analysis

G17. Geopolitics, Conflicts and Security: Spatial Impacts and Perspectives

G18. Voting Patterns, Participation, Discontent, Representation, Euroscepticism

G19. Urban, Regional, and Local Policy Evaluation

G20. Regional Policy, Cohesion Policy, Financial Instruments and Policy Assessment

G21. Multilevel Governance, Local Government, Devolution, Decentralization

G22. Housing, Real Estate, Urban Renewal, Gentrification, Displacement, Urban Policy and Urban Transformation, Living Conditions, Built Environment

G23. Labor Markets, Unemployment, Gig Economy, Digital 'Nomads'

G24. Higher Education Institutions, Universities, and Regional Development, Training, and Lifelong Learning Policies

G25. Enriching Research and Policy Methods in Regional Science: Digital Tools, Artificial Intelligence, Participatory Methods, Mapping Techniques, Stakeholder Involvement

The 64th ERSA Congress promises to be an enriching and memorable experience, both intellectually and socially.

The Chair and the Members of the Local Organizing Committee look forward to welcoming the participants of the 64th ERSA Congress to Athens.

For more information and registration, the reader may visit: https://ersa.eventsair.com/ersa2025.

Event overview edited by Dimitrios Tsiotas,
Assistant Professor, RSI J.

References

- https://ersa.eventsair.com/ersa2025
- https://ipa.panteion.gr/2024/10/08/ersa-2025-congress-in-athens/

Academic Profiles

Associate Professor Damon JONES

Damon Jones, Ph.D., is an Associate Professor at the Harris School of Public Policy at the University of Chicago, where he has been a faculty member since 2010. He received tenure in 2022 and has emerged as an esteemed scholar in public finance, labor economics, and the intersection of economic policy and inequality. Assoc. Prof. Damon Jones earned his Ph.D. in Economics from the University of California, Berkeley, in 2009, and holds a B.A. in Public Policy from Stanford University. He was also a postdoctoral fellow in 2009-2010 at the Stanford Institute for Economic Policy Research. At the University of Chicago, Harris School of Public Policy, he serves as the Associate Director of the Stone Center for Research on Wealth Inequality and Mobility. He is also affiliated with the Abdul Latif Jameel Poverty Action Lab (J-PAL) and the Institute for Research on Poverty at the University of Wisconsin-Madison.

Assoc. Prof. Damon Jones currently serves as Co-Editor of the Journal of Public Economics and as a member of the Editorial Advisory Board of the National Tax Journal, and has held editorial roles at AEJ: Economic Policy (receiving Excellence in Reviewing and Refereeing Awards). His research generally focuses on Public Finance, Household Finance, and Labor Economics, and has already been published in reputable journals, such as the Journal of Economic Literature, the American Economic Journal-Economic Policy, the Journal of Public Economics, and beyond the economics field the JAMA Internal Medicine. His research enjoys a considerable impact, currently recording over 2000 citations, according to the Google Scholar database.

Aside from his academic research, Assoc. Prof. Damon Jones is actively engaged in the wider economics community. He has been elected as a member of the American Economic Association's (AEA) Board of Officers for 2025, and beyond others he serves as a Research Associate at the National Bureau of Economic Research (NBER), in the field of Public Economics and Aging, he is a member of the Board of Directors of the National Tax Association, and he was a member of the AEA Annual Meeting Program Committee in 2023. In 2020, he was awarded by the National Institute for Health Care Management the Annual Health Care Research Award.

Professor Jones is deeply committed to mentoring and expanding access within the economics profession. In his own words, his aim "as a professional economist is to deliver on that promise and make the process of learning, researching, and teaching economics accessible to those who want to be a part of the field. I do not know how much impact any one executive committee member has, but my aim would be to continue opening the door to those who are interested and also working to have the AEA be reflective of and responsive to a broad, diverse, and engaged group of economists", ensuring that the economist discipline remains inclusive, responsive, and engaged with a broad and diverse community.

Academic Profile by:
Dimitrios Tsiotas
Assistant Professor, RSI J

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https://scholar.google.com/citations?hl=el&user=Pwt08AcAAAAJ&view_op=list_works&sortby=pubdate

Professor Sofia Elena COLESCA

Prof. Dr. Sofia Elena Colesca is a Full Professor at the Bucharest University of Economic Studies (ASE), Romania, with expertise in quantitative methods for management, management information systems, and digital and green economy. Prof. Sofia Elena Colesca holds a Ph.D. in Management from the Bucharest University of Economic Studies (2000) and a Bachelor's degree in Control and Computers from the Polytechnic University of Bucharest (1991). Since joining the academic staff at ASE, she has advanced through all teaching ranks, from Teaching Assistant to Full Professor, and during her academic career has significantly contributed to both teaching and research in the fields of her expertise. Her teaching portfolio includes courses in fields such as Document Management, Simulation techniques in Public Administration, e-government, and Office Automation, and visit lectures at other institutions in Spain, the Czech Republic, and China. Her research activity involves participation in 23 national and international research projects, related to sustainability, waste management, innovation, education, knowledge management, and digital transformation.

Prof. Sofia Elena Colesca is a prolific academic who has authored or co-authored nine books and over 100 papers in various journals and conference publications. Her research covers a wide range of topics, and her work has received more than 2,000 citations in the Google Scholar database. Notably, one of her papers has been classified by Web of Science as a Highly Cited Paper in the field of Renewable Energy.

Prof. Sofia Elena Colesca serves as the Director of the Research Centre on Public Administration and Public Services (Bucharest, Romania) and she also serves as Editor-in-Chief for the esteemed journals *Theoretical and Empirical Researches in Urban Management* (indexed in SCOPUS) and *Management Research and Practice* (indexed in Clarivate Analytics' Emerging Sources Citation Index). She also staffs the advisory committees of the journals *Innovation, Quality, Prosperity*; *Management and Economics Review*; and *Administratie si Management Public* (Romanian), and she is a member of the organizing committee of the International Management Conference, (ISI indexed) and International Conference on Public Administration and Management.

Through her integrated academic, editorial, and research skills, Prof. Dr. Sofia Elena Colesca has contributed so far to the fields of digital governance and sustainable urban systems, advancing both theoretical understanding and practical solutions.

Academic Profile by:
Dimitrios Tsiotas
Assistant Professor, RSI J

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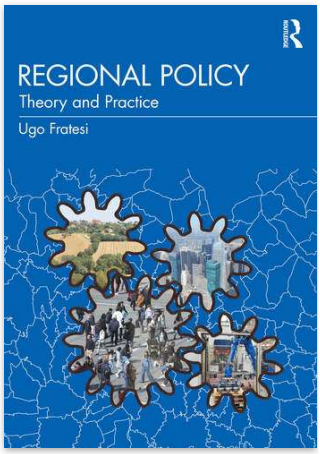
Book Reviews



Regional Policy: Theory and Practice by Ugo Fratesi Routledge, 1st Edition, 2024 | ISBN: 9780815364085 | 414 pages | Published: November 8, 2023

In Regional Policy: Theory and Practice, Ugo Fratesi delivers a comprehensive and timely examination of Regional Policy, an increasingly critical tool for promoting socioeconomic prosperity and simultaneously addressing territorial inequalities. Ugo Fratesi is a Professor at and Polytechnic University of Milan (Politecnico di Milano) and a reputable academic in the field of Regional Science. This first edition, published by Routledge in November 2023, provides an accessible yet comprehensive treatment of the theoretical foundations and practical applications of regional policy within a global context.

The book is structured in four coherent parts. It begins with an exploration of the character, aims, and rationale behind regional policy, establishing the conceptual grounding needed to understand the field. The second part focuses on implementation, presenting the instruments and strategies available to policymakers and shedding light on the real-world challenges in Regional Policy. The third part examines evaluation tools, including methods of impact assessment, modeling, and the use of statistics in policy planning. The final part brings the discussion into practical contexts, showcasing how regional policy is applied across different institutional and geographical contexts through case studies and examples from around the world.

This textbook is particularly suited for advanced students, researchers, and professionals engaged in regional economics, planning, economic geography, and public policy. By addressing both theoretical debates and policy challenges, Regional Policy: Theory and Practice equips readers with the knowledge and tools needed to contribute meaningfully to regional development strategies in diverse contexts.

The work of Ugo Fratesi stands out for its structured approach, comprehensive coverage, and commitment to evidence-based policymaking. Regional policy is essential in any government's toolkit for promoting socioeconomic prosperity. It comes in many forms and can be used to target the development of weak and stronger regions. This textbook provides comprehensive and systematic coverage of regional policy, dealing with core theories and looking at contemporary challenges in practice, addressing regional policy across the world.

As regions worldwide face urgent challenges like inequality, stagnation, and demographic shifts, this book provides essential guidance for creating inclusive and sustainable territorial policies.

More information and purchasing options are available through Routledge:

https://www.routledge.com/Regional-Policy-Theory-and-Practice/Fratesi/p/book/9780815364085

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- https://www.fratesi.net/

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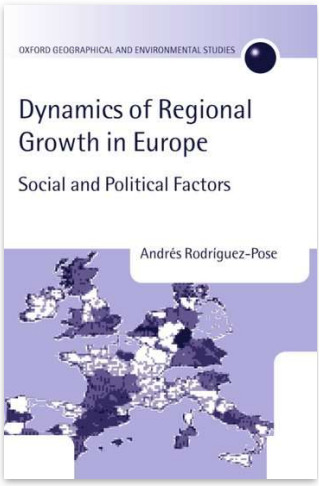

Dynamics of Regional Growth in Europe: Social and Political Factors
by Andrés Rodríguez-Pose | Oxford University Press | ISBN: 9780198233831 | Oxford Geographical and Environmental Studies Series

Dynamics of Regional Growth in Europe: Social and Political Factors by Andrés Rodríguez-Pose is a book offering a comprehensive and analytically rich exploration of the enduring spatial disparities in regional development across Europe. Andrés Rodríguez-Pose is a Professor at the London School of Economics and a reputable academic in Economic Geography. Published by Oxford University Press, as part of the distinguished Oxford Geographical and Environmental Studies Series, this book provides insights into the puzzling question in the field of economic geography regarding why regional inequalities persist despite the structural transformations and integrative forces of globalization, technological change, and capital mobility.

In this book, Rodríguez-Pose presents a multidisciplinary framework that integrates social, political, and institutional dimensions into the analysis of regional growth and development. The book begins by discussing the processes of socioeconomic restructuring and their spatial consequences. It then provides a thorough examination of regional growth patterns, exploring how social conditions, labor market characteristics, education systems, political dynamics, and institutional structures influence the economic dynamics of European regions.

Drawing on comprehensive Eurostat data at the NUTS 2 level, Rodríguez-Pose systematically examines patterns of growth and stagnation across a diverse set of European regions. Tassilo Herrschel (the Geographical Journal) acknowledges added value of the book, first, on the author's comparative approach allowing for the identification of underlying factors explaining persistent divergence between core and peripheral areas and, secondly, on the challenges posed against surficial visions of a "Europe of the regions" whether overlooking the importance of national frameworks in conditioning regional development outcomes.

Each chapter builds a layered and empirically grounded narrative and is structured as follows:

Preface
1:Introduction: The Process of Socio-economic Restructuring and Its Spatial Consequences
2:Introducing Social and Political Factors in the Study of Growth
3:Regions, Nations, and Growth
4:Regional Growth Patterns
5:Social Conditions and Regional Growth in Western Europe
6:Labour Market, Education, and Growth
7:Politics, Institutions, and Growth
8:Regional Politics and Growth in the European Context
Conclusion
Bibliography
Index.

The book of Rodríguez-Pose, Dynamics of Regional Growth in Europe: Social and Political Factors, is particularly valuable for scholars, graduate students, and practitioners in economic geography, regional science, European studies, and political

economy. It also holds practical relevance for policymakers engaged in the EU context. Further information and purchase options are available at:

https://global.oup.com/academic/product/dynamics-of-regional-growth-in-europe-9780198233831

References

- https://global.oup.com/academic/product/dynamics-of-regional-growth-in-europe-9780198233831?cc=gr&lang=en&
- https://www.lse.ac.uk/geography-and-environment/people/academic-staff/andres-rodriguez-pose

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Assistant Professor, RSI J

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.**

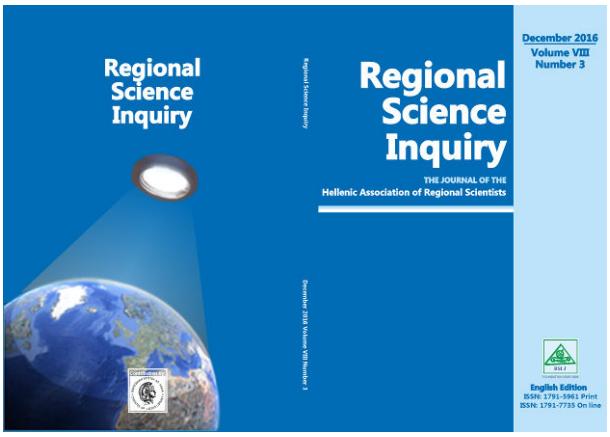
5.1.1. Reference inside the text

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.