# REGIONAL ECONOMIC RESILIENCE AND TOURISM DEMAND: THE CASE OF GREECE

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**Abstract**

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

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

**JEL classification:** R11, R15, R58, Z32

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## 1. <u>Introduction</u>

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

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

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

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

A direction for further research in the use of the 3D resilience index of Tsiotas and Katsaiti (2025) can be the measurement of economic resilience either at the sectoral level or at the regional administrative–geographical scale. In the case of Greece, particular interest lies in the analysis of regional resilience in the tourism sector, given that tourism is a key economic component that has consistently accounted for approximately 15–20% of GDP (Kalantzi et al., 2017). Theoretically, a region's specialization in tourism, as in the cases of Crete, the South Aegean, and the Ionian Islands (Polyzos, 2019), may endow its development model with significant dynamism through the enhancement of economic activity driven by tourism demand. At the same time, it may generate characteristics of economic vulnerability, such as, for instance, when tourist destinations become strongly dependent on externalities in tourism flows (Tsiotas et al., 2020, 2021) and consequently subject to the seasonality of tourism demand. Studies such as those by Psycharis et al. (2014) and Sdrolias et al. (2022) have shown that Greek regions demonstrating notable resilience during the economic crisis of the previous decade (2008) were specialized in the tourism sector, highlighting tourism specialization as a key determinant of economic resilience.

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

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

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

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

## 2. METHODS AND DATA

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In the third stage of the analysis, the results of the 3D tourism resilience index are compared with those of the *LQ* calculations. The comparison is carried out using (*i*) a graphical method based on constructing error bar plots for the mean values of variables' categories with a 95% confidence interval and (*ii*) correlation analysis (Walpole et al., 2012). In the first (error-bars) approach, the *LQ* results are used for the groupings: specifically, the grouping variables are constructed by consolidating the binary states 'specialized' ($LQ>1$) and 'not specialized' ($LQ\leq1$), which are derived from comparing the location quotient values to one for the entire period 2000–2018. From a technical standpoint, the procedure applies as follows: First, the location quotient matrices $\boldsymbol{LQ}=[LQ_{ir}]$ containing $LQ_{ir}$ values for each region and sector are transformed into binary matrices $\boldsymbol{LQ}_{\text{bin,year}}=[\delta_{ir,\text{year}}]$, where $\delta_{ir,\text{year}}=0$ when the region is not specialized in the sector for the given year, and $\delta_{ir,\text{year}}=1$ when it is specialized for each reference year. In the next step, the annual binary matrices are consolidated, keeping a value of 1 for cases where the region has been specialized in the specific sector for all years (2000–2018), and assigning 0 otherwise. This procedure leads to the formation of a longitudinal location quotient matrix $\boldsymbol{LQ}_{\text{bin}}=[\delta_{ir}]$, in which $\delta_{ir}=1$ when the region maintained its specialization throughout the period 2000–2018 in the specific sector, and zero otherwise. Furthermore, the ***LQ***bin matrix contains 10 binary (dummy) variables (corresponding to the available sectors), which are used as grouping variables for the error bar analysis. From an interpretive standpoint, when two error bars overlap, no statistically significant difference can be detected between the mean values (considered as parameters) of the two compared groups (with a probability of only 5% for error). Conversely, when they do not overlap, it can be concluded with 95% confidence that the mean values (considered as parameters) of the compared groups are different. In the second (correlation analysis) approach, the *LQ* variables do not subject to any conversion and are uses as sectorial variables participating in correlation analysis applied to pairs ($LQ_i$, $R_j$), with $i$=A, BE, F, GI, J, K, L, MN, OQ, and RU expressing sectors, and $j$=scalar, engineering, ecological, and evolutionary expressing aspects of the 3D resilience index. In this analysis, we use *Pearson's bivariate coefficient of correlation* (Norusis, 2011; Devore and Berk, 2012; Walpole et al., 2012), which is defined as:

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

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

## 3. RESULTS AND DISCUSSION

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

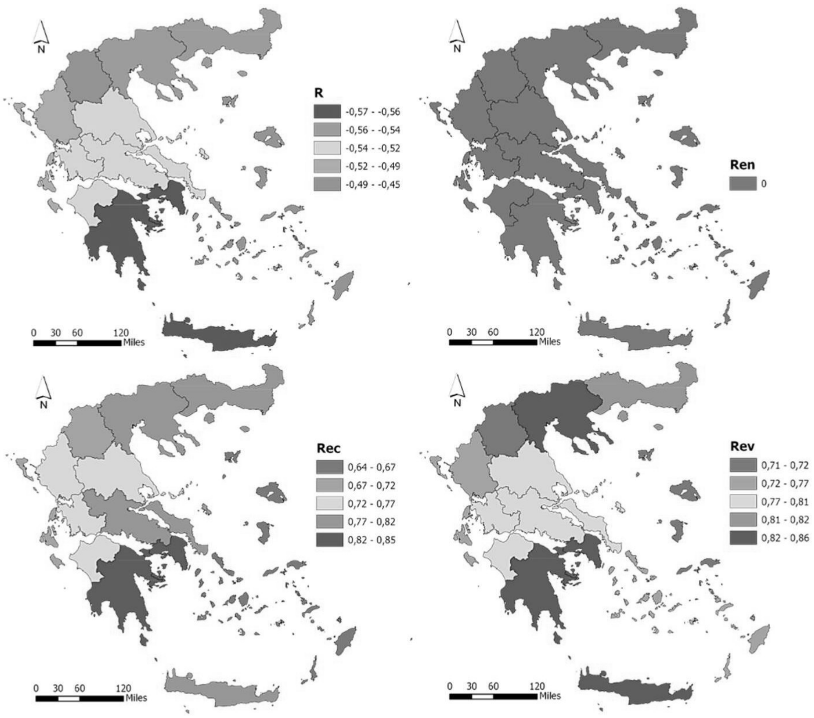
**Table 2**
**Results of the calculation of the 3D tourism resilience index for the NUTS II regions of Greece**

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

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

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

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

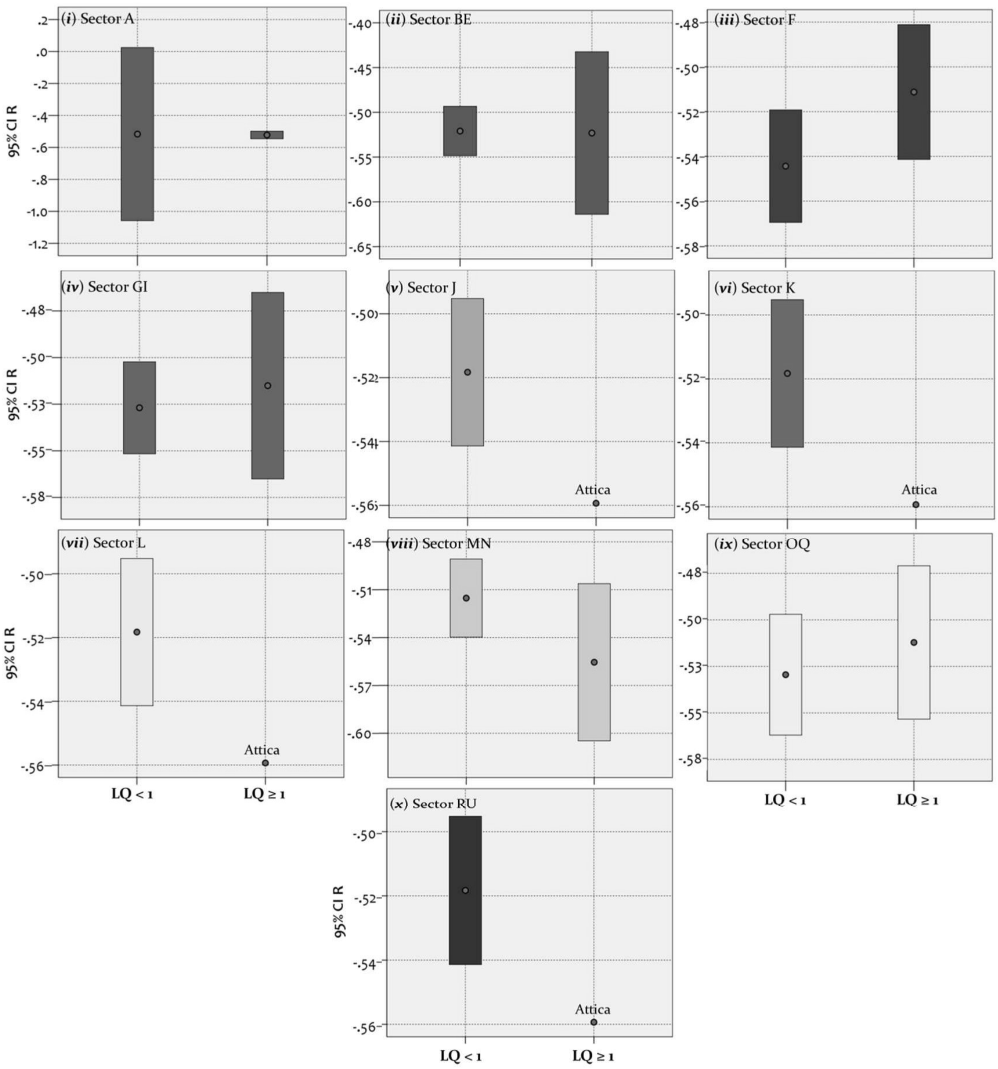



The next part of the analysis concerns the error bar calculations, which compare the temporal 'baseline' performance of economic sectors with the levels of either the scalar resilience index (Figure 2) or the ecological (Figure 3) and evolutionary (Figure 4) components of the 3D index (the engineering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

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

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

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




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

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

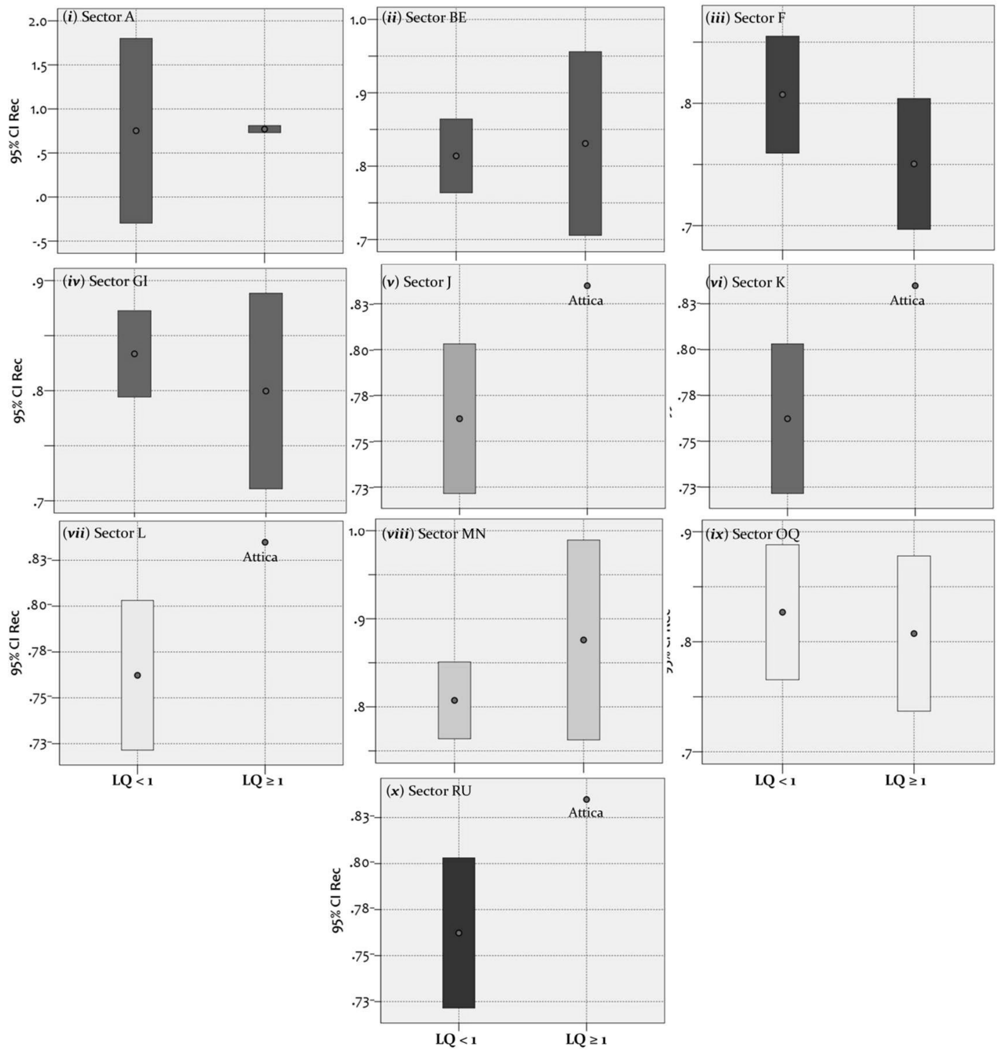
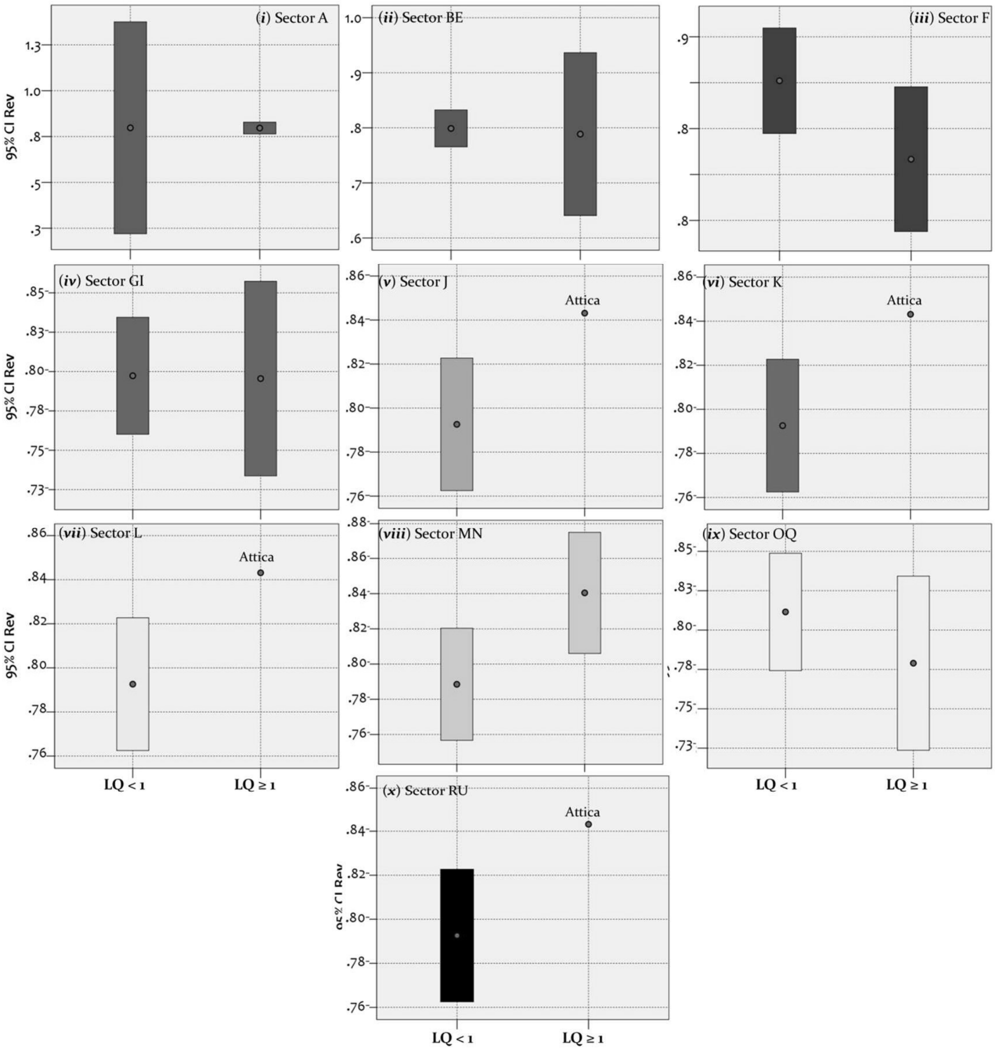


**Figure 4. Error bar charts with 95% confidence intervals of the mean values of the evolutionary resilience ($R_{ev}$) component for the regions of Greece, comparing those specialized ($LQ \geq 1$) and not specialized ($LQ<1$) in the 10 sectors of Table 1.**

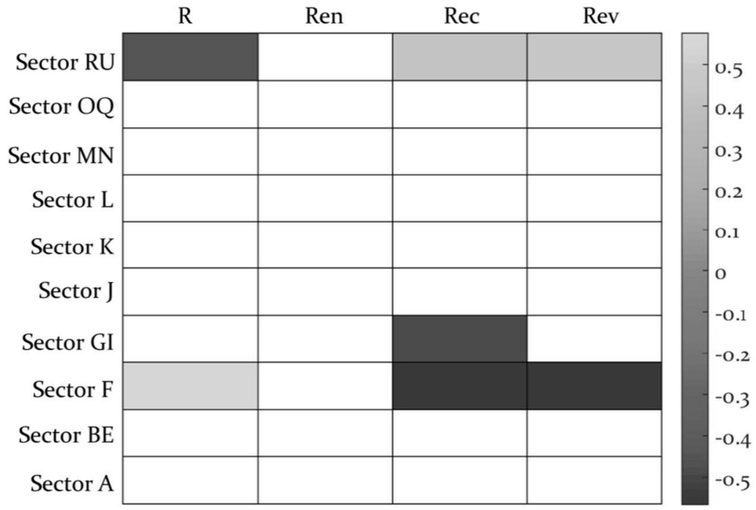



Next, in Figure 2*ix*, we can observe that the regions that are not specialized in sector OQ (public administration and defense, compulsory social security, education, human health and social work activities) showed a slight tendency toward higher tourism resilience. This trend may be interpreted based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

Furthermore, the error bar patterns shown in Figures 3 and 4 are complementary to those in Figure 2. Given the zero values for engineering resilience (indicating an inability of tourism to recover following the 2008 economic crisis), the results in Figures 3 and 4 initially suggest that specialization in sector J (information and communication), K (financial and insurance activities), L (real estate management), and RU (arts, entertainment, recreation, and other activities) is positively associated with both ecological (shift to a new state of functionality) and evolutionary (ongoing adaptability of the regional economy induced by disruption) tourism resilience. On a second reading, given that the Attica region formed the single unit in the statistically significant cases examined, the tourism resilience factors that were detected from the analysis cannot be separated from the economic and tourism development model exemplified by Attica. The tourism development model of the metropolitan Attica region is based on (Tsiotas et al., 2020, 2021; Polyzos, 2023) mechanisms of economies of scale, agglomeration economies, knowledge and information economies, and the relative differentiation of the region's tourism product from the mass 3S (sea, sun, sand) model.

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

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




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

## 4. CONCLUSIONS

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

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

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

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