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Τόμος XXXVII Τεύχος 1-2 Ιανουάριος – Δεκέμβριος 2025


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**ATHENS - ΑΘΗΝΑΙ, 2025**

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# ARCHIVES OF ECONOMIC HISTORY

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# A GEOTHERMAL-FOCUSED ENERGY SECURITY INDEX: CONCEPTUAL FRAMEWORK AND GLOBAL BENCHMARKING OF 35 COUNTRIES

N. KONTOULIS* J. A. PARAVANTIS**

## Abstract

Energy security is increasingly assessed with composite indicators for cross-country comparison and policy benchmarking, yet existing indices often face challenges in conceptual coherence, data heterogeneity, and methodological transparency. This paper develops a Geothermal-focused Energy Security Index (GESI) that benchmarks multidimensional energy security across 35 countries using a 2020 baseline. The index operationalizes seven dimensions —physical availability, technology development, economic affordability, social accessibility, governance, manmade threats, and natural environment— through 33 indicators. Indicators are standardized using z-scores, aggregated into dimension subindices via simple averaging, and combined into an overall score using dimension weights determined through expert consultation. Baseline results show consistently high performance among Scandinavian countries and the United States, whereas lower scores are typically associated with weaker governance and technology-related conditions and/or higher exposure to manmade threats. Beyond country rankings, the GESI provides a transparent measurement architecture that makes the concept-to-indicator mapping explicit and supports cautious interpretation given the sample-relative nature of standardized benchmarking.

*JEL Classification: F52, Q48, C43*

*Keywords: Energy security, Geothermal energy, Composite index, Governance and risk, Indicator-based assessment*

## 1. Introduction

Energy security is widely recognized as a pillar of human security and has become a central concern for policymakers, businesses, and scholars (Sovacool & Mukherjee, 2011). Its prominence has grown in the twenty-first century (Yergin, 2006) as energy systems have been shaped by interacting pressures: price volatility and market complexity (Vivoda, 2010; Chester, 2010), the

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dependence of industrial economies on reliable energy for growth (Bielecki, 2002; Le & Nguyen, 2019), intensifying demand and competition (Vivoda, 2010), geopolitical conflict and disruptions in oil markets (Jonsson et al., 2015; Nance & Boettcher, 2017; Löschel, Moslener, & Rübbelke, 2010; Hedenus, Azar, & Johansson, 2010), and the accelerating constraints of climate change (Toke & Vezirgiannidou, 2013; Kim, 2014; Cevik, 2022).

These developments reinforce that energy security is not only a supply issue but a multidimensional policy challenge with economic, geopolitical, and environmental implications. Recent work also emphasizes that the rapid advancement of emerging energy technologies has become an additional driver pushing energy security higher on policy agendas (van Greevenbroek et al., 2025; Zhao, Li, and Zhang, 2024). In this context, geothermal energy is increasingly discussed as a security-relevant option because it can support stable low-carbon energy provision, while technological advances —particularly enhanced geothermal systems— may broaden applicability beyond conventional hydrothermal settings (Kassem & Moscariello, 2025).

Despite its widespread use, energy security remains difficult to define precisely. It has been described as complex, multifaceted, and dynamic (Sovacool, 2013), and the literature provides no single universally accepted definition (Yergin, 2006; Ang, Choong, & Ng, 2015; Augutis et al., 2020). Definitions and priorities differ across countries because of variation in resource endowments, political and economic structures, geography, and international relations (Luft & Korin, 2009; Chester, 2010; Winzer, 2012). This diversity has expanded the conceptual landscape: Sovacool (2011) reported at least 45 comparable definitions, while Ang, Choong and Ng (2015) identified 83 definitions. The proliferation is not merely academic; it affects how energy security is operationalized and measured.

Even so, several recurring elements can be identified. A widely cited definition emphasizes "*adequate, reliable supplies of energy at reasonable prices*" while explicitly adding that this must occur without jeopardizing "*national values or objectives*" (Yergin, 1988). Many definitions also converge on concepts such as reliable supply, affordability, availability, and diversity, while often underemphasizing risk-oriented concepts such as threat, disruption, vulnerability, robustness, and resilience (Martišauskas, Augutis, & Krikštolaitis, 2018). This gap matters because it shapes indicator selection and the interpretation of composite indices.

Institutional definitions reflect a similar evolution. The International Energy Agency (IEA) defines energy security as the uninterrupted availability of energy sources at an affordable price and distinguishes between short-term

responsiveness to supply-demand shocks and long-term investment adequacy aligned with economic and environmental requirements (IEA, 2011; Jewell, 2011; Kisel et al., 2016). The European Commission further extended this framing by linking uninterrupted availability and affordability with environmental concerns and sustainable development (EC, 2000). At the same time, energy security priorities vary by a country's position in the energy chain: exporters often focus on security of demand, importers on security of supply and diversification, and transit states on their strategic role in connecting producers and consumers (Luft & Korin, 2009; Johansson, 2013). Countries may also share vulnerabilities under certain conditions, such as exposure to oil-price dynamics and fiscal pressures (Raghoo et al., 2018).

This multidimensional framing has become increasingly relevant under energy transition conditions, where the deployment of renewable and low-carbon technologies can affect diversity, emissions, and resilience to disruptions, while also depending on costs, institutional settings, and social acceptance (Hartley & Medlock, 2017; Bourcet, 2020; Chu et al., 2023). Against this background, the present paper develops and applies a transparent, index-based approach to benchmarking geothermal-oriented energy security conditions in 2020. Specifically, it (i) specifies a multidimensional index architecture that links conceptual dimensions to indicator families, (ii) documents the computation pipeline to support comparability and reproducibility, and (iii) reports baseline cross-country results that enable a diagnostic interpretation of strengths and constraints across dimensions.

The remainder of the paper is organized as follows: Section 2 provides a focused review of energy security dimensions and indicator-based frameworks; Section 3 describes the index design, data, and computation procedure; Section 4 presents baseline results and discusses implications and limitations; and Section 5 concludes.

## 2. Literature review

Energy security frameworks differ in dimensional scope and indicator choices, which can limit comparability across studies (Ang, Choong, & Ng, 2015). Evidence from the literature also suggests uneven emphasis across the dimensions of energy security: availability is most frequently represented, followed by affordability, efficiency, and environmental stewardship, with each dimension mapping onto distinct indicator families (Brown et al., 2014). The "four As" framework —availability, affordability, accessibility, and acceptability— provides a widely used organizing baseline (APERC, 2007; Hughes & Shupe,

2010), yet many studies extend beyond it to incorporate technology development, governance, and social and environmental stewardship, while warning that indices can suffer from narrow scope, hidden assumptions, and snapshot bias when methodological choices are not transparent (Sovacool & Mukherjee, 2011; Sovacool, 2013). Renewable energy is relevant across multiple dimensions by supporting diversification and emissions reduction, while also introducing constraints linked to variability, infrastructure needs, and social acceptance (Sovacool & Rafey, 2011; Knox-Hayes et al., 2013; Chu et al., 2023; Stigka, Paravantis & Mihalakakou, 2014; Paravantis et al., 2018).

## 2.1. Rationale and scope of energy security indices

A transparent, reproducible energy security index enables systematic comparison of national performance. The literature has produced a wide range of empirical and conceptual assessments that differ in dimensions, methods, and coverage. A useful classification is by geographical scope: (a) global indices covering many countries (WEF, 2016; WEC, 2018), (b) regional indices focusing on specific areas such as the Asia Pacific (Vivoda, 2010; Sovacool, 2011) or the EU (Le Coq & Paltseva, 2009), including indices tailored to specific country groupings (IEA, 2007), and (c) national-level indices developed for individual countries (Zhang et al., 2013; Lyke et al., 2021). These choices typically reflect both data constraints and the policy questions an index is intended to address.

Index designs also differ in complexity, often reflected in the number of indicators used. While single indicators capture specific aspects of energy security, composite indices combine multiple metrics to represent interdependent components and support multidimensional benchmarking (Yu, Li, & Yang, 2022). Greater complexity can improve conceptual coverage, but it increases the burden of data collection, harmonization, and cross-country comparability. Designing an index therefore requires explicit decisions on dimensional scope and on how concepts are translated into measurable proxies.

## 2.2. Selecting energy security indicators

A central strand of research focuses on choosing indicators that align with the underlying definition and conceptual framework (Song, Zhang, & Sun, 2019). Recent studies have proposed multidimensional metrics to conceptualize and measure energy security (Ren & Sovacool, 2014), and indicator sets are commonly used for cross-country comparisons and performance monitoring (Ang, Choong, & Ng, 2015). However, without clear selection criteria, it remains

difficult to assess whether countries respond adequately to evolving challenges such as climate change, energy transition pressures, and socio-economic constraints (Esfahani et al., 2021).

Most energy security indices rely on multiple indicators to capture multidimensionality (Gasser, 2020), but this creates a parsimony versus stability trade-off. Small indicator sets can make indices highly sensitive to changes in single variables, raising stability concerns (Ang, Choong, & Ng, 2015). Conversely, large sets increase data demands and can obscure redundancy if highly correlated indicators effectively double-count similar phenomena. Cross-country heterogeneity further complicates indicator choice, since differences in resources, political and economic structures, geography, and international relations often lead studies to adopt disparate indicator sets (Gasser, 2020).

To support transparent selection, Foxon et al. (2002) propose retaining indicators that satisfy at least one of five criteria: comprehensiveness, applicability, tractability, transparency, and practicability. Applying such criteria helps reduce ad hoc choices and strengthens interpretability and policy relevance.

## 2.3. Patterns and limitations in existing energy security indices

Existing indices frequently adopt broad —often global— coverage, consistent with viewing energy security as a geopolitical issue in a world of widespread import dependence (Gasser, 2020). At the same time, many indices remain sector-specific (e.g. focusing on electricity, oil, or fossil fuels) and emphasize supply-side concerns, while incorporating geopolitical relationships and trade flows inconsistently and underrepresenting dimensions such as sustainability, equity, and efficiency (Ren & Sovacool, 2014; Gasser, 2020). Geographical coverage is also uneven, with European, Asian, and North American cases more commonly included than South American and African countries (Gasser, 2020).

Illustrative approaches include indices focused on external supply risk that combine diversification, supplier political risk, transit risk, and disruption impacts (Le Coq & Paltseva, 2009), as well as vulnerability indices emphasizing intensity, import dependence, emissions content, electricity supply weaknesses, and transport-fuel diversity (Gnansounou, 2008). Institutional approaches distinguish price-related and volume-related components of insecurity (IEA, 2007). Sustainability benchmarks such as the Environmental Performance Index can complement energy security assessments that include environmental dimensions (Wolf et al., 2022), while global frameworks such as the World Energy Trilemma Index benchmark energy security alongside equity and environmental sustainability (WEC, 2022).

Two implications follow: first, multidimensional indices require explicit concept-to-indicator mapping so that readers understand what is captured — and what is not; second, methodological choices (selection, normalization, aggregation, weighting) must be reported transparently to avoid "Trojan horse" indices whose assumptions are hidden behind a single composite score (Sovacool, 2013). A recent study (Zhang, Sovacool, and Wei, 2026) highlights persistent fragmentation in energy security measurement and calls attention to the need for comparability across studies and country contexts; notably, it retained 1,489 relevant sources, of which 245 explicitly reported quantitative energy security metrics. This motivation is particularly relevant for geothermal energy, where security-relevant outcomes depend not only on subsurface potential but also on enabling conditions —such as technology readiness and system integration constraints— that are captured by multidimensional indicators (Kassem & Moscariello, 2025). These considerations motivate the index architecture and indicator selection approach adopted in this study.

## 3. Methodology

This study develops a Geothermal Energy Security Index (GESI) to benchmark multidimensional energy security across countries using a transparent, replicable computation pipeline accounting for the impact of geothermal energy. Indicator-based composite methods are appropriate for energy security because the concept cannot be meaningfully represented by a single metric and is typically decomposed into multiple dimensions (Gasser, 2020; Ang, Choong, & Ng, 2015). Consistent with the argument that no single indicator captures all aspects of energy security (Kruyt et al., 2009), the GESI combines a parsimonious indicator set within each dimension and aggregates these into subindices and an overall score.

### 3.1. Scope, unit of analysis, and data year

The unit of analysis is the country. The index is computed for a baseline year (2020) for a sample of 35 countries, including 26 EU member states and a set of non-EU countries central to global energy markets and geopolitical dynamics (Iceland, Norway, Switzerland, the United Kingdom, the United States, Russia, China, India, and Turkey). This country-level focus is consistent with the view that energy planning, policymaking, and most energy statistics remain nationally grounded (Brown et al., 2014).

## 3.2. Index architecture: Dimensions and indicators

The GESI comprises seven dimensions operationalized through 33 indicators. Dimension and indicator selection was guided by: (i) prior work on energy security measurement and index design (Paravantis, 2021; Paravantis, 2019; Paravantis et al., 2018), (ii) the literature review synthesized in Section 2, and (iii) data feasibility and coverage constraints. Data were compiled from a mix of open and selected commercial sources, including EIA, CIA World Factbook, BP Statistical Review, WIPO, WEF, the World Bank, Enerdata, WEC, the Economist Intelligence Unit, Our World in Data, Transparency International, ITU publications, and the Global Economy dataset. Given debates about indicator reliability in energy policy contexts (Radovanović, Filipović & Pavlović, 2017; Gogtay & Thatte, 2017), reliability and consistency were treated as primary criteria for indicator inclusion and country coverage.

The seven dimensions are defined as follows:

1. **Physical availability:** adequacy of supply as a foundation for economic activity and welfare (Ren & Sovacool, 2014; Blum & Legey, 2012), while recognizing that in export-dependent contexts security of demand may be salient (Sovacool & Brown, 2010; Azzuni & Breyer, 2017). It is operationalized through six indicators reflecting production capacity, resource endowment, and electricity system output and trade: total energy production in 2020 (quadrillion BTUs, quad) from the U.S. Energy Information Administration (EIA); proven oil reserves (billion barrels, bb) from the Global Economy dataset; electricity generation from fossil fuels (share of total installed capacity, %) from the CIA World Factbook; renewable energy generation (TWh) from the BP Statistical Review; electricity exports (TWh) from the Global Economy dataset; and net electricity generation (TWh) from Eurostat Statistics. Together, these indicators proxy both the scale and composition of national energy production and electricity generation, as well as the capacity to supply (and, where relevant, export) electricity within the baseline year.
2. **Technology development:** innovation and transition readiness shaping the feasibility and diffusion of new energy options, including geothermal enabling factors (APERC, 2007; Chamorro et al., 2014). It is operationalized through seven indicators spanning innovation systems, investment in knowledge creation, transition progress, renewable penetration, and geothermal technical potential: the Global Innovation Index (GII) (0–100) from the World Intellectual Property Organization (WIPO); gross domestic expenditure on R&D (% of GDP) from the Global Economy dataset; the

Energy Transition Index (ETI) (0–100) from the World Economic Forum (WEF); share of energy from renewable sources (RES) (% of gross final energy consumption) from Eurostat; geothermal share (%) from the International Renewable Energy Agency (IRENA); installed electricity generation capacity (GW) from the Global Economy dataset; and geothermal power capacity potential (GW), representing technical potential at depth ranges of 3 to 5, 3 to 7, and 3 to 10 km, based on the assessment of Chamorro et al. (2014). Together, these indicators proxy both the innovation and transition environment in which geothermal and other low-carbon technologies can scale, as well as the resource-related technical opportunity set specific to geothermal energy.

3. **Economic affordability:** capacity to provide energy services at stable and reasonable costs, with attention to efficiency and price exposure (Ang, Choong, & Ng, 2015; Böhringer & Bortolamedi, 2015; Azhgaliyeva, Liu, & Liddle, 2020; Azzuni & Breyer, 2017). It is operationalized using three indicators that proxy economic capacity, energy-efficiency performance, and end-user price conditions: GDP per capita (current US$) from the World Bank; energy intensity, defined as total physical primary energy supply (TPES) relative to GDP (koe/$15p, PPP-adjusted), from Enerdata (World Energy & Climate Statistics) (Böhringer & Bortolamedi, 2015); and the average electricity price per kWh (US$/kWh) from cable.co.uk. Together, these indicators capture both the macroeconomic ability to afford energy services and structural efficiency in energy use, while accounting for price exposure at the point of consumption.
4. **Social accessibility:** equity and institutional conditions relevant to broad access to affordable and reliable energy services. It is operationalized through four indicators that jointly proxy energy access and distributional/institutional context: energy equity (0–100) from the World Energy Council (WEC), which reflects universal access to electricity and clean cooking as well as affordability and prosperity-enabling energy use (Ren & Sovacool, 2014); the Democracy Index (0–10) from the Economist Intelligence Unit (2022), capturing pluralism, civil liberties, and political culture; the GINI income inequality index (0–1) from Our World in Data; and electricity imports (TWh/year) from the Global Economy dataset. Together, these indicators represent both the inclusiveness of energy service provision and institutional/distributional conditions that influence affordability and access outcomes.
5. **Governance:** institutional capacity to manage the energy sector and mitigate risks, including the role of stability and corruption-related proxies (Ren & Sovacool, 2014; Ang, Choong, & Ng, 2015). It is operationalized

through three indicators reflecting political stability, security-related state capacity, and integrity of public institutions: the Political Stability Index (−2.5 to 2.5) from the Global Economy dataset, which proxies the likelihood of destabilization or government overthrow through unconstitutional or violent means and is relevant for energy supply security given the role of governments in shaping supply conditions (Kruyt et al., 2009); military spending (% of GDP) from the Global Economy dataset, reflecting security capacity and the strategic energy–security interdependence; and the Corruption Perceptions Index (CPI) (0–100) from Transparency International, capturing perceived public-sector corruption and associated governance quality. Together, these indicators represent institutional stability and governance integrity conditions that can influence both the robustness of energy systems and the credibility of policy and investment environments.

6. **Manmade threats:** exposure to political violence, fragility, external intervention, and cyber vulnerability affecting energy infrastructure. It is operationalized through five indicators: the Security Threats Index (Global Economy dataset), capturing conflict- and crime-related threats such as attacks, terrorism, coups, and organized crime; the External Intervention Index (Global Economy dataset), reflecting the influence of external actors on state security and economic performance; the Fragile States Index (Global Economy dataset), which summarizes multidimensional vulnerability using conflict-risk and governance-related components; the Global Cybersecurity Index (GCI) (Global Economy dataset; originally developed by the International Telecommunication Union), capturing national commitment and capacity in cybersecurity — a critical consideration given the increasing digital dependence of modern energy infrastructures (ITU, 2021); and coastline percentage from the CIA World Factbook, used as a proxy for strategic geography and maritime access considerations that can shape security exposure and resilience (Germond, 2015). Together, these indicators represent manmade and institutional risk conditions that can affect both the physical protection and the operational continuity of national energy systems.
7. **Natural environment:** environmental constraints and sustainability performance shaping feasible energy-system choices. It is operationalized through five indicators reflecting emissions pressure, decarbonization of electricity, land characteristics, and broader sustainability performance: $CO_2$ emissions per capita (tonnes per capita) from Our World in Data; carbon intensity of electricity ($gCO_2e/kWh$) from Our World in Data; agricultural land share (%) from the CIA World Factbook; forest land share (%) from the CIA World Factbook; and an Environmental Sustainability Index

(World Energy Council), reflecting progress in energy-system sustainability (including efficiency/productivity of the power system, decarbonization, and air-quality-related performance) as embedded in the World Energy Trilemma framework (WEC, 2018). Together, these indicators represent both direct emissions outcomes and structural/environmental characteristics relevant to evaluating the environmental dimension of energy security.

## 3.3. Index computation: Standardization, aggregation, and weighting

To compute the Geothermal Energy Security Index (GESI), we implement a stepwise composite-indicator procedure that transforms the 33 indicators into seven dimensional subindices and an overall score. The computation follows three stages: (i) standardizing indicators to ensure comparability across units and scales, (ii) aggregating standardized indicators within each dimension to obtain subindices, and (iii) combining the subindices into the overall index using an expert-informed weighting scheme. The methodological details for each stage are described below.

### 3.3.1. Normalization of indicators

Normalization is required because the raw indicators differ in measurement units and numerical ranges; without normalization, indicators with larger scales may dominate the composite score. Converting indicators to a common scale therefore enables meaningful cross-country comparison and aggregation (Ang, Choong, & Ng, 2015; Narula et al., 2017; Amin et al., 2021). Prior work shows that normalization choices vary across studies depending on sample size, indicator sets, and design decisions (Abdullah et al., 2021). Among common approaches (e.g. distance-to-reference, min–max rescaling, and banding), we adopt z-score standardization, which is widely used in energy security index studies and is particularly suitable for multi-country assessments (Ang, Choong, & Ng, 2015; Gasser, 2020; Martchamadol & Kumar, 2012).

Z-score standardization is a linear transformation that produces a normalized distribution with mean zero and standard deviation one, preserving the original distributional structure and avoiding fixed bounds that can be sensitive to extreme values (Gasser, 2020). Z-scores indicate the normalized distance of data points from the mean in terms of standard deviation units. As noted by Ang, Choong, and Ng (2015), z-scores are useful for relatively large country samples (here, 35 countries) because they express each country's performance in standard deviation units relative to the sample mean. This facilitates

identification of countries that diverge from broader patterns and supports comparison across heterogeneous indicators.

To ensure interpretability, we aligned indicator direction so that higher standardized values consistently represent "better" energy security performance within a dimension. For indicators where higher raw values imply poorer outcomes (e.g. higher energy intensity, higher emissions, or higher threat exposure), we applied sign reversal during subindex construction so that they contribute negatively (Kruyt et al., 2009). This "polarity alignment" is essential for avoiding contradictory interpretations when aggregating multiple metrics.

Composite index construction is typically constrained by data availability; therefore, indicators and country coverage were selected to maximize feasible and comparable data inputs. At the same time, because the index uses multiple indicators, sensitivity to changes in any single indicator is reduced relative to very small indicator sets. In line with Brown et al. (2014), we used z-score standardization as the principal normalization step to mitigate scale effects and enhance comparability across the set of indicators.

### 3.3.2. Aggregation within dimensions

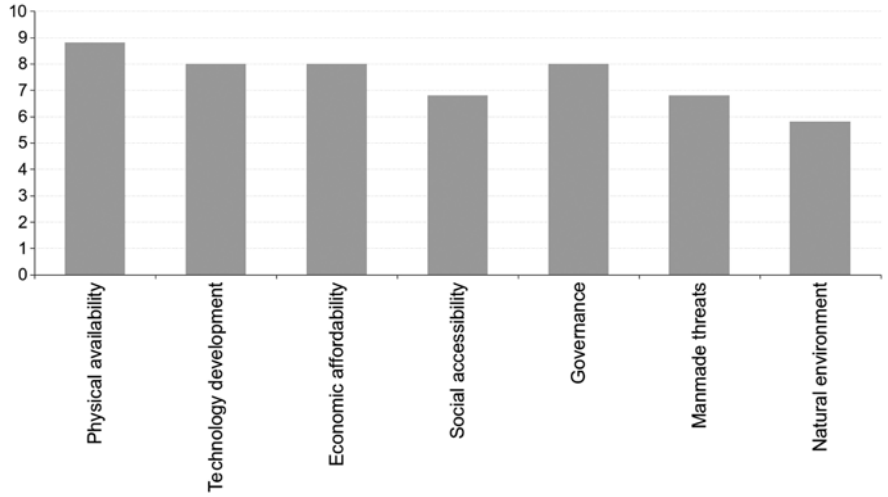
After normalization, we aggregated standardized indicators within each dimension to compute seven dimensional subindices. Aggregation is the process of combining multiple indicators into a single score, enabling interpretation at the dimension level and serving as an intermediate step toward the overall composite index.

Within each dimension, indicators were aggregated using simple additive aggregation (arithmetic mean) without indicator-level weights. This approach prioritizes transparency and interpretability and avoids introducing additional assumptions through indicator weighting at the lower level (Song, Zhang, & Sun, 2019). Additive aggregation is also widely used in the energy security index literature; Song, Zhang, and Sun (2019) report that it is applied in the majority of existing studies, partly because it is straightforward to implement and communicate (Gasser, 2020). In methodological terms, additive aggregation is consistent with the general premise that a composite indicator can be expressed as a weighted combination of underlying series (Rodríguez-Fernández, Carvajal, & Ruiz-Gómez, 2020), provided that scaling and directionality are handled appropriately.

### 3.3.3. Weighting and aggregation across dimensions

To compute the overall index, we combined the seven dimensional subindices using dimension weights. In the composite-indicator literature, weights

**Figure 1: Average expert dimension weights**




can be derived through objective procedures (e.g. PCA, Data Envelopment Analysis, Analytic Hierarchy Process, or equal-weighting rules) or through subjective/knowledge-elicitation approaches (e.g. structured surveys or expert judgement). The present study uses an expert-informed weighting scheme to reflect the relative importance of the seven dimensions, while documenting the approach for transparency. Specifically, a panel of experts rated the relative importance of each dimension on a common scale. The mean importance scores used as dimension weights in the aggregation step were: physical availability 8.8; technology development 8.0; economic affordability 8.0; social accessibility 6.8; governance 8.0; manmade threats 6.8; and natural environment 5.8; and are shown in Figure 1.

The overall GESI score is computed as a weighted average of the seven subindices (i.e. the weighted sum divided by the sum of weights), ensuring comparability across countries within the baseline sample. We recognize that any weighting structure embeds normative judgments and may not be equally appropriate for all country contexts or periods. Accordingly, the weights should be interpreted as a pragmatic specification that supports baseline benchmarking rather than a universally "optimal" weighting structure.

# 4. Results

This section reports baseline findings from the Geothermal Energy Security Index (GESI) for 2020, focusing on overall country rankings and the main patterns observed across the seven dimension subindices.

## 4.1. Country sample

Energy security is inherently relational: at some point along the energy supply chain, almost all countries depend on external products, inputs, or flows (Gasser, 2020). Following Brown et al. (2014), we therefore apply the GESI at the country level rather than to regional aggregates, since national governments remain the primary locus of energy planning and policymaking, and most widely used energy statistics are compiled on a national basis.

The sample includes 35 countries: 26 European Union member states and a set of non-EU countries that are central to global energy markets and geopolitical dynamics (Iceland, Norway, Switzerland, the United Kingdom, the United States, Russia, China, India, and Turkey). Together, these countries accounted for 66.6% of global energy consumption in 2020 (China 26.1%, United States 15.8%, Europe 13.9%, India 5.7%, Russia 5.1%) (BP, 2021). They also contributed 67.3% of global $CO_2$ emissions (China 30.7%, United States 13.8%, Europe 11.1%, India 7.1%, Russia 4.6%), and 79.1% of global renewable energy generation (Europe 29.3%, China 27.4%, United States 17.5%, India 4.8%, Russia 0.1%) (BP, 2021). These shares indicate that the sample captures a substantial portion of global energy and emissions outcomes, making it suitable for benchmarking multidimensional energy security conditions in 2020. Because the index is constructed from standardized indicators, results should be interpreted as comparative (sample-relative) performance within the 35-country set.

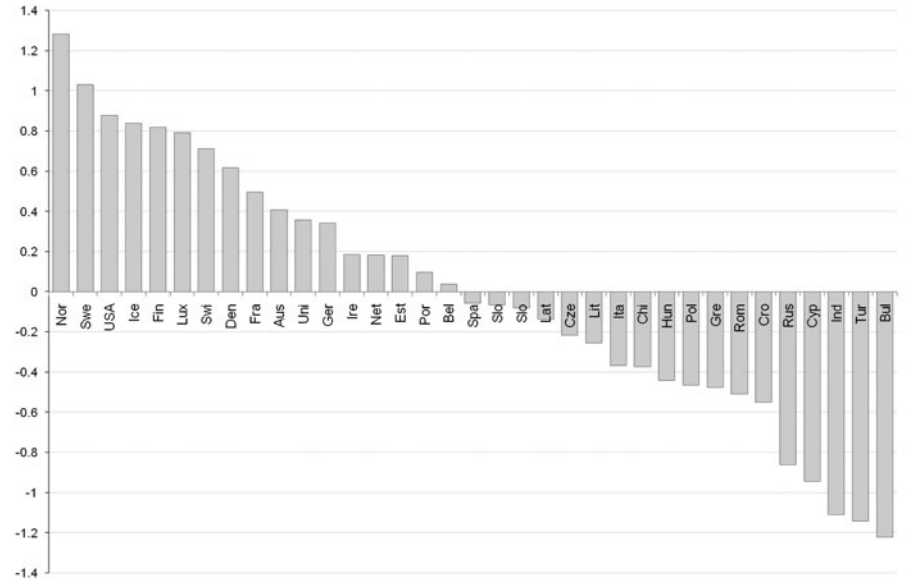
## 4.2. Overall index rankings

The GESI combines seven subindices —physical availability, technology development, economic affordability, social accessibility, governance, man-made threats, and natural environment— into a single composite score. Overall GESI scores and the corresponding dimensional subindices are summarized in Table 1. Figure 2 presents the same ordering by plotting countries' overall GESI scores for 2020 from highest to lowest.

**Table 1: Baseline GESI rankings (2020) and dimensional subindices for the 35-country sample**

| Ranking | Countries | Physical availability subindex | Technology development subindex | Economic affordability subindex | Social accessibility subindex | Governance subindex | Manmade threats subindex | Natural environment subindex | Energy security index |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Norway | 0.570 | 1.041 | 1.872 | 1.426 | 1.968 | 1.664 | 0.330 | 1.283 |
| 2 | Sweden | 0.607 | 1.849 | 0.881 | 0.919 | 1.032 | 1.005 | 0.916 | 1.031 |
| 3 | USA | 2.537 | 1.266 | 1.068 | −1.863 | 1.141 | 0.596 | 0.738 | 0.877 |
| 4 | Iceland | −0.180 | 2.646 | 1.192 | 1.778 | 0.060 | 0.662 | −0.421 | 0.838 |
| 5 | Finland | −0.191 | 1.065 | 0.962 | 0.682 | 1.315 | 0.888 | 1.218 | 0.820 |
| 6 | Luxembourg | −0.350 | −0.569 | 2.346 | 0.734 | 0.618 | 0.936 | 2.402 | 0.793 |
| 7 | Switzerland | 0.452 | 1.323 | 0.819 | 0.190 | 0.971 | 0.452 | 0.688 | 0.713 |
| 8 | Denmark | −0.079 | 1.288 | −0.972 | 0.882 | 1.264 | 1.610 | 0.570 | 0.617 |
| 9 | France | 1.164 | 0.264 | 0.290 | 0.146 | 0.162 | 0.593 | 0.852 | 0.497 |
| 10 | Austria | 0.064 | 0.920 | −0.062 | 0.270 | 0.214 | 0.494 | 1.210 | 0.409 |
| 11 | United Kingdom | −0.236 | 0.585 | 0.141 | 0.036 | 0.914 | 0.783 | 0.352 | 0.357 |
| 12 | Germany | 1.089 | 0.643 | −0.808 | −0.504 | 0.572 | 0.927 | 0.384 | 0.344 |
| 13 | Ireland | −0.877 | −0.264 | 1.059 | 1.169 | −0.324 | 0.633 | 0.232 | 0.185 |
| 14 | Netherlands | −0.556 | 0.270 | −0.393 | 0.669 | 0.957 | 0.830 | −0.424 | 0.182 |
| 15 | Estonia | −0.839 | 0.255 | 0.354 | 0.500 | 1.211 | 0.653 | −0.959 | 0.181 |
| 16 | Portugal | −0.540 | −0.165 | −0.059 | 0.132 | 0.577 | 1.002 | −0.120 | 0.098 |
| 17 | Belgium | −0.296 | 0.143 | −0.674 | 0.656 | −0.060 | 0.390 | 0.389 | 0.039 |
| 18 | Spain | −0.137 | −0.396 | −0.004 | −0.037 | −0.538 | 0.480 | 0.472 | −0.057 |
| 19 | Slovakia | −0.185 | −0.991 | 0.348 | 0.600 | −0.381 | −0.087 | 0.510 | −0.065 |
| 20 | Slovenia | −0.366 | −0.327 | −0.261 | 1.086 | −0.542 | −0.212 | 0.373 | −0.079 |
| 21 | Latvia | −0.572 | −0.116 | −0.115 | −0.051 | 0.030 | −0.074 | 0.074 | −0.135 |
| 22 | Czech Republic | −0.314 | −0.478 | −0.316 | 0.749 | −0.320 | −0.960 | 0.318 | −0.216 |
| 23 | Lithuania | −0.600 | −0.525 | −0.856 | −0.289 | 0.622 | −0.305 | 0.362 | −0.255 |
| 24 | Italy | −0.602 | −0.239 | 0.198 | −0.955 | −0.803 | −0.097 | −0.002 | −0.368 |
| 25 | China | 3.359 | 0.950 | −1.310 | −2.18 | −1.998 | −1.140 | −1.304 | −0.372 |
| 26 | Hungary | −0.498 | −0.717 | −0.195 | −0.225 | −0.415 | −0.846 | −0.122 | −0.440 |
| 27 | Poland | −1.002 | −1.168 | 0.587 | −0.322 | 0.082 | −0.303 | −1.235 | −0.464 |
| 28 | Greece | −0.706 | −1.061 | −0.427 | 0.099 | −0.238 | −0.613 | −0.237 | −0.477 |
| 29 | Romania | −0.459 | −1.039 | 0.392 | −0.568 | −0.656 | −1.297 | 0.106 | −0.508 |
| 30 | Croatia | −0.601 | −0.587 | −1.360 | 0.198 | −0.643 | −0.221 | −0.428 | −0.549 |
| 31 | Russian Federation | 1.566 | −1.395 | −2.411 | −1.340 | −0.907 | −1.633 | −0.143 | −0.861 |
| 32 | Cyprus | −1.315 | −1.052 | −1.007 | 0.614 | −0.342 | −1.249 | −2.451 | −0.945 |
| 33 | India | 1.335 | −1.133 | −0.524 | −2.065 | −1.779 | −1.730 | −2.814 | −1.108 |
| 34 | Turkey | −0.732 | −1.129 | 0.990 | −1.772 | −2.562 | −1.650 | −1.427 | −1.142 |
| 35 | Bulgaria | −0.512 | −1.158 | −1.748 | −1.367 | −1.201 | −2.181 | −0.410 | −1.223 |

**Figure 2: Overall Geothermal Energy Security Index (GESI) scores by country, ranked from highest to lowest (2020 baseline)**




The overall ranking places Norway, Sweden, the United States, Iceland, and Finland among the strongest performers, reflecting consistently high scores across several dimensions. By contrast, Bulgaria, Turkey, India, Cyprus, and the Russian Federation are among the lowest-ranked cases, typically due to weaker performance across multiple subindices rather than a single binding constraint.

Two broad regularities emerge. First, countries with high overall scores tend to exhibit balanced performance across institutional, economic, and technology-related dimensions, rather than relying on one exceptional strength. Second, low overall performance is more often associated with compounded vulnerabilities, where weaknesses in governance, technology development, affordability, and/or exposure to manmade threats reinforce each other.

## 4.3. Dimension level patterns

Examining the subindices clarifies which factors drive cross-country differences in the composite ranking:

1. **Physical availability:** High performance is associated with strong production and generation capacity and/or substantial resource endowments. In this sample, China, the United States, Russia, India, and France rank highly. Lower scores are observed for countries with limited domestic resource bases and greater reliance on imports, including Turkey, Estonia, Ireland, Poland, and Cyprus.
2. **Technology development:** This subindex reflects innovation capacity, R&D effort, transition readiness, and geothermal/renewable positioning. Iceland, Sweden, Switzerland, Denmark, and the United States score strongly, while Turkey, India, Bulgaria, Poland, and Russia rank lower, indicating weaker performance in innovation/transition proxies and capacity indicators.
3. **Economic affordability:** Affordability captures economic capacity and efficiency conditions. Luxembourg, Norway, Iceland, the United States, and Ireland rank highly, while Cyprus, China, Croatia, Bulgaria, and Russia show weaker affordability performance, suggesting stronger price/efficiency constraints within the index structure.
4. **Social accessibility:** This subindex combines equity and institutional proxies with import-related dependence. Iceland, Norway, Ireland, Slovenia, and Sweden perform strongly, whereas Bulgaria, Turkey, the United States, India, and China score lower, reflecting differences in the equity and institutional measures captured.
5. **Governance:** Governance performance is highest for Norway, Finland, Denmark, Estonia, and the United States, consistent with stronger political stability and corruption-related proxies. Lower values are observed for Russia, Bulgaria, India, China, and Turkey, indicating comparatively weaker governance conditions within the index design.
6. **Manmade threats:** High scores correspond to lower threat/fragility exposure and stronger cyber-readiness proxies. Iceland, Denmark, Norway, Slovenia, and Ireland rank highly, while Romania, Russia, Turkey, India, and Bulgaria appear among the lowest performers on this dimension.
7. **Natural environment:** Environmental performance is strongest for Luxembourg, Finland, Austria, Sweden, and France, reflecting lower emissions/intensity metrics and higher sustainability proxies. Lower scores are observed for Poland, China, Turkey, Cyprus, and India, associated with higher emissions intensity and weaker sustainability-related proxies. Where environmental definitions are required, they follow the conventions of the underlying datasets (e.g. Our World in Data).

## 4.4. Discussion

Taken together, the baseline results highlight the interpretive value of a multidimensional approach to energy security: high overall rankings are rarely explained by a single advantage (such as domestic resource endowment), while low rankings seldom reflect one isolated deficit. Instead, cross-country performance reflects interacting conditions across technology capacity, affordability, governance quality, exposure to manmade threats, and environmental constraints (Ang, Choong, & Ng, 2015; Gasser, 2020).

A key interpretive point concerns the evolving balance between "traditional" security concerns and the constraints associated with contemporary energy transitions. Physical availability remains a core pillar of energy security (Kruyt et al., 2009; IEA, 2007), yet the GESI structure shows that strong performance on availability does not guarantee strong overall performance if other dimensions —such as governance, threat exposure, affordability, or environmental performance— remain limiting. This is consistent with arguments that energy security outcomes increasingly depend on institutional and system-level conditions in addition to resources (Sovacool & Mukherjee, 2011; Sovacool, 2013). From a geothermal-oriented perspective, this justifies the inclusion of technology development and transition proxies: realizing the security-relevant benefits of geothermal energy depends not only on subsurface potential but also on innovation systems, transition readiness, and enabling infrastructures and capabilities (APERC, 2007; Ren & Sovacool, 2014; Chamorro et al., 2014).

Dimension-specific patterns also offer policy-relevant diagnostics. Cases that perform strongly in technology development but less well in affordability or governance illustrate that strengthening a single pillar may not translate into higher overall security when other constraints remain binding. Conversely, countries with comparatively favorable affordability profiles but weaker technology development and transition indicators highlight the role of innovation capacity, investment conditions, and institutional readiness as enabling factors for system change. The manmade threats dimension further underlines that energy security is increasingly coupled with broader security conditions, including cyber readiness (ITU, 2021) and institutional fragility, both of which can affect physical infrastructure resilience and the credibility of the investment environment. The inclusion of coastline as a proxy for strategic geography is aligned with wider discussions of how geography conditions security dynamics (Germond, 2015), although it should be interpreted cautiously and in combination with other indicators.

For policy use, the GESI supports three complementary functions. First, it can be used diagnostically by identifying which dimensions contribute most to a country's composite performance under a clearly stated measurement architecture. Second, it encourages a "balanced performance" interpretation: gains in one dimension may be insufficient if governance-related vulnerabilities or threat exposure remain high. Third, it provides a common language for discussing trade-offs across objectives — particularly the tension that can arise between affordability and environmental performance during energy transition processes (WEC, 2022; WEF, 2021). This is directly relevant for geothermal energy: where conditions are suitable, geothermal can support domestic supply and improve emissions-related outcomes, but deployment and system integration still depend on governance capacity, permitting, finance, and broader social and institutional conditions.

Several limitations should be highlighted. First, because indicators are standardized using z-scores, index values are sample-relative and should not be interpreted as absolute levels of "security" (Gasser, 2020). Second, while the indicator set was designed to balance coverage with feasibility, cross-country assessment necessarily relies on proxies and secondary datasets; debates on indicator reliability remain relevant for interpretation (Radovanović, Filipović & Pavlović, 2017; Gogtay & Thatte, 2017). Third, additive aggregation implies compensability across dimensions —strong performance in one area can offset weaker performance in another— so alternative aggregation rules could yield different comparative patterns. Finally, dimension weights reflect expert judgement and provide a pragmatic basis for aggregation, but they may not represent the optimal weighting structure for all country contexts and periods (Paravantis, 2021; Paravantis, 2019; Paravantis et al., 2018). These limitations do not negate the index's value; rather, they clarify that the GESI should be interpreted as a transparent benchmarking framework rather than a definitive or context-free measure.

## 5. Conclusions

This study introduced a Geothermal Energy Security Index (GESI) and employed it for baseline cross-country benchmarking across 35 countries for the year 2020. Reflecting the view of energy security as a multidimensional construct (Sovacool & Mukherjee, 2011; Ang, Choong, & Ng, 2015a), the index integrates seven dimensions —physical availability, technology development, economic affordability, social accessibility, governance, manmade threats, and natural environment— captured through 33 indicators. To enable

comparability across heterogeneous units, indicators were standardized using z-scores and combined into dimension-level subindices and an overall composite score through a transparent calculation pipeline. The seven subindices were then aggregated into an overall score using an expert-informed dimension-weighting scheme documented in the methodology.

The baseline findings indicate that strong overall performance is more often linked to broadly consistent outcomes across dimensions than to a single structural advantage such as resource endowment. Conversely, weaker overall performance tends to arise from reinforcing constraints — such as gaps in technology development, affordability and efficiency conditions, governance quality, exposure to manmade threats, and environmental pressures. These results support the usefulness of multidimensional frameworks for interpreting energy security and for policy-relevant benchmarking (Kruyt et al., 2009; Gasser, 2020).

More broadly, the GESI offers a reproducible measurement architecture that makes explicit how conceptual dimensions are operationalized through indicators and how methodological choices affect comparative results. By combining a geothermal-oriented focus with a transparent concept-to-indicator mapping, the index can support cross-country diagnosis of enabling conditions and constraints relevant to strengthening energy security under low-carbon transition pressures. Interpreted with appropriate caution regarding its sample-relative nature and sensitivity to modelling assumptions, the index can serve as a transparent benchmarking tool and can help structure discussions on the enabling conditions required to strengthen energy security within evolving energy-system constraints.

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# OFFSHORE COMPANIES AND TAX HAVENS: ECONOMIC IMPLICATIONS AND TAX ACCOUNTING PERSPECTIVES – THE CASE OF GREECE

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## Abstract

In this study, the empirical investigation based on the model of Hines (2005) was carried out for the period 2000 - 2019. The purpose was to determine whether the decision of a country to become a tax haven has an effect on its economy and on the state sector. It was found that there does not seem to be a correlation with the decision to make a country a tax haven. In what has to do with the tax revenue, is negatively related to a country's decision to become a tax haven and appears to negatively affect tax revenue as a percentage of GDP. In the last regression there appears to be a negative relationship between the country's decision to become a tax haven and public spending which is statistically significant and shows that this decision negatively affects public spending as a percentage of GDP. In addition, the partial purpose of this study was to present the phenomenon of offshore companies and tax havens.

*JEL Classification: H26, H32, E26*

*Keywords: Tax accounting, Tax avoidance, Tax evasion, Offshore, Companies, Tax heaven*

## 1. Introduction

Offshore companies and tax havens represent one of the most controversial dimensions of modern tax accounting, often standing at the intersection of legal optimization and aggressive tax avoidance. These entities operate in jurisdictions that offer favorable tax treatments, minimal disclosure requirements, and often a high degree of financial secrecy. While such arrangements may serve legitimate business purposes, they also raise critical concerns related to tax evasion, money laundering, and the erosion of national tax bases.

The paper presents the phenomenon of offshore companies, their mode of operation, tax "havens", "black" money laundering procedures, tax evasion.

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The motivation behind this study stems from the ongoing global debate on the impact of tax havens on public finances and economic governance. In particular, this thesis explores the phenomenon of offshore companies, focusing on the incentives behind their formation, the criteria for selecting jurisdictions, and the broader implications for tax revenue and public spending. Emphasis is placed on the case of Greece, a country occasionally characterized in public discourse as a potential or emerging tax haven. The reasons why some choose the coastal route are many, usually the tax benefits provided by the countries that welcome such companies, the speed of their incorporation. In many cases, something that tempts many individuals and legal entities to turn to offshore companies is the anonymity they offer them, as this way money laundering phenomena that do not originate from legal activities can be concealed. To collect the required information, we are going to refer to the available literature, to research and studies that have already been conducted.

The purpose of this study is the analysis of the offshore company, by what criteria the country of establishment of this company is chosen, the general clarification of the operation of these companies. Also the purpose of the work is to study the spectrum of legality through which offshore companies move. We will do a historical review, the reasons for recommendation as well as the advantages and disadvantages will be analyzed. The concept of tax havens will also be analyzed in order to achieve a better understanding of the role of offshore companies. Finally, the research question of this thesis is whether the decision of a country to become a tax "haven" affects its economy and whether it affects the state sector and this will be done with the help of the Hines model with some modifications.

A central contribution of the study lies in the empirical assessment of whether a country's decision to adopt tax haven characteristics has measurable effects on its economic performance and state sector. Drawing on the framework of Hines (2005), and using data from the period 2000–2019, the analysis evaluates the relationship between tax haven status, tax revenue, and public expenditure. The findings suggest a negative correlation between tax haven designation and both tax revenue and public spending, highlighting potential risks associated with such a fiscal strategy. This research also contributes to the field of tax accounting by contextualizing offshore practices within the legal and fiscal landscape, offering a clearer understanding of how tax policies influence corporate behavior and public finance.

The structure of this study is organized as follows. Section 2 presents the conceptual and theoretical framework of offshore companies, including their definition, historical development, operational structure, and the legal and tax

criteria influencing their establishment. Section 3 categorizes the most common types of offshore companies and highlights their functions and tax-related implications. Section 4 explores the international classification of tax havens and the role of secrecy jurisdictions, with a focus on their legal and economic characteristics. Section 5 discusses the connection between offshore companies, tax avoidance, tax evasion, and money laundering. Section 6 shifts the focus to Greece, analyzing the domestic legal framework, the presence of offshore activity, and relevant tax accounting implications. Section 7 offers the empirical analysis. Finally, Section 8 summarizes the main findings, and Section 9 outlines the study's limitations and proposes directions for future research in the fields of tax accounting and fiscal policy.

## 2. Concept and theoretical framework of offshore companies

### 2.1 Legislation

Choosing the most suitable country for the establishment of the offshore company can be difficult and requires special attention. The choice depends on the purposes of the entrepreneur in relation to the offshore company. Thus, the criteria on the basis of which the most suitable country of establishment is selected must be examined separately in each case, depending on the needs of the entrepreneur concerned. The translation of "offshore" company has not been rendered with a single word in Greek, but the terms used in the legal texts are "outside", "overseas", "overseas" or "overseas" where it is recommended mainly in Greek Jurisprudence. An offshore company is a financial entity, regardless of legal type, that is established in economic centers with a very favorable tax regime, mainly on islands, the so-called "tax havens". "Foreign company means a company that has its headquarters in a foreign country and based on its legislation operates exclusively in other countries and enjoys particularly favorable treatment." (Law 2238/1994, Article 31,1, para.) Regardless of the translation version we use, it becomes clear that we are referring to a corporate form, in which there is a difference between the place of establishment and the place of operation and the choice of the place of establishment it is characterized as a "tax haven".

The requirements for companies to register under the relevant provision must follow certain criteria, as stated in Offshore Company Law: Theory, Regulations & Operation.

- Must be incorporated in accordance with the laws and regulations of the offshore company's jurisdictions.

- Offshore companies have their registered office in one of the "tax haven" countries.
- The operations or activities of offshore companies must be carried out exclusively outside their country of establishment and therefore all their income must derive exclusively from their operations abroad.
- These businesses are not allowed to offer products and services within the territory of the country of establishment, either to permanent residents or to foreigners. However, these companies can be managed and have a permanent establishment in these countries.

## 2.2 Historical Review

At the end of the 19th century, the first offshore companies were found, more specifically in the United States of America and in particular in New Jersey and Delaware. In the state of New Jersey, a legislative framework was established regarding the formation and establishment of companies, which would be charged only with a favorable establishment tax. The main objective of this venture was to attract companies from other states and consequently strengthen its coffers. From the 1920s, the first offshore companies appeared in Europe in Monaco, Switzerland and Liechtenstein.

In the year 1935, a very strict banking secrecy was established on the territory of Switzerland and it became a pole of attraction for several companies, trust management of funds, while it was also an example for other states that wanted to attract capital from the whole world. The geopolitical position of these regions, combined with the historical circumstances, did not particularly help, as a result of which they provide facilities to foreign entrepreneurs, to invest capital and use their territory. Later the British adopted and developed the institution in order to deal with political risks during the Second World War.

Offshore companies are primarily of Anglo-Saxon and mainly British invention and therefore many such jurisdictions are former British colonies. It begins with the creation of the Euromarket in the City of London, at the end of the 1950s and then in the overseas possessions of the British crown, mainly Bermuda, the British Virgin Islands, the Cayman Islands and Gibraltar. After the shrinking of the British empire, they became offshore jurisdictions, subject of course to British control, making the City a global financial center. At the beginning of 1970 the Bretton Woods agreement not only did not limit the movement of international capital but also rekindled flight tendencies. In this way, many companies have chosen to transfer part of the funds to offshore

companies, taking advantage of the tax advantages. Then the abandonment of the Bretton Woods agreement in 1971, following actions by President Nixon, led to the initial misjudgment of the decline of the offshore corporation institution. Something that did not pay off, but was consolidated in the world of international transactions (Runciman, 2014). Suffice it to note that today more than 50% of funds traded worldwide pass through so-called "tax havens". The offshore company sector is currently dominant in the shipping, aviation and insurance sectors. Over a million offshore companies have been set up in the last decade.

## 2.3 Advantages and Disadvantages of Offshore Companies

The most important advantage and the main distinguishing feature of offshore companies is the tripartite: Saving money – Speed – Confidentiality. In other words, it ensures the avoidance or evasion of tax obligations in other states, the quick establishment and operation of companies and the safe placement of money in secrecy, that is, without control, as would certainly happen in another country. Offshore companies are also given the opportunity to set up easily and quickly with the payment of a minimum capital. Finally, the complete anonymity of the shareholders is provided in terms of the placement of funds and the absence of control of the origin and legality of these funds. In the event that the owners of the offshore company desire additional confidentiality and anonymity, they are given the opportunity to appoint a representative - administrator, to appear and conduct for all transactions and will act on behalf of the beneficial owners. The public authority, which is responsible for the establishment and registration of offshore companies in special registers, must protect the anonymity of the offshore shareholders and owners.

The most important advantages for establishing and maintaining an offshore company are:

- Low start-up costs with minimal corporate capital.
- Complete anonymity of beneficial owners.
- Possibility of incorporation with a shareholder.
- Tax law provisions are avoided. There is no "whereabouts" and they are not burdened with presumptions for the acquisition and maintenance of the assets.
- Avoidance in many cases of paying tax on deposit interest and tax on dividends.
- There are no exchange restrictions
- There is privacy for transactions and protected from audits.

- Bypassing commitments and obligations from inheritance law.
- Possibility of transferring profits from countries with high tax rates to countries with low or even zero taxation, thus reducing tax obligations.
- Absence of provisions of labor and insurance legislation. For companies that start their operation and employ staff abroad, they are often exempted from paying contributions.
- The seizure of personal property is avoided. With the provisions that protect the anonymity of the real shareholders of offshore companies, they help to cover the real owner of this property.

The aforementioned advantages are not found in all cases of offshore companies. The registered seat of the company, the legislation of the place of its establishment, the tax law, but also the type of the company and what activities it carries out, certainly play a big role. However, in addition to the advantages provided, the disadvantages arising from the establishment and maintenance of these corporate forms should also be taken into account. At the global level, there is the correlation of the use of offshore companies with the phenomena of tax evasion, tax evasion, money laundering originating from criminal activities. For these reasons, they have led to the tightening of the legislative treatment of these companies, creating a set of disadvantages regarding the use of these corporate forms. According to Harvard research the most important disadvantages are the following: (Harvard Business Review. Offshore Corporations)

- In many countries there is legislation against offshore companies making it difficult to conduct business.
- Control tends to be tighter now. For example, to open a bank account in the name of an offshore company, the credit institution requires additional identity verification documents from the signatories on the account and is able to require one or more professional reference letters, in compliance with the relevant regulations under of money laundering.
- In the event that the shareholder dies it is usually necessary to have his will listed for probate in the offshore jurisdiction. It imposes additional costs, delays and administrative inconvenience.
- Usually prohibited from conducting business or maintaining personnel in the offshore country in which they are incorporated. Of course, it depends on the jurisdiction they belong to and the type of company.
- Restrictions are often placed on what an offshore company can do.

## 2.4 Formation, Operation and Structure of Offshore Companies

As we mentioned above, one of the advantages of these companies is the speed of incorporation combined with the lack of unnecessary bureaucratic procedures. The establishment of such a corporate scheme is undertaken by authorized legal or natural persons in the country of establishment, without the personal presence of the shareholders. The statute is in the form of a simple private document and provides freedom of wording and in terms of its content, as it must contain basic information such as:

- Company name.
- Corporate form.
- Type of shareholders.
- Share capital.

The articles of association are filed in the company register of each country and then approved and validated by the competent authority of that country. In some countries it is necessary to establish the company with the assistance of a notary public if the company being incorporated is anonymous or at least that its founding document is notarized. In this case, after its establishment, it issues the corresponding certificate of establishment. Most offshore companies can be established with a single shareholder. The legislation of some states that operate as offshore centers defines a minimum permissible number of shareholders, e.g. as it is in the Republic of Panama where there must be at least two shareholders.

Regarding the company's capital, it should be noted that it is usually nominal and does not correspond to the real assets of the company. It is also not necessary that it be paid into a bank account, nor is it required that its payment be certified by the competent authorities of the states, but it is considered paid at the time of the establishment of the company. Many offshore jurisdictions allow equity to be paid in kind or even in a currency other than the domestic one (Farrell, 2006). A wide range of flexibility is observed in terms of the distribution of company shares as they are freely transferable by each shareholder/owner thereof. A key characteristic of the shares of these companies is the possibility of transferring the shares without the physical presence of the shareholder, as the required procedure can be completed by the company's administrator together with the members of the Board of Directors. This makes it one of the advantages of the operation of offshore companies, since this process, i.e. without the physical presence of the shareholder, achieves confidentiality and ensures the complete anonymity of the shareholders.

The various formalities regarding the structure of an offshore company vary

according to the legislation of each country. But there is a more general trend and it could be broken down into basic conditions:

**1) Keeping a register of its members**
The compliance register of its members includes:
- The names and addresses of the members, together with a statement of the shares held by each member.
- The date of their registration in the company register
- The date of their termination by members of the company.

**2) Definition of membership**
- The founding members of the offshore company are registered in the company's register of members.

**3) The nature of the shares**
- Each share gives the right to vote at the company's General Assembly
- A member's shares and interests are transferred in the manner provided by the company's articles of association, taking into account the applicable national laws governing each country.
- The company is not allowed to create different classes of shares.

**4) Frameworks and possibilities for modifying the share capital**
The modifications allowed are as follows:
- Increasing the company's share capital by creating new shares of a certain amount.
- Consolidation or division of all or part of the company's shares into shares of greater value than its existing shares.
- Subdivision of the company's shares into shares of a smaller amount than the predetermined amount.
- Cancellation of shares which, on the date of the decision to cancel them, have not been received or agreed to be received by any person, thus reducing the amount of the company's share capital correspondingly to the amount of the canceled shares.

## 2.5 Criteria for Selection of Foreign Jurisdiction

Choosing the right country to establish the offshore company can be difficult and certainly depends on the purposes and reasons for its establishment. Thus, the criteria on the basis of which the selection of the countryside is made must

be considered separately and always according to the needs of the entrepreneur and are the following:

### 2.5.1 The Political and Economic Stability of the Country of Jurisdiction

A very important criterion to be taken into account by each entrepreneur who wants to choose a suitable country for an offshore company, it is important to study the economic of the country over time. It is also important to measure the country's political risk (Matthee, 2011).

The most feared form of such risk can be the result of sovereign decisions, nationalizations or otherwise nationalizations. Investors face a political risk arising from increased international globalization. Both the G7 and the G20 have established a link between systemic risk, anti-financial crime laws and practices, and hypothesized that offshores are more likely to present systemic risks due to weak anti-financial crime laws. Political risk is sometimes described as part of country risk. Beginning with the boom in cross-border lending in the 1970s, followed by the abolition of capital controls in the 1980s and the globalization of financial markets in the 1980s and beyond, political risk has become a more important risk for investors. The new political risk was shaped by the 9/11 terrorist attack on the United States and the global financial crisis. It is argued that international institutions have redefined political risk, claiming that offshores, especially in emerging economies, run higher risks of financial crime (Chaikin, 2015). In Greece, the appropriate and effective protection of foreign investments from a part of political risks was devised through their protection with laws of constitutional force with article 107 of the Constitution.

### 2.5.2 The Modern and Flexible Legislation

Tortuous bureaucratic procedures are always a deterrent to choosing a country and establishing an offshore company in it. It must provide for the legislative framework of the country, as simplified as possible installation and operation procedures, to have as few restrictions as possible and state supervision regarding the administration and operation of the offshore. A typical example of the possibilities provided by the simplified legislative framework of offshore jurisdictions as well as the range of regulations that are left to the "invisible hand" of private initiative, the practice of establishing a number of legal entities, based in each outlying center, by consulting companies is recommended. In this context, these companies, without real activity, are established to remain inactive until a buyer is found and are called "self companies" (Masciandaro,

2004). The geographically closest version of this phenomenon to us is the case of Already Incorporated Cypriot Companies.

### 2.5.3 The Tax Reliefs

Regardless of the reason for establishing an offshore company, the main criterion for choosing an offshore jurisdiction is the tax regime and the size of the tax benefits provided. Most jurisdictions tax the respective companies incorporated in the country of incorporation but have reduced or even zero tax rates. Various tax incentives and facilities are provided such as the reduced or zero withholding tax rate when distributing dividends, the non-imposition of tax on the transfer of real estate, exemption from duties and fees, a reduced obligation or the total exemption from the obligation to pay employer contributions and social security contributions, tax exemptions for passenger cars, etc.

### 2.5.4 The Existence of Double Taxation Avoidance Agreements

Offshore centers are distinguished between those that have a network of Double Taxation Avoidance Agreements with other states and those that do not have such agreements. Usually the countries with zero tax rates are those that do not have bilateral treaties, while 31 countries with low but not non-existent taxation also offer benefits from international treaties. These taxes are imposed on the basis of two tax principles. In the "residence" for natural persons or the "permanent establishment" for corporate forms. It is possible for two or more states, based on tax rules, to tax the same or legal entity for the same income or capital and for the same time period twice. Thus, to avoid double taxation, double tax avoidance agreements (Tax Treaties or Double Tax Agreements DTAs) were invented.

The usefulness of bilateral agreements lies in the fact that they offer the possibility of tax planning, which allows the export and repatriation of funds with a low or even zero tax burden. Such contracts may cover a range of taxes, including income, inheritance, value added and other taxes. In addition to bilateral treaties, it is possible to conclude multilateral ones involving several states. The member states of the European Union are parties to a multilateral agreement regarding value added taxes while the International Convention on Mutual Administrative Assistance under the auspices of the Council of Europe and the Organization for Economic Co-operation and Development (OECD) is open for ratification for all states. It is estimated that the existence of such agreements substantially increased the growth of direct investments between the contracting states, specifically at a rate of 27% to 31%. Today Greece counts 56 bilateral Double Taxation Avoidance Agreements.

### 2.5.5 The Degree of Confidentiality and Anonymity of Partners

In most cases the founders wish to remain anonymous. The confidentiality guarantees provided by the state to the shareholders of offshore companies play a decisive role in the choice of jurisdiction. On the other hand, we must take into account that excessive operational freedom gives rise to suspicions that scope is provided for the conduct of illegal activities, and therefore this jurisdiction can be characterized as unreliable and encounter difficulties in trading. The confidentiality that the offshore financial center provides to investors is institutionally expressed by:

1) Failure to maintain public records and registers

2) The possibility of custodians and mediators (nominee shareholders), who will manage the offshore legal framework on behalf of the beneficiaries

3) The legislative provision for the issuance of anonymous shares.

On the other hand, however, we must take into account that the excessive operational freedom of a jurisdiction gives rise to suspicions that scope is provided for the conduct of illegal activities, and therefore this jurisdiction may be characterized as unreliable and encounter difficulties in dealing with various entities in tax-reputable states. Equally important is the existence of complete bank secrecy, which protects against various controls. Of course, apart from the aforementioned criteria, other factors play an important role, such as the existence of a good banking system, a good telecommunications infrastructure, the cost of establishing and maintaining an offshore company, etc.

## 3. Categories of Offshore Companies

### 3.1 Categories of Most Common Offshore Companies

In this chapter we will analyze the categories of the most common fields of activity of offshore companies.

- Holding companies.
- Finance companies.
- Licensing Companies.
- Trading companies.
- Administration companies.
- Trusts.
- Investment companies.
- Banking companies.
- Nominee companies.
- Insurance companies.

- Shipping companies.

### 3.1.1 Holding Companies

The use of offshore holding companies established in offshore centers is to finance the activities of offshore companies. The offshore company operates as a clearing company, with the aim of accumulating them and then reinvesting them, expanding to other countries. Several offshore financial centers provide special tax benefits to holding companies such as:

- The deferred payment of tax on capital gains.
- The absence of exchange controls.
- The deferred payment of tax on dividends.

The ideal structure of a holding company should enable the taxation of profits to be reduced, which requires tax agreements that include:

- Dividends sent by the offshore subsidiary should be exempt or subject to low withholding tax in the subsidiary's tax regime
- Dividends paid by the holding company to the parent should be exempt or subject to low withholding tax in the parent's tax regime
- The profits of the company derived from the sale of its shares in a subsidiary, should either be excluded or subject to low capital gains taxation, in the country of headquarters, according to the tax regime.

The well-known places of establishment of these companies are United Kingdom, Luxembourg, Denmark Netherlands, Gibraltar, Netherlands Antilles, which have organized legislation specifically for the treatment of foreign dividend income as each aforementioned country has a network of bilateral tax treaties. The most common practice of holding companies is to use subsidiaries in third countries rather than branches.

### 3.1.2 Financial Services Companies (Finance Companies)

The purpose of the financial services company is to provide loans to a foreign subsidiary. Withholding taxes are the only taxes that result from interest payments from a company operating in a foreign country to its associated financial services company. Thus such a company provides the possibility to effectively move profits from the foreign subsidiary, which is subject to a jurisdiction with a high tax rate, to the offshore jurisdiction with a low tax rate. So the interest and repayments on the loan to the offshore financial services company significantly reduce the taxable income of the foreign subsidiary. But this has the consequence that the countries of headquarters of the borrowing company impose withholding tax in the amount of the loan interest. To avoid this, i.e. to reduce withholding tax, which results when the borrower pays interest

abroad, companies direct their funds through various friendly jurisdictions that have tax treaties that exempt or reduce withholding taxes or through countries that have signed double taxation agreement. Financial services companies are considered important in the event that a country has high rates of taxation of income and dividends. The repayment of interest not only reduces the taxable profits of the borrowing company but also significantly reduces its dividends to be repaid.

### 3.1.3 Licensing Companies

A company may use an offshore licensing company for the purpose of granting licenses to a foreign subsidiary. Incremental royalty payments for patents, copyrights, scientific information, industrial processes and more operate and are used by many jurisdictions like rent. That is, as an expense, it reduces the taxable profits of businesses. By paying an amount for the use of rights (royalties) to an offshore company, the profits are transferred from the subsidiary to the offshore company, which pays minimal or even zero tax on the royalties it receives. In order for an offshore licensing company to license the use of industrial property, it is necessary to transfer patents or other rights from the parent company's country. Taxes may be imposed when the rights are disposed of offshore. The choice of the appropriate country - offshore headquarters, should be based on the special tax and legal regime. Once the intangible property rights are in the offshore company, they are rented to an intermediary company, which conducts their exploitation. The revenue from the exploitation of the intangibles goes to the intermediary company, which retains a small commission as a fee for its services and remits the rest of the profits to the offshore company. Consequently, the profits from the exploitation of the rights are accumulated in company and tax charges are avoided. However, if the parent company transferred the rights directly to the user company, even if double taxation agreements were in place, it would incur capital gains tax since it would have to show the actual sale value of the right.

### 3.1.4 Trading Companies

Commercial offshore companies are active in import and export trade. These companies can take orders directly from the customer and deliver the products directly from the manufacturer or from the place of purchase. The offshore company is used to effectively transfer profits from a high-tax country to a low-tax country, the so-called triangular trade. An import-export trading company establishes an offshore company that acts as an intermediary between the seller and the buyer. When the founder imports, the supplier ships the goods

directly to the founder and issues the invoice in the name of the offshore company, which in turn invoices the founder at a markup. The parent exporting, the merchandise is shipped to the buyer and the parent invoices the offshore with a lower price which in turn invoices the buyer. In this way the parent reduces the profits it shows and accumulates the capital offshore.

### 3.1.5 Administration Companies

Offshore activities do not always involve a single subsidiary, but sometimes some of them involve an entire group, consisting of the parent company and its subsidiaries, which carry out different activities. The management and control of the group can be carried out through the establishment of an offshore administration service provider. This particular scheme offers advantages due to the concentration of all administrative and management functions in one body. Headquartering is a method of profit shifting where the management activities of a group are undertaken offshore, which is paid a percentage of the group's profits. Offshore management is taxed with low rate, she is not taxed at all on her profits. It is likely that group companies, when making payments to the offshore provision of administrative services, will have to demonstrate that the price for the services is determined under market conditions. Therefore, when there is an intention to create an offshore company providing administrative services, it is important for the shareholders to make sure that the international offshore center has the necessary support services that will enable it to operate effectively.

### 3.1.6 Trusts

As already mentioned, one of the main motivations for creating an offshore company is to ensure the anonymity of its real shareholders. Many times this is achieved through the creation of an offshore trust. A trust is formed every time a person, the founder, transfers assets to another trustee, with the condition that the assets will be managed for the benefit of a third party beneficiary. The trustee is considered the owner of the assets, but his right in rem is limited to serving the purpose of the trust. While the beneficiary has the right to monitor the trust property in case it is transferred to another natural or legal person. The choice of the right administrator, the signing of an understandable contract and the choice of the appropriate international offshore financial center are decisive factors for the creation of an offshore trust. The role of these offshores is to use them as trustees of the trust assets, acting for the benefit of the beneficiaries and thereby contributing to the legal exclusion of the beneficial owner from his property and the avoidance of the beneficiary's tax obligations.

In particular, the selection of the management company or the company from which the manager will be authorized, should be made based on integrity and cost-effectiveness. The International Offshore Financial Center (IOFC) should be stable over time so that to avoid political unrest, as well as the possibility of expropriation of the assets, which have been transferred to the trust. Several companies that provide management services, as an alternative plan to protect their assets, allow the trust and its assets to be quickly relocated, in the event of political unrest in the Offshore center, to another one at no particular cost. That is why it is important to choose a management company, which is connected to other Offshore centers, for the transfer of the trust from one center to another. Some of them provide such services, combined with residence in a safe jurisdiction and the option of transferring the seat of the trust, through the international connections they have, by simply changing the seat of administration and control of the trust, regardless of the seat of the manager. Using a trust often gives greater flexibility and anonymity when transferring and controlling funds or assets. A trust usually does not face the problems with shareholders, dividends or other obligations that another organization faces. In many International Offshore Financial Centers (IOFCs), there is a minimum disclosure obligation. Additionally, one of the advantages of offshore trusts is the ability to accumulate capital. Some IOFCs do not require trustees to distribute trust income to beneficiaries, which allows income to be transferred from the trust to the beneficiary residing in a high tax country. The income accumulated in the offshore trust remains there free of any taxation, until it is repatriated to the country of origin. This conversion of income to capital (on repatriation) may be deliberate, as the beneficiary's country may not tax the distribution of the capital from the trust or tax that amount under a more general right of exploitation.

### 3.1.7 Investment Companies

Funds raised through offshore investment companies can be invested - deposited anywhere in the world. In order to have income tax exemption, there are privileged areas where funds can deposited in tax-free securities or bank deposits where the interest is paid tax-free. So the use of offshore is placed in the appropriate jurisdiction and allows the investment of these revenues effectively in high tax countries, as long as they have signed tax treaties with an offshore center.

### 3.1.8 Banking Companies

In recent years many banking institutions in offshore jurisdictions have

established themselves as tax havens. Many of these institutions are subsidiaries of large banks. Their biggest advantage is that they pay interest free of withholding taxes. They also deal with international financing that is not subject to exchange controls. They are also used by smaller businesses and individuals as centers for managing their clients' available funds.

### 3.1.9 Nominee Companies

It is the structure in which a domestic company acts as an agent of an offshore company. Offshore companies always aim to reduce taxation. These structures offer a high level of reliability and significant benefits. The offshore company is the principal and bears responsibility for all transactions, while the domestic company, as an agent, enters into partnerships and acts on its behalf. The relationship between an agent and an offshore company is defined through a partnership agreement. In addition, a trust can be used, ensuring privacy. The domestic company will represent the offshore in all its transactions and will undertake activities such as invoicing, accounting monitoring, etc. Consequently, the offshore details will not appear on the invoices issued by the representative company and only the details of the representative company will appear in the client's books. This is very important, as many companies do not want their offshore dealings to be obvious. The agent company receives a commission for the services offered.

### 3.1.10 Insurance Companies

Many international organizations have developed the practice of combining an existing trust, which is not a new offshore product, nor a new product. These two products offer new opportunities. The insurance policies are offered by a set of large insurance companies, which are also based offshore. When the customer is insured with an insurance company, he pays an amount. The insurance company, in turn, takes a part of the premium and proceeds with insurance. The insurance company then places the remaining amount together with its own investment funds. In some cases, the choice of placements belongs to the insured, but not the management.

### 3.1.11 Shipping Companies

Many offshore centers provide special tax treatment to companies involved in shipping, including chartering and chartering vessels. Several of them urge shipping companies to take advantage of flags of convenience. With flags of convenience, they have the possibility to register a ship using the offshore flag, whose requirements are less strict than those the company would have in

its home country. Thus the profits arising from the offshore company will be subject to lower taxation. However, it should be noted that in various cases, these special low tax rates do not apply to all income and part of the income is taxed at the full rate when paying for the right to use the flag and registration. The majority of offshores are legal when it comes to human resource and ship safety issues.

## 4. "Tax Havens" – Non-Cooperative Tax States and States with Preferential Tax Status

### 4.1 Introduction

The treatment of offshore companies by Greek tax law following the regulations introduced by the provisions of Law 3842/2010 and the provisions of the new Income Tax Code 4172/2013, depends on the jurisdiction chosen as the company's registered office. Therefore, the crucial criterion to consider a company as offshore, as opposed to any other foreign company, is the place where it has its registered office.

In particular, the provisions of the new Income Tax Code establish two basic concepts: a) that of states with a preferential tax regime and b) non-cooperative states in the tax field. These two concepts are the essential criterion in the effort of the Greek legislator to contribute to the tax treatment of this peculiar "jurisdiction shopping", i.e. the tendency of legal persons and other entities to choose as their tax residence, jurisdictions that fall within the regulatory framework.

### 4.2 Tax Havens

As already mentioned, the main reason for the creation and development of tax havens or offshore centers is the need of the specific states for economic survival and rapid economic growth. The most correct rendering in English is "tax heaven" or oases or paradises as it has prevailed from the French literature "paradis fiscal" (Dharmapala and Hines, 2009). These states are mainly small in size, without significant economic and natural resources, with minimal possibilities of financial independence. These conditions lead the specific states to formulate a policy of incentives and facilities for foreign companies with the aim of attracting the required foreign capital that would ensure economic viability. The real take off of offshore private capital has largely taken place in the past decade. According to IMF data in 2001, the total value of private capital

in offshore jurisdictions was $5 trillion. In 2008 this size more than doubled, approaching 11.5 trillion. Assets held offshore today amount to ⅓ of global assets while ½ of global trade appears to flow through them, 50% of banking assets and ⅓ of foreign direct investment by large multinationals is routed through offshore jurisdictions. International economic evidence overwhelmingly demonstrates that the existence of tax havens creates market failures that affect offshore source countries (Brätland, 2004). It is recorded that the United States annually loses 100 billion dollars in taxes due to tax havens.

**4.2.1 Definition and Classification of "Tax Havens" at an International Level**

The key element in the classification of Tax Havens internationally is the determination of the degree of secrecy and tax secrecy. The Tax Justice Network's Financial Secrecy or Tax Secrecy Index ranks states based on the degree of secrecy and scale of their activities. It helps in understanding the global economy coupled with the degree of secrecy of tax havens as well as illicit flows.

The Financial Secrecy Index was launched in 2009 and has contributed to the research and understanding of tax haven institutions. According to the measurements of the index, a series of data related to exports, bank secrecy, illegal financial flows, etc. are also taken into account, so that the classification of tax havens is determined based on their secrecy and the scale of economic activities. The 2020 results are listed in Appendix (Table A.1).

The areas marked in dark red are overseas territories. The first place in the ranking is held by the Cayman Islands, an overseas territory of the United Kingdom. But it has considerable financial autonomy from the UK but has its supervision and support. Most of the businesses listed in the Cayman Islands belong to the world's largest banks, which account for half of the gross domestic product and are the most popular jurisdiction for hedge funds and insurance companies. (Financial Secrecy Index, 2020, Cayman Islands). In the 2nd place of the ranking is the United States of America. It is a long-term trend as the country has been one of the few jurisdictions that have managed to increase the degree of privacy protection in recent years.

Now the U.S. they have the second most favorable legislation after Kenya for the establishment of shell companies, i.e. companies without real economic activity, which mediate to take advantage of favorable tax and financial privacy arrangements. According to economist James Henry, in his research for the Tax Justice Network, he said "Americans have discovered that they really don't need to go to Panama". Suffice it to say that as a tax haven it is a Delaware address in Wilmington at 1209 North Orange Str, in a regular financial

block and is listed as the headquarters for at least 285,000 separate companies (Waynejune, 2012).

Third place is occupied by Switzerland, which is characterized as the "grandfather" of tax havens and is one of the largest financial centers worldwide. It is also one of the largest tax havens in the world. Switzerland has a very strong banking system, which is based on the following factors: its long tradition of banking secrecy, political stability based on neutrality and the unique system of democracy, and finally the economic consensus of Swiss society (Financial Secrecy Index, 2013).

## 5. Tax Evasion, Tax Avoidance and Money Laundering

### 5.1 Introduction

It has already been mentioned that offshore companies have been identified with the phenomena of tax evasion, tax evasion, tax fraud originating from criminal activities. Mainly ensuring the privacy of the shareholders contributes to the choice of such structures. The large increase in the phenomenon of offshore companies results in the complete erosion of the tax bases of states and the shaking of macroeconomic stability.

#### 5.1.1 Tax Evasion and Tax Avoidance through Offshore Companies

The ways to convert an offshore company into a means of tax evasion/avoidance vary depending on the type of company, the scope of its activities as already analyzed. In any case, the sole purpose of setting up these companies is the route of capital, which has the consequence of a lower taxation up to zero and even the avoidance of other compulsory law provisions. In Greece, the main field of activity of offshore companies is located in the real estate market, but also in their use in triangular transactions. At the level of the European Union and specifically within the framework of the Code of Conduct for business taxation, member states undertake to stop providing and limit any tax measure that establishes a lower level of taxation up to zero compared to the levels in force normally for each member state.

Note that on July 1, 2021, at the OECD conference, 130 countries and jurisdictions have joined a new two-pillar plan to reform international tax rules and ensuring that multinationals pay a fair share of tax wherever they operate. The first pillar will reassign tax rights from their home countries to markets that have business activities and earn profits, regardless of their presence. The second pillar seeks to establish a global minimum corporate tax rate that countries

can use to protect their tax bases. The minimum rate of at least 15% is estimated to generate approximately $150 billion in additional tax revenue annually. Additional benefits will result from the stabilization of the international tax system and increased tax certainty for taxpayers and tax administrations.

Specifically, the Secretary General of the Organization for Economic Cooperation and Development (OECD) at the conference held on July 1, 2021, Mathias Cormann said: "After years of intense work and negotiations, this historic package will ensure that large multinational companies pay their fair share of tax everywhere ", "This package does not eliminate tax competition, as it should not, but it does set multilaterally agreed limitations on it. It also accommodates the various interests across the negotiating table, including those of small economies and developing jurisdictions. It is in everyone's interest that we reach a final agreement among all Inclusive Framework Members as scheduled later this year" (https://www.oecd.org/tax/beps/beps-actions/action1/)

### 5.1.2 Money laundering and offshore companies

In recent years, the globalization of the economy and transactions have led to the internationalization of legal business activities, but the road to delinquent, criminal behavior has also become easier. This international trend accounts for a significant percentage of global transactions in terms of attempted money laundering. The so-called money laundering. This phenomenon is so large that studies rank it as the third largest international "industry" and follows oil and foreign exchange trading. (Robinson,1995). For this reason it is one of the first 103 legal definitions of money laundering found in the United Nations Convention against Illicit Traffic in Narcotic Drugs and Various Substances.

Of the many ways to launder the proceeds of illegal activities, the dominant position is held by companies, which are used in one of the three laundering phases, as defined by the United Nations Office on Drugs and Crime and are: the placement phase, the of stratification and the integration phase.

a) The placement phase is the initial entry of black money into the financial system. This stage serves two purposes. It frees the irregular entrepreneur from holding and keeping huge sums in cash but also achieves their placement legally within the system. So it can take place in different forms such as:

- Paying off loans or credit cards with ill-gotten gains.
- Gambling and games of chance.
- Mixing of illegal profits with legitimate profits of the company.

b) The stratification phase is complicated, because it involves the international movement of capital. The main purpose is to separate black money

from its source. In order not to raise suspicions, offshore companies appear and mediate in the transfer of money. The shares of the offshore company are bought with this money, which in turn makes investments in the jurisdiction in which it wants to import the "recycled" money. When the money goes to the tax haven, it is placed in the account of a "front" company whose sole purpose is to absorb funds.

c) In the final stage of incorporation, the initial illegal profits are returned to the illegal entity, from ostensibly legal sources. Following the previous two stages, black money has been incorporated into the financial system and can be used. The establishment of the offshore company it boils down to delineating virtual roles and establishing a local proxy acting as a representative.

### 5.1.3 The Role of Companies in the Money Laundering Process

#### 5.1.3.1 "Ghost" companies

They are usually presented on bills of lading and remittance orders in the capacity of consignee or other third party concerned so that the final recipient of the money is not shown. They are for the sole purpose of absorbing funds and "disassociating" funds and their origin.

#### 5.1.3.2 "Showcase" companies

These companies are more complex as they also engage in legal actions to cover up other illegal actions. Those who try to launder money, have more than one company and transfer funds derived from criminal activities from one company to another in order to legitimize them.

## 6. Offshore Companies in Greece

### 6.1 Introduction

In the last decade, the phenomenon of offshore companies has developed in Greece. Offshore companies in Greece are mainly active in the following sectors:

- Shipping.
- Stock transactions.
- Trade.
- Repricing and triangular trading.
- Purchase and construction of real estate.
- Commercial agents.
- Yacht.
- Hotel companies.

## 6.2 Tax Treatment of Offshore Companies in Greece

The Greek state voted and published the law 3091/2002 dealing with dealing with offshore activities. This law does not deal with all the issues, but it gives a direction of the will to limit this phenomenon.

The provisions of Laws 3091/2002 and Law 3052/2002 dealing with offshore companies include, among others, the following:

- Taxation of properties owned by offshore companies.
- Bookkeeping by offshore holdings.
- Non-recognition of expenses to and from offshore.
- Non-recognition of fixed asset depreciation when purchased from offshore.
- Non-granting of aid to purchases by offshore companies.

With the tax reform of the above-mentioned laws, decisive amendments were reinstated and the situation changed where Greek businessmen who had significant wealth and wanted to avoid the tax burden of their country, created offshore companies. The main points in which Law 3091/2002 has brought about amendments are:

- Depreciation of fixed assets purchased by a foreign company is not recognized as a deduction from the gross income of the business.
- The costs incurred by companies to purchase goods or receive services from a foreign company, as well as the rights or compensations paid by the company to a foreign company for the use in Greece of technical assistance, patents, trademarks, secret industrial methods and formulas, intellectual property and other related rights, are not deductible from their gross income.
- Foreign companies that have rem rights of full or small ownership or usufruct properties located in Greece, pay a special annual tax of 3% on the objective value of the properties and the tax from 3% became 15%.
- No aid is given in case of purchase or leasing of new machinery and other equipment from a foreign company.

After the implementation of Law 3091/2002, the overpricing that occurred with the triangular transactions, in which the offshore company acted as an intermediary between the partners, was significantly reduced, giving the possibility to overprice goods purchased from EU countries or imported from third countries. Virtual expenses in the form of services received by Greek companies from foreign companies also stopped being created. The cost of maintaining a property in an offshore company is very high with the payment of 30% on the objective value of the property.

## 6.3 Greece as a Tax Paradise

From 01/01/2006 foreign companies may establish themselves in Greece, in accordance with the provisions of Law 89/1967 (Government Gazette A' 132) as in force with Law 3427/2005, with the sole purpose of providing to their headquarters or affiliated companies:

- Consulting services.
- Central accounting support.
- Quality control of production, products.
- Procedures and services.
- Training studies.
- Receiving and providing information and research.

These companies are required to spend annually the amount of at least 100,000 euros, which will be used to cover operating costs, payroll and documented by documentary evidence that meets tax legislation. They are also obliged to invoice this amount plus the specified profit percentage to the affiliated company. They are still obliged to collect the above amount by means of a transfer as shown by a domestic bank receipt, which will mention the legal entity that remits the amount. They must employ a staff of at least four people, one of whom may be on a part-time contract. As they are also obliged to inform the Ministry of Finance within 50 days at the latest for any change in the company. Specifically, with regard to the purchase or construction of real estate, many offshore companies had been active in Greece, having as their only asset a property, mainly of great value. The positives of offshore incorporation for the acquisition of property are:

- Offshore shares are bearer. So they can be freely transferred, just by surrendering them.
- It is almost impossible to prove the real owner of the property since his name is not visible anywhere.
- There is no presumption of acquisition of the property, nor is the capital for the purchase of the property taxed.
- The avoidance of pledges of personal property, by safeguarding against future claims of creditors.
- The avoidance of tax burdens.
- In case of transfer of the property, capital gains tax is not paid.

On the other hand, we have the disadvantages:

- The offshore pays tax on the fictitious rents, collected from the occupant of the property.
- Offshore pays property tax

## 6.4 Documents for the Establishment of Offshore Companies in Greece

For the establishment of offshore companies in Greece, the following supporting documents are necessary, which are submitted to the Ministry of Finance in accordance with Law 89/1967:

### 6.4.1 Documents for Foreign Businesses in Greece

- Application in which the full name, registered office and nationality of the company, the type with which it operates, the composition of the board of directors as well as the persons binding it will be indicated. The details of its legal representative, the people it will employ and their specialties and finally the companies connected to it.
- Certified copy of the company's articles of association, with the relevant amendments.
- Recent certificate from the chamber that will confirm the legal establishment.
- Consolidated balance sheet and results of use of the last two years of the group or parent company.
- Documentation study of the company's proposed profit margin in Greece from its services provided to the group or its headquarters.
- Detailed description of the services provided, as well as the details of the recipient company
- Notarial power of attorney to its legal representative in Greece.

### 6.4.2 Documents for Domestic Businesses in Greece

- Application in which the full name, headquarters, type, composition of the Board of Directors, as well as the persons binding it, will be mentioned. The object of its work, the details of their legal representative, the people it will employ.
- A certified copy of the company's articles of association with the relevant amendments, from which its object can be deduced.
- Recent certification from the relevant prefecture that the company is registered there and its license is still valid for S.A.
- Decision of the Board of Directors of the company or the general assembly of its companies for its subjection to the provisions of Law 89/1967.
- The government newspaper sheet, in which the composition of the Board of Directors was published.
- Consolidated balance sheet and results of use of the last 2 years of the group or parent company.

- Documenting study of the company's profit margin from its services provided to the group.
- Detailed description of the services provided, as well as the details of the recipient or recipients of the services.

# 7. Empirical Analysis

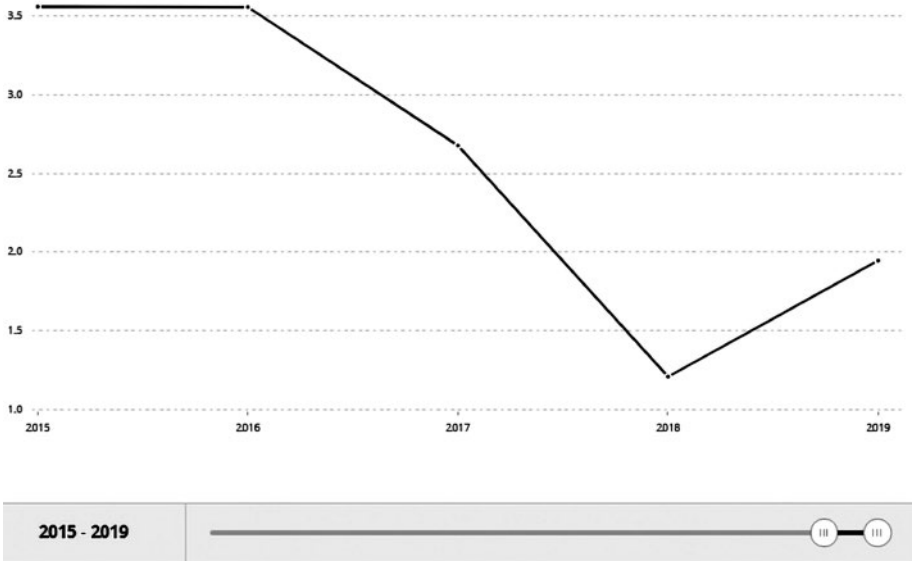
## 7.1 Introduction

The expansion of global business activities from 1980 onwards contributed significantly to the economy of tax havens because the global increase in foreign direct investment (Foreign Direct Investment), increased the demand for activities in tax havens for the purpose of tax avoidance (Hines, 2005).

**Figure 1: Foreign direct investment (1970 - 2015), net flows as a percentage of GDP**


Source: World Bank Database (2020)

**Figure 2: Foreign direct investment (2015 - 2019), net flows as a percentage of GDP**




Source: (World Bank Database., 2020).

In the decade of the 2000s until today, despite the big fluctuations, the average price remains much higher than in the previous decades.

## 7.2 Economic Development of Tax Havens

The list of tax havens are drawn from the Organization for Economic Co-operation and Development (OECD) with the average annual growth of the per capita Gross Domestic and National Product of the tax havens based on data from the World Bank (The World Bank) for the period 2000 – 2019 (Table A.2, Appendix). Due to the nature of tax havens for some countries there are no data and they appear as N/A (Non Available).

Tax havens have a slightly higher average economic growth compared to the rest of the world, as the average growth of GDP per capita for the period 2000-2019 is 0.2% higher than the rest people (Table A.2, Appendix). It would be useful to estimate the determinants of economic growth by including size and wealth as independent variables, as and to test whether there really is a relationship between a country's decision to be a tax haven and economic growth.

We will define the coefficients of the regression, in which the dependent variable is the annual growth of GDP per capita. The independent variables are the natural logarithm of population, the natural logarithm of GDP per capita.

The regression we will consider is:

$$\mathbf{Gdpc = a_0 + a_1POP + a_2GDPC + a_3thaven + e} \quad (1)$$

Where:

Dependent variable Gdpc: annual growth of GDP per capita for 2000 – 2019

Independent variables: POP: natural logarithm of population for 2000 – 2019

GDPC: natural logarithm of GDP per capita 2000 – 2019

Thaven: dummy variable that takes the value 1 if the country is a tax haven, otherwise it takes the value 0.

All data were drawn from the World Bank Database. From Table A.3, Appendix we keep the countries with complete data (Table A.4, Appendix). Using the regression model we have:

**Table 1: Regression for Equation (1)**

| | Coefficient | Standard error | t-statistic | p-value |
|---|---|---|---|---|
| **Constant** | -0.641 | 0.503 | -1.274 | 0.220 |
| **GDPC** | 0.861 | 0.151 | 5.680 | 0.000 |
| **POP** | 0.000 | 0.000 | 2.751 | 0.014 |
| **thaven** | 0.171 | 0.261 | 0.655 | 0.513 |

The natural logarithm of the population is statistically significant at the 5% significance level and has a positive relationship with the dependent variable (Table 1). That is, when the population increases at the same rate, the annual increase in GDP per capita will increase, which shows us that population growth helps a country grow economically. As for the independent variable, the natural logarithm of GDP per capita, which is statistically significant at the 1% significance level which has a positive relationship with the dependent variable. Finally, the dummy variable has a positive relationship but is not statistically significant, which means that the hypothesis that a country's decision to become a tax haven has a positive effect on its economy cannot be confirmed. In conclusion, it seems that the above regression does not confirm

the hypothesis that a country develops economically at high rates if it decides to become a tax haven.

## 7.3 Relationship of State Sector to the Size of the Offshore Country

It is understood that tax revenue collection in offshore countries can be reduced to unsustainable levels by providing low or even zero tax rates to foreign as well as local investors. However, it would be difficult for these countries to attract foreign capital if they did not have low taxation, so these countries could benefit even with low tax rates in terms of their tax revenue. Any change in a state's tax revenue is linked to its public expenditure, which can be payments for operational activities of the government to provide goods and services, payments to employees and other social benefits. Therefore, we can consider that the greater the tax revenue, the greater the state sector of the state. The research will be based on an assumption of Hines (2005) which concludes that tax havens do not have a significantly larger or smaller public sector compared to the rest of the countries. Of course, with what we mentioned before, we would expect that tax havens would have a smaller government sector due to low tax revenues.

The table below includes the list of offshore company names from OECD, the average tax revenue as a percentage of GDP for the years 2000 – 2019 and the average government expenditure as a percentage of GDP for the years 2000 – 2019 by the World Bank (TheWorldBank). We observe that the average of tax havens has higher tax revenues and public expenditure as a percentage of GDP for the period 2000 – 2019 compared to the rest of the world.

The tax havens do not have a very big difference from the world average, although they are smaller countries compared to the rest of the world (Table A.5, Appendix). We will estimate the probability that the size of the country is negatively related to the size of the public sector with regression models (2) and (3)

$$\mathbf{Taxr = a_0 + a_1POP + a_2GNPC + a_3thaven + e} \qquad (2)$$

Where:

Dependent variable taxr: tax revenue as a percentage of GDP for 2000 – 2019

Independent variables: POP: natural logarithm of population for 2000 – 2019

GNPC: natural logarithm of GNP per capita 2000 – 2019

thaven: dummy variable that takes the value 1 if the country is a tax haven, otherwise it takes the value 0.

From Table A.6, Appendix we keep the countries with complete data (Table A.7, Appendix). Using the regression model we have:

**Table 2: Regression for equation (2)**

| | Coefficient | Standard error | t-statistic | p-value |
|---|---|---|---|---|
| **Constant** | 4.175 | 1.116 | 3.739 | 0.007 |
| **GNP** | 1.215 | 0.306 | 3.963 | 0.005 |
| **POP** | -1.06447E-06 | 3.32351E-07 | -3.202 | 0.015 |
| **thaven** | -1.170 | 0.601 | -1.941 | 0.053 |

The natural logarithm of the population has a negative relationship with the dependent variable, that is, tax revenue as a percentage of GDP (Table 2). Our negative relationship shows that smaller countries have larger tax revenues as a percentage of GDP. So we consider, based on the model, that the size of the country is negatively related to the size of the tax revenue of the public sector. The P -value of the independent variable "natural logarithm of the population" is 0.015006448 and is statistically significant at the 5% significance level. The independent variable, the natural logarithm of GDP per capita, has a positive relationship with the dependent variable, which is tax revenue as a percentage of GDP. The P value is 0.005 and it shows us that this independent variable is statistically significant at 1% level of significance. The dummy variable has a negative relationship and is statistically significant at 10% level of significance. So the hypothesis that a country's decision to become a tax haven has a negative effect on its state sector, in terms of tax revenues, is confirmed by this study.

The next equation is the following:

$$\mathbf{Gove = a_0 + a_1POP + a_2GNPC + a_3thaven + e} \quad (3)$$

Where:

Gove dependent variable: public spending as a percentage of GDP 2000 – 2019

Independent variables: POP: natural logarithm of population for 2000 – 2019

GNPC: natural logarithm of GNP per capita 2000 – 2019

thaven: dummy variable that takes the value 1 if the country is a tax haven, otherwise it takes the value 0.

From Table A.8, Appendix we keep the countries with complete data (Table A.8, Appendix). Using the regression model we have:

**Table 3: Regression for Equation (3)**

| | Coefficient | Standard error | t-statistic | p-value |
|---|---|---|---|---|
| **Constant** | 0.133 | 0.410 | 0.324 | 0.758 |
| **Population** | 0.000 | 0.000 | -2.046 | -0.096 |
| **GNP** | 0.196 | 0.085 | 2.310 | 0.068 |
| **thaven** | -6.121 | 0.942 | -6.471 | 0.000 |

The natural logarithm of the population has a negative relationship with the dependent variable, i.e. public expenditure as a percentage of GDP, at the 10% significance level (Table 3). Our negative relationship shows that smaller countries generally have higher public spending as a percentage of GDP. That is, the smaller the country, the smaller its GDP, therefore the value of the fraction Public Expenditure/GDP should increase. The natural logarithm of GDP per capita is statistically significant at the 10% significance level and has a positive relationship with public spending as a percentage of GDP. This can also be explained by regression (2) because the more the state's tax revenues increase, the more the state can give through public spending. The independent dummy variable of tax havens is statistically significant at the 1% significance level and has a negative relationship. Expected because due to the tax facilities provided by tax havens they collect less tax revenue and less public expenditure.

## 8. Conclusions

The questions raised —namely, to what extent a country's decision to become a tax haven significantly influences its economy and how the public sector is affected in terms of tax revenue and public spending due to the benefits offered by foreign capital— have been previously explored. Offshore companies continue to flourish as they can be established quickly, with shareholder confidentiality, allowing for tax evasion and asset protection. Offshore companies are the most favorable and cost-effective choice for those seeking to engage in illicit activities such as money laundering and tax evasion. Many countries aiming to attract foreign capital have created a "friendly" tax environment

and legal framework in order to increase offshore activities and benefit from them. Offshore companies arise both as a solution for small businesses and for individual entrepreneurs to take advantage of the favorable tax regime.

Greece faces the issue of overpricing products through offshore activities, as products imported —often of low value— are routed through offshore companies and overpriced, reducing profits and inflating reported expenses. In the real estate market, most property owners in offshore companies have opted for fictitious property transfers from offshore companies to the actual owners.

In the final part of this study, empirical investigation was conducted based on the Hines (2005) model for the period 2000–2019. The aim was to determine whether a country's decision to become a tax haven affects its economy and public sector. According to the results and the model used, no correlation was found between the decision to become a tax haven and economic development. However, regarding tax revenue, a negative relationship appears with the decision to become a tax haven, indicating a negative effect on tax revenue as a percentage of GDP. In the final regression analysis, a statistically significant negative relationship appears between the decision to become a tax haven and public spending, suggesting that this decision negatively affects public spending as a percentage of GDP. In addition, a secondary objective of this thesis was to present the phenomenon of offshore companies and tax havens.

## 9. Study Limitations and Suggestions for Future Research

However, some limitations were also presented in the empirical investigation regarding tax havens. In all variables there were missing data, i.e. there were no data for all the initially investigated countries, as a result of which there is not a complete picture for variables such as GDP, GDP, tax revenues of states and public expenditures. This is because tax havens do not publish data on offshore companies. Furthermore, the specific model used has been questioned because it does not provide a comprehensive picture of the economic development of tax havens and does not include enough variables to fully explain economic development.

It would be useful to develop future research, where they will enrich the specific model with more explanatory variables, so as to give a different picture of the phenomenon regarding the economic development of tax havens. The ways in which offshore companies contribute to illegal activities such as tax evasion and money laundering could be studied by recording facts and figures as well as looking for ways to deal with the phenomenon. It would also

be interesting to carry out a research that studies the effects that the absence of offshore companies would have on the investment sector in a developed state.

## Declaration of Conflicting Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

## Availability of data

Availability of data and material: On request

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## Appendix

**Table A.1: Financial Secrecy Index 2020**

| Rank | Jurisdiction! | ISO-3 | ISO-2 | FSI ValueZ | FSI Share3 | Secrecy Score4 | Global Scale W< |
|---|---|---|---|---|---|---|---|
| 1 | Cayman Islands | CYM | KY | 1575,19 | 4,63% | 76,08 | 4,58% |
| 2 | United States | USA | US | 1486,96 | 4,37% | 62,89 | 21,37% |
| 3 | Switzerland | CHE | CH | 1402,10 | 4,12% | 74,05 | 4,12% |
| 4 | Hong Kong | HKG | HK | 1035,29 | 3,04% | 66,38 | 4,44% |
| 5 | Singapore | SGP | SG | 1022,12 | 3,00% | 64,98 | 5,17% |
| 6 | Luxembourg | LUX | LU | 849,36 | 2,49% | 55,45 | 12,36% |
| 7 | Japan | JPN | JP | 695,59 | 2,04% | 62,85 | 2,20% |
| 8 | Netherlands | NLD | NL | 682,20 | 2,00% | 67,40 | 1,11% |
| 9 | British Virgin Islands | VGB | VG | 619,14 | 1,82% | 71,30 | 0,50% |
| 10 | United Arab Emirates | ARE | AE | 605,20 | 1,78% | 77,93 | 0,21% |
| 11 | Guernsey | GGY | GG | 564,56 | 1,66% | 70,65 | 0,41% |
| 12 | United Kingdom | GBR | GB | 534,65 | 1,57% | 46,20 | 15,94% |
| 13 | Taiwan | TWN | TW | 507,57 | 1,49% | 65,50 | 0,59% |
| 14 | Germany | DEU | DE | 499,72 | 1,47% | 51,73 | 4,71% |
| 15 | Panama | PAN | PA | 479,51 | 1,41% | 71,88 | 0,22% |
| 16 | Jersey | JEY | JE | 466,81 | 1,37% | 65,53 | 0,46% |
| 17 | Thailand | THA | TH | 448,86 | 1,32% | 73,25 | 0,15% |
| 18 | Malta | MLT | MT | 442,20 | 1,30% | 61,75 | 0,66% |

| Rank | Jurisdiction! | ISO-3 | ISO-2 | FSI ValueZ | FSI Share3 | Secrecy Score4 | Global Scale W< |
|---|---|---|---|---|---|---|---|
| 19 | Canada | CAN | CA | 438,38 | 1,29% | 55,84 | 1,60% |
| 20 | Qatar | QAT | QA | 433,05 | 1,27% | 77,00 | 0,09% |
| 21 | South Korea | KOR | KR | 411,06 | 1,21% | 61,58 | 0,55% |
| 22 | Bahamas | BHS | BS | 407,28 | 1,20% | 75,38 | 0,09% |
| 23 | Algeria | DZA | DZ | 400,56 | 1,18% | 79,63 | 0,05% |
| 24 | Kenya | KEN | KE | 398,19 | 1,17% | 75,95 | 0,08% |
| 25 | China | CHN | CN | 397,25 | 1,17% | 59,85 | 0,64% |
| 26 | Lebanon | LBN | LB | 385,52 | 1,13% | 63,98 | 0,32% |
| 27 | Cyprus | CYP | CY | 383,38 | 1,13% | 61,08 | 0,48% |
| 28 | Kuwait | KWT | KW | 369,17 | 1,08% | 70,58 | 0,12% |
| 29 | Ireland | IRL | IE | 363,80 | 1,07% | 48,15 | 3,46% |
| 30 | Gibraltar | GIB | Gl | 359,89 | 1,06% | 69,48 | 0,12% |
| 31 | Macao | MAC | MO | 356,53 | 1,05% | 65,00 | 0,22% |
| 32 | Malaysia | MYS | MY | 352,69 | 1,04% | 69,53 | 0,12% |
| 33 | France | FRA | FR | 350,53 | 1,03% | 49,90 | 2,25% |
| 34 | Nigeria | NGA | NG | 348,53 | 1,02% | 70,15 | 0,10% |
| 35 | Angola | AGO | AO | 345,45 | 1,01% | 79,73 | 0,03% |
| 36 | Austria | AUT | AT | 317,00 | 0,93% | 56,50 | 0,54% |
| 37 | Vietnam | VNM | VN | 299,30 | 0,88% | 74,33 | 0,04% |
| 38 | Israel | ISR | IL | 291,49 | 0,86% | 58,68 | 0,30% |
| 39 | Sri Lanka | LKA | LK | 290,64 | 0,85% | 72,18 | 0,05% |
| 40 | Bermuda | BMU | BM | 289,07 | 0,85% | 72,73 | 0,04% |
| 41 | Italy | ITA | IT | 287,80 | 0,85% | 50,38 | 1,14% |
| 42 | Jordan | JOR | JO | 260,39 | 0,76% | 78,30 | 0,02% |
| 43 | Isle of Man | IMN | IM | 258,34 | 0,76% | 64,68 | 0,09% |
| 44 | Russia | RUS | RU | 256,35 | 0,75% | 57,05 | 0,26% |
| 45 | Saudi Arabia | SAU | SA | 245,47 | 0,72% | 66,68 | 0,06% |
| 46 | Egypt | EGY | EG | 241,93 | 0,71% | 71,38 | 0,03% |
| 47 | India | IND | IN | 238,68 | 0,70% | 47,84 | 1,04% |
| 48 | Australia | AUS | AU | 238,07 | 0,70% | 50,09 | 0,68% |
| 49 | Marshall Islands | MHL | MH | 236,43 | 0,69% | 70,10 | 0,03% |
| 50 | Belgium | BEL | BE | 236,21 | 0,69% | 45,05 | 1,72% |
| 51 | Mauritius | MUS | MU | 235,82 | 0,69% | 71,53 | 0,03% |
| 52 | Liechtenstein | LIE | LI | 229,68 | 0,67% | 74,98 | 0,02% |
| 53 | Cameroon | CMR | CM | 229,23 | 0,67% | 71,48 | 0,02% |
| 54 | Bangladesh | BGD | BD | 228,79 | 0,67% | 72,73 | 0,02% |
| 55 | Turkey | TUR | TR | 225,72 | 0,66% | 59,50 | 0,12% |
| 56 | Romania | ROU | RO | 224,13 | 0,66% | 62,63 | 0,08% |
| 57 | New Zealand | NZL | NZ | 219,00 | 0,64% | 59,20 | 0,12% |
| 58 | South Africa | ZAF | ZA | 218,59 | 0,64% | 56,24 | 0,19% |
| 59 | Poland | POL | PL | 212,10 | 0,62% | 55,55 | 0,19% |
| 60 | Philippines | PHL | PH | 201,18 | 0,59% | 62,85 | 0,05% |
| 61 | Venezuela | VEN | VE | 197,00 | 0,58% | 69,03 | 0,02% |

| Rank | Jurisdiction! | ISO-3 | ISO-2 | FSI ValueZ | FSI Share3 | Secrecy Score4 | Global Scale W< |
|---|---|---|---|---|---|---|---|
| 62 | Anguilla | AIA | Al | 192,99 | 0,57% | 78,20 | 0,01% |
| 63 | Barbados | BRB | BB | 192,86 | 0,57% | 74,00 | 0,01% |
| 64 | Sweden | SWE | SE | 182,86 | 0,54% | 45,65 | 0,71% |
| 65 | Latvia | LVA | LV | 182,83 | 0,54% | 59,13 | 0,07% |
| 66 | Spain | ESP | ES | 164,30 | 0,48% | 43,95 | 0,72% |
| 67 | Czechia | CZE | CZ | 163,30 | 0,48% | 55,40 | 0,09% |
| 68 | St. Kitts and Nevis | KNA | KN | 162,25 | 0,48% | 75,18 | 0,01% |
| 69 | Guatemala | GTM | GT | 162,15 | 0,48% | 73,50 | 0,01% |
| 70 | Ukraine | UKR | UA | 160,45 | 0,47% | 64,90 | 0,02% |
| 71 | Norway | NOR | NO | 157,88 | 0,46% | 44,30 | 0,60% |
| 72 | Morocco | MAR | MA | 157,49 | 0,46% | 67,75 | 0,01% |
| 73 | Brazil | BRA | BR | 157,21 | 0,46% | 51,68 | 0,15% |
| 74 | Maldives | MDV | MV | 155,39 | 0,46% | 79,83 | 0,00% |
| 75 | Hungary | HUN | HU | 151,52 | 0,44% | 53,80 | 0,09% |
| 76 | Portugal | PRT | PT | 151,18 | 0,44% | 54,03 | 0,09% |
| 77 | Puerto Rico | PRI | PR | 150,53 | 0,44% | 73,14 | 0,01% |
| 78 | Tunisia | TUN | TN | 147,48 | 0,43% | 66,48 | 0,01% |
| 79 | Indonesia | IDN | ID | 143,84 | 0,42% | 51,08 | 0,13% |
| 80 | Mexico | MEX | MX | 139,81 | 0,41% | 52,75 | 0,09% |
| 81 | Bahrain | BHR | BH | 137,99 | 0,41% | 62,40 | 0,02% |
| 82 | Chile | CHL | CL | 135,12 | 0,40% | 55,79 | 0,05% |
| 83 | Costa Rica | CRI | CR | 132,24 | 0,39% | 62,33 | 0,02% |
| 84 | Iceland | ISL | IS | 129,31 | 0,38% | 57,38 | 0,03% |
| 85 | El Salvador | SLV | SV | 123,12 | 0,36% | 64,10 | 0,01% |
| 86 | Samoa | WSM | WS | 120,86 | 0,35% | 74,63 | 0,00% |
| 87 | Finland | FIN | Fl | 119,34 | 0,35% | 52,13 | 0,06% |
| 88 | Paraguay | PRY | PY | 117,59 | 0,35% | 77,45 | 0,00% |
| 89 | US Virgin Islands | VIR | VI | 117,03 | 0,34% | 73,89 | 0,00% |
| 90 | Uruguay | URY | UY | 115,47 | 0,34% | 57,00 | 0,02% |
| 91 | Bolivia | BOL | BO | 114,74 | 0,34% | 79,10 | 0,00% |
| 92 | Turks and Caicos Islands | TCA | TC | 114,32 | 0,34% | 77,83 | 0,00% |
| 93 | Croatia | HRV | HR | 112,33 | 0,33% | 55,08 | 0,03% |
| 94 | Argentina | ARG | AR | 109,37 | 0,32% | 54,98 | 0,03% |
| 95 | Seychelles | SYC | SC | 108,53 | 0,32% | 70,44 | 0,00% |
| 96 | Curacao | CUW | CW | 103,60 | 0,30% | 74,85 | 0,00% |
| 97 | Denmark | DNK | DK | 103,52 | 0,30% | 45,33 | 0,14% |
| 98 | Tanzania | TZA | TZ | 100,62 | 0,30% | 70,78 | 0,00% |
| 99 | Rwanda | RWA | RW | 100,47 | 0,30% | 63,00 | 0,01% |
| 100 | Pakistan | PAK | PK | 97,92 | 0,29% | 55,05 | 0,02% |
| 101 | Peru | PER | PE | 96,18 | 0,28% | 57,00 | 0,01% |
| 102 | Colombia | COL | CO | 92,25 | 0,27% | 56,48 | 0,01% |
| 103 | Greece | GRC | GR | 91,65 | 0,27% | 51,48 | 0,03% |

| Rank | Jurisdiction! | ISO-3 | ISO-2 | FSI ValueZ | FSI Share3 | Secrecy Score4 | Global Scale W< |
|---|---|---|---|---|---|---|---|
| 104 | Slovakia | SVK | SK | 91,29 | 0,27% | 50,93 | 0,03% |
| 105 | Lithuania | LTD | LT | 89,83 | 0,26% | 50,30 | 0,04% |
| 106 | Vanuatu | VUT | VU | 88,59 | 0,26% | 76,30 | 0,00% |
| 107 | Dominican Republic | DOM | DO | 86,68 | 0,25% | 58,73 | 0,01% |
| 108 | Kazakhstan | KAZ | KZ | 82,30 | 0,24% | 64,48 | 0,00% |
| 109 | Monaco | MCO | MC | 79,90 | 0,23% | 70,30 | 0,00% |
| 110 | Belize | BLZ | BZ | 78,07 | 0,23% | 73,93 | 0,00% |
| 111 | Liberia | LBR | LR | 77,59 | 0,23% | 78,24 | 0,00% |
| 112 | Aruba | ABW | AW | 76,65 | 0,23% | 73,28 | 0,00% |
| 113 | Botswana | BWA | BW | 58,37 | 0,17% | 62,24 | 0,00% |
| 114 | St. Vincent and the Gren | VCT | VC | 57,72 | 0,17% | 65,65 | 0,00% |
| 115 | Bulgaria | BGR | BG | 57,53 | 0,17% | 49,45 | 0,01% |
| 116 | North Macedonia | MKD | MK | 54,86 | 0,16% | 64,05 | 0,00% |
| 117 | Ghana | GHA | GH | 54,47 | 0,16% | 51,70 | 0,01% |
| 118 | Dominica | DMA | DM | 53,75 | 0,16% | 73,65 | 0,00% |
| 119 | Montenegro | MNE | ME | 53,65 | 0,16% | 60,03 | 0,00% |
| 120 | Ecuador | ECU | EC | 50,66 | 0,15% | 47,21 | 0,01% |
| 121 | Estonia | EST | EE | 46,03 | 0,14% | 43,05 | 0,02% |
| 122 | Antigua and Barbuda | ATG | AG | 39,05 | 0,11% | 76,08 | 0,00% |
| 123 | Andorra | AND | AD | 38,84 | 0,11% | 58,33 | 0,00% |
| 124 | Gambia | GMB | GM | 37,72 | 0,11% | 74,88 | 0,00% |
| 125 | Brunei | BRN | BN | 34,62 | 0,10% | 78,30 | 0,00% |
| 126 | Grenada | GRD | GD | 34,56 | 0,10% | 70,55 | 0,00% |
| 127 | Trinidad and Tobago | TTO | TT | 29,63 | 0,09% | 64,65 | 0,00% |
| 128 | Slovenia | SVN | SI | 27,48 | 0,08% | 37,55 | 0,01% |
| 129 | San Marino | SMR | SM | 20,82 | 0,06% | 60,45 | 0,00% |
| 130 | Montserrat | MSR | MS | 15,43 | 0,05% | 74,60 | 0,00% |
| 131 | Nauru | NRU | NR | 13,79 | 0,04% | 59,95 | 0,00% |
| 132 | St. Lucia | LCA | LC | 12,25 | 0,04% | 71,03 | 0,00% |
| 133 | Cook Islands | COK | CK | 12,09 | 0,04% | 70,30 | 0,00% |

https://fsi.taxjustice.net/en/introduction/fsi-results

**Table A.2: Average annual growth of GDP and GNP per capita in % 2000 – 2019**

| Countries | Average Annual GDP growth per capita Growth GDP | Average Annual growth of GDP per capita Growth GNP |
|---|---|---|
| Andorra | N/A | N/A |
| Anguilla | N/A | N/A |
| Antigua and Barbuda | 2.53 | N/A |
| Aruba | N/A | N/A |
| Bahamas | 1.13 | 0.94 |
| Bahrain | 4.43 | 0.16 |
| Bermuda | N/A | N/A |
| Belize | 3.47 | 1.06 |
| British Virgin Islands | N/A | N/A |
| Cayman Islands | N/A | N/A |
| Cook Islands | N/A | N/A |
| Cyprus | 2.57 | 0.78 |
| Dominica | 1.41 | N/A |
| Gibraltar | N/A | N/A |
| Grenada | 2.72 | N/A |
| Guernsey | N/A | N/A |
| Isle of Man | N/A | N/A |
| Jersey | N/A | N/A |
| Liberia | 2.42 | 1.50 |
| Liechtenstein | 2.00 | N/A |
| Malta | 4.72 | 2.04 |
| Marshall Islands | 1.81 | 1.87 |
| Mauritius | 4.08 | 3.90 |
| Monaco | 3.38 | N/A |
| Montserrat | N/A | N/A |
| Nauru | 7.45 | N/A |
| Netherlands Antilles | N/A | N/A |
| Niue | N/A | N/A |

| Countries | Average Annual GDP growth per capita Growth GDP | Average Annual growth of GDP per capita Growth GNP |
|---|---|---|
| Panama | N/A | 3.77 |
| Samoa | 2.56 | N/A |
| San Marino | 0.28 | N/A |
| Seychelles | 3.01 | -2.60 |
| St. Lucia | 1.71 | N/A |
| St. Kitts & Nevis | N/A | N/A |
| St. Vincent and the Grenadines | 2.10 | N/A |
| Turks & Caicos Islands | N/A | N/A |
| US Virgin Islands | N/A | N/A |
| Vanuatu | 2.87 | 1.93 |
| World' s Average | 2.92 | 1.62 |
| Tax Haven's Average | 2.84 | 1.65 |

Source: Word Bank Database

**Table A.3: Average of variables for using regression (1)**

| Countries | Growth GDP | GDPC | POP |
|---|---|---|---|
| Andorra | N/A | 0.80 | 78006.60 |
| Anguilla | N/A | N/A | N/A |
| Antigua and Barbuda | 2.53 | 1.19 | 87009.50 |
| Aruba | N/A | N/A | N/A |
| Bahamas | 1.13 | N/A | 389482.00 |
| Bahrain | 4.43 | -0.40 | 1143073.30 |
| Bermuda | N/A | N/A | N/A |
| Belize | 3.47 | 0.95 | 318732.50 |
| British Virgin Islands | N/A | N/A | 26096.85 |
| Cayman Islands | N/A | N/A | N/A |
| Cook Islands | N/A | N/A | N/A |
| Cyprus | 2.57 | 1.29 | 1088419.60 |

| Countries | Growth GDP | GDPC | POP |
|---|---|---|---|
| Dominica | 1.41 | 1.26 | 70782.55 |
| Gibraltar | N/A | N/A | 33222.80 |
| Grenada | 2.72 | 2.26 | 106790.75 |
| Guernsey | N/A | N/A | N/A |
| Isle of Man | N/A | N/A | N/A |
| Jersey | N/A | N/A | N/A |
| Liberia | 2.42 | -0.53 | 3829047.00 |
| Liechtenstein | 2.00 | 1.13 | 35863.10 |
| Malta | 4.72 | 3.35 | 424254.25 |
| Marshall Islands | 1.81 | 1.03 | 55804.95 |
| Mauritius | 4.08 | 3.69 | N/A |
| Monaco | 3.38 | 2.34 | 35542.65 |
| Montserrat | N/A | N/A | N/A |
| Nauru | 7.45 | 6.85 | 10173.80 |
| Netherlands Antilles | N/A | N/A | N/A |
| Niue | N/A | N/A | N/A |
| Panama | N/A | N/A | N/A |
| Samoa | 2.56 | 1.91 | 185743.15 |
| San Marino | 0.28 | -0.82 | N/A |
| Seychelles | 3.01 | 2.01 | 88160.25 |
| St. Lucia | 1.71 | 0.87 | N/A |
| St. Kitts & Nevis | N/A | N/A | 52834.00 |
| St. Vincent and the Grenadines | 2.10 | 1.97 | 108738.95 |
| Turks & Caicos Islands | N/A | N/A | N/A |
| US Virgin Islands | N/A | N/A | N/A |
| Vanuatu | 2,87 | 0,32 | 237283.30 |

Source: Word Bank Database.

Note: Due to the nature of tax havens for many countries there is no data for this shown as N/A. For this reason, the sample, for the use of regression, will be smaller, so that all variables have values.

**Table A.4: Average of variables for using regression (1)**

| Countries | Growth GDP | POP | GDPC |
|---|---|---|---|
| Andorra | 2.53 | 78006.6 | 0.8 |
| Antigua and Barbuda | 2.53 | 87009.5 | 1.19 |
| Bahrain | 4.43 | 1143073.3 | -0.4 |
| Belize | 3.47 | 318732.5 | 0.95 |
| Cyprus | 2.57 | 1088419.6 | 1.29 |
| Dominica | 1.41 | 70782.55 | 1.26 |
| Grenada | 2.72 | 106790.75 | 2.26 |
| Liberia | 2.42 | 3829047 | -0.53 |
| Liechtenstein | 2 | 35863.1 | 1.13 |
| Malta | 4.72 | 424254.25 | 3.35 |
| Marshall Islands | 1.81 | 55804.95 | 1.03 |
| Mauritius | 4.08 | 35542.65 | 3.69 |
| Monaco | 3.38 | 35542.65 | 2.34 |
| Nauru | 7.45 | 10173.8 | 6.85 |
| Samoa | 2.56 | 185743.15 | 1.91 |
| San Marino | 0.28 | 35863.1 | -0.82 |
| Seychelles | 3.01 | 88160.25 | 2.01 |
| St. Lucia | 1.71 | 35863.1 | 0.87 |
| St. Vincent and the Grenadines | 2.1 | 108738.95 | 1.97 |
| Vanuatu | 2.87 | 237283.3 | 0.32 |

**Table A.5: Average Tax Revenue and Public Expenditure as a percentage of GDP in % 2000 – 2019**

| Countries | Tax revenues / GDP | Public expenditures / GDP |
|---|---|---|
| Andorra | N/A | N/A |
| Anguilla | N/A | N/A |
| Antigua and Barbuda | 17.08 | 21.88 |
| Aruba | N/A | N/A |
| Bahamas | 11.75 | 12.93 |
| Bahrain | 3.78 | 21.72 |
| Barbados | 25.26 | 31.58 |
| Bermuda | N/A | N/A |
| Belize | 22.38 | 23.85 |

| Countries | Tax revenues / GDP | Public expenditures / GDP |
|---|---|---|
| British Virgin Islands | N/A | N/A |
| Cayman Islands | N/A | N/A |
| Cook Islands | N/A | N/A |
| Cyprus | 31.04 | 49.09 |
| Dominica | 22.04 | 24.02 |
| Gibraltar | N/A | N/A |
| Grenada | 18.68 | 18.76 |
| Guernsey | N/A | N/A |
| Isle of Man | N/A | N/A |
| Jersey | N/A | N/A |
| Liberia | 17.67 | 18.29 |
| Liechtenstein | N/A | N/A |
| Luxembourg | 25.10 | 38.07 |
| Malta | 37.54 | 59.96 |
| Marshall Islands | 17.41 | 55.47 |
| Mauritius | 16.70 | 20.13 |
| Monaco | N/A | N/A |
| Montserrat | N/A | N/A |
| Nauru | 22.63 | 87.00 |
| Netherlands Antilles | N/A | N/A |
| Niue | N/A | N/A |
| Panama (English) | N/A | N/A |
| Samoa | 22.19 | 29.54 |
| San Marino | 15.29 | 33.15 |
| Seychelles | 27.55 | 30.50 |
| St. Lucia | 20.07 | 19.08 |
| St. Kitts & Nevis | 20.62 | 22.90 |
| St. Vincent and the Grenadines | 22.56 | 23.71 |
| Turks & Caicos Islands | N/A | N/A |
| US Virgin Islands | N/A | N/A |
| Vanuatu | 17.22 | 24.07 |
| World's Average | 14.86 | 28.13 |
| Tax Haven's Average | 20.69 | 31.54 |

Source: Word Bank Database.
Note: Due to the nature of tax havens for many countries there is no data for this shown as N/A. For this reason, the sample, for the use of regression, will be smaller, so that all variables have values.

## Table A.6: Average of variables for using regression (2)

| Countries | Tax revenue / GDP | Population | GNP |
|---|---|---|---|
| Andorra | N/A | 78006.6 | N/A |
| Anguilla | N/A | N/A | N/A |
| Antigua and Barbuda | 17.08 | 87009.5 | N/A |
| Aruba | N/A | 100967.5 | N/A |
| Bahamas | 11.75 | 389482 | 0.94 |
| Bahrain | 3.78 | 1143073.3 | 0.16 |
| Barbados | 25.26 | 280477.05 | N/A |
| Bermuda | N/A | 64245.45 | N/A |
| Belize | 22.38 | 318732.5 | 1.06 |
| British Virgin Islands | N/A | 26096.85 | N/A |
| Cayman Islands | N/A | 54930.75 | N/A |
| Cook Islands | N/A | N/A | N/A |
| Cyprus | 31.04 | 1088419.6 | 0.78 |
| Dominica | 22.04 | 70782.55 | N/A |
| Gibraltar | N/A | 33222.8 | N/A |
| Grenada | 18.68 | 106790.75 | N/A |
| Guernsey | N/A | N/A | N/A |
| Hong Kong | N/A | 7507000.00 | 3.34 |
| Ireland | 23.36 | 4904000.00 | 2.92 |
| Isle of Man | N/A | 82189.4 | N/A |
| Jersey | N/A | N/A | N/A |
| Liberia | 17.67 | 3829047 | 1.5 |
| Liechtenstein | N/A | 35863.1 | N/A |
| Luxembourg | 25.10 | 513488.8 | -1.24 |
| Malta | 37.54 | 424254.25 | 2.04 |
| Marshall Islands | 17.41 | 55804.95 | 1.87 |
| Mauritius | 16.70 | 1266000 | 3.9 |
| Monaco | N/A | 35542.65 | N/A |
| Montserrat | N/A | N/A | N/A |
| Nauru | 22.63 | 10173.8 | N/A |
| Netherlands Antilles | N/A | N/A | N/A |
| Niue | N/A | N/A | N/A |
| Panama (English) | N/A | N/A | 3.77 |
| Samoa | 22.19 | 185743.15 | N/A |
| San Marino | 15.29 | 33860 | N/A |
| Seychelles | 27.55 | 88160.25 | -2.6 |

| Countries | Tax revenue / GDP | Population | GNP |
|---|---|---|---|
| St. Lucia | 20.07 | 182790 | N/A |
| St. Kitts & Nevis | 20.62 | 52834 | N/A |
| St. Vincent and the Grenadines | 22.56 | 108738.95 | N/A |
| Turks & Caicos Islands | N/A | N/A | N/A |
| US Virgin Islands | N/A | N/A | N/A |
| Vanuatu | 17.22 | 237283.3 | 1.93 |

Note: Due to the nature of tax havens for many countries there is no data for this shown as N/A. For this reason, the sample, for the use of regression, will be smaller, so that all variables have values.

**Table A.7: Average of variables for using regression (2)**

| Countries | Tax revenues / GDP | Population | GNP |
|---|---|---|---|
| Bahrain | 3.78 | 1143073.30 | 0.16 |
| Bahamas | 11.75 | 389482.00 | 0.94 |
| Mauritius | 16.70 | 1266000.00 | 3.90 |
| Vanuatu | 17.22 | 237283.30 | 1.93 |
| Marshall Islands | 17.41 | 55804.95 | 1.87 |
| Liberia | 17.67 | 3829047.00 | 1.50 |
| Jordan | 22.38 | 318732.50 | 1.06 |
| Ireland | 23.36 | 4904000.00 | 2.92 |
| Luxembourg | 25.10 | 513488.80 | -1.24 |
| Seychelles | 27.55 | 88160.25 | -2.60 |
| Cyprus | 31.04 | 1088419.60 | 0.78 |
| Malta | 37.54 | 424254.25 | 2.04 |

**Table A.8: Average of variables for using regression (3)**

| Countries | Public expenditures / GDP | Population | GNP |
|---|---|---|---|
| Andorra | N/A | 78006.6 | N/A |
| Anguilla | N/A | N/A | N/A |
| Antigua and Barbuda | 21.88 | 87009.5 | N/A |
| Aruba | N/A | 100967.5 | N/A |

| Countries | Public expenditures / GDP | Population | GNP |
|---|---|---|---|
| Bahamas | 12.93 | 389482 | 0.94 |
| Bahrain | 21.72 | 1143073.3 | 0.16 |
| Barbados | 31.58 | 280477.05 | N/A |
| Bermuda | N/A | 64245.45 | N/A |
| Belize | 23.85 | 318732.5 | 1.06 |
| British Virgin Islands | N/A | 26096.85 | N/A |
| Cayman Islands | N/A | 54930.75 | N/A |
| Cook Islands | N/A | N/A | N/A |
| Cyprus | 49.09 | 1088419.6 | 0.78 |
| Dominica | 24.02 | 70782.55 | N/A |
| Gibraltar | N/A | 33222.8 | N/A |
| Grenada | 18.76 | 106790.75 | N/A |
| Guernsey | N/A | N/A | N/A |
| Hong Kong | N/A | 7507000.00 | 3.34 |
| Ireland | 34.66 | 4904000.00 | 2.92 |
| Isle of Man | N/A | 82189.4 | N/A |
| Jersey | N/A | N/A | N/A |
| Liberia | 18.29 | 3829047 | 1.5 |
| Liechtenstein | N/A | 35863.1 | N/A |
| Luxembourg | 38.07 | 513488.8 | -1.24 |
| Malta | 59.96 | 424254.25 | 2.04 |
| Marshall Islands | 55.47 | 55804.95 | 1.87 |
| Mauritius | 20.13 | 1266000 | 3.9 |
| Monaco | N/A | 35542.65 | N/A |
| Montserrat | N/A | N/A | N/A |
| Nauru | 87.00 | 10173.8 | N/A |
| Netherlands Antilles | N/A | N/A | N/A |
| Niue | N/A | N/A | N/A |
| Panama (English) | N/A | N/A | 3.77 |
| Samoa | 29.54 | 185743.15 | N/A |
| San Marino | 33.15 | 33860 | N/A |
| Seychelles | 30.50 | 88160.25 | -2.6 |
| St. Lucia | 19.08 | 182790 | N/A |
| St. Kitts & Nevis | 22.90 | 52834 | N/A |
| St. Vincent and the Grenadines | 23.71 | 108738.95 | N/A |
| Turks & Caicos Islands | N/A | N/A | N/A |
| US Virgin Islands | N/A | N/A | N/A |

| Countries | Public expenditures / GDP | Population | GNP |
|---|---|---|---|
| Vanuatu | 24.07 | 237283.3 | 1.93 |

Note: Due to the nature of tax havens for many countries there is no data for this shown as N/A. For this reason, the sample, for the use of regression, will be smaller, so that all coefficients have values.

**Table A.9: Average of variables for using regression**

| Countries | Public expenditures / GDP | Population | GNP |
|---|---|---|---|
| Bahamas | 12.93 | 389482.00 | 0.94 |
| Mauritius | 20.13 | 1266000.00 | 3.9 |
| Bahrain | 21.72 | 1143073.30 | 0.16 |
| Belize | 23.85 | 318732.50 | 1.06 |
| Vanuatu | 24.07 | 237283.30 | 1.93 |
| Seychelles | 30.50 | 88160.25 | -2.6 |
| Luxembourg | 38.07 | 513488.80 | -1.24 |
| Cyprus | 49.09 | 1088419.60 | 0.78 |
| Marshall Islands | 55.47 | 55804.95 | 1.87 |
| Malta | 59.96 | 424254.25 | 2.04 |

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# THE EVOLUTION OF ENERGY SECURITY STUDIES: INSIGHTS FROM BIBLIOMETRIC ANALYSIS

P. KARSIOTIS* A. ADAMOPOULOS**

## Abstract

Over the past decades, the literature on energy security has expanded rapidly and across multiple disciplines, resulting in a fragmented and conceptually diverse body of research. Despite the obvious importance of energy security, it has not been possible to agree on a commonly accepted definition in the scientific community, as energy security has different meaning depending on the occasion and context. This study provides a comprehensive bibliometric analysis of energy security literature to examine its intellectual structure, thematic evolution, and research dynamics over time. Using bibliographic data retrieved from Scopus database, the analysis applies descriptive statistics, citation analysis, co-citation analysis, co-authorship networks, and keyword co-occurrence techniques to map the development of the field of energy security and the results reveal distinct phases in the evolution of energy security research, moving from a dominant focus on fossil fuel supply security and price stability toward broader frameworks incorporating energy transition, sustainability, resilience and geopolitics. Influential journals, authors, and institutions shaping the field are identified, along with major thematic clusters and emerging research frontiers. The findings highlight increasing interdisciplinarity and international collaboration, alongside persistent regional and methodological gaps. By systematically mapping the evolution of energy security studies, this paper contributes to a clearer understanding of the field's knowledge base and provides guidance for future research and policy-relevant inquiry.

*JEL Classification: Q48, C38, O13*

*Keywords: Energy security, Bibliometric analysis, Keyword analysis, Thematic cluster*

## 1. Introduction

In times of geopolitical turmoil, as new challenges emerge, old concepts regain wide attention and adapt to new reality. The need to secure essential energy resources is vital for the proper functioning of economic activity, yet this is not always an easy task. Random events can, at any moment, disrupt fragile balances and threaten energy supply routes, especially for countries that lack energy independence, like EU countries, this possibility is particularly

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alarming. After the Russian annexation of Crimea and the invasion in Ukraine, energy security has emerged as one of the most pressing challenges in contemporary global governance, economic development, and environmental sustainability and academic concern is reflected in the related literature growth. Energy security is highly connected to fossil fuels, particularly oil, as the energy mix is dominated by fossil fuels. Early conceptualizations of energy security were largely supply-oriented and defined as the uninterrupted availability of energy at affordable prices (WB, 2005) mostly influenced by the oil crises of the 1970s. However, as energy systems became more complex and interconnected, scholars began to argue that such narrow definitions were insufficient to capture the broader range of risks facing energy systems.

While ensuring energy sufficiency is a fundamental issue, there are also other dimensions that concern modern societies and are linked to energy security. First, the technological framework has made significant progress, both in terms of energy production from renewable sources and in energy efficiency, which allows the use of less energy. On the other hand, there is a particularly strong societal awareness of environmental issues, as the adverse effects of anthropocentric activity place a significant burden on the environment. These more contemporary dimensions are incorporated by the scientific community into a new analytical framework.

Contemporary literature conceptualizes energy security as a multidimensional phenomenon encompassing those technical, economic, geopolitical, environmental, and social dimensions (Cherp & Jewell, 2014; Sovacool, 2011). As Cherp & Jewell (2014) propose, energy security should be understood in terms of "low vulnerability of vital energy systems", in this context energy security should not be seen simply as having enough energy or access to resources, but rather as the ability of energy systems to withstand and cope with risks. Managing risks and building resilient systems has become a crucial part of energy security.

An important aspect in the evolution of literature is the distinction between supply-side and demand-side energy security. Supply-side perspectives focus primarily on production, imports, infrastructure, and reserves, while demand-side approaches emphasize energy efficiency, consumption patterns, and demand management (Winzer, 2012). Demand-side measures, such as improving energy efficiency, are increasingly viewed as cost-effective strategies for enhancing energy security while simultaneously achieving climate goals.

One of the most widely cited frameworks in energy security research is the "four As" model: availability, accessibility, affordability, and acceptability (Kruyt et al., 2009). Availability refers to the physical presence of sufficient

energy resources, whether domestic or imported, to meet current and future demand. Accessibility emphasizes the ability of a country or region to secure energy supplies through stable infrastructure, trade routes, and geopolitical relationships. Affordability relates to the economic dimension of energy security, highlighting the importance of stable and reasonable energy prices for consumers and industries. Acceptability addresses environmental and social concerns, including greenhouse gas emissions, local pollution, and public acceptance of energy technologies. In recent years, the acceptability dimension has gained prominence due to growing awareness of climate change and sustainability challenges.

Energy security is increasingly linked with environmental security, as dependence on carbon-intensive energy sources poses long-term risks to ecological systems and human well-being (Sovacool & Mukherjee, 2011). Consequently, renewable energy sources are often framed as enhancing energy security by reducing import dependence, diversifying energy mixes, and lowering exposure to volatile fossil fuel markets (Ang et al., 2015). However, scholars also caution that renewable energy introduces new security challenges, such as intermittency, critical mineral supply risks, and grid stability issues.

Energy security is also deeply intertwined with geopolitics and international relations, so that control over energy resources, transit routes, and strategic chokepoints has long influenced global power dynamics. Studies highlight how geopolitical tensions, conflicts, and sanctions can disrupt energy flows and increase vulnerability, particularly energy-import-dependent countries (Yergin, 2006). At the same time, globalization and market integration have created new forms of interdependence, complicating traditional notions of national energy security. From a regional perspective, energy security priorities differ significantly between developed and developing economies.

While industrialized countries often emphasize supply diversification and decarbonization, developing countries may prioritize energy access and affordability to support economic growth and poverty reduction (Sovacool, 2012). This diversity of priorities contributes to the conceptual ambiguity of energy security but also underscores its relevance across different contexts.

Overall, the literature reveals that energy security has evolved from a narrow focus on fossil fuel supply disruptions to a comprehensive framework encompassing resilience, sustainability, and socio-economic considerations. This conceptual expansion has led to a rapidly growing and increasingly interdisciplinary body of research. Understanding these conceptual dimensions is essential for interpreting bibliometric patterns in the energy security literature

and for identifying dominant themes, emerging topics, and research gaps explored in subsequent sections of this study.

Addressing these gaps, the present study employs a comprehensive bibliometric approach to systematically examine the literature on energy security. By employing performance analysis and science mapping techniques, this study investigates key indicators of scholarly productivity, identifies influential authors, journals, and countries, and explores thematic clusters and research trends. The analysis covers publications indexed in major databases over the last two decades, providing an updated and integrative perspective on the evolution of energy security research.

The objectives of this study are fourfold:

- To analyze the temporal growth of publications and citations in energy security research.
- To identify the most influential journals, authors, and institutions contributing to the field.
- To examine collaborative networks at the author, institutional, and country levels.
- To map thematic clusters and emerging research trends to identify gaps and future research directions.

## 2. Literature review

In response to rapid increase in literature, bibliometric analysis has emerged as a complementary and increasingly popular approach for reviewing energy related research. Bibliometric methods enable the quantitative evaluation of large volumes of academic publications, allowing scholars to identify influential authors, journals, institutions, and countries, as well as to detect thematic clusters and emerging research fronts (Donthu et al., 2021). Bibliometric is an important tool and in comparison, to traditional reviews, bibliometric studies offer greater transparency, reproducibility, and scalability, making them particularly suitable for interdisciplinary fields such as energy security.

Esfahani et al. (2021) provide a comprehensive knowledge map, identifying the most critical dimensions of energy security such as technology, trade, acceptability, productivity, diversity, equity, availability, governance, and efficiency. They highlight that while energy security remains the overarching term, renewable energy security and energy supply security have become dominant sub-topics. Zhou et al. (2018) note that the term energy security gained significant traction after the oil shocks of the 1970s and the Kyoto Protocol (1997), with a rapid growth phase occurring after 2009.

Jabeen et al. (2021) conduct a comparative review focusing on the sustainability of renewable sources, identifying biofuels, solar energy, wind energy, and renewable electricity as the most examined resources of the last decade. Their findings underscore that developed countries are significantly ahead in replacing fossil fuels with renewables, while underdeveloped nations still face economic barriers to adaptation. Furthermore, Jiang and Liu (2023) highlight the contradictions inherent in this transition. They argue that energy security must be balanced against social, economic, and environmental issues, such as land use and climate change. Their evaluation of "disruptive innovation" indicates that major breakthroughs in the field are increasingly linked to renewable energy storage and conversion technologies.

Jiang and Liu (2023) observe that China has gradually overtaken UK and US to become the largest producer of literature in the field, indicating a notable trend across literature is the shifting center of energy security research. This is also noted by Gou et al. (2022), who identify the USA and China as the top two contributors to safety and security research based on system dynamics. This shift reflects the broader global trend of East and South Asian regions becoming central to the global energy transition and technological innovation.

The application of complex modeling techniques has become essential for understanding energy systems. Gou et al. (2022) demonstrate the utility of system dynamics in safety and security research. They argue that system dynamics allows researchers to identify risk factors and predict system stability in energy consumption. Their analysis identifies system safety and reliability and power system dynamics as current research frontiers. This methodology is critical for managing the variability of renewable sources like wind and solar, which require robust storage and grid stability solutions.

## 3. Data analysis

Corpus data was collected from the Scopus database, a widely recognized and reliable source for academic research citations on 15 December 2025. The search focused on records containing the term "energy security" in titles, abstracts, and keywords. Due to Scopus's download limit of 20.000 records, the results were restricted to documents in English and specific types: articles, conference papers, books, book chapters, and reviews. This process yielded a total of 19.155 records spanning 1999 to 2025. As shown in Table 1, journals and conference papers make up the majority of publications at 55% and 22%, respectively; book chapters account for 12%, while reviews and books comprise the remaining 11%.

**Table 1: Overview of energy security corpus**

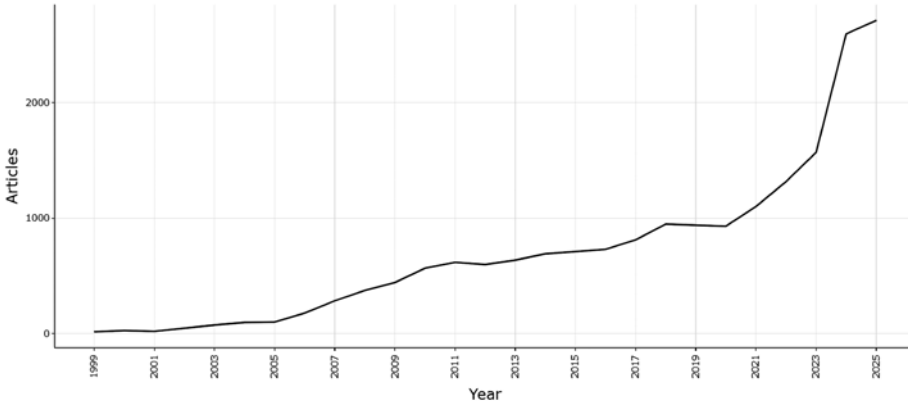
| Description | Results |
|---|---|
| **Main information about data** | |
| Timespan | 1999 : 2025 |
| Sources (Journal, Books, etc) | 3.113 |
| Documents | 19.155 |
| Annual Growth Rate % | 21,54 |
| Document Average Age | 7,36 |
| Average citation per doc | 22,59 |
| References | 125.414 |
| **Document contents** | |
| Keyword Plus (ID) | 51.151 |
| Athor's Keywords (DE) | 33.103 |
| **Authors** | |
| Authors | 41.255 |
| Authors of single-authored docs | 3.225 |
| **Authors collaboration** | |
| Single-authored docs | 4.171 |
| Co-Authors per doc | 3,32 |
| International co-authorships % | 22,65 |
| **Document types** | |
| Article | 10.509 |
| Book | 515 |
| Book chapter | 2.374 |
| Conference Paper | 4.184 |
| Review | 1.573 |

The field exhibits a strong and sustained expansion, with an annual growth rate of 21,54%, highlighting the rapidly increasing scholarly attention to energy security. On average, the documents are relatively recent, with a mean age of 7,36 years, and demonstrate a solid academic impact, receiving an average of 22,59 citations per document. Collectively, the dataset includes 125.414 cited references, indicating a well-developed and interconnected body of literature. In terms of content, 51.151 Keywords Plus and 33,103 author-provided keywords were identified, reflecting both conceptual diversity and thematic richness within the field.

Figure 1 illustrates the annual evolution of scientific publications from the period 1999 to 2025, revealing a clear pattern of long-term growth with distinct developmental phases. Overall, the trajectory reflects the progressive consolidation and subsequent acceleration of scholarly interest, consistent with the emergence and expansion of a dynamic research field.

During the initial period (1999 – 2004), publication output remains relatively low, with only a small number of articles published annually. From 2005 the curve shows a steady and sustained increase in annual publications and by 2010, annual output had increased several-fold compared to the early years. This phase aligns closely with Russia's annexation of Crimea in 2014 and the onset of the conflict in Ukraine, which fundamentally altered the European security environment. The close reliance of Europe on Russian gas and the sanctions taken against one of Europe's major energy suppliers left Europe in a desperate attempt to change the energy mix and ensure a stable energy supply from alternative roots.

**Figure 1: Annual Scientific Production**



## 4. Empirical analysis and results

To analyze the temporal evolution of the selected research topic, we employed a life cycle analysis of scientific production based on a logistic growth model, as shown in Figure 2. This approach is grounded in theories of scientific paradigms and innovation diffusion, which posit that research topics typically follow an S-shaped trajectory characterized by emergence, rapid expansion, maturity, and eventual decline. Logistic models have been widely applied in bibliometric studies to capture such cumulative growth patterns and to estimate key developmental milestones of scientific fields.

The logistic model demonstrates a strong fit to the observed publication trajectory, with an $R^2$ value of 0.915, indicating that over 91% of the variance in annual publication counts is explained by the model. This high explanatory power supports the appropriateness of the logistic growth assumption for modeling the evolution of this research topic.

The model forecasts a peak annual output of approximately 7.150 publications, expected to occur around the year 2040. Because the predicted peak lies well beyond the last observed year in the dataset, the field can be classified as being in a rapid growth phase, with annual production still increasing and far from reaching maturity. According to the logistic life cycle framework, this phase is characterized by heightened scholarly interest, expanding research communities, and increasing institutional and funding support.

The main literature consists of 3.113 distinct sources. The bibliometric analysis of the research landscape reveals a highly concentrated distribution of literature across a select group of academic journals and conference proceedings. As illustrated in Figure 3 the field exhibits a “long-tail” distribution pattern, where a small number of core sources account for most of the scholarly output. Energy Policy and Energies emerge as the leading peer-reviewed journals, contributing 579 and 558 documents, respectively.

The prominence of these titles, alongside Renewable and Sustainable Energy Reviews (387) and Applied Energy (210), underscores a research climate heavily focused on the intersection of technical engineering, policy framework, and environmental sustainability. Furthermore, the inclusion of the IOP Conference Series and E3S Web of Conferences indicates that the field is dynamic, with a substantial portion of the knowledge exchange occurring through rapid-dissemination conference platforms. The presence of Sustainability and the Journal of Cleaner Production further confirms that the thematic core of the analyzed literature is rooted in the “Green” transition and sustainable development (Figures 2, 3).

**Figure 2: Life Cycle**

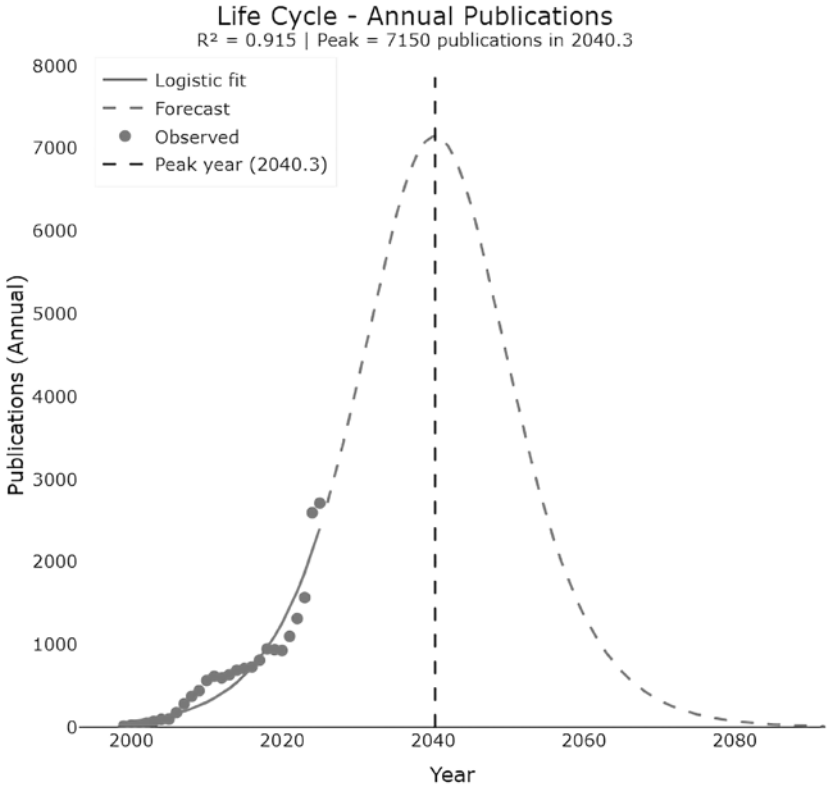
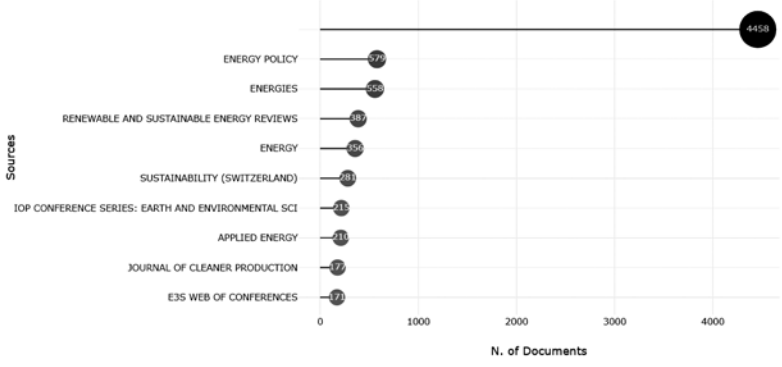



**Figure 3: Most relevant sources**



In bibliometric research, Source Local Impact (Figure 4) serves as a vital metric for identifying the most influential journals within a specific field of study. While the previous chart highlighted productivity in terms of volume of documents, local impact measures quality and resonance through the H-index. Unlike global citation counts, local impact focuses exclusively on citations generated by other papers within the uploaded dataset. This filters out general prestige and highlights the journals that are truly driving the conversation on this specific topic. Journals like Energy Policy and Applied Energy often appear at the top of these lists because they provide the foundational theories and data used by subsequent researchers in the field. High local impact scores indicate that a source is not just a prolific publisher, but a central pillar of the intellectual structure, shaping the development and direction of the research theme.

The datasets count 41.125 authors meaning 3.4 co-authors per document. Top 10 authors and their productivity over time are displayed in Figure 5, which provides a longitudinal perspective on the research activity and impact of the field's leading scholars. In this visualization, each horizontal line represents an author's individual timeline, beginning with their first publication in the dataset and extending to their most recent contribution. The size of the bubbles on these timelines is proportional to the number of documents published each year, while the color intensity reflects the Total Citations (TC) per year. By tracking these patterns, researchers can identify authors who have shaped the field's foundation over decades, as well as "rising stars" whose recent, highly cited works are currently driving the academic discourse.

Zhang J exhibits the longest sustained presence in the field, with activity dating back to 2003. However, a prominent trend across nearly all identified authors, particularly Wang Y, Zhang Y, and Li X, is a marked increase in publication volume and citation weight during the most recent five-year period (2020–2025). In this list appears Benjamin Sovacool, whose most impactful contributions occurred between 2010 and 2014. This suggests that while other authors are currently reaching their professional zenith, Sovacool provided foundational high-impact work that likely shaped the field's earlier development. Conversely, authors such as Wang X and Li J represent a newer cohort of influential researchers who entered the field around 2010–2011 and have maintained consistent growth since.

The provided choropleth map (Figure 6) illustrates the global distribution of scientific production and research contributions, highlighting a clear concentration of academic output in specific geographical regions. The map utilizes a blue color gradient where darker shades signify a higher volume of

**Figure 4: Sources' Local Impact**

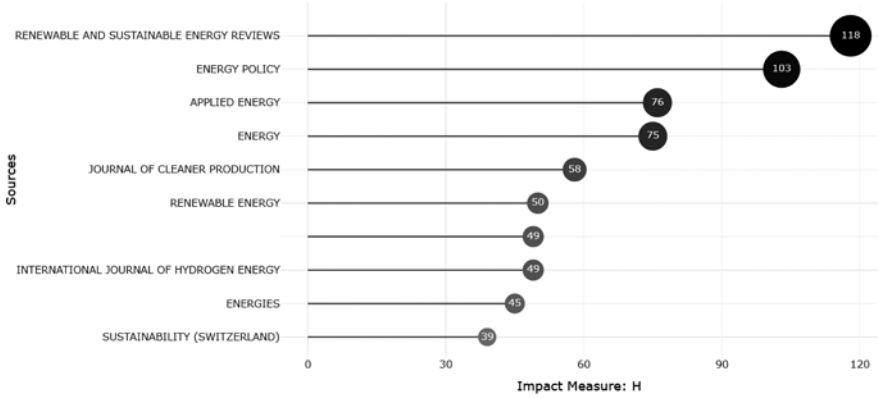
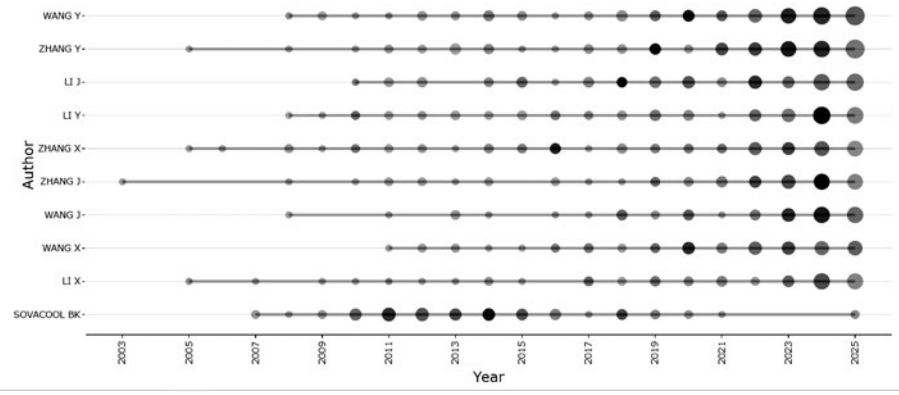



**Figure 5: Authors' Production over Time**




publications or research intensity, while lighter shades and grey areas indicate lower production or a lack of data. The most striking feature of the visualization is the dominance of China and the United States, both of which are rendered in the darkest shade of blue. This indicates that these two nations serve as the primary global epicenters for the research field in question. Their significant contribution reflects well-established research infrastructures, substantial funding, and a high density of academic institutions. Following closely is India, which is depicted in a medium-to-dark blue shade, marking it as a major contributor within the Global South. This underscores India's growing role in

the international scientific community and its increasing output in emerging research domains.

The distribution across other continents reveals a more fragmented landscape. In Europe, most European countries, including the United Kingdom, Germany, France, and Italy exhibit a consistent medium-blue shade. This suggests a steady and significant contribution to the field. In America, beyond the United States, Canada and Brazil show moderate levels of production. Mexico and several South American countries contribute to a lesser extent, shown in lighter blue. Australia demonstrates a moderate level of activity, while New Zealand shows a lighter presence. Countries like Iran, Pakistan, and South Korea show notable research activity, filling out the Asian continent's strong showing on the map. In contrast, large portions of Africa and parts of Central Asia and South America are shaded in light blue or grey. A somehow unexpected result is the gray color on the map that the Russian Federation sets. Indeed, this result is somewhat strange and should be investigated further. However, it should be pointed out that this may be due to the selection of the sample, as it was limited exclusively to English-language journals and documents.

However, the global landscape of scientific research has undergone a dramatic transformation over the last two decades, characterized by a shift from Western dominance toward a more multipolar distribution of knowledge production. As shown in Figure 7, for much of the early 21st century, the USA maintained a significant lead, showing a steady upward trend in article production that accelerated notably after 2010. Despite this consistent growth, the most remarkable trend is the exponential rise of China. Starting from a negligible output in 1999, China's publication volume surpassed that of the United Kingdom and India around 2017 and eventually overtook the USA by approximately 2023.

By 2025, China's output reached a peak of over 6.000 annual articles, significantly eclipsing all other nations. India has also emerged as a major player, exhibiting a growth curve that mirror's China's trend, albeit at a lower volume, surpassing the United Kingdom and Japan in recent years. While the UK and Japan show positive growth, their slopes are significantly flatter compared to the rapid acceleration seen in China and India. This data confirms that while the USA remains a cornerstone of global research, the center of gravity in scientific production is rapidly shifting toward Asia, driven by an unprecedented surge in Chinese and Indian scholarly output.

In terms of most frequent words, this massive increase in publication volume is intrinsically linked to the urgent global focus on the

**Figure 6: Countries production**

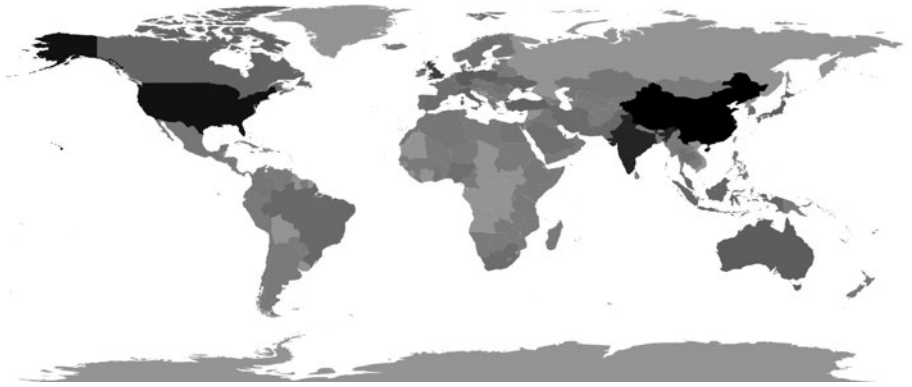
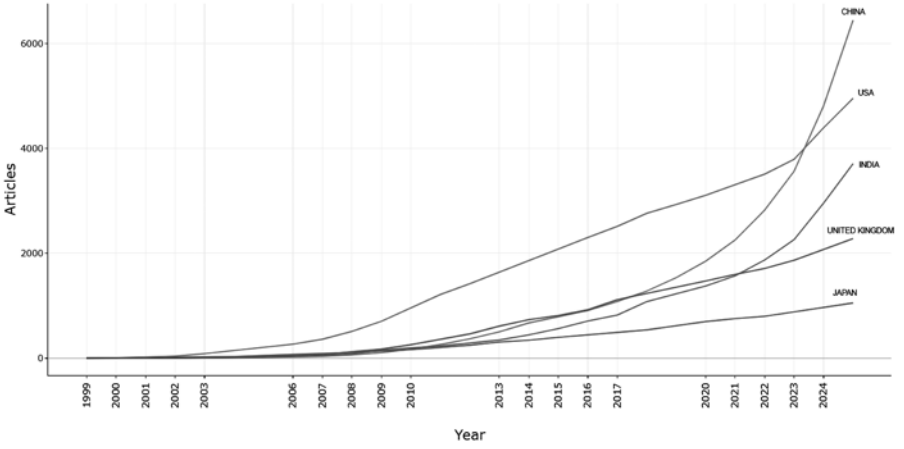


**Figure 7: Countries production over time**




"Energy-Climate-Economy" nexus. Keyword analysis (Figure 8), which provides a clear snapshot of the conceptual core of the research field, reveals that energy policy is the most dominant theme with 4.701 occurrences, acting as the central pillar for research in this field. This is followed by broader concerns regarding sustainable development (2.170), climate change (2.043) and greenhouse emissions (1.200), which provide the environmental context for modern energy transitions. The thematic data highlights a strategic shift toward decarbonization, with renewable energies, energy efficiency, and the mitigation of greenhouse gases appearing as high-frequency research priorities.

Interestingly, more specific technical categories such as renewable energies (1.479) and energy efficiency (1.473) appear with nearly identical frequencies. This parity reflects a balanced academic interest in both supply side solutions and transitioning to green sources to a demand side management with major concern reducing consumption through efficiency. Collectively, these keywords illustrate a research landscape that is multidisciplinary, shifting away from purely technical engineering challenges toward a more holistic, policy-driven approach to global sustainability. While the discourse is heavily weighted toward sustainability, the persistent occurrence of fossil fuels and economics indicates that the transition is being analysed through a lens of pragmatic financial feasibility and current energy dependencies. Renewable energies and energy efficiency hold an important place in energy security analysis.

By constructing the thematic map (Figure 9) the prominence of nodes such as "energy security" and "energy policy" at the center of the network indicates their roles as "bridge" concepts. These terms possess high centrality, meaning they serve as the conceptual glue connecting technical engineering research with socio-economic and environmental policy discussions. For researchers, this output serves as a strategic roadmap, identifying not only the dominant trends but also the gaps where interdisciplinary integration, such as the link between biofuel technology and regional energy security, is most active.

Thematic analysis reveals that this explosion in volume is anchored by "Motor Themes" such as climate change, fossil fuels, and greenhouse gases, which possess both high development and relevance degrees. These issues drive the research agenda, while energy policy, energy security, and general energy studies function as foundational "Basic Themes". Quantitatively, energy policy is the most frequent keyword with 4.701 occurrences, underscoring its role as the critical nexus for the field. While "Niche Themes" like alternative energy, China, and sustainability show high internal development, traditional "Declining Themes" include nuclear energy and nuclear fuels, which exhibit low centrality and density. Ultimately, the data portrays a vibrant, multipolar research environment where the focus has moved from purely economic considerations to integrated sustainable development and climate mitigation strategies, led largely by China's aggressive research expansion.

## 5. Conclusions

This study presents a comprehensive bibliometric analysis of the energy security field, examining 19.155 papers sourced from the Scopus database spanning from 1995 to 2025. The analysis investigates document types, annual

**Figure 8: Most frequent words**

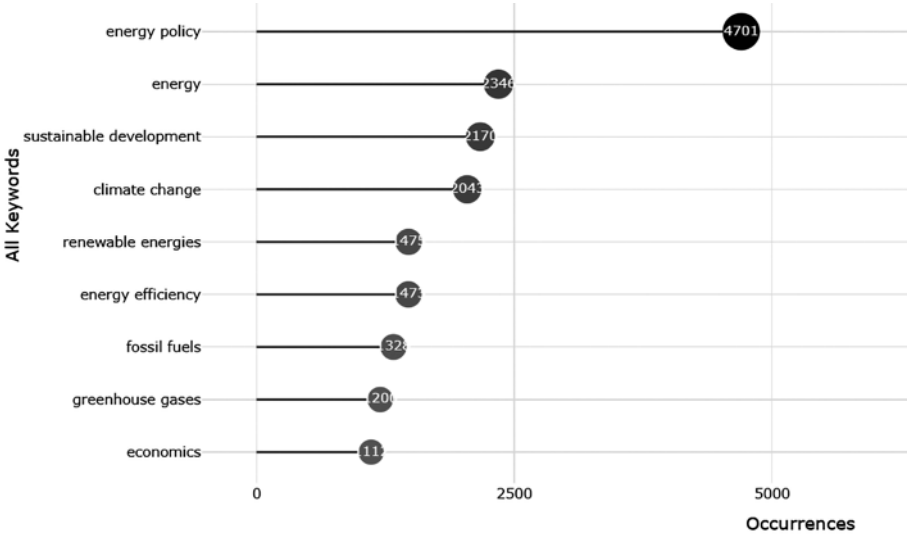
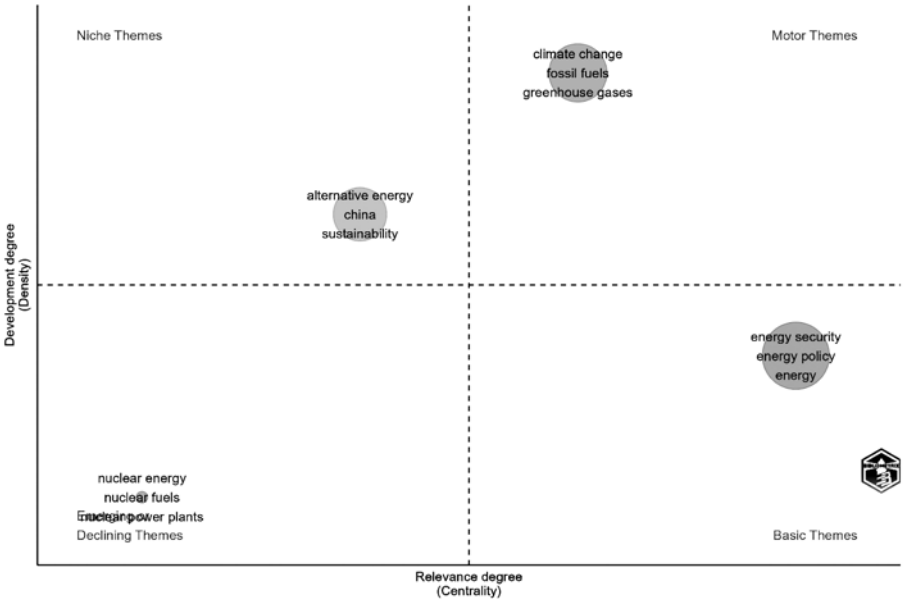



**Figure 9: Thematic Map**



publication and citation trends, as well as the distribution of source journals, countries/regions, institutions, scholars, and research topics. Furthermore, recent research hotspots are identified, influential and disruptive publications are highlighted, and collaborative network characteristics at various levels are assessed. The main finding of this research is that the issue of energy security is very important in scientific research and will probably continue to be of great concern not only to the scientific community but also to politics. Despite the individual peculiarities, the issue of energy security is inextricably linked to ensuring economic prosperity and scientific research tries to penetrate in as many aspects as it can, in order to answer important research questions and guide political actors to correct decisions.

The principal findings of this study indicate sustained growth in both the number of annual publications and the frequency of citations within the field of energy security. Research outputs are dispersed across a wide range of journals, reflecting both significant technical depth and meaningful intersections with social science perspectives. The diversity of contributing countries, institutions, and scholars continues to expand, with international collaboration shaped by fragmented networks and geopolitical considerations.

While the United Kingdom and the United States have historically played a pioneering role, China has recently emerged as a leading contributor, and major research centers are increasingly concentrated in East and South Asia. Key topics attracting scholarly attention include the tensions between energy security and social, economic, environmental, land, and climate factors; the complex interactions between energy supply systems and global geopolitical dynamics; and the crucial role of renewable energy and related technologies in enhancing national and regional energy security. Finally, effective governance in this domain requires integrated strategies that encompass policy, economic, and technological dimensions, underscoring the multidimensional nature of energy security challenges.

This work offers the first objective and thorough bibliometric assessment of energy security research, delivering essential insights for the academic community and supporting both early-career researchers and those from adjacent fields. As with any bibliometric study, certain limitations exist, most notably, the potential exclusion of significant non-English articles and works not explicitly labeled as energy security within database searches. For future research, leveraging multiple data sources will further improve measurement precision.

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# SATELLITE LAW AND BUSINESS

## A. MANIATIS*

## Abstract

Artificial satellites first appeared in the realm of science fiction with Edward Everett Hale's "The Brick Moon", nearly a century before the launch of *Sputnik I* in 1957, ushered in the modern era of both space science and space law. Satellite law, as an emerging yet increasingly distinct subfield of space law, delineates the regulatory framework for artificial satellites through the interplay of international treaties, European Union competences, and domestic legal regimes. The Greek experience of the late 1980s, when the Municipality of Thessaloniki contested the State broadcasting monopoly via satellite retransmission, demonstrates the practical salience of this field, revealing its capacity to influence processes of market liberalization and to recalibrate constitutional understandings of information and communication freedoms. Although no dedicated subgenre of science fiction is centered exclusively on satellites, these devices frequently appear in broader space narratives, popularized in mainstream culture by works such as the blockbuster "Gravity" (depicting the International Space Station, a habitable artificial satellite), which sparked renewed public interest in space exploration. Besides, satellites today serve vital commercial purposes, including telecommunications. Finally, the paper proposes the introduction of the English neologism "doryphorical", derived from the Greek adjective "doryphorikos" ("δορυφορικός"), to describe entities that act like satellites –secondary, attendant, or orbiting a central element– capturing both literal and metaphorical uses.

*JEL Classification: K*

*Keywords: Doryphorical ("doryphorikos" / "δορυφορικός"), Science fiction literature, Satellite business, Satellite law, Space law*

## 1. Introduction: outer space and the concept of satellite

Outer space has become one of the most recent frontiers for humanity, not only in terms of technology and exploration but also regarding its economic potential. It is noteworthy that a fundamental distinction exists between airspace and outer space, although the legal boundary between them remains unclear. Furthermore, this distinction is reflected in the different regulatory regimes adopted for each domain. While there was an early idea to apply a

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unified legal framework to "space" as a whole, this notion was never realized in juridical terms.

Besides, it is notable that the term "satellite" is itself multifaceted. Natural satellites, such as moons, exist for many planets in the Earth's solar system. Earth's own Moon has long inspired scientific inquiry and cultural fascination. Astronomy, one of the oldest sciences, has focused heavily on the Moon since antiquity, particularly during the era of pre-telescopic observation and speculative cosmology.

Even early science fiction explored the Moon and artificial satellites. A notable example is "True History" by Lucian of Samosata, often regarded as the first science-fiction work. Writing in Greek, Lucian imagined lunar inhabitants, called "Selenites". His portrayal of these beings, while fantastical, anticipates later concepts such as the "Martians" in modern science fiction (Maniatis and Adamopoulos, 2025a).

Given these developments, this paper explores satellite law and also the role of artificial satellites in the international business sector.

It begins by referring to some aspects of satellite law, especially as far as the historical challenge of the consecrated State monopoly in the television sector in the Greek legal order is concerned (2).

Afterwards, it sheds light on other questions, beyond legal science, such as science fiction literature and art related to satellites and their entrepreneurial impact (3).

It then highlights the commercial applications of satellite technology across industries (4).

Furthermore, it discusses global navigation satellite systems, focusing on the historical and strategic development of the Galileo project (5).

Finally, it ends up to some conclusions regarding both juridical and entrepreneurial aspects of satellites (6).

Research Question (RQ): We suppose that artificial satellites constitute a multifaceted business phenomenon, extending beyond their technological utility.

## 2. Aspects of satellite law

Space law gradually developed as a distinct field, independent from the older, more established body of air law. The use of constellations and celestial mapping to identify space locations is considered as a form of legal custom, namely an archetype source of space law (Halunko, 2019). The earliest reference to this field appeared in a 1910 article published in Paris, though it remained an abstract idea without substance (Doyle, 2011). This theoretical stage ended in

1957, with the launch of *Sputnik 1*, the first artificial satellite, by the Soviet Union into a low-Earth elliptical orbit. Following this historic event, no official protest was raised by any State – an indication that a new legal custom may have been born: that every State has the right to launch spacecraft into outer space (Halunko, 2019).

This customary right is often extended to include non-State actors, provided they are licensed by a polity with space capabilities (Halunko, 2019). This recognition of an "instant custom," whereby the right to launch satellites emerged immediately after *Sputnik I*, has been debated in doctrine (Maniatis, 2024). On the one hand, public international law accepts that many treaties codify pre-existing customary norms, and a rule may exist in both treaty and customary form – binding even non-signatories. On the other hand, a custom generally emerges from repeated State practice over time, not from a single isolated act. Therefore, whether an "instant" custom meets the criteria of customary international law remains questionable.

Satellite law is an expression that might initially appear unusual, if not even inapplicable to the current taxonomy of legal science. Nevertheless, it has gradually emerged as a recognizable field of inquiry within the broader domain of space law. Unlike space law in general, which encompasses all legal relations concerning outer space, satellite law focuses specifically on the regulation of artificial satellites and their multiple functions, ranging from telecommunications and broadcasting to navigation and Earth observation. It does not constitute an entirely self-standing branch, but it has acquired sufficient distinctiveness to justify scholarly and policy attention.

From an international perspective, the foundations of satellite law lie in the core United Nations treaties on outer space.

Artificial satellites today fall under the jurisdiction of several core legal instruments, such as the following UN treaties: the Outer Space Treaty (1967), the Liability Convention (1972), and the Registration Convention (1975). The Outer Space Treaty of 1967 did not identify outer space as "common heritage of mankind", unlike the marginal 1979 Moon Agreement, whose provisions apply inter alia to Mars (Maniatis and Adamopoulos, 2025b). The mainstreaming legal text established the principle that outer space, including the Moon and other celestial bodies, is not subject to national appropriation and must be used for peaceful purposes. This has direct implications for satellites, which by definition operate beyond national airspace. The Liability Convention of 1972 clarified the responsibility of States for damage caused by their space objects, while the Registration Convention of 1975 obliged States to maintain registries of satellites and communicate orbital data to the United Nations. Taken

together, these instruments create a framework of accountability, transparency, and cooperation that governs the satellite domain. In addition, the International Telecommunication Union (ITU) plays a central role in allocating orbital slots and frequency bands, a technical yet profoundly legal activity, since spectrum and orbital positions are scarce and valuable resources.

Parallel to these developments, the European Union has progressively asserted competence in space activities. Although "space" was not explicitly mentioned in the founding treaties, Article 189 of the Treaty on the Functioning of the European Union (TFEU), introduced by the Lisbon Treaty which entered into force in 2009, conferred upon the EU the competence to pursue activities in the field of space policy. This competence is classified as supporting and coordinating, meaning that the EU may support, coordinate, or supplement the actions of its Member States, but may not harmonize national legislation. In practice, the EU has created a regulatory and institutional system through the European Union Space Program Regulation (EU) 2021/696, which governs programs such as Galileo, EGNOS, and Copernicus, while also launching newer initiatives like GOVSATCOM and IRIS. Although the EU itself is not a party to the UN space treaties, it encourages their implementation through both domestic measures and international cooperation. The institutional role of the European Commission and the European Union Agency for the Space Program (EUSPA) signals a marked evolution in the governance of European satellite activities.

At the national level, States adopt different legal approaches to satellites depending on their technological capacity and economic interests. Countries with established space industries, such as the United States, France, Japan, and increasingly India and the People's Republic of China, have detailed legislation governing satellite licensing, liability, and commercial exploitation. Others, like Greece, have historically interacted with satellites primarily as end users, often within the domain of broadcasting. Yet even in such cases, important legal controversies have arisen, demonstrating the reach and necessity of satellite law.

The Greek case of the late 1980s is especially illustrative. After winning the municipal elections in 1986, certain mayors from the opposition political party "New Democracy" attempted to challenge the state monopoly on television broadcasting, then controlled by the Hellenic Broadcasting Corporation (being denominated "Hellenic Radio and Television Broadcasting" and known with the acronym "ERT", in Greek). The monopoly was not merely political but also fiscal: it was reinforced by a broadcasting tax imposed on households and even on legal persons. Against this backdrop, the Municipality of Thessaloniki,

under Mayor Sotirios Kouvelas, began in 1987 to retransmit foreign satellite television programs to the public, free of charge. This initiative directly confronted the existing legal order and provoked a vigorous reaction from the central state, which initiated criminal proceedings.

The case that followed became emblematic. Kouvelas was prosecuted before the Three-Member Misdemeanor Court of Thessaloniki. Remarkably, the court acquitted him by majority, reasoning that the law criminalized only the unauthorized "transmission" of television programs, whereas the Municipality was engaged in their "retransmission." Since the applicable legislation did not explicitly mention retransmission, the judges concluded that the conduct did not fall within the scope of the penal provision. This was a narrow and almost literalist interpretation, but in conformity with fundamental principles of criminal law in favor of defendants.

The acquittal of Kouvelas underscored two broader points of legal significance. First, it revealed how technological innovation like the availability of satellite signals receivable by municipalities can outpace existing statutes, compelling courts to interpret law under conditions of uncertainty. Second, it demonstrated that local governments could act as catalysts for liberalization in sectors previously dominated by the State. The symbolic value of a municipality broadcasting foreign channels to its citizens free of charge was immense: it challenged the very notion of exclusive state control over information flows. In the years that followed, this confrontation contributed to the gradual dismantling of the broadcasting monopoly in Greece, first in radio and later in television. By the early 1990s, private channels had emerged, and the landscape of Greek media was irreversibly transformed.

This episode also shows the practical utility of satellite law. Far from being an abstract domain of international treaties, it directly affected questions of freedom of expression, market liberalization, and the balance between central and local government powers. It exemplifies how satellite technology intersects with constitutional law (freedom of speech, right to information), administrative law (decentralization, competences of municipalities), and criminal law (interpretation of penal statutes). Moreover, it highlights the need for clarity in distinguishing between technical terms, such as "transmission" and "retransmission", which have profound legal consequences. In sum, the Greek case illustrates the broader thesis that satellite law, although still an emerging field, is indispensable for regulating complex interactions between technology, business, and fundamental rights.

## 3. Satellite science fiction and business

Public perceptions of science fiction literature often gravitate toward its more extravagant or speculative depictions of space exploration. However, the genre encompasses a broader and more nuanced engagement with space-related themes. While iconic narratives frequently depict contact between humans and extraterrestrial beings, science fiction has also long addressed the human relationship with spaceborne technology – particularly artificial satellites. These portrayals frequently explore extraterrestrial societies, alien technologies, interspecies communication, and philosophical inquiries into humanity's role in the cosmos (Seed, 2011).

Artificial satellites have occupied a consistent place in science fiction, predating their material realization, while modern space science, understood as a coordinated discipline integrating rocketry, planetary science, and spaceflight engineering, emerged in the early 20th century through the pioneering work of Tsiolkovsky, Goddard, and Oberth, literary representations of satellites appeared earlier (McDougall, 1985). The aforementioned launch of *Sputnik 1* in 1957 marked a historic turning point in space history, inaugurating the Space Age and institutionalizing space science as a global, interdisciplinary enterprise (Dick, 2012).

One of the earliest fictional representations of an artificial satellite can be found in Edward Everett Hale's short story "The Brick Moon" (1869). Although Hale was not a scientist, his narrative imaginatively envisioned a man-made satellite designed to aid global navigation. In the story, a group of individuals is inadvertently launched with the brick-structured satellite and survives in Earth's orbit, effectively anticipating the concept of sustained human life in space (Westfahl, 2005). It is particularly notable that this narrative was conceived several decades prior to the advent of human spaceflight. During the same period, widespread skepticism persisted –even among scientists– regarding the feasibility of space travel (Winter, 1997).

The intersection of literary imagination and satellite technology continued to evolve through the 20th century. Antoine de Saint-Exupéry, although not explicitly writing about satellites, engaged with interstellar themes in "The Little Prince" (1943), where the protagonist travels from asteroid B-612 to Earth (Saint-Exupéry, 1943). In parallel, Arthur C. Clarke was among the first to conceptualize geostationary satellites for global communication, an idea he articulated in non-fiction (Clarke, 1945) before incorporating similar concepts in his literary works. Clarke's seminal novel "2001: A Space Odyssey" (1968) integrates satellite-like technology in orbital and interplanetary contexts, while

also introducing artificial intelligence (AI) through the character of HAL 9000, an advanced autonomous system with control over a spacecraft's functions (Clarke, 1968).

Following the launch of *Sputnik 1*, science fiction narratives involving satellites proliferated, often reflecting the geopolitical anxieties of the Cold War. Satellites featured prominently in themes such as global surveillance, orbital weaponization, and militarized space control (Seed, 2011). Philip K. Dick's "The Game-Players of Titan" (1963) intertwines satellite-based technologies with telepathy and alien governance (Dick, 2012). Similarly, Larry Niven's "Known Space" series (from 1964 onward) includes orbital platforms and artificial satellites as integral elements in human-alien interactions (Niven, 1994).

The conceptualization of sentient or autonomous satellites has emerged as a recurrent motif. In Clarke's work, HAL 9000 exhibits traits of agency and self-awareness, albeit within a spacecraft rather than a literal satellite. In John Barnes' Orbital Resonance (1991), satellite habitats function as miniature societies that address complex issues such as identity, governance, and ecological adaptation in space (Barnes, 1991).

In more recent decades, satellites have symbolized themes of surveillance, dependency on technology, and loss of privacy. For instance, the television anthology "Black Mirror" portrays dystopian scenarios where satellites facilitate invasive surveillance, raising ethical and philosophical questions (Waldron, 2019). In these contexts, dystopia, defined as an oppressive and dehumanized society, contrasts sharply with the utopian visions that once defined early space narratives (Jameson, 2005).

Contemporary authors, such as Greg Egan, envision advanced satellite constellations capable of instantaneous communication or even consciousness transmission (Egan, 1997). Moreover, satellite infrastructure is frequently employed in hybrid science fiction narratives involving alien contact, interstellar colonization, or planetary defense, where satellites serve as communication relays, sensor arrays, or early warning systems (Stableford, 2006).

Within science fiction publishing, satellite-related themes represent a niche yet enduring subdomain. They are typically interwoven into broader narratives concerning space exploration, futuristic warfare, or global communications. Unlike hard science or technical works, science fiction literature tends to be story-driven and emotionally engaging, enabling it to reach mass audiences. Some satellite-themed works have even attained considerable international acclaim.

A prominent cinematic example is "Gravity" (2013), directed by Alfonso Cuarón. The film dramatizes a satellite-induced cascade of orbital debris,

known as the Kessler Syndrome, which endangers astronauts aboard the International Space Station (ISS), which is a habitable, large artificial satellite. The narrative centers on Dr. Ryan Stone (Sandra Bullock) and Lieutenant Matt Kowalski (George Clooney), with Kowalski's in-orbit sacrifice forming the film's emotional core. "Gravity" grossed over $700 million globally and won seven Academy Awards (Brody, 2013). The film underscores how cinematic portrayals of satellites have popularized space environments among global audiences.

The United States remains the dominant global player in both satellite innovation and space-themed cinema. While other countries, such as India with "Mission Mangal", produce noteworthy films, the influence of the U.S. film industry in shaping public perceptions of space remains unparalleled (Rajagopalan, 2020).

From the literary domain, "The Martian" (2011), by Andy Weir, exemplifies the strategic role of satellites in realistic space scenarios. Though the novel focuses on the survival of an astronaut stranded on Mars, satellite communication plays a critical role in reestablishing contact and coordinating rescue efforts. The protagonist, Mark Watney, is ultimately rescued by his crew through a complex orbital maneuver involving the Hermes spacecraft (Weir, 2011). The book's success, bolstered by its 2015 film adaptation starring Matt Damon, highlighted the appeal of scientifically grounded space fiction, with the film grossing over $630 million worldwide.

In conclusion, satellites occupy a unique intersection between science, fiction, and business. Whether as technological instruments in nonfiction or narrative devices in fiction, satellites contribute to public engagement with space and inspire both commercial ventures and speculative imagination. Their dual presence in scientific literature and creative storytelling affirms their centrality in contemporary representations of space.

## 4. Commercial satellite applications: key business sectors

The satellite industry has evolved from a government-dominated field into a thriving commercial market, with private enterprises driving innovation across multiple sectors. Today, satellites serve as critical infrastructure for global business operations, enabling high-speed communications, precise navigation, real-time Earth observation, and enhanced security.

One of the most lucrative segments of the satellite business is telecommunications, where companies leverage geostationary (GEO) and low Earth orbit (LEO) satellites to provide global connectivity. Traditional satellite operators

have long delivered television broadcasting and military communications, but recent advancements have spurred competition from NewSpace ventures. SpaceX's Starlink, Amazon's Project Kuiper, and OneWeb are deploying massive LEO constellations to offer high-speed Internet, particularly in underserved regions. These initiatives not only bridge the digital divide but also create new revenue streams through subscription-based models and enterprise solutions. Furthermore, satellite-based 5G backhaul and Internet of Things (IoT) connectivity are emerging as growth areas, enabling seamless machine-to-machine communication in remote locations.

Satellites equipped with high-resolution cameras, multispectral sensors, and synthetic aperture radar (SAR) have revolutionized Earth observation, transforming data into a valuable commodity. Companies provide imagery for agriculture, urban planning, disaster management, and climate monitoring. Precision farming, for instance, relies on satellite data to optimize crop yields, reduce water usage, and monitor soil health, generating significant cost savings for agribusinesses. Similarly, insurance firms use satellite analytics to assess natural disasters, while oil and gas companies monitor pipeline infrastructure. The rise of artificial intelligence-powered analytics platforms has further enhanced the commercial viability of Earth observation, allowing businesses to derive actionable insights from vast datasets.

Satellites also play a crucial role in locating and assessing Earth's natural resources, such as oil, minerals, and groundwater. Equipped with advanced remote sensing technologies, including multispectral, hyperspectral, and synthetic aperture radar (SAR), satellites detect surface and subsurface features by analyzing reflected or emitted electromagnetic radiation. For oil exploration, satellites identify geological formations, seepages, and hydrocarbon indicators, reducing the need for costly ground surveys. Similarly, mineral deposits are mapped using spectral signatures, while thermal and microwave sensors help locate water resources. Satellite data enables efficient, large-scale resource prospecting with minimal environmental disruption, supporting sustainable extraction and economic planning.

Furthermore, military and security activities are closely related to the use of satellites. The defense sector remains a major driver of satellite commerce, with governments and private firms investing in reconnaissance, surveillance, and secure communications. Military satellites provide real-time intelligence, electronic warfare capabilities, and encrypted data transmission. The commercialization of synthetic aperture radar (SAR) satellites enables all-weather, day-night monitoring for both defense and civilian security applications. Private military and cybersecurity firms also utilize satellite data to track illicit

activities, from illegal fishing to cross-border smuggling, creating a growing market for space-based security solutions.

## 5. The Global Navigation Satellite Systems sector

Global Navigation Satellite Systems (GNSS), including GPS (United States), Galileo (European Union), GLONASS (Russia), and BeiDou (People's Republic of China), form the backbone of a multibillion-dollar global industry that is indispensable to logistics, aviation, maritime navigation, land transportation, telecommunications, precision agriculture, and autonomous systems. These four systems represent the primary fully operational global GNSS constellations in service as of 2025. Regional or augmentation systems such as India's NavIC and Japan's QZSS also exist, but they are not yet fully global in scope.

Besides, the European Space Policy contributes to strategic autonomy. By strategic autonomy is meant a virtuous compromise: neither autarky nor dependence, but the promise that Europe will retain its freedom of action and control over its destiny. The EU thus guaranteed Europeans autonomy in the fields of satellite navigation, with Galileo and EGNOS (which is used to improve the performance of global satellite navigation systems such as GPS and Galileo), and Earth observation, with Copernicus.

Galileo belongs to the EU, but the European Space Agency (ESA) acts as the technical and procurement agent. It is designed to provide high-precision positioning and timing services worldwide. It was formally launched in 2002 as a joint initiative of the EU and the European Space Agency (ESA), following initial discussions in the late 1990s under the European Community. The project experienced significant delays due to funding disputes, technical challenges, and coordination issues among member states. The first experimental satellite, GIOVE-A, was launched in 2005, but full operational capability was not achieved until 2016, well behind the original 2008 target. Early setbacks included the withdrawal of private sector financing in 2007 and later technical issues, such as incorrect orbital deployments in 2014. Despite these delays, Galileo is now fully operational, providing an independent and reliable alternative to other global navigation systems, like GPS and GLONASS.

In April and September 2024, two new pairs of first-generation Galileo satellites were successfully launched. These additions brought the total number of satellites in orbit to 32, of which 24 are actively operational while others serve as in-orbit reserves. This has substantially reinforced the reliability and precision of the Galileo system, which is currently considered fully operational.

The deployment of the first generation of satellites is nearing completion.

The launches in 2024 were key milestones, and the final first-generation satellites are scheduled for deployment between 2025 and 2026. These remaining additions will further enhance the resilience and performance of the overall constellation.

In parallel, the development of the second generation of Galileo satellites –referred to as G2– is actively underway. This new generation promises several technological advancements, including enhanced navigation antennas, electric propulsion, fully digital payloads, and advanced atomic clocks. The production of twelve G2 satellites is in progress, managed jointly by Airbus Defence and Space in Germany and Thales Alenia Space in Italy.

The first launch of the G2 satellites is expected to take place in 2026 using the Ariane 6 launcher. Once operational, these second-generation satellites will significantly boost the accuracy, security, and technological edge of Europe's satellite navigation capabilities.

As far as BeiDou is concerned, it deserves a special analysis on the matter, in particular compared to GPS. It achieved full global coverage in 2020 and has since positioned itself as a strategic alternative to the U.S. GPS system, especially in Asia, Africa, and parts of the Global South. While GPS remains the most widely used GNSS globally, due to its early development and widespread integration, BeiDou has rapidly gained adoption through China's Belt and Road Initiative and offers compatibility with GPS, Galileo, and GLONASS on many modern receivers. BeiDou distinguishes itself, by offering unique services not available in GPS, such as two-way messaging and regional short message communication, which are particularly useful in remote or emergency conditions. GPS has traditionally been favored for its long-standing reliability and precision, but BeiDou's third-generation satellites (BDS-3) now provide comparable accuracy and resilience, with improved anti-jamming and signal integrity features. The People's Republic of China has encouraged the use of BeiDou domestically, by requiring its integration into smartphones, vehicles, and infrastructure, aiming for technological sovereignty in navigation services, a goal mirrored by the strategic independence sought by Europe's Galileo.

In general, beyond consumer applications like smartphone navigation, businesses depend on precise positioning for fleet management, supply chain optimization, and drone delivery services. Autonomous vehicles, both terrestrial and maritime, integrate satellite navigation with AI to improve safety and efficiency. Additionally, industries such as construction and mining use GNSS for machine guidance, reducing operational costs and improving accuracy. As location-based services expand, new business models, such as pay-per-use precision navigation for autonomous drones, are expected to emerge.

## 6. Conclusion: satellites as pioneers in law and business

The present study leads to the following concluding observations:

### a. The Greek case of centrifugal liberalization of the State monopoly in television broadcasting

The broadcasting revolution of the late 1980s in Greece stands as a pivotal case of political contestation and gradual liberalization of a tightly held monopoly of the State, which existed despite the fact that the political regime on the matter was democratic and liberal. By experimenting with satellite retransmission, the Municipality of Thessaloniki under Mayor Sotirios Kouvelas effectively tested the limits of the law and exposed its inconsistencies. For the first time, a municipality, rather than the central public power, provided access to foreign programming, thereby democratizing the flow of information while the Cold War was still ongoing. The symbolic and practical consequences were profound. On the one hand, the State monopoly of "ERT" was no longer unassailable; on the other, private actors and local governments sensed that new opportunities were emerging. Within a few years, Greece witnessed the establishment of private radio and television stations, signaling the end of centralized control and the beginning of a pluralistic media market. From the standpoint of satellite law, the case illustrates how legal interpretation can accelerate structural reforms that legislation alone had failed to initiate. More broadly, it demonstrates the interplay between technology and law: satellite signals, once thought to be beyond the reach of municipalities, became the instrument through which political actors challenged entrenched monopolies. Thus, the Hellenic case exemplifies how satellite law is not confined to technical regulation but can influence constitutional freedoms, market liberalization, and the redefinition of state authority. It is a reminder that satellites are not only technological assets but also legal and political instruments capable of reshaping entire sectors of national life.

### b. The dynamic development of science fiction literature related to satellites

The presence of artificial satellites in science fiction reflects the genre's broader engagement with themes of technology, power, and humanity's future both on and beyond Earth. Far from being a peripheral concern, satellites occupy a central role in illustrating the human ascent into the space age and the ambivalent

relationship with the tools it creates. Alongside, scientific literature on artificial satellites represents a structured, albeit commercially marginal, segment within the publishing industry, holding nonetheless significant academic and professional value. In contrast, popular science and science fiction works focusing on satellites tend to enjoy greater public reach and commercial potential.

This dynamic development is not confined to literature alone. Various films exemplified by "Gravity" do more than achieve box office success; they transform space exploration into a captivating theme for global audiences. Accordingly, the central Research Question (RQ) of this paper is confirmed: the value of artificial satellites transcends their technological function and extends into the realms of cultural production and public imagination, even though no distinct literary subgenre focusing exclusively on satellites exists yet.

Furthermore, it is to underline that, in a sense, films like "Gravity" can be seen as almost prophetic, illustrating scenarios of human spaceflight challenges that, years later, find echoes in real-life incidents, such as the delayed safe return of two astronauts from the ISS in 2025. NASA astronauts Sunita "Suni" Williams and Barry "Butch" Wilmore were initially scheduled for a weeklong mission aboard Boeing's Starliner spacecraft, launched on June 5, 2024. However, due to propulsion system malfunctions, including thruster failures and helium leaks, their return was delayed. NASA decided to send Starliner back uncrewed and extended their stay at the ISS until March 18, 2025, when they returned to Earth aboard SpaceX's Crew-9 Dragon capsule.

### c. Space science inspired by astronomy

The terminology used in satellite systems reflects deep-rooted connections with astronomical concepts, let alone classical and well-known ones. The vocable "constellation", now a technical standard in aerospace engineering and satellite communications, is directly inspired by the astronomical idea of star groupings forming observable patterns. In the satellite context, constellation denotes a coordinated system of orbiting satellites, such as GPS, Galileo, or Starlink, working in synchrony to provide comprehensive coverage.

Despite their functional nature, satellite constellations retain the intuitive clarity of their astronomical roots. Building on this linguistic inspiration, we propose the introduction of the English scholarly adjective "doryphorical" (directly from the Greek adjective "doryphorikos", namely "δορυφορικός") to describe phenomena that are secondary, orbiting, or satellite-like in nature. Derived from "doryphoros" ("δορυφόρος"), literally "spear-bearer" or "bodyguard", this term can enrich academic discussions around dependent systems

or auxiliary entities. Besides, it could be a practical alternative of the vocable "satellite", which has no one-word synonym in English.

### d. Satellites as indispensable business tools

The diversification of satellite applications has transformed them into critical instruments of economic development. Satellites now underpin vast sectors, from telecommunications and logistics to agriculture, environmental monitoring, and defense. As technology evolves and costs decrease, the satellite industry continues to open new frontiers, embedding itself within the global commercial ecosystem.

The coming decades will witness satellites at the heart of innovations in quantum communication, AI-based orbital systems, and climate observation. As orbital infrastructure expands, these devices will not only enhance connectivity and data transmission but also serve as platforms for cutting-edge experimentation. This positions space as the next arena for geopolitical influence and technological leadership.

### e. The EU's shortcomings in technological leadership

The European Galileo program, while strategically vital and technically mature, has been hampered by substantial delays due to funding gaps, private sector withdrawals, and political fragmentation among Member States. Since reaching operational status in 2016, Galileo has grown into a cornerstone of Europe's strategic space infrastructure, with the second generation of satellites (G2) expected to launch from 2026 onward.

Nevertheless, the United States' GPS system, being operational since 1995, continues to outperform Galileo in terms of maturity, accuracy, and reliability. Europe thus finds itself lagging in an area critical for digital sovereignty. According to Loesekrug-Pietri (2023), the EU must rekindle a level of urgency and ambition reminiscent of the 1960s U.S. Apollo program. That initiative, backed by substantial public investment and driven by geopolitical competition, not only culminated in the 1969 Moon landing but also catalyzed lasting technological innovation. The metaphorical proposal for an "Apollo 2.0" calls on Europe to move beyond defensive posture and adopt a bold, pan-European R&D offensive to compete on equal terms with the United States and the People's Republic of China.

In this light, Greece should also consider harnessing space technologies,

both current and emerging, not only for the advancement of its economy but also for national defense (Kolovos, 2006).

In closing, public engagement with artificial satellites must go beyond science fiction or cinematic fascination. Legal and policy frameworks should evolve to encompass space law, with new conceptualizations of space-related fundamental rights, such as inter alia the rights to observation, exploration, and even space tourism. The future of satellites is not solely technological – it is legal, cultural, and economic. As this paper has argued, artificial satellites are not only tools of business but also instruments of civilization.

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Space science has been complemented by legal science on space, which should promote human rights and sustainable development. Moreover, satellites have already proven to be pioneers in this field.

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# A SUSTAINABILITY MODEL FOR CULTURAL HERITAGE SITES: CARRYING CAPACITY ASSESSMENT OF THE WHITE TOWER OF THESSALONIKI

**G. KARAGIANNIS***

## Abstract

This study examines the White Tower of Thessaloniki as a key cultural landmark that concentrates historical, social, and economic functions within the urban landscape. The main objective of the research is to explore the sustainability of this cultural heritage site through the application of a simplified mathematical model that evaluates three core dimensions of sustainable cultural development: visitor pressure, management and maintenance capacity, and overall operational sustainability. The analysis is based on empirical data regarding visitor numbers, spatial capacity limitations, ticket revenue, and operational characteristics of the monument. Using these parameters, a sustainability index is estimated in order to assess the relationship between visitor flows and the adequacy of management resources. The results indicate that the White Tower operates close to its sustainability threshold, particularly during periods of increased tourism pressure. The findings suggest that targeted management measures, such as visitor flow regulation and increased reinvestment in maintenance resources, can significantly improve the sustainability performance of the site. The study contributes to the broader discussion on sustainable cultural heritage management by proposing a simple analytical framework that can support policy design for urban cultural monuments experiencing high visitor pressure.

*JEL Classification: Z32, Z11, Q56, C65*

*Keywords: White Tower, Cultural heritage management, Sustainable cultural development, Tourism carrying capacity, Urban cultural landmarks, Sustainability modeling*

## 1. Introduction

Urban cultural landmarks play an important role in shaping the historical identity, spatial structure, and social life of contemporary cities. Cultural heritage sites are not only architectural remnants of the past but also active elements of the urban environment that contribute to social cohesion, cultural identity, and local economic activity (Throsby, 2010). In many cities, historic monuments

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function as reference points within the urban landscape, attracting both residents and visitors and generating cultural and economic value. The White Tower of Thessaloniki represents one of the most recognizable cultural landmarks in Greece and a central symbol of the city's identity. As a historic monument located in the coastal urban core, it operates simultaneously as a cultural site, a tourist attraction, and a public space embedded within the everyday life of the city. In this sense, the monument illustrates how heritage sites can function as active components of the urban system rather than as isolated historical artifacts. In recent decades, the management of cultural heritage has increasingly been associated with the broader framework of sustainable development. Tourism development and heritage protection must be balanced in order to avoid excessive visitor pressure that may threaten the long-term sustainability of cultural sites (Mathieson & Wall, 1982; Mowforth & Munt, 1998). For this reason, the concept of tourism carrying capacity has become an important analytical tool in cultural heritage management, allowing researchers and policy makers to evaluate the relationship between visitor flows, spatial limitations, and management capacity (ESPON, 2020; European Expert Network on Culture, 2019).Within this context, the White Tower constitutes an interesting case study for examining the sustainability of urban cultural monuments that attract high visitor flows while operating within limited spatial conditions. The aim of this study is to investigate the sustainability of the White Tower through the application of a simplified analytical model that evaluates visitor pressure, spatial capacity, and maintenance adequacy. By combining empirical visitor data with a sustainability index approach, the study seeks to contribute to the discussion on sustainable cultural heritage management in urban environments. The aim of this study is to examine the sustainability of the White Tower as an urban cultural heritage site through the application of a simplified analytical model. The model evaluates visitor pressure, carrying capacity, and maintenance adequacy in order to estimate a sustainability index for the monument.

## 1.1 The Roles of the White Tower in the Urban Environment

The White Tower of Thessaloniki performs multiple roles within the urban environment, extending beyond its historical significance as a monument. Cultural heritage sites in urban contexts often operate as dynamic elements that interact with the social, economic, and spatial structures of the city. In this sense, monuments can function as nodes where cultural memory, tourism activity, and everyday urban practices converge (Throsby, 2010). First, the White Tower performs an important urban and spatial role within the city. Its

location at the coastal front of Thessaloniki, at the boundary between the historic and the modern city center, makes it a prominent reference point within the urban landscape. As a landmark, it acts as a point of orientation and as a starting point for urban routes connecting major cultural and historical sites such as the Rotunda, the Arch of Galerius (Kamara), and the museums located in the wider city center. Second, the monument also performs a significant social role. The surrounding public space is not used exclusively by visitors to the monument but also by residents of the city. The area functions as a place for walking, social interaction, and cultural activities, integrating the monument into the everyday life of the urban community. Such interaction between cultural heritage and public space strengthens the social value of monuments and contributes to the cultural identity of the city. Third, the White Tower also plays an important economic and tourism role. Cultural monuments located in central urban areas often attract large numbers of visitors, generating economic activity in surrounding sectors such as hospitality, catering, recreation, and retail services. Tourism activity linked to cultural heritage sites can therefore contribute significantly to local economic development (Mathieson & Wall, 1982; Mowforth & Munt, 1998). However, high visitor concentrations may also lead to pressures associated with tourism carrying capacity and urban sustainability (Latinopoulos, 2015). Consequently, the White Tower can be understood not only as a historical monument but also as a multifunctional cultural element within the urban system of Thessaloniki. Its role within the city illustrates the complex interaction between cultural heritage, tourism activity, urban space, and sustainable development.

## 1.2 The Roles of the Monument

The concept of a cultural condenser refers to spatial entities that accumulate and amplify cultural, social, and economic capital, functioning as nodes that contribute to the reproduction of urban identity and collective memory. In the case of the White Tower of Thessaloniki, this function derives not only from its historical significance but also from its continuous interaction with the urban fabric of the city and the everyday practices that take place in the surrounding public space. The White Tower performs multiple complementary roles within the urban environment. First, the monument plays an important urban and spatial role. Its location at the boundary between the historic and the modern city center makes it a highly attractive landmark within the urban landscape. Urban attractiveness is closely related to the physical environment, available services, and the overall image of a place, factors that significantly influence

visitor flows and the functional role of urban spaces (Sideri, 2017). In the case of the White Tower, the monument functions as both a point of orientation and a starting point for urban routes leading to important cultural sites such as the Rotunda, the Arch of Galerius (Kamara), the city museums, and the Aristotelous Square axis. Second, the monument performs an important social role. The surrounding public space is not used exclusively by visitors to the monument but also by residents of the city. The area functions as a place for walking, social interaction, and cultural activities. As a result, the monument remains integrated into the everyday life of the local community rather than existing as an isolated tourist attraction. Third, the White Tower also has a significant economic and tourism role. As one of the most visited cultural landmarks in Thessaloniki, it generates considerable economic activity in the surrounding urban area. The concentration of visitors stimulates sectors such as hospitality, catering, recreation, and retail trade. However, such spatial concentration of tourism-related activities may also create pressures associated with tourism monoculture and overtourism, making the development of new management strategies necessary in order to ensure balanced urban development (Karagiannis, 2025). Therefore, the White Tower should not be viewed solely as a historic monument but as a multifunctional cultural element within the urban system of Thessaloniki. Its role as a cultural condenser highlights the complex relationship between heritage, urban space, tourism dynamics, and sustainable urban development.

## 2. Methodology

This study adopts a simplified analytical approach in order to investigate the sustainability of the White Tower as an urban cultural heritage site. The methodological framework combines empirical data analysis with the development of a basic mathematical model designed to evaluate the relationship between visitor pressure, spatial capacity, and maintenance resources. The White Tower constitutes a cultural monument located within a dense urban environment and characterized by both historical significance and high visitor activity. Under such conditions, the sustainability of the monument cannot be assessed solely through visitor numbers. Instead, it is necessary to examine the relationship between visitor flows, spatial limitations, and the management capacity required to maintain the monument in adequate conservation conditions. The empirical analysis is based on a set of operational parameters related to the functioning of the monument. These include the annual number of visitors, the maximum number of visitors allowed simultaneously inside the monument due

to spatial limitations, the ticket pricing structure, and the daily operating hours of the site. By combining these parameters, it becomes possible to estimate the effective daily carrying capacity of the monument and to evaluate whether current visitor flows remain within sustainable limits. The concept of tourism carrying capacity has been widely discussed in the literature as a key tool for assessing the relationship between visitor activity and the ability of cultural sites to accommodate tourism pressure without compromising their long-term sustainability (Coccossis & Mexa, 1997; ESPON, 2020). In addition to visitor pressure, the methodological framework also incorporates the dimension of maintenance and management resources, which represents a crucial factor for the long-term sustainability of cultural heritage sites. The adequacy of available resources for conservation, monitoring, and visitor management is considered essential in order to ensure that the level of use of the monument remains compatible with its preservation requirements (Latinopoulos, 2015). Based on these parameters, the study develops a simplified sustainability model that allows the evaluation of different management scenarios and their potential impact on the long-term sustainability of the monument. The model makes it possible to explore how variations in visitor flows, spatial capacity, and maintenance resources influence the overall sustainability performance of the site.

## 3. Mathematical Model

### 3.1 Model Specification

In order to evaluate the sustainability of the White Tower as an urban cultural heritage site, this study develops a simplified analytical model based on normalized indicators. The model aims to capture the relationship between visitor pressure and the adequacy of maintenance and management resources. The sustainability of the monument is expressed through a sustainability index S, which takes values in the interval $S \in [0,1]$. The index combines two fundamental dimensions: the level of visitor pressure in relation to the carrying capacity of the monument and the adequacy of available maintenance resources per visitor. This approach allows the evaluation of whether the level of use of the monument remains compatible with its long-term conservation and management requirements. Variables The model is defined using the following variables:

**Table 1: Definition of Variables**

| Variable | Description |
|---|---|
| V | Number of visitors (per day or per year) |
| K | Carrying capacity of the monument (same time unit as V) |
| M | Available maintenance and management resources for the same period |
| m | Minimum required maintenance cost per visitor |

Based on the variables presented above, the sustainability of the monument is evaluated through the interaction between visitor pressure and maintenance adequacy. Two normalized coefficients are used in order to capture these two dimensions of sustainability. The first coefficient represents the saturation level of the monument and expresses the relationship between visitor flows and the carrying capacity of the site. It is defined as:

$$C= \min (1, K/V)$$

When the number of visitors remains below the carrying capacity, the coefficient takes the value of 1, indicating that the monument operates within acceptable limits. When visitor flows exceed the carrying capacity, the value of the coefficient decreases, reflecting increasing pressure on the monument. The second coefficient represents the adequacy of maintenance resources in relation to the number of visitors and is defined as:

$$E=\min (1, M/(mV))$$

This coefficient measures whether the available maintenance resources are sufficient to meet the minimum required maintenance expenditure per visitor. The overall sustainability of the monument is expressed through the sustainability index SSS, which is defined as the average of the two coefficients:

$$S=(C+E)/2$$

The sustainability index takes values within the interval $S\in[0,1]$, where values closer to 1 indicate higher sustainability conditions, while lower values indicate increasing pressure on the monument and reduced sustainability performance. The index is defined as the average of the saturation coefficient and the maintenance adequacy coefficient, assigning equal weight to visitor pressure and maintenance capacity. This assumption reflects the idea that both dimensions are equally important for the sustainable operation of cultural heritage sites, as excessive visitor pressure and insufficient maintenance resources

may independently threaten the long-term preservation and functionality of the monument. In order to examine the practical implications of the proposed model, the analytical framework is applied to the case of the White Tower of Thessaloniki. The following section estimates the operational carrying capacity of the monument and applies the model using observed visitor data and operational characteristics of the site.

## 3.2 Carrying Capacity Estimation

In order to apply the proposed model, it is necessary to estimate the operational carrying capacity of the monument. According to the operational constraints of the White Tower, a maximum of 70 visitors are allowed simultaneously inside the monument. This spatial limitation is related to the internal structure of the building and to the need to maintain appropriate environmental and safety conditions. To transform this simultaneous capacity into a daily carrying capacity, the duration of the average visit must also be considered. Assuming a daily operating period of approximately 12 hours (720 minutes) and an average visit duration of d minutes, the daily carrying capacity of the monument can be approximated as:

$$Kday = 70 \times 720/d$$

Under these assumptions, if the average visit duration is approximately 45 minutes, the estimated daily carrying capacity is around 1,120 visitors. If the average visit duration is shorter, for example around 30 minutes, the potential daily capacity may increase to approximately 1,680 visitors. These estimates provide a practical operational range for the carrying capacity of the monument.

## 3.3 Empirical Application of the Model

Based on the estimated carrying capacity and observed visitor data for the White Tower, the model can be applied in order to evaluate the sustainability conditions of the monument under different levels of visitor pressure and maintenance resource allocation. The empirical application of the model is presented through a set of scenarios reflecting different levels of visitor demand and management conditions.

**Table 2: Sustainability Scenarios**

| Scenario | Visitors | Capacity | Maintenance Rate | Sustainability Index |
|---|---|---|---|---|
| A | 800 | 910 | 10% | 0.75 |
| B | 1500 | 910 | 10% | 0.56 |
| C | 1500 | 1120 | 20% | 0.87 |

The results indicate that sustainability levels decline significantly when visitor numbers exceed the carrying capacity of the monument. However, improvements in management capacity and maintenance resources may substantially enhance sustainability performance even under conditions of high visitor pressure.

## 4. Discussion

The empirical application of the proposed sustainability model provides useful insights into the relationship between visitor pressure and maintenance capacity in urban cultural heritage sites. The results suggest that the sustainability performance of the White Tower is strongly influenced by the interaction between visitor flows and the availability of maintenance resources. Under conditions where visitor numbers remain close to the estimated carrying capacity of the monument, the sustainability index maintains relatively high values. However, when visitor flows exceed the carrying capacity, the saturation coefficient declines significantly, leading to lower sustainability levels. These findings highlight the importance of monitoring visitor flows and implementing appropriate visitor management strategies in order to prevent excessive pressure on cultural heritage sites. Similar concerns regarding the relationship between tourism demand and site capacity have been widely discussed in the literature on tourism carrying capacity (Coccossis & Mexa, 1997; Mathieson & Wall, 1982). At the same time, the results demonstrate that the adequacy of maintenance resources plays a crucial role in determining the sustainability performance of the monument. Even under conditions of high visitor demand, improvements in maintenance and management capacity may significantly enhance the sustainability index. This observation supports the argument that effective cultural heritage management requires not only visitor regulation but also sufficient investment in conservation and management resources, a view frequently emphasized in the literature on sustainable tourism development (Mowforth & Munt, 1998; Latinopoulos, 2015). These

findings are also consistent with recent studies highlighting the importance of integrating cultural heritage management within broader frameworks of sustainable urban development. Cultural monuments located within dense urban environments often experience increasing tourism pressure, making the development of adaptive management strategies particularly important for ensuring their long-term sustainability (ESPON, 2020). Overall, the analysis illustrates how simplified analytical models may provide useful tools for evaluating the sustainability conditions of cultural heritage sites and for supporting evidence-based management decisions in urban cultural environments.

## 5. Sustainable Management Strategies for the White Tower

The results of the analysis suggest several practical management strategies that could enhance the sustainability of the White Tower as an urban cultural heritage site. First, the implementation of a time-slot booking system could significantly improve visitor flow management. By distributing visitors across predefined time intervals of approximately 30–45 minutes, peak congestion periods may be reduced while maintaining a stable level of visitor access. Such systems are increasingly used in major cultural heritage sites as an effective mechanism for regulating visitor pressure without requiring structural interventions in the monument. Second, the introduction of extended seasonal opening hours, particularly during the peak tourist period between May and September, could increase the operational carrying capacity of the monument. Under such conditions, the estimated daily carrying capacity could increase from approximately 900 visitors per day to a range between 1,100 and 1,600 visitors, depending on the average visit duration. According to the proposed sustainability model, this adjustment alone may increase the sustainability index by approximately 15–25%. Third, the study suggests the establishment of a minimum reinvestment policy for maintenance and management resources. Allocating at least 20% of ticket revenues to conservation activities, monitoring systems, and digital visitor flow management tools could significantly improve maintenance adequacy. Under these conditions, the maintenance adequacy coefficient may approach the optimal value of $E \approx 1$, improving the overall sustainability of the monument. Another important strategy involves the spatial distribution of cultural tourism within the wider historic center of Thessaloniki. The development of thematic cultural routes linking the White Tower with other major landmarks such as the Rotunda, the Arch of Galerius (Kamara), and the Upper Town could reduce visitor concentration at the monument while maintaining overall visitor numbers in the city. Finally, three possible development scenarios may be considered for the period 2025–2030. In

the absence of management interventions, visitor numbers may exceed 260,000 annually, potentially leading to sustainability levels below 0.55 during peak periods. A partial intervention strategy, based solely on extended opening hours, may stabilize the sustainability index around 0.70–0.75 but remains vulnerable to further increases in tourism demand. In contrast, a comprehensive strategy combining time-slot booking, reinvestment of revenues into maintenance, and the development of cultural routes could stabilize the sustainability index above 0.85, transforming the White Tower into a pilot example of sustainable cultural heritage management in Greece.

## 6. Conclusions

This study examined the sustainability conditions of the White Tower of Thessaloniki through the development and application of a simplified analytical model that integrates visitor pressure and maintenance adequacy. By combining these two dimensions into a normalized sustainability index, the model provides a structured framework for evaluating the relationship between tourism activity and the operational capacity of an urban cultural heritage site. The empirical application of the model demonstrates that sustainability levels are strongly influenced by the interaction between visitor flows and the availability of maintenance resources. When visitor numbers remain close to the operational carrying capacity of the monument, sustainability levels remain relatively high. However, when visitor flows exceed this capacity, the sustainability index declines significantly, indicating increased pressure on the monument and potential risks for its long-term preservation. The analysis also highlights the importance of effective management strategies in improving sustainability conditions. Measures such as visitor flow regulation, extended operating hours, and the reinvestment of tourism revenues into maintenance activities may significantly enhance the sustainability performance of the monument even under conditions of increased tourism demand. More broadly, the proposed modeling approach demonstrates how simplified analytical tools can support decision-making in the management of cultural heritage sites located within dense urban environments. By linking visitor activity with maintenance capacity, the model provides a practical framework for evaluating sustainability conditions and designing adaptive management strategies. Future research could further refine the model by incorporating additional variables related to visitor behavior, seasonal fluctuations, and environmental conditions. Such extensions could contribute to the development of more comprehensive analytical tools for sustainable cultural heritage management.

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