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# Unleashing the Environmental Impacts of Tourism and Eco-Technologies: Does Financial Stability Matter?

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## Abstract

Tourism-intensive economies face increasing environmental challenges because rapid tourism expansion, energy-intensive infrastructure, and growing urbanization continuously intensify ecological pressure. Despite the growing literature on tourism and environmental sustainability, limited attention has been given to the moderating role of Financial Stability (FST) in shaping the environmental effects of tourism and Eco-Technologies (ECT). This study therefore investigates how FST interacts with tourism and green innovation to influence environmental quality. Using panel data for the top 20 most visited economies over the period 2007-2024, the study employs the two-step System Generalized Method of Moments (System-GMM) estimator to address endogeneity and dynamic panel issues. The findings reveal that ECT, FST, and economic globalization improve environmental quality, whereas tourism expansion deteriorates ecological sustainability. More importantly, the interaction results indicate that FST strengthens the positive environmental contribution of ECT and mitigates the adverse environmental effects of tourism activities. These findings suggest that financially resilient economies are more capable of supporting sustainable tourism transformation and green technological transition. Therefore, policymakers should integrate green innovation strategies with stable financial systems to achieve long-term environmental sustainability.

**Keywords:** Tourism, Eco-technologies, Financial stability, Economic globalization, Ecological sustainability.

## 1 | Introduction

The environmental sustainability of the world's most visited economies has become increasingly complex as tourism-driven growth reshapes economic structures and patterns of resource consumption [1], [2]. Unlike traditional industrial economies, highly visited countries rely heavily on service-sector expansion, international mobility, urban infrastructure, and tourism-related investment, all of which intensify environmental pressure

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in multiple dimensions. The continuous growth of tourism activities stimulates transportation networks, hospitality industries, construction projects, and energy demand, creating a structural dependence between economic prosperity and environmental exploitation [3]. In these economies, environmental quality is no longer viewed solely as a social or ecological concern; rather, it has become an essential determinant of long-term economic competitiveness and tourism sustainability. Destinations suffering from ecological degradation, excessive pollution, and declining natural attractiveness may gradually lose their comparative advantage in international tourism markets [4]. At the same time, the concentration of tourism activities in urban and coastal regions places substantial pressure on ecosystems, biodiversity, and environmental carrying capacity, particularly in countries experiencing mass tourism expansion [5]. Consequently, the economic success of tourism-intensive economies increasingly depends on their ability to balance tourism growth with ecological sustainability. As emphasized by Avcı et al. [6], the environmental future of highly visited economies will largely be determined by how effectively these countries integrate sustainable tourism policies, green technologies, and environmental governance into their broader economic development strategies.

Tourism has gradually transformed from a traditional service activity into a multidimensional economic force capable of reshaping environmental dynamics at national and global levels. In the world's most visited economies, tourism stimulates transportation networks, construction activities, hospitality industries, recreational services, and consumer spending, thereby becoming deeply embedded within broader economic production systems. However, the environmental implications of this transformation are highly complex. The expansion of tourism not only increases fossil fuel consumption and transportation-related emissions but also intensifies ecological pressure through land-use changes, waste generation, biodiversity loss, and excessive exploitation of natural resources [3]. Despite these environmental costs, tourism simultaneously possesses the capacity to encourage environmental improvement when sustainability becomes integrated into tourism strategies. Tourism-dependent economies increasingly recognize that environmental degradation threatens the long-term attractiveness of destinations and consequently undermines future tourism revenues and economic stability. This awareness has encouraged investments in sustainable tourism infrastructure, renewable energy utilization, green mobility systems, and eco-friendly tourism services [5]. Consequently, tourism no longer operates solely as a source of environmental pressure; it also functions as a catalyst for environmental transformation and green transition. As highlighted by Avcı et al. [6], the environmental consequences of tourism in highly visited economies largely depend on the degree to which tourism development is aligned with environmental sustainability policies, technological innovation, and energy transition strategies. Therefore, the tourism-environment nexus should not be interpreted through a purely linear perspective but rather as a dynamic interaction shaped by economic structure, environmental governance, and sustainability orientation.

The growing environmental challenges confronting modern economies have elevated green technological innovation, Eco-Technologies (ECT), from a complementary policy instrument to a central pillar of sustainable development strategies. In highly visited economies, environmental sustainability increasingly depends on the ability of governments and industries to decouple economic expansion from ecological degradation through technological transformation. Green technologies contribute to this transition by improving energy efficiency, reducing pollution intensity, facilitating renewable energy integration, and promoting environmentally responsible production systems [7]. In tourism-intensive economies specifically, eco-technological innovation plays a strategic role because tourism activities are highly dependent on transportation systems, energy-intensive infrastructure, and urban services. Consequently, technological progress within transportation, accommodation, construction, and waste management sectors directly influences environmental performance. More importantly, green innovation reshapes the environmental trajectory of economic growth by enabling economies to sustain tourism expansion while simultaneously reducing ecological pressure [8]. However, the environmental effects of ECT are not automatically positive. Technological innovation often stimulates additional production activities, infrastructure investment, and resource extraction that may temporarily intensify environmental degradation during early implementation stages [9]. This duality reveals that the effectiveness of green technological innovation depends heavily on

institutional quality, environmental regulation, and financial support mechanisms. Thus, eco-technological innovation should not be viewed simply as a technological solution but rather as a structural transformation process capable of redefining the relationship between economic development and environmental sustainability in tourism-oriented economies.

Financial Stability (FST) plays a fundamental role in shaping environmental sustainability because stable financial systems reduce macroeconomic uncertainty, improve investment confidence, and support long-term green economic transformation. In highly visited economies, FST facilitates sustainable investment in tourism infrastructure, renewable energy systems, and environmentally friendly transportation networks, all of which directly influence environmental quality [10]. A stable financial environment also enhances the capacity of financial institutions to support green innovation and sustainable development projects through efficient capital allocation and lower financing risks [11]. Moreover, financially stable economies are generally more capable of implementing effective environmental policies and maintaining sustainable tourism activities without generating excessive ecological pressure [12]. However, the environmental effects of FST depend largely on how financial resources are allocated across economic sectors. If stable financial systems primarily support carbon-intensive industries and unsustainable tourism expansion, environmental degradation may intensify despite financial resilience. Therefore, in tourism-intensive economies, FST can either enhance or undermine environmental quality depending on whether financial systems are aligned with green investment strategies and low-carbon development pathways.

The environmental role of FST extends beyond its direct influence on investment and production activities because stable financial systems also shape how tourism and green technological innovation affect ecological sustainability. In tourism-intensive economies, FST determines the capacity of governments, firms, and industries to undertake long-term investments in environmentally sustainable infrastructure, renewable energy systems, and eco-technological transformation. When financial systems operate efficiently and sustainably, tourism industries gain greater access to funding for clean transportation systems, energy-efficient accommodation facilities, and environmentally friendly operational practices [13]. In this sense, FST acts as a transmission mechanism that can strengthen the environmental benefits of green innovation while reducing the ecological costs associated with tourism expansion. Moreover, financially stable economies are generally more capable of supporting research and development activities, environmental technologies, and green industrial transformation, thereby accelerating ecological transition processes [14]. However, FST may also produce adverse environmental consequences if financial resources continue to support pollution-intensive sectors and unsustainable tourism expansion [15]. This finding indicates that the environmental effects of tourism and eco-technological innovation cannot be fully understood without considering the moderating role of financial systems. Consequently, FST should not be treated merely as an economic variable but as an institutional mechanism capable of shaping the direction, intensity, and sustainability of environmental transformation in the world's most visited economies.

The selection of the top 20 most visited economies for this study is supported by several theoretical and empirical considerations. First, these economies account for a substantial share of global tourism arrivals, tourism revenues, transportation activities, and service-sector growth, making them highly relevant for investigating the relationship between tourism and environmental quality [6]. Second, these countries are characterized by advanced tourism infrastructure, high levels of urbanization, and intensive energy consumption, all of which significantly influence ecological sustainability and environmental pressure [4]. Third, the selected economies are among the leading adopters of green technological innovations, renewable energy systems, and sustainable development policies, thereby providing an appropriate framework for analyzing the environmental impacts of ECT and financial systems [5]. Furthermore, these economies possess relatively developed financial systems and stronger financial integration, making them suitable for examining the moderating role of FST in the tourism-environment nexus [7]. According to global tourism statistics, the world's most visited economies are also among the largest contributors to global energy demand and greenhouse gas emissions, implying that environmental policies implemented in these countries may generate significant global environmental spillover effects [13]. Additionally, these countries display considerable

diversity in economic structures, tourism dependence, and environmental policies, enhancing the robustness and generalizability of empirical findings. Consequently, focusing on the top 20 most visited economies provides stronger policy implications for achieving sustainable tourism development, environmental sustainability, and green economic transformation.

This study contributes to the existing literature in several important ways. First, unlike many previous studies that mainly utilized CO2 emissions as a proxy for environmental quality, this research employs the Load Capacity Factor (LCF), which provides a broader and more comprehensive measure of ecological sustainability by incorporating both ecological footprint and biocapacity dimensions. Second, the study simultaneously investigates the effects of tourism, ECT, FST, and economic globalization on environmental quality within a unified analytical framework. Third, one of the primary novelties of this study is the examination of the direct and indirect (moderating) role of FST in the relationship between tourism, green technological innovation, and environmental quality. Specifically, the study explores whether FST can strengthen the positive environmental impacts of eco-technological innovation while mitigating the negative ecological consequences of tourism expansion. Fourth, the focus on the top 20 most visited economies allows the study to capture the environmental dynamics of highly tourism-dependent economies that significantly influence global sustainability outcomes. Finally, by integrating moderation analysis with the LCF indicator, this study provides a more policy-relevant and comprehensive understanding of sustainable development pathways in tourism-intensive economies.

The primary objective of this study is to investigate the impacts of tourism, ECT, FST, and economic globalization on environmental quality measured by the LCF in the top 20 most visited economies. The study seeks to evaluate how these variables influence ecological sustainability and environmental performance in tourism-oriented economies. Furthermore, the study aims to examine whether FST moderates the effects of tourism and ECT on environmental quality. In particular, the research intends to determine whether financially stable systems can strengthen the environmental benefits of ECT while reducing the ecological damages associated with tourism expansion. Additionally, the study aims to provide empirical evidence that can assist policymakers in developing integrated strategies for sustainable tourism development, ECT, and environmental protection.

The remainder of this study is organized as follows. First, the paper presents a comprehensive introduction followed by a review of the relevant literature. Next, the methodology section explains the data, model specification, and estimation techniques employed in the analysis. The subsequent section discusses the empirical findings and their interpretations. Finally, the study concludes by outlining the major conclusions, policy recommendations, research limitations, and potential directions for future studies. Overall, this structure provides a comprehensive framework for understanding environmental sustainability issues within the top 20 most visited economies.

## 2|Literature Review

The relationship between tourism and environmental quality has attracted considerable attention in recent decades due to the rapid expansion of international tourism and its growing contribution to global economic activity. Tourism is often regarded as a double-edged phenomenon in the environmental sustainability debate [16]. On the one hand, tourism development stimulates transportation services, accommodation facilities, infrastructure expansion, and energy consumption, all of which contribute to environmental degradation and increased carbon emissions [3]. The continuous growth of international tourist arrivals has intensified pressure on ecosystems, natural resources, and urban environments, particularly in highly visited economies where tourism activities are concentrated in coastal and metropolitan areas. From this perspective, tourism expansion is frequently associated with excessive energy use, ecological imbalance, and environmental pollution. Supporting this view, Sun et al. [17] for 88 BRI countries and Bano et al. [18] for Pakistan reveal that tourism variables increase CO2 emissions, causing environmental degradation.

On the other hand, a growing strand of literature argues that tourism can contribute positively to environmental sustainability when supported by green policies and sustainable tourism practices. Tian et al. [19] demonstrated that the tourism sector plays a role in improving environmental quality by reducing CO2 emissions. Tourism-dependent economies increasingly recognize that environmental quality represents a strategic asset for maintaining destination competitiveness and long-term tourism revenues [4]. Consequently, many countries have integrated eco-tourism strategies, renewable energy adoption, and environmentally friendly transportation systems into tourism development policies. Erdoğan et al. [5] demonstrated that eco-friendly technologies significantly mitigate the environmental consequences of tourism activities in highly visited countries. Similarly, Avcı et al. [6] found that tourism development may improve environmental quality when combined with green technological innovation and sustainable energy transition. Therefore, the tourism-environment nexus remains highly complex and conditional, depending on the sustainability orientation of tourism policies, technological advancement, and institutional quality.

ECT have become one of the central pillars of sustainable development and environmental protection strategies in modern economies. Increasing environmental degradation, climate change concerns, and ecological pressure have encouraged governments and industries to adopt environmentally friendly technologies aimed at reducing pollution and improving energy efficiency. Green technological innovation generally refers to the development and implementation of eco-friendly production processes, renewable energy systems, low-carbon technologies, and sustainable infrastructure that minimize environmental damage while supporting economic growth [7]. In tourism-intensive economies, green innovation plays a particularly important role because tourism activities are closely linked with transportation systems, urban infrastructure, and energy-intensive services. The existing literature largely supports the argument that green technological innovation contributes positively to environmental sustainability. Eco-technological progress reduces carbon emissions by improving energy efficiency, facilitating the renewable energy transition, and decreasing dependence on fossil fuels [8]. Moreover, green technologies enable tourism-oriented economies to maintain economic growth while reducing ecological pressure and environmental degradation. Aydin et al. [20] emphasized that environmental technologies significantly improve ecological sustainability by enhancing environmental efficiency and supporting low-carbon transition pathways. Similarly, Avcı et al. [6] found that green technological innovation reduces environmental degradation in highly visited economies by promoting sustainable tourism development and cleaner production systems. However, some studies argue that the environmental effects of technological innovation may not always be immediately positive. The development and diffusion of advanced technologies may initially increase industrial activities, energy demand, and resource extraction, thereby generating temporary environmental pressure [9]. Consequently, the effectiveness of green technological innovation depends largely on institutional quality, environmental regulations, and financial support mechanisms. Despite these mixed findings, the literature generally concludes that green technological innovation remains an essential mechanism for achieving sustainable environmental transformation.

FST has recently emerged as an important determinant of environmental sustainability because stable financial systems facilitate long-term investment planning, reduce economic uncertainty, and support sustainable economic transformation. Unlike the traditional financial development literature, which mainly focuses on the expansion of financial markets and credit accessibility, the FST perspective emphasizes the resilience, efficiency, and sustainability of financial systems in supporting environmentally responsible economic activities [21], [22]. In tourism-intensive economies, FST is particularly important because tourism activities require continuous investment in transportation infrastructure, urban services, renewable energy systems, and sustainable tourism facilities [23]. A stable financial environment enhances the capacity of governments and private sectors to finance green projects, support environmental innovation, and promote renewable energy transition under lower financial risk conditions. FST also improves institutional confidence and encourages long-term sustainable investments that contribute to environmental quality and ecological sustainability. Recent studies suggest that financially stable economies are generally more capable of implementing effective environmental policies and supporting green technological transformation processes. For instance, Destek and Sarkodie [12] argued that FST stimulates environmental innovation by reducing financing constraints and

improving access to green investment opportunities. Similarly, Wang et al. [24] and Wang et al. [25] emphasized that FST supports renewable energy transition and strengthens sustainable development pathways. Nevertheless, the relationship between FST and environmental quality remains conditional and multidimensional. Financially stable systems may still contribute to environmental degradation if financial resources are primarily directed toward carbon-intensive industries, unsustainable tourism expansion, and environmentally harmful economic activities. Therefore, the environmental consequences of FST largely depend on the allocation efficiency of financial resources, environmental governance quality, and the extent to which financial systems are aligned with green investment strategies and low-carbon development goals. Based on the above-mentioned discussion, *Fig. 1* presents the theoretical framework of the study.

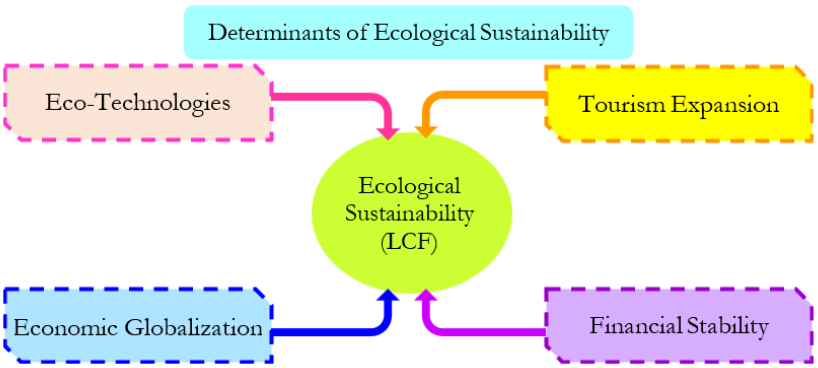


**Fig. 1. Theoretical framework of the study.**

# 3 | Data and Methodology

## 3.1 | Data

This study investigates the environmental impacts of tourism, ECT, FST, and economic globalization on environmental quality in the world's top 20 most visited economies over the period 2007-2024. The selected countries include Austria, Croatia, Canada, China, Denmark, France, Germany, Greece, Hungary, Italy, Japan, Mexico, Poland, Portugal, Spain, Türkiye, Thailand, the United Arab Emirates, the United States, and the United Kingdom. *Table 1* presents the symbols, definitions, measurement units, and data sources of the variables employed in the analysis. Environmental quality is proxied by the LCF, calculated as the ratio of biocapacity to ecological footprint, with data obtained from the Global Footprint Network (GFN). Tourism activity (TUR), measured by international tourism arrivals, is collected from the World Development Indicators (WDI) database of the World Bank. ECT, measured by environmental-related technologies as a percentage of all technologies, is sourced from the OECD database. FST, represented by stock price volatility, is retrieved from the Knoema database. In addition, economic globalization (EGL), which combines trade and financial globalization indicators, is obtained from the KOF Swiss Economic Institute.

**Table 1. Statistical summary of variables.**

| Variable | Symbol | Measurement | Source |
|---|---|---|---|
| Load Capacity Factor | LCF | Biocapacity / Ecological Footprint | GFN |
| Eco-Technologies | ECT | Environmental Related Technologies (% of all Technologies) | WDI |
| Tourism | TUR | International tourism, number of arrivals | OECD |
| Financial Stability | FST | Stock Price Volatility (%) | Knoema |
| Economic Globalization | EGL | Combination of Trade and Financial Globalization | KOF |

## 3.2 | Methodology and Model Construction

### 3.2.1 | Methodological framework

To empirically investigate the determinants of environmental quality across the world's 15 most visited economies over the period 2007-2024, this study adopts a dynamic panel-data approach based on the two-step System Generalized Method of Moments (System-GMM) estimator. The selection of this estimator is motivated by several econometric considerations commonly encountered in macro-panel analyses, including endogeneity bias, reverse causality, omitted-variable problems, country-specific heterogeneity, heteroskedasticity, and potential autocorrelation in the error structure. Compared with conventional static panel estimators, the System-GMM framework provides more reliable and consistent parameter estimates in the presence of these issues [26]. The appropriateness of the dynamic GMM technique becomes particularly relevant in panel structures characterized by a larger cross-sectional dimension relative to the time dimension. In the present study, the dataset consists of N = 20 countries observed over T = 18 years, a structure that aligns well with the econometric requirements of GMM estimation. The dynamic specification additionally enables the incorporation of the lagged dependent variable, thereby capturing the persistence of environmental quality over time. The methodological foundations of dynamic panel GMM originate from the pioneering contribution of Arellano and Bond [27], who introduced the first-difference GMM estimator. Subsequently, Blundell and Bond [28] extended this framework by developing the System-GMM estimator, which combines equations in first differences with equations in levels and employs internal instruments derived from lagged observations. This enhanced specification improves estimation efficiency and substantially mitigates the weak-instrument problem that often affects the difference-GMM estimator, particularly when explanatory variables exhibit high persistence over time.

Given these advantages, the present study relies on the two-step System-GMM estimator. The two-step procedure is preferred because it generates asymptotically efficient estimates and produces robust standard errors in the presence of heteroskedasticity and cross-sectional variability. Furthermore, the use of internal instruments contributes to alleviating simultaneity concerns between environmental quality and the explanatory variables. To ensure the validity and robustness of the estimated models, several post-estimation diagnostic tests are employed. First, the Hansen J-test of over-identifying restrictions is used to assess the validity of the instrumental variables. Failure to reject the null hypothesis indicates that the selected instruments are exogenous and appropriately specified [29]. Second, the Arellano–Bond serial correlation tests are implemented to examine the presence of autocorrelation in the differenced residuals. The consistency of the System-GMM estimator is confirmed when first-order serial correlation is detected while second-order serial correlation remains statistically insignificant [30].

## 3.3 | Model Specification

In line with the theoretical underpinnings of environmental sustainability and tourism-led development, this study specifies a dynamic empirical model to examine the impacts of ECT, tourism activity, economic globalization, and FST on environmental quality, proxied by the LCF. According to the study of Fakher et al. [31] and Fakher et al. [32], the baseline dynamic model is formulated as follows:

$$\ln \mathrm{LCF}_{it} = \alpha_0 + \gamma \ln \mathrm{LCF}_{it-1} + \beta_1 \ln \mathrm{ECT}_{it} + \beta_2 \ln \mathrm{TUR}_{it} + \beta_3 \ln \mathrm{EGL}_{it} + \beta_4 \ln \mathrm{FST}_{it} + \varepsilon_{it}. \quad (1)$$

where $i$and $t$denote country and time dimensions, respectively. LCF represents the LCF as an indicator of environmental quality, while ECT, TUR, EGL, and FST denote ECT, tourism activity, economic globalization, and FST, respectively. The inclusion of the lagged dependent variable captures the dynamic persistence of environmental conditions over time. To further investigate whether FST moderates the environmental effects of ECT and tourism, the baseline model is extended by incorporating interaction terms between FST and the key explanatory variables. The extended specification is expressed as:

$$\ln LCF_{it} = \alpha_0 + \delta \ln LCF_{it-1} + \beta_1 \ln ECT_{it} + \beta_2 \ln TUR_{it} + \beta_3 \ln EGL_{it} + \beta_4 \ln FST_{it} + \beta_5 \ln(ECT_{it} \times FST_{it}) + \beta_6 \ln(TUR_{it} \times FST_{it}) + \varepsilon_{it}. \quad (2)$$

In *Eq. (2)*, the interaction term $(ECT \times FST)$ captures the moderating role of FST in shaping the environmental impact of ECT, while the interaction term $(TUR \times FST)$ evaluates whether the environmental consequences of tourism are conditioned by the level of FST within the economy. The inclusion of these interaction effects enables a more comprehensive understanding of the conditional mechanisms through which financial-sector conditions influence environmental sustainability outcomes. Moreover, economic globalization is incorporated as a control variable to account for the broader effects of global economic integration, trade openness, and international capital mobility on environmental quality. Overall, this modeling framework allows the study to simultaneously assess both the direct and indirect effects of the explanatory variables on environmental sustainability in the leading tourism-oriented economies of the world.

# 4 | Empirical Results and Discussion

We provide empirical findings of the study in this section. For the first step, a summary of the dataset explaining the range of values of study variables is presented in *Table 2*.

**Table 2. Statistics for data description.**

| | LCF | ECT | TUR | EGL | FST |
|---|---|---|---|---|---|
| Mean | 0.433 | 0.821 | 19.287 | 28.182 | 1.607 |
| Maximum | 0.881 | 1.812 | 19.811 | 35.089 | 3.276 |
| Minimum | 0.108 | 0.288 | 17.332 | 11.207 | -0.887 |
| Skewness | 0.187 | 3.107 | 1.288 | 0.238 | -2.317 |
| Kurtosis | 4.116 | 4.223 | 5.227 | 3.662 | 10.551 |
| Jarque-Bera | 33.418** (0.002) | 5.891** (0.020) | 127.012*** (0.000) | 4.112* (0.051) | 7.108** (0.012) |

Note: ***, **, and * divulge significant at 1 %, 5 %, and 10%, respectively.

The descriptive statistics reported in *Table 2* provide preliminary insights into the distributional properties of the variables. The descriptive statistics reported in *Table 2* provide preliminary evidence regarding the distributional characteristics of the study variables. The mean values together with the differences between minimum and maximum observations indicate an acceptable degree of variation across the selected countries and over the study period, suggesting that the dataset contains sufficient informational diversity for empirical estimation. In addition, the skewness and kurtosis statistics reveal that some variables deviate from a normal distribution, which is a common feature in macro-panel datasets. The Jarque–Bera test results also confirm the presence of non-normality for several variables. Nevertheless, these distributional properties do not undermine the reliability of the empirical analysis because the System-GMM estimator employed in this study is particularly robust to heteroskedasticity, autocorrelation, and non-normality problems. Moreover, the System-GMM approach is highly appropriate for dynamic panel structures characterized by cross-country heterogeneity and potential endogeneity issues. Therefore, the statistical properties presented in *Table 2* further justify the suitability and reliability of the selected estimation technique for the current analysis. The empirical findings reported in *Table 3* reveal several important insights regarding the determinants of environmental quality in the world's most visited economies.

**Table 3. The results of the system GMM estimation.**

| Variables | Model-1 | Model-2 | Model-3 |
|---|---|---|---|
| LnECT | 0.128* (0.000) | 0.126* (0.000) | 0.125* (0.000) |
| LnTUR | -0.255*** (0.000) | -0.249*** (0.000) | -0.252*** (0.000) |
| lnEGL | 0.112** (0.003) | 0.115** (0.002) | 0.114** (0.003) |
| lnFST | 0.321*** (0.003) | 0.320*** (0.002) | 0.319*** (0.003) |
| Ln(ECT*FST) | - | 0.008** (0.003) | - |
| Ln(TUR*FST) | - | - | 0.002** (0.001) |
| **Diagnostic Tests** | | | |
| AR(1) test | -3.15 (0.002) | -2.70 (0.003) | -1.81 (0.018) |
| AR(2) test | 0.45 (0.556) | 1.13 (0.233) | 1.27 (0.346) |
| Hansen test | 13.88 (0.726) | 13.99 (0.661) | 12.79 (0.553) |
| Sargan test | 22.19 (0.181) | 2.35 (0.371) | 1.38 (0.382) |
| Notes: ***, **, and * indicate significant at 1 % and 5 %, respectively. | | | |

The positive impact of ECT on the LCF suggests that green technological innovation plays a crucial role in improving environmental sustainability within highly visited economies. This result is particularly consistent with the economic structure of the selected countries, many of which possess advanced tourism infrastructure, strong innovation capacity, and significant investments in renewable energy and environmentally friendly technologies. In these economies, environmental technologies improve energy efficiency, reduce carbon-intensive production processes, and facilitate cleaner transportation and tourism services. Since tourism activities in developed and highly visited economies are heavily dependent on transportation systems, hospitality infrastructure, and urban services, the adoption of ECT helps mitigate the environmental burden associated with large-scale tourism activities. The findings therefore indicate that technological transformation has become an essential mechanism through which tourism-dependent economies attempt to reconcile economic growth with environmental sustainability objectives.

In contrast, the negative coefficient of tourism indicates that the expansion of tourism activities intensifies environmental pressure and weakens ecological sustainability. This outcome reflects the structural reality of the world's most visited economies, where mass tourism significantly increases transportation demand, fossil-fuel consumption, urban congestion, waste generation, and pressure on natural ecosystems. International tourism expansion often stimulates airport activities, hotel construction, transportation services, and recreational infrastructure, all of which increase energy consumption and ecological degradation. Although many tourism-oriented economies have implemented sustainable tourism policies, the scale and intensity of tourism growth may still exceed the environmental carrying capacity of destinations. This concern is particularly relevant for highly urbanized and coastal tourism economies where tourism concentration generates excessive environmental stress. Therefore, the findings imply that tourism-led growth, in the absence of sufficiently strong environmental management mechanisms, may undermine long-term ecological sustainability.

The positive contribution of economic globalization to environmental quality suggests that global integration may facilitate environmental improvement in advanced tourism economies. One possible explanation is that globalization enables the transfer of green technologies, environmental knowledge, sustainable production standards, and cleaner energy systems across countries. In globally integrated economies, international trade and financial openness may encourage stricter environmental regulations, greater environmental awareness, and higher demand for sustainable tourism services. Moreover, the selected economies are generally characterized by stronger institutional quality and higher environmental standards, which allow them to benefit from globalization through technological diffusion rather than pollution-intensive industrial relocation. Consequently, globalization appears to function as a channel through which environmentally sustainable practices and low-carbon technologies are transmitted into tourism-dependent economies.

The results further reveal that FST improves environmental quality, emphasizing the importance of stable financial systems in supporting sustainable economic transformation. In highly visited economies, FST reduces uncertainty and enhances long-term investment capacity, thereby facilitating financing for renewable

energy projects, green infrastructure, environmentally friendly transportation systems, and sustainable tourism facilities. Stable financial environments also strengthen institutional confidence and improve the ability of governments and private sectors to undertake long-term environmental investments. Since tourism industries require continuous infrastructure modernization and technological upgrading, financially stable systems provide the necessary capital conditions for achieving environmental transition without disrupting economic growth. Thus, FST emerges not merely as a macroeconomic condition, but as a strategic institutional mechanism that supports ecological sustainability.

More importantly, the interaction effects provide deeper insights into the conditional role of FST in shaping environmental outcomes. The positive interaction between ECT and FST indicates that the environmental benefits of green technological innovation become stronger in financially stable economies. This finding suggests that FST enhances the effectiveness of eco-technological transformation by improving access to capital, reducing financing constraints, and encouraging long-term green investment. In financially stable environments, governments and firms are more capable of supporting research and development activities, clean energy transition, and sustainable technological adoption. As a result, ECT generates larger environmental gains because financial systems provide the institutional and financial support necessary for the successful implementation and diffusion of green innovation.

Similarly, the positive interaction between tourism and FST implies that FST mitigates the adverse environmental consequences of tourism expansion. Although tourism itself exerts environmental pressure, financially stable economies appear more capable of managing tourism-related ecological costs through sustainable infrastructure investment, environmental regulation, and green tourism policies. In other words, stable financial systems enable tourism-dependent economies to transform tourism activities into more environmentally sustainable forms by financing cleaner transportation systems, energy-efficient tourism facilities, waste management technologies, and sustainable urban infrastructure. This finding is particularly important for the world's most visited economies because it demonstrates that the environmental impact of tourism is not purely deterministic; rather, it depends significantly on the institutional and financial capacity of economies to support sustainable tourism transformation. A schematic summary of the empirical findings is presented in *Fig. 2*. The figure illustrates the direct effects of tourism, ECT, economic globalization, and FST on environmental quality, while also highlighting the moderating role of FST in strengthening sustainable environmental outcomes in the world's most visited economies.

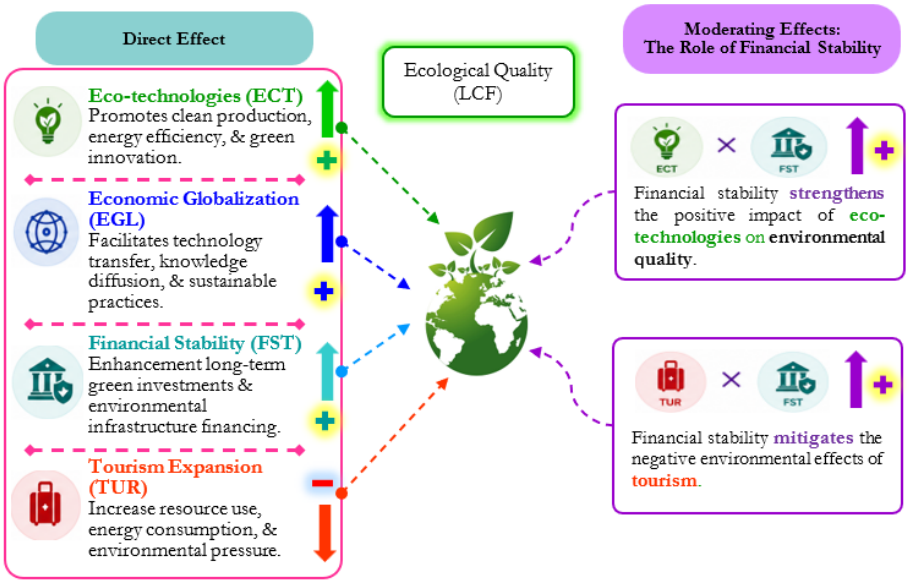


**Fig. 2. Schematic presentation of the summary of empirical findings.**

## 5 | Conclusion

Environmental sustainability has become a major concern for the world's most visited economies because tourism expansion, urbanization, and increasing energy consumption continuously intensify ecological pressure. In such economies, maintaining environmental quality is essential not only for ecological balance but also for sustaining tourism competitiveness and long-term economic growth. Accordingly, this study examined the impacts of tourism, ECT, FST, and economic globalization on environmental quality in the top 20 most visited economies over the period 2007-2024 using the two-step System-GMM estimator. The empirical findings revealed that ECT, FST, and economic globalization improve environmental quality, whereas tourism expansion deteriorates environmental sustainability due to excessive resource consumption and environmental pressure generated by tourism-related activities. The interaction effects further demonstrated that FST plays an important moderating role in environmental sustainability. Specifically, FST strengthens the positive environmental effects of ECT by facilitating green investment and technological diffusion. Moreover, FST mitigates the negative environmental consequences of tourism by supporting sustainable tourism infrastructure, cleaner transportation systems, and environmentally friendly tourism development. Overall, the findings suggest that environmentally sustainable tourism development largely depends on the integration of green innovation policies with stable financial systems.

### 5.1 | Policy Recommendations

Based on the findings, policymakers in highly visited economies should increase investments in ECT, renewable energy systems, and sustainable tourism infrastructure to improve environmental quality. Governments should also implement stricter environmental regulations for tourism activities and encourage eco-friendly tourism practices to reduce ecological pressure. In addition, strengthening FST is essential for supporting long-term green investment and sustainable tourism transformation. Policymakers should therefore promote green financing instruments, sustainable investment policies, and financial mechanisms that facilitate the adoption of environmentally friendly technologies. Finally, greater international cooperation in green technology transfer, sustainable tourism policies, and environmental governance can further help tourism-oriented economies achieve long-term ecological sustainability.

## Authors' Contributions

Z. M. A.: Writing-original draft, Methodology, Data Curation, Conceptualization, Software, and Visualization, and Validation. S. H.: Validation, Writing-Review & Editing, and Formal Analysis. Z. A.: Writing-Review & Editing, Formal Analysis, and Investigation. The authors have read and agreed to the published version of the manuscript.

## Data Availability

The data are available on request from the corresponding author.

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No external funding was received for this research.

## Conflict of Interest

There are no competing interests to declare.

## Consent for Publication

The authors have given consent for the publication of this manuscript.

## Ethics Approval and Consent to Participate

The authors confirm that this research did not involve human participants or animal subjects.

## References


[1] Fakher, H. A. (2021). The role of environmental sustainability, foreign direct investment and trade openness in economic growth: with emphasis on the causal linkage. *Big data and computing visions*, *1*(2), 57–70. https://doi.org/10.22105/bdcv.2021.142227

[2] Fakher, H. A. (2020). Analytical insights on the relationship between economic growth and environmental degradation in framework of EKC hypothesis and various environmental indicators. *Innovation management and operational strategies*, *1*(3), 252–268. https://doi.org/10.22105/imos.2021.272348.1032

[3] Ahmad, F., Draz, M. U., Su, L., & Rauf, A. (2019). Taking the bad with the good: The nexus between tourism and environmental degradation in the lower middle-income Southeast Asian economies. *Journal of cleaner production*, *233*, 1240–1249. https://doi.org/10.1016/j.jclepro.2019.06.138

[4] Ghosh, S., Balsalobre-Lorente, D., Doğan, B., Paiano, A., & Talbi, B. (2022). Modelling an empirical framework of the implications of tourism and economic complexity on environmental sustainability in G7 economies. *Journal of cleaner production*, *376*, 134281. https://doi.org/10.1016/j.jclepro.2022.134281

[5] Erdoğan, S., Gedikli, A., Cevik, E. I., & Erdoğan, F. (2022). Eco-friendly technologies, international tourism and carbon emissions: Evidence from the most visited countries. *Technological forecasting and social change*, *180*, 121705. https://doi.org/10.1016/j.techfore.2022.121705

[6] Avcı, P., Sarıgül, S. S., Karataşer, B., Çetin, M., & Aslan, A. (2024). Analysis of the relationship between tourism, green technological innovation and environmental quality in the top 15 most visited countries: evidence from method of moments quantile regression: P. Avcı et al. *Clean technologies and environmental policy*, *26*(7), 2337-2355. https://doi.org/10.1007/s10098-023-02708-8

[7] Habiba, U., Xinbang, C., & Anwar, A. (2022). Do green technology innovations, financial development, and renewable energy use help to curb carbon emissions? *Renewable energy*, *193*, 1082–1093. https://doi.org/10.1016/j.renene.2022.05.084

[8] Ali, E. B., Shayanmehr, S., Radmehr, R., Bayitse, R., & Agbozo, E. (2024). Investigating environmental quality among G20 nations: The impacts of environmental goods and low-carbon technologies in mitigating environmental degradation. *Geoscience frontiers*, *15*(1), 101695. https://doi.org/10.1016/j.gsf.2023.101695

[9] Adebayo, T. S., Oladipupo, S. D., Adeshola, I., & Rjoub, H. (2022). Wavelet analysis of impact of renewable energy consumption and technological innovation on CO2 emissions: evidence from Portugal. *Environmental science and pollution research*, *29*(16), 23887–23904. https://doi.org/10.1007/s11356-021-17708-8

[10] Charfeddine, L., & Kahia, M. (2019). Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: a panel vector autoregressive (PVAR) analysis. *Renewable energy*, *139*, 198–213. https://doi.org/10.1016/j.renene.2019.01.010

[11] Saidi, K., & Mbarek, M. Ben. (2017). The impact of income, trade, urbanization, and financial development on CO2 emissions in 19 emerging economies. *Environmental science and pollution research*, *24*(14), 12748–12757. https://doi.org/10.1007/s11356-016-6303-3

[12] Destek, M. A., & Sarkodie, S. A. (2019). Investigation of environmental Kuznets curve for ecological footprint: the role of energy and financial development. *Science of the total environment*, *650*, 2483–2489. https://doi.org/10.1016/j.scitotenv.2018.10.017

[13] Musah, M., Mensah, I. A., Onifade, S. T., Ankrah, I., & Gyamfi, B. A. (2025). On China's sustainable future: How do eco-technological innovations and financial development moderate the tourism-environmental pollution nexus? *Journal of cleaner production*, *498*, 144987. https://doi.org/10.1016/j.jclepro.2025.144987

[14] Chen, D., Hu, H., & Chang, C.-P. (2023). Green finance, environment regulation, and industrial green transformation for corporate social responsibility. *Corporate social responsibility and environmental management*, *30*(5), 2166–2181. https://doi.org/10.1002/csr.2476

[15] Shobande, O. A., & Ogbeifun, L. (2022). The criticality of financial development and energy consumption for environmental sustainability in OECD countries: Evidence from dynamic panel analysis. *International journal of sustainable development & world ecology*, *29*(2), 153–163. https://doi.org/10.1080/13504509.2021.1934179

[16] Liu, Z., Lan, J., Chien, F., Sadiq, M., & Nawaz, M. A. (2022). Role of tourism development in environmental degradation: A step towards emission reduction. *Journal of environmental management*, *303*, 114078. https://doi.org/10.1016/j.jenvman.2021.114078

[17] Sun, X., Chenggang, Y., Khan, A., Hussain, J., & Bano, S. (2021). The role of tourism, and natural resources in the energy-pollution-growth nexus: An analysis of belt and road initiative countries. *Journal of environmental planning and management*, *64*(6), 999–1020. https://doi.org/10.1080/09640568.2020.1796607

[18] Bano, S., Alam, M., Khan, A., & Liu, L. (2021). The nexus of tourism, renewable energy, income, and environmental quality: An empirical analysis of Pakistan. *Environment, development and sustainability*, *23*(10), 14854–14877. https://doi.org/10.1007/s10668-021-01275-6

[19] Tian, X. L., Bélaïd, F., & Ahmad, N. (2021). Exploring the nexus between tourism development and environmental quality: Role of Renewable energy consumption and Income. *Structural Change and economic dynamics*, *56*, 53-63. https://doi.org/10.1016/j.strueco.2020.10.003

[20] Aydin, M., Sogut, Y., & Erdem, A. (2024). The role of environmental technologies, institutional quality, and globalization on environmental sustainability in European Union countries: new evidence from advanced panel data estimations. *Environmental science and pollution research*, *31*(7), 10460–10472. https://doi.org/10.1007/s11356-024-31860-x

[21] Fakher, H. A., & others. (2023). The impact of gross domestic product, financial development, energy consumption on environmental quality: With emphasis on six environmental indicators. *Journal of natural environment*, *76*(2), 345–363. https://www.sid.ir/fileserver/jf/721-285046-x-1370621.pdf

[22] Fakher, H.-A., Abedi, Z., Ahmadian, M., & Shaygani, B. (2018). Comparative examine the impact of financial development (based on money market and capital market) in the intensity of economic growth effects on the environmental performance. *Environmental researches*, *9*(17), 133–146. https://dor.isc.ac/dor/20.1001.1.20089597.1397.9.17.17.4

[23] Fakher, H. A., Ahmed, Z., Acheampong, A. O., & Nathaniel, S. P. (2023). Renewable energy, nonrenewable energy, and environmental quality nexus: An investigation of the N-shaped Environmental Kuznets Curve based on six environmental indicators. *Energy*, *263*, 125660. https://doi.org/10.1016/j.energy.2022.125660

[24] Wang, Z., Pham, T. L. H., Sun, K., Wang, B., Bui, Q., & Hashemizadeh, A. (2022). The moderating role of financial development in the renewable energy consumption-CO2 emissions linkage: The case study of Next-11 countries. *Energy*, *254*, 124386. https://doi.org/10.1016/j.energy.2022.124386

[25] Wang, N., Zhang, X., Wang, Z., Chen, Y., & Li, S. (2023). Can financial development improve environmental quality? New findings from spatial measures of Chinese urban panel data. *Heliyon*, *9*(7), 1-16. https://www.cell.com/action/showPdf?pii=S2405-8440%2823%2905162-9

[26] Apergis, N., & Ozturk, I. (2015). Testing environmental Kuznets curve hypothesis in Asian countries. *Ecological indicators*, *52*, 16–22. https://doi.org/10.1016/j.ecolind.2014.11.026

[27] Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277–297. https://doi.org/10.2307/2297968

[28] Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

[29] Twerefou, D. K., Danso-Mensah, K., & Bokpin, G. A. (2017). The environmental effects of economic growth and globalization in Sub-Saharan Africa: A panel general method of moments approach. *Research in international business and finance*, *42*, 939–949. https://doi.org/10.1016/j.ribaf.2017.07.028

[30] Cao, B., Fu, K., Tao, J., & Wang, S. (2015). GMM-based research on environmental pollution and population migration in Anhui province, China. *Ecological indicators*, *51*, 159–164. https://doi.org/10.1016/j.ecolind.2014.09.038

[31] Fakher, H. A., Panahi, M., Emami, K., Peykarjou, K., & Zeraatkish, S. Y. (2021). New insights into development of an environmental–economic model based on a composite environmental quality index: A comparative analysis of economic growth and environmental quality trend. *Environmental energy and economic research*, *5*(3), 1-24. https://dor.isc.ac/dor/20.1001.1.25384988.2021.5.3.6.4

[32] Fakher, H. A., Panahi, M., Emami, K., Peykarjou, K., & Zeraatkish, S. Y. (2021). New insight into examining the role of financial development in economic growth effect on a composite environmental quality index. *Environmental science and pollution research*, *28*(43), 61096–61114. https://doi.org/10.1007/s11356-021-15047-2