# 9. DIGITALIZATION MEETS GREEN FINANCE: POLICY-DRIVEN TRANSFORMATION FOR SUSTAINABLE TOURISM IN EUROPE

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## Abstract

The goal of European economies is to create sustainable tourism growth while also protecting the environment. This work examines the impact of financial, economic, and trade globalization (TGL; FGL; EGL), green finances (GFN), green transport technologies (GTT), and digitalization (DIG), alongside environmental policy (EPY) on tourist arrivals (ITA) and the accomplishment of sustainable development goals (SDG). The analysis focuses on the top 8 tourism destinations in Europe from 2000 to 2022. Unit roots are tested using CIPS, whereas cross-sectional reliance is tested using second-generation methods. Parameters were computed via the CCEMG and AMG methods. Moreover, the causal relationship is estimated by the Bootstrap Granger Causality test. The results confirm that GFN, GTT, and EPY significantly increase ITA and promote progress towards SDG in Europe. Meanwhile, TGL and PM2.5 are negatively associated with SDG, and the Eco-Kuznets Curve is negatively associated with ITA. It was also found that the interactive terms of GFDG (Interaction of GFN and DIG) and GTRE (Interaction of GTT and renewable energy) significantly increase ITA and SDG. Furthermore, outcomes showed two-way causality between GFN and ITA, as well as between DIG and ITA. Policymakers are encouraged to increase green technology investment, enhance DIG, and strengthen EPY to ensure sustainable tourism in Europe.

**Keywords:** Globalization; Green financing strategies; Policy interventions; Tourist arrivals; Sustainable Development Goals; Digitalization; Europe.

**JEL Classification:** Q01, Q56, Q58, C33, L83

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***Acknowledgement:*** Supported by Beijing Natural Science Foundation (No.9244023) and NCUT Yuxiu Innovation Project (No.2024NCUTYXCX212).

# 1. Introduction

The UN Sustainable Development Goals (SDG, 2015) provide a global roadmap for a sustainable future with environmentally friendly growth (Wang et al., 2023; Awan et al., 2024). The 12th SDG emphasizes maintaining sustainable production and consumption patterns, including evaluating tourism's impact on sustainability (Iftikhar et al., 2022). The SDG is planned to be achieved by 2030, and it requires the coordination and active participation of all UN member states. Nowadays, everyone is focusing on this global agenda. Europe always tries to lead in adopting every sustainable step. Europe is currently in a phase of sustainable development and is striving to strengthen policy frameworks to address environmental challenges (Yunze et al., 2024). The European Union (EU) has committed to ambitious goals that include GHG reduction and climate neutrality objective achievement till 2050 (Khurshid et al., 2023a). These efforts highlight Europe's crucial role in the global sustainability agenda in which tourism plays a key part in achieving the SDG and ensuring long-term well-being for its citizens.

The current evidence indicates both the advantageous and detrimental impact of tourism on economic growth (Iftikhar et al., 2022). Its causes and consequences vary with the region and economic context. On the negative side, tourism can cause unequal profit distribution, cultural erosion, social conflicts, increased land prices, and various environmental challenges (Zhu et al., 2021; Ziegler et al., 2023). However, tourism also brings significant positive outcomes by boosting economic development, creating jobs, stabilizing demographics, and improving living standards (Azmi et al., 2023). Also, tourism encourages the preservation of cultural and natural heritage and enhances sustainable development (Cranmer et al., 2023). The commercial benefits of tourism often outweigh its socio-cultural and environmental drawbacks. This makes tourism a source of economic progression and also for the well-being of the people. Furthermore, tourism has long been a significant driver of economic growth as it provides employment opportunities and generates revenue for governments (Dwyer, 2023). It is also economically beneficial because it brings foreign exchange to the host country. However, with its expansion, its environmental footprint becomes increasingly apparent. This is leading to challenges for clean growth. Meanwhile, attaining clean growth is a main point of SDG (Saleem et al., 2024; Xin et al., 2024). The rising global importance of sustainable development has led to a re-evaluation of tourism practices worldwide. In response, the adoption of green financing (GFN), digitalization (DIG), and supportive policy frameworks are becoming essential for the long-term viability of the tourism sector, especially in tourism-dependent regions (Khurshid et al., 2023b).

The theoretical and empirical literature on Economics highlights various factors that contribute to SDG and sustainability in the tourism sector, where GFN has a critical position (Li et al., 2023; Wang et al., 2022). GFN facilitates the flow of capital toward environmentally friendly projects that enable funds for renewable energy and sustainable infrastructure (Gao et al., 2024). Moreover, DIG enhances efficiency and transparency, allows for better resource management, and the development of innovative solutions in tourism (Liu et al., 2024). Meanwhile, effective policy frameworks create a conducive environment for integrating these elements, ensuring that economic growth aligns with environmental sustainability (Wang et al., 2023; Khurshid et al., 2024a). Together, these forces can provide a sustainable base for tourism that not only promotes economic viability but also preserves cultural and natural resources for future generations. Lastly, globalization (GL) is also a key driver of tourism development (Chishti et al., 2024), which helps foster sustainable development (Khurshid et al., 2024b).

Europe has the world’s most visited tourism destinations, and it plays a major role in advancing sustainable tourism (Laroche et al., 2023). The continent is not only a leading tourist hub but also a front-runner in implementing green technologies and environmental policies aimed at combating climate tourism’s environmental impact (Streimikiene, 2023). With tourism adding to the GDP of several European countries, the integration of green finance and digitalization becomes crucial for ensuring that tourism aligns with SDGs. Europe executed a strategy in 2020 that was aimed at maintaining the EU leisure industry and other sectors in line with SDG by incorporating sustainable digital revolution strategies (Civelek et al., 2023). In this regard, scholarly work is also required to come up with empirical outcomes to guide policymakers.

Several studies explored available sustainable tourism indicators and drivers in different regions and countries (Iftikhar et al., 2022; Rasoolimanesh et al., 2023; Chen et al., 2023). Nonetheless, the existing literature does not properly provide clear and acceptable criteria for tourism growth in the rapid era of digitalization and innovation to achieve environmental sustainability (Streimikiene, 2023). Furthermore, most studies on the assessment of sustainable tourism lack empirical research and comparative analyses of the most desired countries with respect to tourism. Furthermore, most studies tend to focus on sustainable tourism factors in isolation, without accounting for their interactions and combined impact on tourist arrivals, environmental quality, and SDG (Huo et al., 2024).

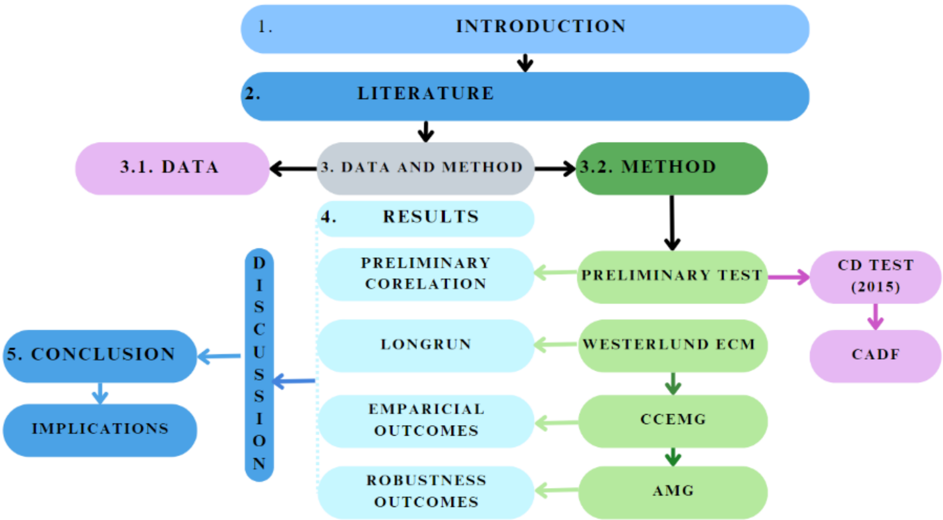
The objective is to investigate how financial, economic, and trade globalization (TGL; FGL; EGL), green financing strategies, including green finances (GFN), green transport technologies (GTT), and digitalization (DIG), alongside environmental policy (EPY) influence tourist arrivals (ITA) and the attainment of SDG in the top 8 tourism destinations of Europe. The specific research issues, based on which three empirical models are developed, are as follows:

- How do green financing, digitalization, transport infrastructure, and economic globalization affect tourist arrivals in the top 8 European destinations?
- What is the impact of global tourism policies, hospitality costs, financial globalization, and energy consumption on tourism development in Europe, and how does this relate to the EKC hypothesis?
- How do tourism revenues, environmental factors (e.g., PM2.5), green financing, and policy interventions influence progress toward the SDG in European countries?

The study examines sustainable tourism and SDG achievement in Europe's top 8 tourism hotspots. These countries' GL, GFN, DIG, and EPY approaches are crucial to understanding how to maximize sustainable tourism given their shared sustainability goals and environmental and economic concerns. Empirical research has neglected this combination of factors, particularly the joint effect of GFN and DIG on ITA and SDG. In addition, this investigation makes a distinctive contribution to the intersection of digitalization, ITA, and GFN. This area of tourism economics, as well as GL effect, is relatively underexplored. The study also pioneers the application of the EKC hypothesis to the tourism sector. There is little research on its applicability. This illuminates Europe's top tourist destinations' economic growth and environmental sustainability trade-offs. This regional focus on Europe's top 8 tourism hotspots allows for a more context-specific analysis of how mature tourism markets respond to policy interventions. This regional focus fills a literature gap and informs policymaking. GL, GFN, DIG, and EPY are highlighted for sustainable tourist growth. The study of mitigation technologies and environmental policies like GTT that minimize PM2.5 without affecting tourism revenue makes current work policy relevant. Moreover, the impact of tourism on SDG targets is also examined in the research. Likewise, the impact of interacting terms GFDG (GFN and DIG) and GTRE (GTT and renewable energy) on ITA and SDG is examined. This effort promotes academic discussion of a more sustainable and financially resilient tourist sector.

Tourism and SDG relationship has become a significant focus of research in recent years (Iftikhar et al., 2022; Rasoolimanesh et al., 2023), particularly in light of the increasing environmental concerns (Idroes et al., 2024). Scholars have explored various facets of sustainable tourism, including the roles of GL (Sharif et al., 2021), green financing (Hailiang et al., 2023), digitalization (Filipiak et al., 2023), and policy interventions (Greene et al., 2024). However, few studies have examined how these variables interact to shape sustainable tourism outcomes in Europe, particularly in its top tourism destinations (Rasoolimanesh et al., 2023; Crabolu et al., 2024). This review critically examines the existing literature on these topics. It highlights the key areas where this study contributes new insights.

**Figure 1. Remainder of the Study**




# 2. Literature review

## 2.1. *Globalization, Green Financing, Digitalization and Sustainable Tourism Development*

Globalization (GL) has significantly impacted tourism (Sharif et al., 2021), with trade, financial, and economic GL accelerating the movement of people, goods, and services outside the country. Economic GL, in particular, has been linked to both positive and negative environmental outcomes in tourism. Danish and Wang (2018) suggested that GL fosters economic growth but also increases the ecological footprint of tourism through carbon emissions. Besides, Ehigiamusoe *et al.* (2023) exhibited that the leisure industry and GL boosted economic growth but also caused environmental degradation. They examined how GL mitigated the influence of tourism on CO2 emissions and environmental footprints in Africa. The findings displayed that GL reduced the negative impact of tourism actions on carbon emissions. Similarly, GFN has appeared as a crucial tool for promoting sustainable tourism by funding eco-friendly projects and infrastructure (Hailiang et al., 2023). Studies have demonstrated that GFN can incentivize hotels, transport systems, and tourist attractions to adopt energy-efficient technologies (Hall et al., 2020). Shang *et al.* (2023) examined GFN's impact on Asian tourism renewable energy deployment from 1992 to 2021. They estimated parameters using ARDL. The results revealed that green bonds improved green efficiency over time. Their suggestions included developing eco-tourism regionalism and green tourism construction. Fu *et al.* (2024) stressed GFN's role in minimizing tourism's environmental impact. They applied modern methods and showed that GFN improves Chinese tourism's environmental sustainability. DIG has improved tourism operations with digital platforms, big data analytics, and AI (Filipiak et al., 2023). Liu *et al.* (2024) found that DIG and intelligent innovation enabled Chinese enterprises move from large-scale parks to intelligent leisure from 2012 to 2020. DIG upgraded with digital acceleration and reconstructive wisdom. The study developed a model for intelligent tourism firms to avoid strategic change. Digital rural revival, national touristic intelligence, and corporate change are informed by it. Despite the importance of both green finance and digitalization, limited research has explored their combined impact on sustainable tourism, leaving a gap that this study seeks to address.

### *2.2. Green Transport, Renewable Energy, Policy Interventions and EKC Role in Sustainable Tourism*

The integration of green transport technologies, such as electric vehicles, and the adoption of green energy use have the potential to mitigate the leisure industry's environmental impact (Khurshid et al., 2023c). Prakhar *et al.* (2024) explored tourist perceptions of electric vehicles (EVs) in Delhi using a survey of 226 respondents. Key findings showed that enhancing enjoyment, reducing costs, and improving image and performance increased EV adoption with less environmental degradation. Their recommendations included infrastructure improvements, supportive policies, and marketing efforts to boost EV usage at tourist destinations. Furthermore, renewable energy in tourism is increasingly supported by global initiatives aimed at achieving SDG 7- Clean Energy and SDG 13-of Climate Action. Studies have underscored the critical role of renewable energy in reducing tourism’s reliance on fossil fuels, thus supporting cleaner, greener growth (Hailiang et al., 2023). The literature also emphasizes that countries with stringent environmental policies tend to perform better in achieving sustainable tourism outcomes (Nepal et al., 2019; Roussel & Audi, 2024). Therefore, it is also necessary to integrate environmental policy into every model of achieving sustainable tourism.

The EKC hypothesis, developed initially to explain the economic growth and environmental degradation relationship, has been applied to various sectors, including tourism (Pata et al., 2023). Studies applying the EKC hypothesis to tourism have found mixed results. For example, Sun *et al.* (2022) studied 81 EKC Curve studies from 2013 to 2021 to investigate how tourism influences national greenhouse gases. There was no consensus due to differences in geography, affluence, and tourism's economic importance. The study suggested rethinking tourism-carbon linkages and approaches to comprehend tourism's involvement in national de-carbonization better. Ciarlantini *et al.* (2023) evaluated tourism and air quality growth in five European sites from 2009 to 2018. Panel results contradicted the tourism-induced EKC hypothesis. They found that domestic tourists increased emissions, whereas intercontinental tourists decreased them. So, there is a need for more empirical studies testing the EKC hypothesis specifically in the tourism sector, particularly within the European context.

### *2.3. Research Gap*

There are still considerable gaps in our comprehension of the integrated impacts of green financing, digitalization, and policy interventions on tourism sustainability. Most studies tend to focus on these factors in isolation, without accounting for their interactions and combined impact on ITA, environmental quality, and SDG. Furthermore, the EKC hypothesis has been underexplored in the tourism context, especially in Europe’s top tourism destinations. This study fills these gaps by analyzing the joint impact of GL, GFN, and DIG and testing the EKC hypothesis in tourism. This is to offer a regional analysis of policy interventions in the top 8 tourism destinations of Europe.

## 3. Data and Method

### *3.1. Data*

The period for the study is from 2000 to 2022. The study selected 8 Top tourist destinations in Europe (Popescu, 2017), which are AUS- Austria, FRA- France, DEU- Germany, GRC- Greece, ITA- Italy, ESP Spain, and TUR Turkey. Data is sourced from the OECD Databank, World Bank, and the following web. The missing values are filled with country-related websites.

**Table 1. Variables Details with Descriptive Statistics**

| Abv. | Variables | Mean | SD | VR | Min | Max |
|---|---|---|---|---|---|---|
| ***SDG*** | Sustainable Development goals | 77.87 | 2.91 | 8.48 | 70.25 | 83.36 |
| ***ITA*** | Tourist Arrivals | 7.57 | 1.41 | 1.98 | 5.72 | 14.70 |
| ***GTT*** | Green Transport Tech. | 13.64 | 7.04 | 49.51 | 1.75 | 32.18 |
| ***GFN*** | Green Finances | 4.48 | 0.39 | 0.16 | 3.55 | 5.07 |
| ***EPY*** | Environmental policy | 2.22 | 1.06 | 1.13 | 0.00 | 4.89 |
| ***URB*** | Urbanization | 17.32 | 0.86 | 0.74 | 15.89 | 18.24 |
| ***RT*** | Transport performance indicators | 2.35 | 0.15 | 0.02 | 2.07 | 3.04 |
| ***TGL*** | Trade globalization | 75.59 | 10.45 | 109.1 | 47.18 | 88.98 |
| ***FGL*** | Financial globalization | 78.33 | 13.75 | 189.1 | 40.58 | 98.03 |
| ***EGL*** | Economic globalization | 76.97 | 11.21 | 125.5 | 49.67 | 92.85 |
| ***ECT*** | Energy consumption in transport | 27.65 | 3.01 | 9.03 | 58.54 | 98.52 |
| ***PM2.5*** | Particulate Matter | 17.25 | 4.51 | 20.34 | 9.55 | 25.79 |
| ***EKC*** | Eco- Kuznets Curve | 24.01 | 0.76 | 0.57 | 22.23 | 25.20 |
| ***RHP*** | Restaurant and hotel price index | 91.76 | 22.37 | 500.4 | 17.53 | 125.3 |
| ***DIG*** | Digitalization | 64.92 | 18.42 | 339.1 | 12.59 | 93.23 |
| ***GFDC*** | *(GFN*DIG)* Interaction of green finances and digitalization | | | | | |
| ***GTRE*** | *(GTT*RE)* Interaction of green transport and renewable energy | | | | | |

## *3.2. Theoretical and Empirical Modeling*

This part covers the conceptual models for the current research. The empirical models are formulated based on the principles of tourism economics, green finance, and sustainable development. It is intended to examine how GL, GFN, DIG, and EPY impact ITA and SDG across selected European economies. The models are grounded in the EKC and the economic theories related to GL and GFN for sustainable growth (Kuznets, 2019). The first empirical model focuses on ITA as the dependent variable, along with independent variables, including transport performance indicators (RT), EGL, GFN, DIG, urbanization (URB), and GTRE. The objective is to assess how these factors influence tourist inflow and contribute to sustainable tourism growth (Porter & Linde, 1995).

The first empirical model is specified as follows:

$$ITA_{it} = \sigma_0 + \gamma_1 GFN_{it} + \gamma_2 DIG_{it} + \gamma_3 URB_{it} + \gamma_4 GTRE_{it} + \gamma_5 EGL_{it} + \gamma_6 RT_{it} + u_{it} + \epsilon_{it} \quad (1)$$

*for t* = 1……..,*T* and *i* = 1………, *N*

The second empirical model of the current study investigates the determinants of ITA. The focus is on GTT, RHP, FGL, ECT, EKC, and the combined influence of GFN and DIG (GFDG). This model assesses the moderating impact of global and regional policy factors on tourism growth with respect to clean energy usage and environmental policies (Khurshid et al., 2022a, b).

The second empirical model is specified as follows:

$$ITA_{it} = \sigma_0 + \gamma_1 GTT_{it} + \gamma_2 RHP_{it} + \gamma_3 FGL_{it} + \gamma_4 ECT_{it} + \gamma_5 EKC_{it} + \gamma_6 GFDC_{it} + u_{it} + \epsilon_{it} \quad (2)$$

The third empirical model focuses on the SDG as the dependent variable. The purpose is to understand how tourism-related activities and environmental policies contribute to the broader sustainability objectives of UN (Brundtland, 1985). The independent variables include ITA, PM2.5, GFN, EPY, TGL and GTRE. This model examines how various environmental and GL factors interact to promote SDG achievement through cleaner and more sustainable tourism practices.

The third empirical model is expressed as:

$$SDG_{it} = \sigma_0 + \gamma_1 ITA_{it} + \gamma_2 PM2.5_{it} + \gamma_3 GFN_{it} + \gamma_4 EPY_{it} + \gamma_5 TGL_{it} + \gamma_6 GTRE_{it} + u_{it} + \epsilon_{it} \quad (3)$$

The γ's denote the coefficients of the independent variables, while u_it and ϵ_it represent unobserved factors and error terms, respectively.

### *3.3. Methods*

This study initially calculated the descriptive statistics to gain an initial understanding of the variables used. This step provides the reader with insight into the distribution, mean, and variation of the variables. Subsequently, we look for cross-sectional dependence (CD) in the data. This is crucial in panel data studies, as ignoring it can lead to biased results. The Pesaran (2015) CD test is applied for this purpose. It is widely recognized for its effectiveness in accounting for correlations across cross-sectional units. Given the evidence of CD, we proceed with 2nd generation stationarity tests.

The study used Pesaran's Cross-Sectional Augmented Dickey-Fuller (CADF) test to determine stationarity. It controls for CD by supplementing the usual ADF regression by longitudinal means of the dependent parameter and lagged initial differences (Pesaran, 2007). This ensures that non-stationarity issues are addressed without losing the robustness of the analysis. Khurshid and Deng (2021) also employed the same test in their work. At that time, the Westerlund (2007) Error Correction Model (ECM) was utilized to investigate the presence of long-run associations among the parameters considered in the current study. This test helps determine whether the variables are co-integrated, which is essential for understanding their long-term equilibrium (Pedroni, 2004). In our analysis, no evidence of a long-run relationship among the variables is found.

The Common Correlated Effects Mean Group (CCEMG) estimator and the AMG predictor are used to estimate parameters since long-run co-integration is not present. Pesaran (2006) first presented the CCEMG estimator. It allows for varying slope coefficients between units by taking into account both cross-sectional dependence and heterogeneity. This method is highly suited for datasets with large time dimensions because it handles unobserved common factors influencing the variables (Chudik & Pesaran 2015). Then, we applied the AMG estimator for analysis. It was introduced by Eberhardt and Teal (2010) and Eberhardt and Bond (2009). This further strengthens the robustness of the results by considering heterogeneous dynamics across cross-sections. These estimators enable us to derive unbiased and efficient estimates despite the occurrence of heterogeneity and CD in the data (Xia et al., 2022).

Finally, to explore causal relationships between variables, we apply the Bootstrap Granger Causality method. This method addresses issues of non-normality and heteroscedasticity in the data by generating multiple bootstrap samples (Kónya, 2006). The country-specific causality is very much desired for the policy implications.

## 4. Results and Discussion

### *4.1. Results of Preliminary Testing*

The descriptive statistics values are presented in Table 1. The data analysis shows that RHP has the highest average value of 91.76. This shows a high level of restaurant and hotel prices in the sample countries. Conversely, EPY has the lowest average value of 2.22. It reflects the relatively limited implementation of environmental regulations across the selected nations. In terms of variability, RHP also exhibits the highest SD value of 22.37. It suggests significant fluctuations in hospitality prices across countries. This variation is also reflected in the high maximum value of 125.3 compared to the minimum of 17.53. Moreover, GFN and RT have low SD (0.39 and 0.15). This suggests that these variables show little fluctuation, and their mean values are likely representative of the overall sample.

Table 2 supports the existence of CD amongst the parameters. The outcomes from the CD test show significant CD across most variables, suggesting that shocks or changes in one country affect others. Table 2 contains the findings of the CADF test. It shows stationarity outcomes for each variable at both the level and first difference. The results show that the majority of parameters are non-stationary at each of their levels. However, after first differencing, the majority of the variables show stationarity. This suggests that these variables become stationary after differencing. That is, they are first-order integrated.

**Table 2. Unit Root and Cross-Sectional Outcomes**

| | Stats | SDG | ITA | GTT | GFN | EPY | URB | RT |
|---|---|---|---|---|---|---|---|---|
| Pesaran (2015) | CD | 24.28*** | 2.778 | 5.092 | 24.28*** | -1.65 | 11.43*** | 18.85*** |
| | | **RT** | **FGL** | **EGL** | **PM25** | **EKC** | **RHP** | **DIG** |
| | | 18.85*** | 12.84*** | 10.88*** | 16.87*** | 22.91*** | 21.82*** | 23.68*** |
| Pesaran's CADF | | **SDG** | **ITA** | **GTT** | **GFN** | **EPY** | **URB** | **RT** |
| | level | -2.33** | -2.29* | -2.16 | -1.91 | -4.09*** | -1.58 | -2.25* |
| | 1st Diff | -3.25*** | -4.24*** | -4.29*** | -3.35*** | -4.79*** | -2.75*** | -1.97 |
| | | **RT** | **FGL** | **EGL** | **PM25** | **EKC** | **RHP** | **DIG** |
| | level | -2.25* | -2.4** | -2.08 | -3.15*** | -1.87 | -1.38 | -0.79 |
| | 1st Diff | -1.97 | -2.89*** | -2.75*** | -4.6*** | -2.72*** | -2.8*** | -2.87 |

*Note: ***, **, * p < .01, 0.05, and 0.10*

Further, the outcomes of co-integration in Table 3 display that the Gt statistic fails to indicate significance across all variables, suggesting no firm evidence of long-run relationships. Similarly, the Ga statistic also shows no significance. The Pt and Pa statistics follow the same pattern, with P-values exceeding 0.5 in most cases, indicating weak evidence of co-integration or long-run dependencies. Overall, the test results suggest that the variables do not exhibit strong long-run relationships.

**Table 3. Co-integration Results**

| Stats | Value | Z-value | P-value | R. P-value | Value | Z-value | P-value | R. P-value | Value | Z-value | P-value | R. P-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gt | -0.282 | 3.943 | 1 | 1 | -0.93 | 1.203 | 0.88 | 0.86 | -0.801 | 0.476 | 0.68 | 0.46 |
| Ga | -0.606 | 3.263 | 0.99 | 1 | -2.61 | 1.66 | 0.95 | 0.76 | -2.181 | 1.008 | 0.84 | 0.44 |
| Pt | -1.816 | 1.456 | 0.92 | 0.94 | -2.39 | 0.256 | 0.60 | 0.56 | -1.853 | 0.35 | 0.36 | 0.16 |
| Pa | -1.346 | 1.31 | 0.90 | 0.94 | -2.38 | 0.064 | 0.52 | 0.54 | -1.43 | 0.394 | 0.34 | 0.14 |

## 4.2 CCEMG Estimates

The preliminary testing suggested that we employ CCEMG and AMG for parameter estimation. CCEMG results are given in Table 4, and AMG outcomes are presented in Table 5. The findings of the first model, with ITA as a dependent variable, demonstrate that various parameters have a significant impact on ITA. RT and EGL have strong positive effects, with coefficients of 0.951 and 0.156, respectively. Chishti *et al.* (2024) also found the same conclusion. This suggests that improved transport performance and economic openness contribute significantly to tourist inflows. DIG also shows a substantial positive impact (0.925). The same was also advocated by recent studies (Liu *et al.,* 2024). It indicates that technological advancements enhance tourism. The interaction term of MTRE also exhibits a positive effect (1.183). This clearly underlines the importance of green transport solutions for Europe. This is in line with the findings of Khurshid *et al.* (2023b). At last, the Wald chi-squared value of 91.49 suggests that the model is highly significant.

ITA is also a dependent variable in empirical model 2. Results show that Green GTT and FGL have positive and significant effects with coefficients of 0.133 and 0.119, respectively. That is similar to the outcomes found by Khurshid *et al.* 2023a. This indicates that advancements in green transportation and financial integration positively impact tourism in Europe. However, RHP and ECT negatively impact tourist arrivals with coefficients of -0.016 and -0.148, respectively. The results are the same as those of Prakhar *et al.* (2024). Furthermore, the EKC hypothesis is supported by a significant negative coefficient of -1.142. This suggests that in the early stages of economic growth, tourism development leads to increased environmental degradation. However, as income levels rise, environmental conditions begin to improve. This demonstrates the short-term challenge of tourism expansion and environmental sustainability, which will improve as economies expand. The Wald chi-squared value confirms the model's significance.

In the last empirical model with SDG as the dependent variable, the results reveal that GFN and EPY have significant positive effects on SDG. The coefficient values are 2.905 and 0.076, respectively. This implies that financial investment in green technologies and strong environmental policies significantly enhance sustainability outcomes in the selected European countries. However, $PM_{2.5}$ has a negative impact on SDG (-0.135). This indicates that pollution hampers progress toward sustainable development. Furthermore, MTRE also shows a positive and significant impact (0.735), reinforcing the importance of green transport solutions in achieving sustainability. Various studies in Europe and other regions found the same results (Khurshid *et al.,* 2023c). The Wald chi-squared value of 15.99 suggests that the model is significant.

Moreover, all models have significant cross-sectional averages for ITA_avg, RT, and SDG. In the first model, ITA and RT exhibit positive coefficients (0.734 and 0.759), demonstrating that average tourist arrivals and transit performance boosts tourism growth. In the second model, GTT and FGL averages of 0.118 and 0.128 indicate that green transport technology and financial GL benefit tourism. The final model shows higher positive coefficients for SDG and GFN, demonstrating that the average level of SDGs and green financing affect sustainability outcomes. All models' c_d_p coefficients have low p-values. This makes the typical dynamic procedure important. The estimates are precise, and the shared dynamic process across models is strong, demonstrating the robustness of the outcomes.

**Table 4. CCEMG Results**

| ITA | Coef. | ITA | Coef. | SDG | Coef. |
|---|---|---|---|---|---|
| 1 | | 2 | | 3 | |
| RT | 0.951*** (0.267) | GTT | 0.133*** (0.024) | ITA | 0.027** (0.003) |
| EGL | 0.156*** (0.019) | RHP | -0.016* (0.008) | PM25 | -0.135*** (0.077) |
| GFN | 1.325 1.559 | FGL | 0.119** (0.015) | GFN | 2.905** (1.429) |
| DIG | 0.925*** (0.018) | ECT | -0.148*** (0.038) | EPY | 0.076* (0.016) |

| ITA | Coef. | ITA | Coef. | SDG | Coef. |
|---|---|---|---|---|---|
| 1 | | 2 | | 3 | |
| URB | -0.730<br>(1.111) | EKC | -1.142***<br>(0.465) | TGL | -0.071*<br>(0.026) |
| GTRE | 1.183***<br>(0.417) | GFDC | 2.017***<br>(1.093) | GTRE | 0.735***<br>(0.106) |
| ITA_avg | 0.734**<br>(0.285) | ITA_avg | 0.284**<br>(0.064) | SDG_avg | 1.146***<br>(0.177) |
| RT_avg | 0.759**<br>(0.199) | GTT_avg | 0.118**<br>(0.012) | ITA_avg | 0.019**<br>(0.001) |
| EGL_avg | 0.046<br>(0.026) | RHP_avg | 0.019*<br>(0.007) | PM25_avg | -0.104**<br>(0.013) |
| GFN_avg | 0.546<br>(0.316) | FGL_avg | 0.128*<br>(0.018) | GFN_avg | 3.196**<br>(1.488) |
| DIG_avg | 0.418***<br>(0.018) | ECT_avg | 0.112**<br>(0.036) | EPY_avg | 0.058*<br>(0.011) |
| URB_avg | -3.241<br>(3.360) | EKT_avg | -0.450<br>(0.738) | TGL_avg | -0.018<br>(0.040) |
| GTRE_avg | 0.285***<br>(0.055) | GFDC_avg | 1.497***<br>(0.531) | GTRE_avg | 0.574<br>(0.113) |
| _cons | 74.68<br>(82.74) | _cons | -13.59***<br>(4.913) | _cons | -9.807***<br>(3.596) |
| Wald chi2 | 91.49*** | | 19.63*** | | 15.99*** |

*Note: * p < 0.05, ** p < 0.01, *** p < 0.001*

### *4.3. AMG Estimates*

The AMG results from three models demonstrate that several factors affect ITA and SDG in Europe. RT, EGL, GFN, and DIG boost ITA in the first model. The second empirical model shows that GTT and FGL promote tourism while RHP and ECT hinder it. GFN and EPY help SDG in the third model. In contrast, PM2.5 was detrimental. Green transport and renewable energy (MTRE) improve tourism and sustainability across all models. The Wald chi-squared and RMSE values corroborate model significance and accuracy. In sum, AMG results complement CCEMG findings. That highlights the importance of GFN, DIG, EP, and eco-friendly technology in European tourism and SDG promotion.

**Table 5. AMG Results**

| ITA | Coef. | ITA | Coef. | SDG | Coef. |
|---|---|---|---|---|---|
| *RT* | 0.409**<br>(0.129) | GTT | 0.132**<br>(0.024) | ITA | 0.043***<br>(0.001) |
| *EGL* | 0.147***<br>(0.025) | RHP | -0.112***<br>(0.003) | PM25 | -0.131**<br>(0.048) |
| *GFN* | 0.050***<br>(0.001) | FGL | 0.216***<br>(0.011) | GFN | 0.131**<br>(0.031) |
| *DIG* | 0.410***<br>(0.010) | ECT | -0.113***<br>(0.022) | EPY | 0.025*<br>(0.002) |
| *URB* | -2.937<br>2.333 | EKC | 0.361**<br>(0.159) | TGL | -0.119**<br>(0.018) |
| *GTRE* | 1.490*** | | | GTRE | 0.451*** |

| ITA | Coef. | ITA | Coef. | SDG | Coef. |
|---|---|---|---|---|---|
| | (0.449) | | | | (0.099) |
| c_d_p | 0.663*** | c_d_p | 0.230* | c_d_p | 0.946*** |
| | (0.104) | | (0.103) | | 0.099 |
| *_cons* | 6.001 | *_cons* | -0.735 | *_cons* | 71.66*** |
| | (2.73) | | (2.746) | | (7.690) |
| *RMSE* | 0.148 | | 0.126 | | 0.282 |
| *Wald chi2* | 13.86 | | 22.24 | | 16.67 |
| *Obs* | 184 | | 184 | | 184 |
| *Groups* | 8 | | 8 | | 8 |

## 4.4. Discussion

The findings suggest that green financing strategies and advancements in digitalization are essential drivers for promoting sustainable tourism in the top 8 European countries. The significant positive effects of green transport technologies and DIG highlight the importance of eco-friendly infrastructure and technological innovation in enhancing ITA in Europe. This also validates the initiatives taken by the EU regarding the adoption of new technologies in various sectors (Ma et al., 2023; Yunze et al., 2024). Moreover, Europe, by adopting clean and sustainable practices, can also influence the behavior and perception of tourists. They can bring back these ideas to their homelands. This can expand the clean and green strategies across the globe. Previous studies also demonstrated that investments in green initiatives stimulate technological advancements and attract tourists who are increasingly conscious of sustainable practices. Additionally, the positive impact of economic GL indicates that open economies with strong global ties are more likely to benefit from tourism growth. This also shows that GL can be used as a tool to enhance economic and social benefits gained from tourism. However, the negative influence of URB suggests that rapid urban expansion can hinder tourism. This happens due to environmental degradation or overcrowding (Chishti et al., 2024). Thus, policy interventions aimed at improving urban sustainability and integrating green practices in urban planning are crucial for fostering tourism growth in these countries.

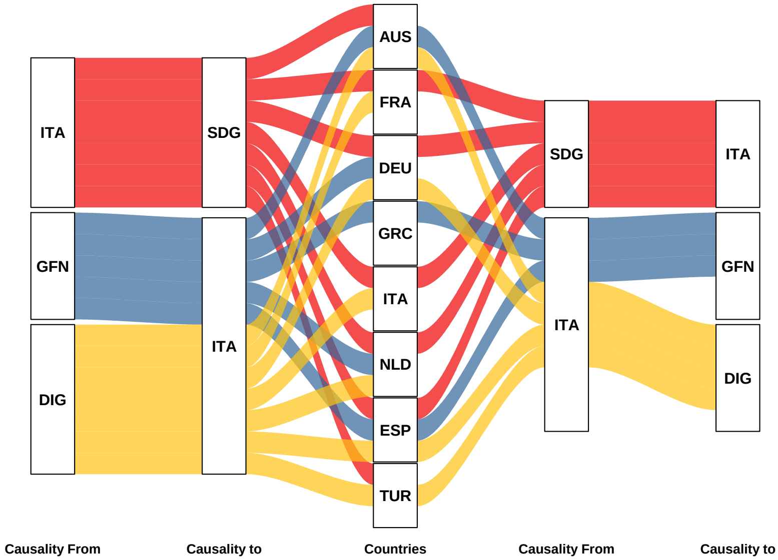
Furthermore, the negative effect of RHP indicates that higher costs in the hospitality sector can deter tourists. This result clearly shows that if European countries want to enhance their tourism, they need competitive pricing and cost-efficient services in tourism hotspots. This is an era of competition and inflation (Amiti et al., 2024), and tourists obviously prefer comparatively less expensive destinations (Fichter & Román, 2023). Additionally, the ECT underscores the environmental costs associated with fossil-fuel-dependent transportation systems in Europe. Therefore, transitioning to more energy-efficient and eco-friendly transport systems remains essential for sustainable tourism development. The main component of tourism, transportation, must be switched towards cleaner strategies.

As far as SDGs are concerned, the focus shifts to the impact of GFN and EPY. GFN and EPY are found to be the most desirable channels for attaining SGD in Europe. This is also emphasized by various studies (Khurshid et al., 2023a, b; Ma et al., 2023; Yunze et al., 2024). SDG attainment demonstrates that financial investments in green technologies and strong regulatory frameworks are vital for promoting sustainability. This also validates that the policy interventions play a critical role in ensuring that tourism activities align with broader environmental and sustainability goals. However, the negative impact of PM2.5 highlights the detrimental effects of pollution on sustainability outcomes. This suggests that, like all other sectors, pollution also hampers sustainable tourism development. Therefore, it is strongly suggested that more stringent regulations are needed to reduce emissions and improve air quality.

### *4.5. Causality test outcomes*

Table A in the Appendix and Figure 2 exhibit the bootstrap panel causality test results for ITA and SDG. AUS and TUR exhibit a substantial one-way causality from ITA to SDG, but the converse relationship is insignificant. However, FRA, DEU, ITA, NLD, and ESP are two-way causal. Tourism growth promotes sustainability, and SDG progress boosts tourism in these nations. The two variables are not causally related to GRC.

**Figure 2. Causality Outcomes in Visual Form**




The causality test between GFN and ITA shows two-way causality for AUS, GRC, and ESP. This shows that green financial investments drive and are driven by tourism growth in these nations. One-way causality exists between GFN and ITA in DEU and NLD and ITA and GFN in Italy. Green finance encourages tourism in the former and green investments in the latter. Finally, DIG and ITA have considerable two-way causation for AUS, DEU, ESP, and TUR. The DIG improves tourism, which boosts digital innovation. FRA, ITA, and NLD demonstrate DIG-ITA one-way causality. This highlights how digitalization promotes tourism in these countries. However, only GRC has a one-way causality between ITA and NLD. These causality results support two things. First, the variables are justified in inclusion and relevance. The prior estimations of a significant link between variables are confirmed. In sum, there is a robust interdependence among ITA, GFN, DIG, and SDG in Europe's most prominent tourism destinations.

## 5. Conclusion and Policy Implications

This study examines the impact of GL, GFN, DIG, and policy interventions on promoting sustainable tourism and achieving SDG across eight leading European tourism destinations. The study investigates how factors such as GFN, GTT, FGL, EGL, FGL, EPY, and DIG contribute to ITA and SDG. Using advanced econometric techniques like CCEMG and AMG for parameter estimation, alongside Bootstrap Granger Causality for causality analysis, the study provides robust evidence of the effectiveness of these strategies in fostering sustainable tourism and long-term development goals. The findings demonstrate that GFN, GTT, and EPY significantly increase ITA and promote progress towards SDG in Europe. Meanwhile, TGL and PM2.5 are negatively associated with SDG, and the Eco-Kuznets Curve is negatively associated with ITA. It was also found that the interactive terms of GFDG (Interaction of GFN and DIG) and GTRE (Interaction of GTT and renewable energy) significantly increase ITA and SDG. Two-way causality is observed between GFN and ITA and between DIG and ITA. In particular, GTT and DIG have the most substantial positive impacts. Therefore, the policymakers are encouraged to continue expanding investment in green technologies and GL practices, enhance DIG, and strengthen EPY to ensure sustainable tourism in the studied area.

The findings of this study also direct European policymakers to continue investing in green technologies and digital solutions to support the sustainable tourism sector. Moreover, strengthening EPY and promoting eco-friendly infrastructure like green transport systems and renewable energy sources are needed for SDG attainment in the region. The study also emphasizes the need for competitive pricing in the hospitality sector and a shift toward energy-efficient transport systems to mitigate negative environmental impacts. Furthermore, addressing the challenges posed by urbanization requires targeted urban planning that prioritizes environmental conservation and economic growth. Policymakers of the considered countries should also focus on reducing the negative impacts of PM2.5 through stricter environmental regulations. Also, collaboration between government, industry, and academia is crucial to drive innovation in green technologies further and ensure that the tourism sector continues to flourish. Moreover, it is also suggested that governments prioritize GFN and GL. Furthermore, the adoption of sustainable technologies by tourism-related businesses must be incentivized. By doing this, Europe can lead the way in sustainable tourism development by reducing its environmental impact while promoting economic growth.

There are a few limitations to this study despite the fact that it offers a thorough analysis of the tourism industry and SDG. The variability in the implementation and effectiveness of green strategies across different European countries must be considered. Additionally, the study relies on historical data, which may not fully capture future trends or advancements in technology. Finally, the study focuses exclusively on Europe and may not be directly applicable to other parts of the world..

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# Appendix:

**Table A. Results of Bootstrap Panel Causality**

| | | ***Coeff.*** | **SE** | ***t*-value** | ***P*-value** | | ***Coeff.*** | **SE** | ***t*-value** | ***P*-value** |
|---|---|---|---|---|---|---|---|---|---|---|
| **AUS** | ***ITA to SDG*** | 0.734 | 0.079 | 10.261 | 0 | ***SDG to ITA*** | 0.203 | 0.109 | 0.135 | 0.861 |
| **FRA** | | 0.556 | 0.065 | 7.578 | 0 | | 0.163 | 0.125 | 4.015 | 0.001 |
| **DEU** | | 0.713 | 0.197 | 8.265 | 0 | | 0.062 | 0.036 | 3.991 | 0.002 |
| **GRC** | | 0.313 | 0.148 | 1.546 | 0.215 | | 0.009 | 0.047 | 0.658 | 0.552 |
| **ITA** | | 0.608 | 0.189 | 6.017 | 0 | | 0.148 | 0.025 | 5.063 | 0 |
| **NLD** | | 0.570 | 0.048 | 9.864 | 0 | | 0.160 | 0.013 | 5.520 | 0 |
| **ESP** | | 0.684 | 0.063 | 15.735 | 0 | | 0.108 | 0.014 | 4.924 | 0 |
| **TUR** | | 0.961 | 0.072 | 11.869 | 0 | | 0.131 | 0.139 | 1.514 | 0.266 |
| **AUS** | ***GFN to ITA*** | 0.714 | 0.415 | 4.418 | 0.002 | ***ITA to GFN*** | 0.554 | 0.146 | 6.751 | 0 |
| **FRA** | | 0.042 | 0.253 | 1.328 | 0.276 | | 0.178 | 0.013 | 3.961 | 0.001 |
| **DEU** | | 0.614 | 0.044 | 4.557 | 0 | | 0.284 | 0.252 | 1.275 | 0.143 |
| **GRC** | | 0.413 | 0.831 | 5.041 | 0 | | 0.658 | 0.143 | 4.749 | 0 |
| **ITA** | | 0.116 | 0.253 | 1.512 | 0.221 | | 0.043 | 0.016 | 2.182 | 0.043 |
| **NLD** | | 0.742 | 0.136 | 8.169 | 0 | | 0.113 | 0.025 | 2.012 | 0.162 |
| **ESP** | | 0.961 | 0.227 | 7.514 | 0 | | 0.548 | 0.231 | 5.462 | 0 |
| **TUR** | | 0.561 | 0.379 | 2.031 | 0.114 | | 0.274 | 0.203 | 1.586 | 0.517 |
| **AUS** | ***DIG to ITA*** | 0.568 | 0.202 | 5.217 | 0 | ***ITA to DIG*** | 0.121 | 0.153 | 4.017 | 0 |
| **FRA** | | 0.825 | 0.231 | 7.612 | 0 | | 0.014 | 0.036 | 0.917 | 0.518 |
| **DEU** | | 0.571 | 0.216 | 5.283 | 0 | | 0.109 | 0.017 | 3.414 | 0.031 |
| **GRC** | | 0.726 | 0.231 | 1.740 | 0.163 | | 0.441 | 0.118 | 7.259 | 0 |
| **ITA** | | 0.822 | 0.147 | 7.234 | 0 | | 0.314 | 0.016 | 0.513 | 0.673 |
| **NLD** | | 0.787 | 0.045 | 4.731 | 0 | | 0.130 | 0.255 | 0.354 | 0.685 |
| **ESP** | | 1.562 | 1.637 | 8.436 | 0 | | 0.793 | 0.201 | 2.922 | 0.038 |
| **TUR** | | 1.051 | 0.713 | 5.108 | 0 | | 0.612 | 0.421 | 5.717 | 0 |