ISSN 0861-6604
ISSN 2534-8396

D. A. TSENOV ACADEMY OF ECONOMICS

BUSINESS management

Published by the D. A. Tsenov Academy
of Economics – Svishtov

SVISHTOV * 2026 YEAR XXXVI * BOOK 3

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The printing of the issue 3-2026 is funded with a grand from the Scientific Research Fund, Contract KP-06-NP7/18/05.12.2025 by the competition "Bulgarian Scientific Periodicals - 2026". The Scientific Research Fund is not responsible for the content of the materials.

Submitted for publishinq on 16.09.2026, published on 18.09.2026,
format 70x100/16, total print 80

© D. A. Tsenov Academy of Economics, Svishtov,
2 Emanuil Chakarov Str, telephone number: +359 631 66298
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BUSINESS management

D. A. Tsenov Academy of Economics, Svishtov

Year XXXVI * Book 3, 2026

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IS SUSTAINABLE TOURISM VALID FOR THE BALKAN COUNTRIES? EVIDENCE FROM THE ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS

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Abstract: The transition toward sustainable tourism has become increasingly important for the Balkan countries, where tourism represents a significant source of economic activity but also generates growing environmental pressures. This study examines the environmental implications of tourism development in eleven Balkan countries over the period 1995–2024 by investigating the relationships among greenhouse gas emissions, economic growth, electricity consumption, and international tourist arrivals within the Environmental Kuznets Curve (EKC) framework. The empirical analysis applies panel cointegration tests, FMOLS and DOLS long-run estimators, the Pooled Mean Group (PMG) estimator, and the Dumitrescu–Hurlin panel causality test. The results provide evidence of a U-shaped EKC relationship, indicating that greenhouse gas emissions initially decline with economic growth but increase again at higher income levels. Electricity consumption and tourist arrivals exert positive and statistically significant long-run effects on greenhouse gas emissions. The causality analysis further reveals bidirectional causality between greenhouse gas emissions and electricity consumption, together with unidirectional causal relationships from GDP to greenhouse gas emissions, tourist arrivals, and electricity consumption, and from tourist arrivals to

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greenhouse gas emissions and electricity consumption. The study contributes to the existing literature by providing recent regional evidence for a heterogeneous group of tourism-intensive Balkan economies and by jointly examining tourism activity, energy consumption, economic growth, and environmental pressure within a unified panel framework. The findings indicate that tourism-led growth in the region cannot be assumed to become environmentally sustainable automatically as income increases, highlighting the need for tourism decarbonization, greater reliance on renewable energy, and country-sensitive environmental policies.

Keywords: environment, sustainable tourism, carbon emission, environmental Kuznets curve, Balkan countries

JEL: Q56, Q51, F18.

DOI: https://doi.org/10.58861/tae.bm.2026.3.05

Introduction

Integration processes in the global economy have accelerated in the recent era. This acceleration has increased the volume of cross border tourism Abuseridze et al., 2024; Ismailov et al., 2026; Dorokhova et al., 2026; Laktionova et al., 2024; Petrova et al., 2025A). Rapid growth has also continued despite economic crises and instabilities (Paramati et al., 2017). The contribution of this growth can be seen in both developed and developing countries (Eyuboglu & Uzar, 2020). Similar to developed ones, developing countries may also benefit from the opportunities provided by the changes in the tourism sector to accomplish economic growth and development in globalization goals.

Accomplishing economic goals may result in undesired outcomes for the environment Petrova et al., 2025B; Pohuda et al., 2025; Popova et al., 2023; Popova et al., 2022; Sushchenko et al., 2025). Tourism activities affect the use of land, energy consumption, local species, the spread of diseases, and the overall perception of the environment (Gossling, 2002). Furthermore, tourism activities can significantly alter the environment through increased energy consumption and greenhouse gas emissions driven by economic growth (Dinget et al., 2021).

EKC framework provides insight into the link between economic growth and environmental degradation. According to the EKC, environmental harm tends to rise during the initial phases of economic development. As economy grows and awareness of the environment increases, degradation level starts decreasing, hence resembling an inverted U-shaped relationship (Dinda, 2004). However, studies like Huang et al. (2024), Wang et al. (2024), and Caporin et al. (2024) reveal other variations of the EKC, such as U-shaped

relationships. In this context, environmental degradation levels decrease up to a certain point of economic growth, after which they begin to rise again. This trend can be attributed to rapid industrial development and increased consumption.

EKC hypothesis can also be tested via several variables. The relationships between GDP, electricity consumption, CO2 emissions, and tourist arrivals are analyzed through several studies such as Jamil and Ahmad (2010), Chen et al. (2007), Narayan et al. (2010), Leitao & Lorente (2020), Katircioglu (2014), and Solarin (2014). The results of the studies vary depending on the scope. For instance, the relationship between electricity consumption and tourism arrivals can be found bidirectional or unidirectional depending on the region.

Despite the growing body of research examining the Environmental Kuznets Curve and the environmental consequences of tourism, several issues remain insufficiently addressed in the Balkan context. First, much of the existing evidence focuses either on individual countries or on broader and economically heterogeneous international samples, while comparatively limited attention has been devoted to the Balkan region as an interconnected tourism area. Second, previous studies frequently examine tourism, energy use, and economic growth separately, although these processes interact simultaneously in determining environmental pressure. Third, the empirical evidence concerning the shape of the EKC remains inconclusive, with inverted U-shaped, N-shaped, and statistically insignificant relationships reported across countries, periods, and sectors. These conflicting findings make additional regional evidence particularly relevant.

The Balkan countries provide an informative setting for such an analysis. Although they differ in income levels, tourism intensity, energy structures, and environmental performance, they share geographical proximity, strong cross-border tourism linkages, considerable dependence on European tourism markets, and common challenges associated with balancing tourism-led development with environmental protection. Rather than assuming complete economic homogeneity across the countries, the present study treats the Balkans as a geographically interconnected regional panel while explicitly allowing for cross-sectional dependence and country-specific heterogeneity in the empirical analysis.

Against this background, the study aims to investigate the environmental effects associated with tourism development in eleven Balkan countries during the 1995–2024 period. Its contribution is threefold. First, it provides updated regional evidence on the EKC by covering a 30-year period

that captures substantial changes in economic development, tourism activity, and energy consumption across the region. Second, it jointly considers economic growth, electricity consumption, tourist arrivals, and greenhouse gas emissions within a unified empirical framework, thereby linking tourism development more directly to its energy and environmental consequences. Third, by combining long-run panel estimators with country-specific PMG dynamics and panel causality analysis, the study distinguishes between common regional relationships and heterogeneous adjustment patterns across individual Balkan economies. This approach provides a more differentiated basis for evaluating whether tourism-led economic development in the region is compatible with long-term environmental sustainability.

Literature Review

Recent scientific literature on the Environmental Kuznets Curve (EKC) hypothesis in the context of sustainable tourism, particularly in the Balkan countries, reveals varying degrees of validation. The EKC assumes economic growth rises degradation levels at the beginning and degradation starts declining after reaching a higher economic level. This phenomenon occurs by adaptation of cleaner technologies. Therefore, tourism growth—a significant economic driver for the Balkans—shares a complex relationship with its associated environmental impacts.

Testing of the EKC has been one of the research areas in recent studies. For instance, Ozturk et al. (2016) test the hypothesis within the framework of tourism by utilizing ecological footprint, GDP, energy consumption, urbanization, and trade openness as variables. The results of the study indicate EKC to be more prominent in countries with higher incomes. Mahadevan and Suardi (2024) also use a similar approach and related indicators in both developing and developed countries. The study reveals an inverted U-shaped relationship in developed countries whereas a U-shaped relationship is observed in developing ones.

Awan et al. (2024) analyzes the relationship between environment, globalization, and tourism in South Asian Association for Regional Cooperation (SAARC) region where Ghosh (2020) focuses on differentiating income levels on the estimations. Both studies suggest that rising emission levels are intrinsically linked to globalization and tourism development.

However, Ghosh (2020) suggests that the relationship is reverse on higher income levels.

Resembling the previous studies, De Vita et al. (2015) focus on Türkiye and reveals how CO_2 emissions are linked to tourism. The study suggests that policies on environment should not sacrifice the tourism based economical growth. Khan et al. (2020) also states the importance of tourism in developing economies to stay competitive. Bella (2018) backs the previos results for France by stating how valuable tourism is to French economy.

Anser et al. (2020) focus on G7 countries and observe an inverted U-shaped EKC. The research is rather valuable since the results indicate the importance of efficiency in resources, sustainability of tourism, and rationality in income distribution, resulting in environmental improvement. In their investigation, Porto et al. (2023) emphasize how the EKC differs in the world suggesting highly polluted areas should pay more attention to the environment. The EKC is also validated by Shah et al. (2025) by tackling with economic complexity. However, the study implies how the value added by development in tourism activities is superior in general rather than just focusing on reducing the level of emissions.

Studies like Gossling (2002) highlight the global environmental consequences of tourism, emphasizing that while tourism stimulates economic development, it also leads to increased CO2 emissions, particularly in countries with emerging economies. In the Balkan context, rapid tourism development has been linked with environmental degradation, especially in terms of pollution and resource depletion. These effects are consistent with the early stages of the EKC hypothesis, where pollution rises due to economic activities. A study by Munir et al. (2024) investigates the relationships between tourism, emissions, and electricity in Pakistan. This study suggests that while an increase in consumption of electricity and tourism activities effect emissions negatively, use of renewable energies can be beneficial in decreasing the CO2 emissions.

Research on Türkiye, a neighboring country to the Balkans, by Eyüboğlu & Uzar (2020), indicates that tourism, economic growth, and energy consumption affect CO2 emissions. The study also demonstrates how tourism-driven emissions can be mitigated through sustainable policies. This suggests that Balkan countries could follow a similar path, where environmental impacts are reduced through renewable energy adoption, eco-friendly tourism initiatives, and regulatory frameworks. Another study by Odhiambo (2024) investigates sub-Saharan African countries and discusses the relationship between tourism and CO2 emissions. While the results

suggest an inverted U-shaped curve for middle-income countries, the relationship is not present for the low-income countries.

Other related studies also validate the EKC with the presence of an inverted U-shaped curve. For instance, Ochoa-Moreno et al. (2022) focus on Greece, which shares cultural and economic similarities with many Balkan countries, and evaluate the causal relationships between economic growth, tourism, and CO2 emissions. The findings indicate that Greece's tourism had a positive correlation with emissions, supporting the EKC's initial stages. However, like other regions, emission reductions were possible through advanced environmental policies and technologies. Moreover, Alola et al. (2021) investigated similar relationships for OECD countries under the EKC hypothesis. The results of the study suggest an evidence of an inverted U-shaped EKC in lower quantiles in the panel. However, no EKC or U-shaped hypothesis is observed between the 0.25th and 0.90th quantiles. Additionally, variables such as urbanization, tourism, and energy consumption are significant across all quantiles.

The EKC validity with an inverted U-shape can be seen in further studies. Ekonomou & Halkos (2024) focus on the impacts of tourism growth on environment in the Eurozone. According to the study, the EKC is found valid between the variables. Also, the causality tests in the analysis are not significant between capital investment and air pollution, thus implying the importance of sustainability. Additionally, Majumdar & Paris (2022) focus on urbanization, bank credits, and energy use in their study testing the EKC in the UAE. The findings in the research suggest the validity of EKC for emissions and GDP per capita, environmental degradation and number of tourists. Hence, the implementation of sustainable economy policies is considered important.

An inverted U-shaped curve for the EKC can also be observed in studies such as Nawarathna (2024). This study tests the EKC hypothesis in South Asia and reveals an inverted U-shaped relationship, meaning a negative link between resources and the environment. Nevertheless, the relationship between tourism and environment is positive. Similarly, Satrovic & Adedoyin (2023) focus on southeastern Europe in the analysis of EKC and the results show an inverted U-shaped relationship between environment and economic indicators validating the EKC hypothesis. This can also be seen in Sharma et al. (2023). This research explores the EKC in India and finds a significant, positive long-term relationship between tourism, economic growth, and carbon emissions, thereby confirming the validity of the EKC. Verbic et al. (2021) discuss the effects of urbanization and energy

consumption for EKC in southeastern Europe. In the study, an inverted U-shaped curve is observed between real GDP per capita and CO2 emissions, hence verifying the EKC.

The validity of EKC can also be seen in Zaman et al. (2016) in selected developed and developing countries by revealing an inverted U-shaped for the regions of East Asia and Pacific, European Union and high-income countries. Pata et al. (2023) also discuss EKC in ASEAN countries. The results indicate that tourism and FDI rise CO2 emissions, whereas real income and trade openness reduce degradation. Policies should also be adjusted for using renewable energy and supporting sustainability since EKC is valid. Whereas Purwono et al. (2024) analyze the relationship between urbanization, tourism, renewables, and CO2 emissions in 77 countries and suggest that both control and research variables are significant, the impacts on CO2 still differ.

In some studies, EKC shows mixed results. In their study, Bulut et al. (2023) analyzed the effect of income, government spending, and tourism consumption on CO2 emissions under EKC hypothesis with Armey Curve (AC) in the USA. The results of the study vary in each state. For instance, in some states both EKC and AC are inverted U-shaped, while in others AC can be valid but others show a U-shaped output. Hence, each state should implement policies accordingly. A study by Isik et al. (2020) examined the EKC hypothesis in G7 nations to explore the interplay between renewable energy consumption, tourism, and CO2 emissions. The findings indicate that the EKC, when factoring in tourism, holds true exclusively for France. While an increase in renewable energy consumption lessens the emission level in the UK, the US, Italy and France, international tourism positively affects CO2 emissions in Italy. Therefore, alternative policies should be adopted within the group regarding their tourism activities.

Voumik et al. (2023) focus on the Middle East in their study regarding the EKC. According to their results, the EKC is not valid in most of the region, suggesting that tourism may reduce environmental degradation. Besides tourism, renewable energy has a similar effect, while indicators such as population growth, energy consumption, and trade openness show the opposite effect. Another study by Zhang and Lu (2022) explores the relationship between tourism and air pollution in China. The results of the study vary at the national and regional levels. While an inverted U-shaped curve is observed at the national level, tourism and air pollution indicate a U-shaped curve at the regional level in eastern China, which validates the U-shaped EKC hypothesis.

Sector-specific studies also reveal differing results. For instance, Htike (2021) analyzes the Environmental Kuznets Curve (EKC) at the sectoral level across 86 developed and developing countries, finding that the EKC is valid in certain sectors but varies in others. Consequently, the author suggests that policymakers should adopt sector-specific strategies rather than broad, one-size-fits-all measures. Similarly, Pablo-Romero (2023) examines the sectoral EKC for the 15 most visited countries, noting that while the hypothesis holds true for the energy sector, an N-shaped relationship emerges in the transportation and commercial/public services sectors. Furthermore, the study identifies a significant negative relationship between energy consumption and tourism.

Some studies reveal a U-shaped curve in the EKC hypothesis. Studies like that of Ehigiamusoe (2020) analyze the relationship between tourism and environmental degradation in African countries. While cointegration between the variables is found, tourism's effect on environmental degradation results in a U-shaped form. The study reveals the importance of green tourism for policymakers. Another study by Gan et al. (2024) concentrates on the relationship between tourism and CO2 emissions in China specifically. This study reveals that environmental regulations, urbanization, and tourism income may reduce emissions, while economic expansion, population, and tourism increase them. This indicates that the impact of tourism is significant, and the direct effects of carbon emissions and economic growth reveal a U-shaped curve.

The inverted U-shaped Environmental Kuznets Curve (EKC) has recently been shown to transition into a standard U-shaped curve, as demonstrated by Wang & Kim (2024). Analyzing the EKC across the United States, their study reveals that many states have exhibited a U-shaped pattern since 2015, with most currently positioned on the downward slope. This shift from an inverted U-shape to a U-shape is primarily attributed to rising transportation emissions and heightened seasonal energy demands. Consequently, targeted environmental and energy policies are essential to prevent a renewed surge in emissions as economic activity continues to grow.

The empirical literature does not provide a uniform conclusion regarding the relationship between tourism development, economic growth, energy use, and environmental degradation. Instead, three broad patterns can be distinguished. The first strand supports the conventional inverted U-shaped Environmental Kuznets Curve, according to which environmental degradation initially increases with economic development but begins to

decline after a certain income threshold. Evidence consistent with this pattern has been reported for different developed and developing economies and has frequently been associated with technological progress, improvements in energy efficiency, stricter environmental regulation, and the increasing use of cleaner energy sources.

The second strand of the literature reports a U-shaped relationship. Under this pattern, environmental pressure initially declines as income increases but begins to rise again at higher levels of economic activity. Recent studies associate such a reversal with expanding transport activity, increasing energy demand, urbanization, consumption growth, and the environmental pressures generated by tourism-intensive economic development. This interpretation is particularly relevant for tourism economies because higher income and tourism expansion may simultaneously stimulate investment in environmental protection and generate additional mobility, accommodation, infrastructure, and energy demand.

A third group of studies provides mixed, country-specific, sector-specific, or statistically insignificant EKC results. These findings suggest that the income–environment relationship is conditional rather than universal. Differences in economic structure, energy mix, tourism intensity, environmental regulation, urbanization, and institutional conditions may alter both the direction and magnitude of the relationship. Consequently, the existence and shape of the EKC should not be assumed a priori but should be empirically evaluated within the specific regional and sectoral context under consideration.

This lack of consensus is particularly important for the Balkan region. Existing studies provide relevant evidence for individual Balkan or neighboring economies and broader groups such as the European Union, OECD countries, and South-Eastern Europe. Nevertheless, comparatively less attention has been devoted to examining tourism activity, electricity consumption, economic growth, and greenhouse gas emissions jointly for a broad Balkan panel over a recent and sufficiently long period. Moreover, the considerable differences among Balkan economies make it important to distinguish between common long-run regional relationships and country-specific adjustment processes.

Accordingly, the research gap addressed by this study is not merely geographical. The study investigates whether the interaction between tourism expansion, energy consumption, economic growth, and environmental pressure produces a common long-run pattern across the

Balkan region while allowing for heterogeneous short-run adjustment across countries. By combining the EKC framework with tourism and electricity-consumption variables and by employing complementary panel estimators and causality analysis, the study provides evidence on whether tourism-led development in the Balkans is associated with an automatic improvement in environmental quality or whether environmental pressure may re-emerge as economic activity expands.

Data and Methodology

The empirical analysis covers eleven Balkan countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, North Macedonia, Romania, Serbia, Slovenia, Greece, and Türkiye. These countries are examined within a common regional framework due to their geographical proximity, strong cross-border tourism linkages, significant tourism potential, and shared need to reconcile tourism-led economic development with environmental protection.

The inclusion of these countries does not imply that they constitute a fully homogeneous economic group. On the contrary, substantial differences exist among them in terms of income levels, tourism intensity, energy structures, and environmental performance. These differences are treated as an important characteristic of the empirical setting. The regional panel approach is therefore designed to identify common long-run relationships while allowing for country-specific heterogeneity in short-run dynamics and adjustment processes.

The econometric strategy explicitly addresses these characteristics of the sample. Cross-sectional dependence tests are employed because economic, tourism-related, energy, and environmental shocks may be transmitted across geographically and economically interconnected countries. Homogeneity tests are additionally applied to assess whether country-specific effects are present. Furthermore, the Pooled Mean Group estimator allows short-run coefficients and adjustment dynamics to differ across countries while estimating a common long-run relationship. In this way, the analysis does not assume identical behaviour across the Balkan economies but instead evaluates whether a shared long-term pattern exists alongside heterogeneous country-specific responses. The study uses annual data for the period 1995–2024. Greenhouse gas emissions data are obtained from the Climate Watch database, gross domestic product data - from the

World Bank, electricity consumption data - from the International Energy Agency (IEA), and international tourist arrivals - from the UN Tourism Statistics Database. The empirical model includes greenhouse gas emissions as the indicator of environmental pressure, GDP and its squared term - to test the nonlinear EKC relationship, electricity consumption - to capture the energy requirements associated with economic and tourism activity, and international tourist arrivals as a measure of the scale of tourism activity. The variables included in the paper are explained below:

$ln(ghg)$: Greenhouse Gases of Balkan Countries ($MtCO_2e$)

$ln(gdp)$: Gross Domestic Product of Balkan Countries (current US$)

$ln(gdp)^2$: Square of Gross Domestic Product of Balkan Countries (current US$)

$ln(electricity)$: Electricity Consumption of Balkan Countries (TWh)

$ln(arrivals)$: Tourist Arrivals in Balkan Countries (Thousands)

It should be emphasized that the present study does not construct a comprehensive index of sustainable tourism. Sustainable tourism is a multidimensional concept encompassing environmental, economic, social, and institutional dimensions, whereas the empirical model focuses specifically on its environmental dimension. International tourist arrivals therefore represent the scale of tourism activity rather than sustainability itself, while greenhouse gas emissions are used as an indicator of environmental pressure associated with economic, energy, and tourism activities.

Accordingly, sustainable tourism is considered in this study as the broader analytical and policy context within which the environmental consequences of tourism development are evaluated, rather than as a directly observed composite variable. The empirical analysis examines whether the expansion of tourism activity in the Balkan countries is compatible with improvements in environmental quality when its interaction with economic growth and electricity consumption is taken into account. An increase in international tourist arrivals cannot, by itself, be interpreted as evidence of either sustainable or unsustainable tourism. Its environmental implications depend on the associated energy requirements, emission intensity, infrastructure, transportation patterns, and environmental management practices.

This operationalization enables the study to assess one specific but important dimension of tourism sustainability: the long-run relationship between tourism expansion and environmental pressure. Consequently, the findings should be interpreted as evidence concerning the environmental

sustainability implications of tourism development rather than as a comprehensive assessment of sustainable tourism performance in the Balkan countries. The selection of variables follows the specific objective of the study and the theoretical structure of the EKC framework rather than an attempt to capture all possible determinants of greenhouse gas emissions. GDP and its squared term constitute the core variables for testing the nonlinear relationship between economic development and environmental pressure implied by the EKC hypothesis. Electricity consumption is included because both broader economic activity and tourism development generate energy demand, making electricity use an important channel through which economic and tourism expansion may affect environmental pressure. International tourist arrivals are included to capture the scale of tourism activity and assess whether tourism expansion is associated with changes in greenhouse gas emissions within the EKC framework.

Other factors, including urbanization, renewable energy use, trade openness, and institutional quality, may also influence environmental outcomes. However, the empirical specification adopted in this study is deliberately focused on the tourism–growth–energy–environment nexus. The exclusion of these additional determinants should therefore be considered when interpreting the estimated relationships and is acknowledged as a limitation of the study. Future research may extend the present framework by incorporating these variables and examining whether the estimated relationships remain stable under alternative model specifications (1):

$$ln(ghg)_{it} = \beta_0 + \beta_1 ln(gdp)_{it} + \beta_2 ln(gdp)_{it}^2 + \beta_3 ln(electricity)_{it} + \beta_4 ln(arrivals)_{it} + \varepsilon \quad (1)$$

Cross-sectional dependencies of the variables are examined via the tests revealed by Breusch-Pagan LM (Breusch & Pagan, 1980), Pesaran CD (Pesaran, 2004) and Pesaran scaled LM (Pesaran, 2004), while homogeneity of variables is tested with the homogeneity tests put forward by Swamy (1970) and Pesaran & Yamagata (2008). Stationarity analysis of the variables are performed by Im et al. (2003), Breitung (2000) and Pesaran (2007) unit root tests. The long-term relationships between the variables are examined using the cointegration tests developed by Kao (1999), Pedroni (1999, 2004), and Westerlund (2005). Long-term coefficient estimates of the variables are revealed using the pooled mean group estimator (PMG) in order to determine the effects of tourism on the environment. Ultimately, the causal relationships among the variables are examined using the causality test developed by Dumitrescu and Hurlin (2012).

Cross Sectional Dependence and Panel Unit Root Test

Determining the correct estimator to analyze cross-sectional dependence and homogeneity within the scope of panel data analysis is greatly important. As integration levels among countries have risen by globalization, paying attention to the cross-sectional dependence and homogeneity of variables in panel data analyses is important. Therefore, the cross-sectional dependence between countries is tested by means of Breusch-Pagan LM (Breusch & Pagan, 1980) (2), Pesaran CD (Pesaran, 2004) (3) and Pesaran scaled LM (Pesaran, 2004) (4).

$$LM = T\sum_{\text{i}=1}^{N-1}\sum_{J=\text{i}+1}^{N} P_{ij}^2 \sim X^2_{\frac{N(N-1)}{2}} \quad (2)$$

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} P_{ij}\right) \sim N(0,1) \quad (3)$$

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} P_{ij}\,(T\rho_{ij}^2 - 1) \sim N(0,1) \quad (4)$$

The homogeneity of the variables is evaluated using the tests proposed by Swamy (1970) and Pesaran and Yamagata (2008). The models for homogeneity tests put forward by Swamy (1970) (5) and Pesaran and Yamagata (2008) (6,7) are given below:

$$\hat{S} = \chi^2_{k(N-1)} = \sum_{i=1}^{N}(\hat{\beta}_i - \bar{\beta}^*)'\hat{V}_i^{-1}(\hat{\beta}_i - \bar{\beta}^*) \quad (5)$$

$$\tilde{\Delta} = \sqrt{N}\,\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}} \quad (6)$$

$$\tilde{\Delta}_{adj} = \frac{\sqrt{N}N^{-1}\tilde{S} - k}{\sqrt{Var(T,k)}} \quad (7)$$

To analyze the variables included in the research models, they should not contain unit roots at their levels or in their first differences. After conducting tests for cross-sectional dependence and homogeneity, the panel unit root tests of the first and second generations, as proposed by Im et al. (2003) (8,9), Breitung (2000) (10), and Pesaran (2007) (11,12), are applied.

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{\rho_i}\beta_{ij}\Delta y_{i,t-j} + X'_{it}\delta + \varepsilon_{it} \quad (8)$$

$$\Gamma_{\bar{t}} = \frac{\sqrt{N}\{\bar{t}_{NT} - E(t_T|\rho_i=0)\}}{\sqrt{Var(t_T|\rho_i=0)}} \quad (9)$$

$$\Delta y^*_{i,t} = a y^*_{i,t-1} + v_{i,t} \quad (10)$$

$$y_{it} = (1-\varphi)_{\mu_i} + \varphi_i y_{i,t-1} + u_{it} \quad (11)$$

$$CIPS = N^{-1}\sum_{i=1}^{N} CADF_i \quad (12)$$

Panel Cointegration Test and Long-Term Coefficient Estimation

The long-term relationships between the variables in the model are examined using the panel cointegration tests proposed by Kao (1999), Pedroni (1999, 2001a, 2004), and Westerlund (2005). These tests provide robust results by combining statistics calculated for each unit in the panel data analysis. Moreover, the restrictive distribution of the combined test ensures that the series exhibit a tendency toward normal distribution after standardization. Panel cointegration analyses are performed using the following models (13,14,15,16,17):

$$y_{it} = \alpha_i + \delta_{it} + \beta_{1i}x_{1it} + \beta_{2i}x_{2it} + \cdots + \beta_{Mi}x_{Mit} + e_{it} \quad (13)$$

$$y_{it} = \alpha_i + \beta X_{it} + e_{it} \quad (14)$$

$$y_{it} = y_{it-1} + u_{i,t} \quad (15)$$

$$x_{it} = x_{it-1} + e_{i,t} \quad (16)$$

$$e_{it} = \rho e_{it-1} + u_{it} \quad (17)$$

$$VR = \sum_{i=1}^{N}\sum_{t=1}^{T}\hat{E}_{it}^{2}\hat{R}_{i}^{-1} \quad (18)$$

The long-term relationships among the variables were analyzed, followed by the estimation of long-term coefficients. In the presence of cointegration, the Ordinary Least Squares (OLS) estimator may produce inconsistent, biased, and misleading parameter estimates (Johansen, 1988; 1995). To overcome this limitation, several estimation techniques have been developed specifically for cointegrated panel data. Among the most commonly applied methods for estimating long-term coefficients are the Fully Modified Ordinary Least Squares (FMOLS) estimator, introduced by Phillips and Hansen (1990) and Pedroni (2001b), and the Dynamic Ordinary Least Squares (DOLS) estimator, proposed by Kao and Chiang (2001), Saikkonen (1991), and Stock and Watson (1993). These techniques effectively address serial correlation and endogeneity issues, ensuring more robust and reliable estimations.

The Panel FMOLS estimator, introduced by Pedroni (2001b), effectively mitigates serial correlation and endogeneity issues, ensuring consistent and unbiased estimates of cointegrated vectors. Accordingly, the panel FMOLS estimation is performed using the following panel regression model (19):

$$\hat{\beta}_{FMOLS} = \frac{1}{N}\sum_{i=1}^{N}\left(\sum_{i=1}^{T}\left(x_{i,t} - \bar{x_i}\right)^2\right)^{-1}\left(\sum_{i=1}^{T}\left(x_{i,t} - \bar{x_i}\right)y_{i,t}^{*} - T\hat{\gamma}_i\right) \quad (19)$$

Like the panel FMOLS estimator, the panel DOLS estimation method mitigates the correlation between variables and the error term by

incorporating lagged values into the cointegration framework. The panel DOLS estimator is implemented using the following model (20):

$$\hat{\beta}_{DOLS} = \frac{1}{N}\sum_{i=1}^{N}\left(\sum_{i=1}^{T} z_{i,t} z_{i,t}'\right)^{-1}\left(\sum_{i=1}^{T} z_{i,t}\left(y_{i,t} - \bar{y}_i\right)\right) \quad (20)$$

The short- and long-term coefficients of the variables are estimated with the PMG method proposed by Pesaran et al. (1999). In this method, models become more dynamic as a result of estimating both long-term and short-term coefficients. The factors affecting the dependent variable are separated into short- and long-term. The obtained long-term coefficients do not change between units (countries), while the constant term, short-term coefficients and error term variances are assumed to be different between units.

In this context, the use of error correction model is important in examining the differences and/or changes in tourism policies or other variables over time between countries in terms of their effects on the dependent variable. As stated previously, PMG estimators distinguish between short-term and long-term coefficients. Since tourism policy implementations vary across countries, these estimators matter in examining the impact of tourism on the environment. The PMG estimator is implemented through the following model (21):

$$\Delta y_{it} = \emptyset_i \varphi_{i,t-1} + \sum_{l=1}^{p-1} \lambda_{il}' \Delta y_{i,t-1} + \sum_{j=1}^{q-1} \delta_{ij}' \Delta X_{i,t-j} + \gamma_i' X_{it}' + \alpha_i + \beta_i t + u_{it} \quad (21)$$

Panel Causality Test

Following the analysis of short- and long-term relationships among the variables, causality is examined using the Dumitrescu and Hurlin (2012) panel causality test. Dumitrescu and Hurlin (2012) assert that the reliability of causal relationship results improves with an increase in the number of observations. Furthermore, they highlight that consistent outcomes can be achieved in panel data analyses regardless of whether the time dimension is larger or smaller than the cross-sectional dimension. Dumitrescu and Hurlin panel causality test model used in the analysis is given below (22):

$$Y_{i,t} = a_i + \sum_{k=1}^{k} Y_i^{(k)} Y_{i,t-k} + \sum_{k=1}^{k} \beta_i^{(k)} X_{i,t-k} + e_{i,t} \quad (22)$$

Empirical Results

In order to analyze the relationships between tourism and the environment in the Balkan countries, cross-sectional dependence and homogeneity of the variables are tested first.

Table 1

Cross-Section Dependence and Homogeneity Test Results

Test	Statistic	Prob.
CD_{BP}	574.268***	0.000
CD_{LM}	49.511***	0.000
CD	15.499***	0.000
$\hat{\Delta}$	8.097**	0.000
$\hat{\Delta}_{adj}$	9.053***	0.000
Swamy's Test	1973.42***	0.000

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

It is substantial to test the cross-sectional dependence and homogeneity of variables for using accurate estimators in panel data analyses. The results in Table 1 indicate that the null hypothesis, which suggests the absence of cross-sectional dependence among the units, has been statistically rejected. It is determined that the economic shocks that may arise due to the common characteristics of the countries such as having high economic potential within the scope of the analysis may also affect others. Moreover, the null hypothesis was rejected in all models according to the results of homogeneity tests. Therefore, it is seen that there are country-specific effects in the research model.

Table 2

Panel Unit Root Test Results

Test	Im, Pesaran, and Shin		Breitung		PESCADF	
	Constant	Constant and Trend	Constant	Constant and Trend	Constant	Constant and Trend
Level						
$ln(ghg)$	-1.077	-3.699***	0.254	-0.656	-1.948	-2.903**
$ln(gdp)$	0.682	-3.753***	5.529	-0.285	-2.857***	-3.121***
$ln(gdp)^2$	0.978	-3.659***	5.642	-0.332	-2.811***	-3.085**
$ln(electricity)$	-2.548***	-4.051***	1.324	-3.355***	-1.915	-3.071***
$ln(arrivals)$	-0.559	-5.021***	0.365	-4.108	-1.563	-2.843**
First Difference						
$ln(ghg)$	-13.652***	-12.298***	-9.662***	-10.131***	-3.824***	--3.859***
$ln(gdp)$	-10.932***	-8.889***	-5.022***	-6.683***	-4.296***	-4.437***
$ln(gdp)^2$	-10.892***	-8.839***	-5.216***	-6.837***	-4.262***	-4.393***
$ln(electricity)$	-18.938***	-19.894***	-6.723***	-8.137***	-4.234***	-4.147***
$ln(arrivals)$	-18.431***	-16.565***	-12.461***	-11.287***	-3.701***	-3.818***

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2 presents the unit root test results as part of the analysis. The second-generation unit root test provides reliable outcomes even when cross-sectional dependence is present. Both first- and second-generation unit root tests are employed to evaluate the stationarity of the variables. Based on the test results, it is observed that the variables in the analysis exhibit stationarity at different levels.

Table 3
Panel Cointegration Test Results

Test	Statistic	Prob.
Pedroni (2001a)		
PP Panel- Stat.	-6.332***	0.000
ADF Panel- Stat.	-6.648***	0.000
PP Grup- Stat.	-3.627***	0.000
ADF Grup- Stat.	-4.616***	0.000
Kao (1999)		
ADF- Stat.	-3.586***	0.000
Westerlund (2005)		
Varience Stat.	1.831**	0.028

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3 presents the results of the panel cointegration tests. The findings indicate the existence of a long-term relationship between greenhouse gas emissions, economic growth, electricity consumption, and tourist arrivals in the Balkan countries. Furthermore, the results confirm that the cointegration relationship among these variables is supported by the panel cointegration analysis conducted in the study.

Table 4
Panel FMOLS and Panel DOLS Long-Term Coefficient Estimation Results

	Panel FMOLS		*Panel DOLS*	
Variables	*Long-Term Coefficients*	*T Statistics*	*Long-Term Coefficients*	*T Statistics*
$ln(gdp)$	-1.162***	-93.359 [0.013]	-1.561***	-3.411 [0.458]
$ln(gdp)^2$	0.019***	2.722 [0.013]	0.092***	3.264 [0.009]
$ln(electricity)$	0.128**	6.865 [0.018]	0.637***	3.533 [0.076]
$ln(arrivals)$	0.153***	4.364 [0.035]	0.055**	2.156 [0.032]
R^2	0.83		0.86	
Observation	319		330	

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. [ ] indicates standard error.

The long-term coefficient estimations were conducted using the panel FMOLS and panel DOLS methods, with the results presented in Table 4. The findings indicate that the coefficients capturing the impact of GDP on GHG emissions are negative and statistically significant in both estimation approaches. Specifically, the panel FMOLS and panel DOLS results suggest that a 1% increase in GDP leads to a long-term reduction in GHG emissions by approximately 1.16% and 1.56%, respectively. In contrast, the coefficients for the squared GDP variable are positive and statistically significant across both methods. The results show that a 1% increase in squared GDP increases GHG emissions by approximately 0.02% and 0.09%, respectively, in the long run. These findings confirm the validity of the U-shaped Environmental Kuznets Curve (EKC) hypothesis in the Balkan countries, indicating that while GHG emissions initially decline with economic growth, they eventually rise again as income levels continue to increase.

The panel FMOLS and panel DOLS estimation results confirm that electricity consumption has a positive and statistically significant effect on GHG emissions in the Balkan countries. Specifically, a 1% increase in electricity consumption results in a long-term rise in GHG emissions by approximately 0.13% and 0.64%, respectively, according to the two estimation methods. Likewise, the impact of tourism, measured by the number of international arrivals, is also found to be positive and statistically significant in both models. The findings indicate that a 1% increase in tourist arrivals leads to a long-term increase in GHG emissions by approximately 0.15% and 0.06%, respectively. These results underscore that, while tourism contributes to economic growth in the Balkan countries, it also accelerates environmental resource consumption. The associated rise in energy demand and resource use exacerbates environmental degradation, ultimately leading to higher GHG emissions.

An important feature of the empirical results is their qualitative consistency across the alternative long-run estimation methods. Both the FMOLS and DOLS estimators produce the same directional pattern for the main explanatory variables: GDP has a negative coefficient, squared GDP has a positive coefficient, while electricity consumption and international tourist arrivals have positive coefficients. The consistency of the signs across the two estimators strengthens confidence that the main long-run findings are not specific to a single estimation technique. Nevertheless, this consistency should be interpreted as supporting evidence for the stability of the main empirical pattern rather than as a formal robustness test covering all possible alternative model specifications.

Several mechanisms may provide an economic interpretation of this pattern. At earlier stages of the observed relationship, improvements in production efficiency, technological development, environmental regulation,

and changes in economic structure may contribute to lower emission intensity. However, as economic activity continues to expand, scale effects may begin to outweigh these environmental improvements. Higher levels of production and consumption can generate additional energy demand, transportation activity, infrastructure use, and mobility, thereby increasing environmental pressure. In tourism-oriented economies, this effect may be reinforced by the additional demand associated with accommodation, passenger transportation, tourism infrastructure, and other tourism-related services. These mechanisms should be regarded as plausible interpretations of the estimated U-shaped relationship rather than as separately identified causal channels in the present model.

The U-shaped result is also consistent with broader empirical literature showing that the EKC does not follow a universal functional form. Previous studies have reported conventional inverted U-shaped relationships, U-shaped relationships, and other country- or sector-specific patterns. In particular, the U-shaped evidence reported by Ehigiamusoe (2020), Gan et al. (2024), and Wang and Kim (2024) supports the possibility that environmental pressure may re-emerge as economic activity expands. By contrast, other studies report inverted U-shaped or mixed EKC patterns, confirming that the income–environment relationship depends on the geographical context, energy structure, sectoral composition, and period under investigation. The findings of the present study therefore contribute to this debate by showing that, for the Balkan panel over 1995–2024, higher levels of economic development are not necessarily associated with a permanent reduction in greenhouse gas emissions.

Table 5

Pooled Mean Group (PMG) Estimator Results

Units	*ECT*	$ln(gdp)$	$ln(gdp)^2$	$ln(electricity)$	$ln(arrivals)$
Panel	-0.147***	-4.089***	0.086***	2.081***	0.185***
Albania	-0.836***	0.312	0.074	0.095	0.087**
Bosnia and Herzegovina	-0.473***	7.394***	-0.152***	0.354***	0.044
Bulgaria	-0.164	-0.691	0.057	1.331**	0.176
Croatia	-0.281***	5.337	-0.106	0.519***	0.096***
Montenegro	-0.534***	-1.642**	3.718**	-0.364	-0.391
North Macedonia	-0.122**	1.931	-0.043	0.399**	0.024
Romania	-0.114	-0.477	0.108	0.547	0.113
Serbia	-0.199**	-1.362**	0.286**	0.497	-0.005
Slovenia	-0.059**	-3.257**	0.543**	1.157*	0.038
Türkiye	-0.167**	1.182***	-0.108***	1.093***	0.044
Greece	-0.141***	-5.558	0.106	0.214***	0.053***

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The findings presented in Table 5 indicate that the error correction term (ECT) is negative (-0.147), and it is statistically significant at the 1% level, resulting in the rejection of the null hypothesis. This suggests the presence of a long-term relationship among the variables under consideration. The negative ECT highlights short-term discrepancies and the rate at which equilibrium is restored in subsequent periods. Furthermore, the long-term coefficient for GDP is negative (-4.089) and statistically significant at the 1% level, while the square of GDP is positive (0.086) and also significant at the 1% level. Additionally, the long-term coefficients for electricity consumption (2.081) and tourist arrivals (0.185) are both positive and statistically significant.

The PMG estimator allows for the analysis of both long- and short-term relationships for each unit. The results derived from the PMG method for each country are presented in Table 4. The findings indicate that the error correction terms (ECT) for Albania, Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, Slovenia, Türkiye and Greece are statistically significant and negative. This confirms the existence of a long-term relationship between greenhouse gases, economic growth, electricity consumption, and tourist arrivals in the Balkan nations. Additionally, the ECT parameters for these countries suggest that short-term deviations will be swiftly corrected in the long run. In contrast, the ECT values for Bulgaria and Romania are negative but statistically insignificant, implying that no long-term relationship exists between the variables in these countries.

The country-specific PMG results reveal substantial heterogeneity in the adjustment dynamics across the Balkan countries. The error-correction term (ECT) is negative and statistically significant for nine of the eleven countries, indicating that deviations from the estimated long-run equilibrium are corrected over time, although the speed of adjustment differs considerably across economies. Albania exhibits the strongest adjustment response (ECT = −0.836), suggesting comparatively rapid correction of short-run disequilibria. Montenegro (ECT = −0.534) and Bosnia and Herzegovina (ECT = −0.473) also display relatively strong adjustment dynamics. Croatia (ECT = −0.281) and Serbia (ECT = −0.199) show more moderate adjustment, while Türkiye (ECT = −0.167), Greece (ECT = −0.141), North Macedonia (ECT = −0.122), and Slovenia (ECT = −0.059) exhibit slower convergence toward the estimated long-run equilibrium.

Bulgaria and Romania constitute notable exceptions. Although their ECT coefficients are negative (−0.164 and −0.114, respectively), they are not statistically significant. Consequently, the country-specific PMG estimates do

not provide sufficient statistical evidence of a stable error-correction mechanism for these two countries. This result is important because it demonstrates that the common regional relationship identified by the panel analysis should not be interpreted as implying identical adjustment processes across all Balkan economies.

The nonlinear GDP coefficients also vary across countries. The combination of the GDP and squared GDP coefficients does not provide an identical EKC pattern for each economy, and statistical significance differs substantially across the sample. This heterogeneity reinforces the need to distinguish the overall panel-level EKC relationship from country-specific dynamics. Accordingly, the U-shaped relationship, identified for the regional panel, should be interpreted as a common long-run regional pattern rather than as evidence that each of the eleven countries individually follows the same environmental trajectory.

Table 6
Dumitrescu-Hurlin's (2012) Panel Causality Tests Results

Causality Relationship	Z^{HNC} *N, T*	Z^{HNC} *N*
$ln(gdp) \not\Rightarrow ln(ghg)$	3.125***	2.536***
$ln(ghg) \not\Rightarrow ln(gdp)$	1.076	0.762
$ln(electricity) \not\Rightarrow ln(ghg)$	3.759***	3.679***
$ln(ghg) \not\Rightarrow ln(electricity)$	5.069***	4.221***
$ln(arrivals) \not\Rightarrow ln(ghg)$	7.266***	6.299***
$ln(ghg) \not\Rightarrow ln(arrivals)$	0.381	0.159
$ln(electricity) \not\Rightarrow ln(gdp)$	0.698	0.435
$ln(gdp) \not\Rightarrow ln(electricity)$	7.634***	6.441***
$ln(arrivals) \not\Rightarrow ln(gdp)$	0.545	0.302
$ln(gdp) \not\Rightarrow ln(arrivals)$	13.343***	11.385***
$ln(arrivals) \not\Rightarrow ln(electricity)$	7.417***	6.253***
$ln(electricity) \not\Rightarrow ln(arrivals)$	0.972	0.672

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The outcomes of the panel causality test are presented in Table 6. The analysis reveals a bidirectional causality between greenhouse gas emissions and electricity consumption in the Balkan nations. Moreover, a unidirectional causal flow is identified from GDP to greenhouse gas emissions, tourist arrivals and electricity consumption in these countries. Additionally, a unidirectional causality is observed from tourist arrivals to greenhouse gas emissions and electricity consumption in the Balkan region.

Potential endogeneity should nevertheless be considered when interpreting these results, as economic growth, energy consumption, tourism activity, and environmental pressure may interact simultaneously. Within the cointegrated panel framework, the use of FMOLS and DOLS helps mitigate endogeneity and serial-correlation problems in the estimation of long-run relationships. In addition, the Dumitrescu–Hurlin test provides complementary evidence regarding the direction of predictive causal relationships among the variables. In particular, the bidirectional relationship between greenhouse gas emissions and electricity consumption indicates that the interaction between energy use and environmental pressure cannot be interpreted as strictly one-directional.

However, these econometric procedures do not eliminate all potential sources of endogeneity, particularly those arising from omitted variables, unobserved structural characteristics, or simultaneous relationships among the variables. Therefore, the estimated long-run coefficients should be interpreted primarily as relationships within the specified panel framework rather than as structural causal effects. Future research may further address these issues by employing alternative identification strategies and additional model specifications.

Conclusion and Discussion

The momentum of integration processes in the global economy has increased the volume of international tourism. Globalization and the expanding tourism sector have also provided critical opportunities for developing countries to accelerate their economic growth. However, the resulting increase in tourist arrivals has simultaneously driven up environmental problems. The Balkan countries have become a group of countries that have significant opportunities and attract attention with their tourism potential in the global economy. The relationship between tourism and environment, and the policies to be developed have become important for Balkan countries within this scope. This paper aims to analyze the environmental impacts of tourism with a sustainable tourism approach in the Balkan countries. In this direction, panel cointegration, panel causality and long-term coefficient analyses are carried out.

As a result of the analysis conducted in this study, unidirectional relationships from GDP to electricity consumption in Balkan countries were identified, aligning with the literature findings of Jamil and Ahmad (2010),

Chen et al. (2007), and Narayan et al. (2010). Accordingly, it is substantial for the Balkan countries to create economic policies that encourage environmentally friendly electricity production and consumption in order to increase their economic growth and development levels. However, in the literature there is a unidirectional causality relationship from GDP and tourist arrivals to greenhouse gases of these countries, similar to the findings of Leitão & Lorente (2020), and Katircioglu (2014). In addition, bidirectional causality relationships between consumption of electricity and greenhouse gases of these countries in line with the findings of Eyuboglu and Uzar (2020) and Munir et al. (2024). Moreover, a unidirectional causality relationship from GDP to tourist arrivals is determined, while a unidirectional causality relationship from tourist arrivals to consumption of electricity is observed by Solarin (2014) in Balkan countries. These results show that tourism in the Balkan countries has a significant impact on the environment in these countries. The establishment of environmentally sensitive sustainable tourism policies is of great importance in accordance with the economic growth and development goals in the Balkan countries.

In line with the findings, environmentally sustainable tourism policies are pioneering steps for the economic growth and development. Enhancing sustainable tourism policies is essential for protecting the environment in the Balkan countries. In this context, the validity of a U-shaped EKC hypothesis is determined in the Balkan countries and the right strategies should be developed to prevent environmental degradation that may occur in the long term (Ehigiamusoe, 2020, Gan et al., 2024, and Wang & Kim, 2024). In addition, it is important to consume electricity produced from renewable energy sources and develop an environmentally sensitive tourism policy, in order for countries to achieve their long-term economic growth and development goals.

The results for electricity consumption and international tourist arrivals are consistent with this interpretation. Both FMOLS and DOLS indicate positive long-run relationships between electricity consumption and greenhouse gas emissions and between tourist arrivals and greenhouse gas emissions. Thus, the renewed increase in environmental pressure at higher levels of economic activity may be associated with a situation, in which the expansion of energy demand and tourism activity outpaces improvements in energy efficiency and environmental performance. The causality results provide additional evidence of the close interaction between energy use and environmental pressure, particularly through the bidirectional predictive relationship between electricity consumption and greenhouse gas emissions.

The U-shaped result is also consistent with the broader empirical literature showing that the EKC does not follow a universal functional form. Previous studies have reported conventional inverted U-shaped relationships, U-shaped relationships, and other country- or sector-specific patterns. In particular, the U-shaped evidence reported by Ehigiamusoe (2020), Gan et al. (2024), and Wang and Kim (2024) supports the possibility that environmental pressure may re-emerge as economic activity expands. By contrast, other studies report inverted U-shaped or mixed EKC patterns, confirming that the income–environment relationship depends on the geographical context, energy structure, sectoral composition, and period under investigation. The findings of the present study therefore contribute to this debate by showing that, for the Balkan panel over 1995–2024, higher levels of economic development are not necessarily associated with a permanent reduction in greenhouse gas emissions.

Acknowledgements

This research has been funded by Project No. IP- 5 - 2025: "Artificial Intelligence and Sustainable Economic Development – Causal Links".

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