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The Environmental Consequences of Tourism: Revisiting Carbon Emissions in Middle Eastern Countries

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This study examines the impact of tourism on carbon dioxide (CO_2) emissions in five major Middle Eastern tourist destinations: Türkiye, Lebanon, Jordan, Cyprus, and Egypt. Using the Autoregressive Distributed Lag (ARDL) model, it investigates both short- and long-term effects, with the Toda-Yamamoto Granger causality test applied for robustness. Findings reveal that the short-term impact of tourism on CO_2 emissions varies across countries; however, in the long term, tourism contributes to a reduction in CO_2 emissions in all five destinations. The research findings underscore the critical importance of

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adopting sustainable tourism practices across all five countries. Efforts should focus on promoting ecotourism and enforcing environmental regulations. Additionally, tailored, country-specific strategies are essential. Egypt and Türkiye should prioritize the development of eco-friendly infrastructure and the adoption of smart tourism technologies to enhance sustainability. Cyprus should focus on advancing sustainable tourism by linking coastal, rural, and urban areas through eco-route integration. Meanwhile, Lebanon and Jordan should emphasize clean energy initiatives and innovation to drive sustainable tourism development.

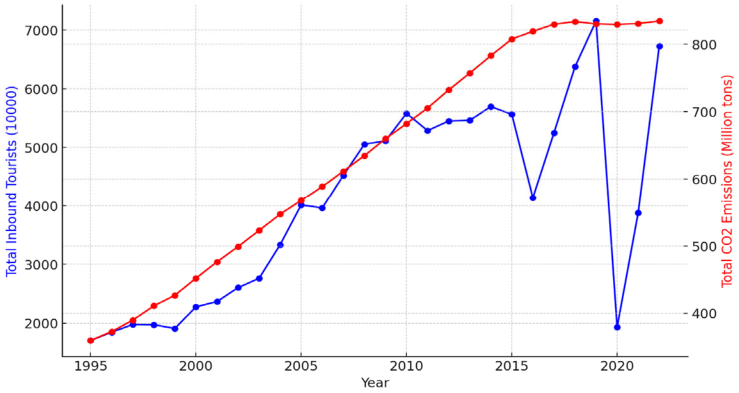
[Key Words: **tourism, carbon dioxide emissions, Middle Eastern countries, Autoregressive Distributed Lag (ARDL) Model, Toda-Yamamoto Granger Causality Test**]

Ⅰ. Introduction

Tourism has brought substantial economic benefits to many countries, contributing to job creation and supporting economic growth in host nations (Baloch, 2023). According to the UNWTO (2023)) the global tourism industry accounted for 9.1% of the world's GDP. While tourism is widely recognized for its positive economic impact, it is also associated with environmental challenges. As concerns over global warming and climate change intensify, reducing carbon dioxide (CO_2) emissions and promoting sustainable development have become pressing priorities for the global community. Consequently, the potential environmental impact of tourism cannot be overlooked. Notably, the tourism sector is responsible for approximately 8% of global greenhouse gas emissions, primarily stemming from transportation, accommodation, and tourism-related consumption (Zhan, 2023).

In the Middle East, where governments are focused on diversifying their economies, tourism has emerged as a critical area of development (Kim et al., 2024). In 2023, the Middle East attracted 86.3 million international tourists, marking a 22% increase compared to 2019, with total tourism revenue reaching 413.2 billion USD, or 9% of GDP (WTTC, 2023). This growth rate is projected to outpace the overall economic growth of the region, with an expected average annual growth of 7.7% by 2032. According to the UNWTO Barometer, the Middle East is the only region globally where tourism has surpassed pre-pandemic levels, driven by pent-up demand, improved air connectivity, and proactive government policies to boost tourism.

<Figure 1> Total Inbound Tourists and CO_2 Emissions in Five Middle Eastern Countries (1995-2022)



Source: Author's calculations based on data from the World Development Indicators (WDI) and United Nations World Tourism Organization (UNWTO) databases.

<Figure 1> illustrates the trends in inbound tourism and CO_2 emissions in five Middle Eastern tourism destinations: Türkiye, Lebanon, Jordan, Cyprus, and Egypt, where tourism represents a substantial share of GDP. These countries experienced rising carbon emissions alongside increasing tourist arrivals until around 2010. After 2010, however, tourist numbers began to fluctuate, with a significant drop in 2019–2020, likely due to the COVID-19 pandemic, whereas CO_2 emissions remained relatively stable. <Table 1> further reveals that while both tourist numbers and tourism revenue as a percentage of GDP have increased, CO_2 emissions per unit of GDP have shown a decreasing trend, particularly in the years preceding the pandemic.

<Table 1> Tourism's Contribution to GDP and CO_2 Emissions in Five Middle Eastern Countries (1995-2022)

Country	1995			2010			2022		
	Tourist (10000)	CO2 (PGDP)	Revenue (%GDP)	Tourist (10000)	CO2 (PGDP)	Revenue (%GDP)	Tourist 10000	CO2 PGDP	Reven. %GDP
Türkiye	772.67	21	2.87	2863.2	18	3.42	4456.44	15	5.11
Lebanon	80.23	25	9.6	245.94	20	20.0	311.97	18	29.4
Jordan	327.70	29	6.13	780.61	25	10.33	466.84	21	11.28
Cyprus	210.00	17	8.26	217.30	14	14.3	320.11	11	12
Egypt	313.30	24	3.3	1473.1	20	5.2	1172.4	17	2

Source: Author's calculations based on data from the WDI, UNWTO, and International Energy Agency (IEA) databases.

Notes: Tourist = International tourist arrivals; CO2 (PGDP) = CO_2 emissions (kg) per GDP (USD); Revenue (% of GDP) = Tourism revenue as a percentage of GDP.

The evidence presented in <Figure 1> and <Table 1> highlights the complex relationship between tourism and environmental impact in these leading tourist destinations, underscoring the need for more nuanced exploration. Furthermore, as reviewed in Section II, existing literature indicates that the effect of tourism on CO_2 emissions remains inconclusive. Most studies focusing on Middle Eastern countries have employed panel data models, which may not fully capture the unique characteristics of each country, limiting their utility for developing tailored policy recommendations. Single-country studies for these five Middle Eastern nations are limited and often based on outdated data. While time-series studies have been conducted for Türkiye, research on the other four countries remains scarce, with no systematic analysis of tourism's impact on CO_2 emissions for Jordan and Lebanon.

To address these research gaps, this study aims to enhance our understanding of tourism's environmental impact in Lebanon, Egypt, Türkiye, Jordan, and Cyprus. Using the Autoregressive Distributed Lag (ARDL) model, this research will examine the dynamic relationship between tourism and environmental outcomes in each country individually. Additionally, the Toda-Yamamoto Granger causality test will be employed to strengthen the robustness of the findings. The remainder of this paper is organized as follows: Section II reviews the relevant literature, Section III outlines the research methodology, Section IV presents the empirical results, and Section V concludes with a discussion of policy implications.

Ⅱ. Literature Review

The literature on the impact of tourism on CO_2 emissions presents mixed findings. On one hand, tourism development tends to increase carbon emissions, primarily driven by energy consumption and infrastructure expansion (Ali et al., 2021), as well as intensified activities in sectors such as dining, accommodation, transportation, and sightseeing (Raihan, 2024; Xiong et al., 2022). On the other hand, tourism can also contribute to emission reductions by encouraging sustainable practices, such as adopting new energy technologies, improving transportation efficiency, and promoting low-carbon ecotourism (Balli et al., 2023). The promotion of green energy and sustainable tourism practices, along with advancements in environmental technologies and innovations, plays a key role in mitigating tourism's adverse effects on climate change (Ghosh et al., 2022). Cultural factors associated with eco-tourism also contribute significantly to improving environmental quality (Koçak et al., 2020). Furthermore, the implementation of environmental policies, continuous education, and the adoption of smart tourism practices bolster efforts toward environmental enhancement (Hailiang et al., 2023). Some studies suggest a dynamic relationship, where emissions initially increase with tourism growth but may decrease after reaching an economic threshold, forming an inverted U-shaped curve (Ghosh et al., 2022).

Studies on the Middle East often employ panel data analysis by grouping countries with other regions, such as the Mediterranean, West Asia, and North Africa (Voumik et al., 2023; Ghaderi, 2023; Aziz and Sarwar, 2023). While panel data models increase the degrees of freedom through a larger sample size, they may not fully capture the unique characteristics of each Middle Eastern country.

Additionally, several studies have examined the impact of tourism on CO_2 emissions in specific Middle Eastern countries using time series data, particularly Türkiye. These studies, however, yield varied conclusions. While some report that tourism increases emissions through rising tourist arrivals and revenues (Eyuboglu and Uzar, 2019; Tandoğan and Genç, 2019; Raihan and Tuspekova, 2022), others find that ecotourism innovation in Türkiye can reduce emissions (Direkci and Govdeli, 2016; Kılavuz et al., 2021).

For Egypt, while Sghaier et al. (2019) conducted a panel study incorporating Egypt with other North African countries, Raihan et al. (2023) applied Dynamic Ordinary Least Squares (DOLS) to analyze the dynamic impact of Egypt's tourism sector on CO_2 emissions from 1990 to 2019. Both studies concluded that tourism development significantly contributes to carbon emissions. For Cyprus, Katircioglu et al. (2014) employed the ARDL model on data from 1970 to 2009, showing that tourism drives energy consumption and, consequently, carbon emissions.

This review highlights several research gaps. First, the effect of tourism on carbon emissions remains inconclusive. Second, studies focusing on Middle Eastern countries generally use a panel data approach, which may not fully capture the unique characteristics of each country. Thus, individual country studies are crucial for developing tailored policy recommendations. Third, with the exception of Türkiye, single-country studies using time series data are rare. Although a few studies have examined Türkiye using time series models, the findings remain inconclusive, and the data are outdated, only extending to 2018. More recent studies with updated data are needed for Türkiye. Fourth, single-country studies on Egypt and Cyprus are limited, and there is a lack of research focused on Lebanon and Jordan.

To address these research gaps, this study applies the Autoregressive Distributed Lag (ARDL) model to assess the impact of tourism on CO_2 emissions for each country individually, using the latest available data. Additionally, the Toda-Yamamoto Granger causality test is employed to enhance the robustness of the findings.

Ⅲ. Theory and Methodology

1. Theory and Model Specification

This study adopts the IPAT model as its theoretical framework, initially proposed by Ehrlich and Holdren (1971), which explains how environmental impact (I) is driven by three anthropogenic forces: population (P), affluence (A), and technology (T).

$$I = P \times A \times T \tag{1}$$

The IPAT model was later extended to the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model by Dietz and Rosa (1997). The STIRPAT model incorporates regression analysis to capture the stochastic and nonlinear relationships among these driving forces, enabling more accurate quantification of each factor's contribution to environmental impact. The STIRPAT model is represented as follows:

$$I = a \times P^{b} \times A^{c} \times T^{d} \times \epsilon \tag{2}$$

where I denotes environmental impact, a is a constant, P represents population, A is affluence, T is technology, b, c, and d are elasticity coefficients of the respective independent variables, and ϵ is the error term. In this study, the STIRPAT model framework is applied to assess tourism's impact on CO_2 emissions in five Middle Eastern countries. Here, CO_2 emissions represent the environmental impact (I). The population factor (P) is proxied by the urbanization rate (URBAN), as urbanization drives demand for construction, infrastructure, electricity, heating, and transportation, all of which contribute to carbon emissions (Khan et al., 2022).

Affluence (A) is represented by GDP per capita (GDPPC), reflecting the tendency of higher economic growth to correlate with increased carbon emissions due to industrialization and consumption. Technology (T) is represented by trade openness (TRADE), as suggested by Duodu and Mpuure (2023). Trade openness has a dual effect on carbon emissions: it can increase emissions by relocating pollution-intensive industries and increasing transportation emissions, but it may also reduce emissions through the trade of green products and technology transfer (Balsalobre et al., 2023; Obobisa, 2024).

Following Le and Nguyen (2021), the STIRPAT model is further modified to include the number of international tourist arrivals (TOURA) to capture tourism's effect on carbon emissions. Consequently, CO_2 emissions are determined by four main variables as specified in Equation (3):

$$CO2 = f\ (TOURA,\ GDPPC,\ TRADE,\ URBAN) \tag{3}$$

The logarithmic form of this model, allowing for elasticity estimation, is represented as Equation (4):

$$lnCO2t = \beta 0 + \beta 1lnTOURAt + \beta 2lnGDPPCt + \beta 3lnTRADEt + \beta 4lnURBANt + \epsilon t \tag{4}$$

where CO2 represents carbon dioxide emissions, TOURA denotes international tourist arrivals, GDPPC is GDP per capita, TRADE indicates trade openness, URBAN is the urbanization rate, and ϵ represents the error term.

2. Autoregressive Distributed Lag (ARDL) model

For empirical estimation, the STIRPAT model in Equation (4) is transformed into an Autoregressive Distributed Lag (ARDL) model. The ARDL model is selected due to the characteristics of our dataset, which contains a mix of I(0) and I(1) variables, as confirmed by unit root test results presented in <Table 2>. The concepts of I(0) and I(1) variables describe the stationarity and integration order of time series data. An I(0) variable refers to a stationary series, where its mean, variance, and autocovariance remain constant over time. In contrast, an I(1) variable represents a non-stationary time series, often characterized by trends or seasonality. The distinction between I(0) and I(1) is critical in time series modeling, as combining these variables without appropriate treatment can result in spurious regression outcomes. Typically, an I(1) variable can be transformed into stationarity by taking its first difference.

Additionally, our study aims to investigate both the long-term and short-term impacts of tourism on CO_2 emissions, which the ARDL model is well-suited to capture. The ARDL specification of Equation (4) is thus represented in Equation (5).

$$\begin{aligned}\varDelta \ln CO2_t = {} & \alpha + \sum_{i=1}^{a}\beta_i \varDelta \ln CO2_{t-i} + \sum_{i=1}^{b}\gamma_i \varDelta \ln TOURA_{t-i} + \sum_{i=1}^{c}\delta_i \varDelta \ln GDPPC_{t-i} + \\ & \sum_{i=1}^{d}\eta_i \varDelta \ln TRADE_{t-i} + \sum_{i=1}^{e}\mu_i \varDelta \ln URBAN_{t-i} + \lambda \ln CO2_{t-1} + \chi \ln TOURA_{t-1} + \\ & \kappa \ln GDPPC_{t-1} + \sigma \ln TRADE_{t-1} + \omega \ln URBAN_{t-1} + \varepsilon_t \end{aligned} \tag{5}$$

Following Pesaran et al. (2001), we employ a three-step modeling process:

First, conduct a bounds cointegration test by testing the null hypothesis of no long-term relationship among the variables ($H0: \lambda = \chi = \kappa = \sigma = \omega = 0$).

Second, estimate the long-run relationship specified in Equation (6) to identify the long-term impacts of the independent variables on CO_2 emissions.

$$\ln CO2_t = \Omega_0 + \Omega_1 \ln TOURA_t + \Omega_2 \ln GDPPC_t + \Omega_3 \ln TRADE_t + \Omega_4 \ln URBAN_t + \nu_t \tag{6}$$

where the long-run coefficients are computed as $\Omega_1 = -\chi/\lambda$, $\Omega_2 = -\kappa/\lambda$, $\Omega_3 = -\sigma/\lambda$, $\Omega_4 = -\omega/\lambda$ and ν_t is an error term.

Third, we estimate the associated error correction model, as specified in Equation (7), to capture the short-term effects of tourism on carbon emissions.

$$\begin{aligned}\Delta \ln CO2 = \alpha + \sum_{i=1}^{a} \beta_i \Delta \ln CO2_{t-i} + \sum_{i=1}^{b} \gamma_i \Delta \ln TOURA_{t-i} + \sum_{i=1}^{c} \delta_i \Delta \ln GDPPC_{t-i} + \\ \sum_{i=1}^{d} \eta_i \Delta \ln TRADE_{t-i} + \sum_{i=1}^{e} \mu_i \Delta \ln URBAN_{t-i} + \psi ECM_{t-1} + \varepsilon_t\end{aligned} \tag{7}$$

The coefficient ψ of the error correction term (ECM) indicates the speed of adjustment back to equilibrium following a shock to the system; thus, this coefficient is expected to be negative. The coefficients βi, γi, δi, ηi, and μi represent the short-term effects of the respective variables.

To determine the appropriate lag length for the ARDL model, this study follows the approach of Bahmani-Oskooee et al. (2019). Given the short time series data, the maximum lag length is restricted to 4 to preserve degrees of freedom and ensure model efficiency. The optimal lag length is then selected based on the Akaike Information Criterion (AIC), which is widely preferred for its ability to identify a more flexible lag structure. The lag combination that minimizes the AIC value is chosen as the optimal lag length, ensuring the model captures the underlying dynamics effectively while addressing the limitations of small sample sizes.

Although the ARDL model offers numerous advantages, it is not without limitations. First, its empirical results are highly sensitive to the selection of lag lengths. Incorrect lag specifications can result in biased estimates, spurious relationships, or omitted dynamics. In this study, the maximum lag length is restricted to 4 due to the constraints of short time series data, which may introduce potential biases in the estimates. Consequently, the results should be interpreted with caution. Second, variations in data frequency and quality can influence the accuracy of the model, particularly in the context of long-term analysis (Kripfganz and Schneider, 2023). Third, the model does not adequately account for external factors such as global economic fluctuations, pandemics, or geopolitical risks, which may significantly impact the results. Finally, while appropriate lag lengths were selected, differences in time effects and policy implementation lags across countries could affect the consistency and comparability of the findings (Nkoro and Uko, 2016).

3. The Toda-Yamamoto Approach for Granger Causality Test

To enhance the robustness of the findings from the ARDL model, we also employed the Toda-Yamamoto method (Toda and Yamamoto, 1995) to perform Granger causality tests among the studied variables. This method was chosen because it allows for the inclusion of variables with different integration orders, I(0) and I(1)) in the testing process. Equation (8) illustrates the causal relationships running from CO_2 emissions, tourism, GDP per capita, trade openness, and urbanization rate to CO_2 emissions. The optimal lag length (r) is determined using the Akaike Information Criterion (AIC). The term $d_{\max}$ represents the maximum order of integration of the studied variables, which is 1 in our study. We then construct an augmented VAR model with $r + d_{\max}$ lags for each variable and conduct the Granger causality test using the Wald test. The same procedure is applied to the remaining equations.

$$\begin{aligned}\ln CO2_t = {} & \alpha_0 + \sum_{i=1}^{r} \alpha_{1i} \ln CO2_{t-i} + \sum_{j=r+1}^{dmax} \alpha_{2j} \ln CO2_{t-j} + \sum_{i=1}^{r} \beta_{1i} \ln TOURA_{t-i} \\ & + \sum_{j=r+1}^{dmax} \beta_{2j} \ln TOURA_{t-j} + \sum_{i=1}^{r} \gamma_{1i} \ln GDPPC_{t-i} + \sum_{j=r+1}^{dmax} \gamma_{2j} \ln GDPPC_{t-j} \\ & + \sum_{i=1}^{r} \sigma_{1i} \ln TRADE_{t-i} + \sum_{j=r+1}^{dmax} \sigma_{2j} \ln TRADE_{t-j} + \sum_{i=1}^{r} \eta_{1i} \ln URBAN_{t-i} \\ & + \sum_{j=r+1}^{dmax} \eta_{2j} \ln URBAN_{t-j} + u_{1t}\end{aligned} \tag{8}$$

$$\begin{aligned}\ln TOURA_t = {} & \theta_0 + \sum_{i=1}^{r} \theta_{1i} \ln TOURA_{t-i} + \sum_{j=r+1}^{dmax} \theta_{2j} \ln TOURA_{t-j} + \sum_{i=1}^{r} \iota_{1i} \ln CO2_{t-i} \\ & + \sum_{j=r+1}^{dmax} \iota_{2j} \ln CO2_{t-j} + \sum_{i=1}^{r} \kappa_{1i} \ln GDPPC_{t-i} + \sum_{j=r+1}^{dmax} \kappa_{2j} \ln GDPPC_{t-j} \\ & + \sum_{i=1}^{r} \mu_{1i} \ln TRADE_{t-i} + \sum_{j=r+1}^{dmax} \mu_{2j} \ln TRADE_{t-j} + \sum_{i=1}^{r} \varPhi_{1i} \ln URBAN_{t-i} \\ & + \sum_{j=r+1}^{dmax} \varPhi_{2j} \ln URBAN_{t-j} + u_{2t}\end{aligned} \tag{9}$$

$$\begin{aligned}\ln GDPPC_t = {} & I_0 + \sum_{i=1}^{r} I_{1i} \ln GDPPC_{t-i} + \sum_{j=r+1}^{dmax} I_{2j} \ln GDPPC_{t-j} + \sum_{i=1}^{r} \rho_{1i} \ln CO2_{t-i} \\ & + \sum_{j=r+1}^{dmax} \rho_{2j} \ln CO2_{t-j} + \sum_{i=1}^{r} o_{1i} \ln TOURA_{t-i} + \sum_{j=r+1}^{dmax} o_{2j} \ln TOURA_{t-j} \\ & + \sum_{i=1}^{r} \upsilon_{1i} \ln TRADE_{t-i} + \sum_{j=r+1}^{dmax} \upsilon_{2j} \ln TRADE_{t-j} + \sum_{i=1}^{r} \psi_{1i} \ln URBAN_{t-i} \\ & + \sum_{j=r+1}^{dmax} \psi_{2j} URBAN_{t-j} + u_{3t}\end{aligned} \tag{10}$$

$$\begin{aligned}\ln TRADE_t = {} & \varTheta_0 + \sum_{i=1}^{r} \varTheta_{1i} \ln TRADE_{t-i} + \sum_{j=r+1}^{dmax} \varTheta_{2j} \ln TRADE_{t-j} + \sum_{i=1}^{r} N_{1i} \ln CO2_{t-i} \\ & + \sum_{j=r+1}^{dmax} N_{2j} \ln CO2_{t-j} + \sum_{i=1}^{r} H_{1i} \ln TOURA_{t-i} + \sum_{j=r+1}^{dmax} H_{2j} \ln TOURA_{t-j} \\ & + \sum_{i=1}^{r} \varLambda_{1i} \ln GDPPC_{t-i} + \sum_{j=r+1}^{dmax} \varLambda_{2j} \ln GDPPC_{t-j} + \sum_{i=1}^{r} K_{1i} \ln URBAN_{t-i} \\ & + \sum_{j=r+1}^{dmax} K_{2j} \ln URBAN_{t-j} + u_{4t}\end{aligned} \tag{11}$$

$$\begin{aligned}\ln URBAN_t = {} & \lambda_0 + \sum_{i=1}^{r} \lambda_{1i} \ln URBAN_{t-i} + \sum_{j=r+1}^{dmax} \lambda_{2j} \ln URBAN_{t-j} + \sum_{i=1}^{r} \chi_{1i} \ln CO2_{t-i} \\ & + \sum_{j=r+1}^{dmax} \chi_{2j} \ln CO2_{t-j} + \sum_{i=1}^{r} \beta_{1i} \ln TOURA_{t-i} + \sum_{j=r+1}^{dmax} \beta_{2j} \ln TOURA_{t-j} \\ & + \sum_{i=1}^{r} \varphi_{1i} \ln TRADE_{t-i} + \sum_{j=r+1}^{dmax} \varphi_{2j} \ln TRADE_{t-j} + \sum_{i=1}^{r} \zeta_{1i} \ln GDPPC_{t-i} \\ & + \sum_{j=r+1}^{dmax} \zeta_{2j} \ln GDPPC_{t-j} + u_{5t}\end{aligned} \qquad (12)$$

4. Data and Source

Among the Middle Eastern sovereign states, this research focuses on eight nations where the tourism sector plays a significant role in contributing to GDP, with an average impact exceeding 3%. However, due to data availability constraints, Bahrain, Qatar, and the United Arab Emirates were excluded from this analysis, resulting in a final sample of five countries: Türkiye, Lebanon, Jordan, Cyprus, and Egypt. The study utilizes annual time series data for estimation, with specific time periods varying based on data availability. The datasets for Cyprus and Jordan cover the period from 1980 to 2022, while data for Türkiye and Egypt span from 1983 to 2022, and Lebanon's data are analyzed from 1993 to 2022. The CO_2 emissions, measured in tons per capita, are sourced from the Emissions Database for Global Atmospheric Research (EDGAR). International tourist arrivals, expressed as the ratio of inbound tourists to the total population, are obtained from the national statistical offices of Türkiye, Jordan, and Cyprus, and from the central banks of Lebanon and Egypt. Data for GDP, trade openness, and urbanization rate are obtained from the World Development Indicators (WDI). The urbanization rate is represented by the proportion of the urban population to the total population. GDP per capita is measured in current USD. Trade openness is defined as the ratio of the sum of total imports and exports to GDP.

Ⅳ. Empirical Results

1. The Augmented Dickey-Fuller (ADF) Unit Root Test

<Table 2> presents the unit root test results using the Augmented Dickey-Fuller (ADF) test. The results indicate that all studied variables are either I(0) or I(1). Since there are no I(2) variables, the ARDL model is suitable for our research.

<Table 2> Augmented Dickey-Fuller Unit Root Test

Variable	Form	Türkiye		Lebanon		Jordan		Cyprus		Egypt	
		t-stat	I(n)	t-stat	I(n)	t-stat	I(n)	t-stat	I(n)	t-stat	I(n)
lnCO2	Level	−3.787 **	I(0)	−2.563	I(1)	−2.396	I(1)	−0.934	I(1)	−0.158	I(1)
	1st Diff			−5.046 ***		−6.251 ***		−5.668 ***		−5.558 ***	
lnTOURA	Level	0.427	I(1)	−3.318 *	I(0)	−0.103	I(1)	−3.671 **	I(0)	0.167	I(1)
	1st Diff	−1.843 **				−6.948 ***				−1.695 *	
lnGDPPC	Level	−1.418	I(1)	−0.781	I(1)	−2.374	I(1)	−0.861	I(1)	−0.895	I(1)
	1st Diff	−6.473 ***		−3.534 *		−4.137 ***		−5.422 ***		−4.033 ***	
lnTRADE	Level	−3.666 **	I(0)	−1.853	I(1)	−3.233 *	I(0)	−1.392	I(1)	−2.871 *	I(0)
	1st Diff			−4.259 ***				−5.572 ***			
lnURBAN	Level	−6.185 ***	I(0)	−4.067 ***	I(0)	−3.881 **	I(0)	−2.335	I(1)	−2.996 **	I(0)
	1st Diff							−5.202 ***			

Note: I(n): Variable is integrated of order n. Statistical significance levels: 1% (***), 5% (**), and 10% (*).

2. The Bound Test

This study employs the bounds test within the ARDL modeling framework (Pesaran et al., 2001) to examine the presence of cointegration. The bounds test results in <Table 3> show that the calculated F-statistics for all five countries exceed the upper critical value at the 5% significance level, indicating the existence of long-term relationships among the studied variables.

<Table 3> ARDL Co-integration Bounds Test

Country		Türkiye	Lebanon	Jordan	Cyprus	Egypt
Calculated F-statistics		7.87	9.89	5.568	8.75	4.594
F-critical values						
1% Level	Lower Bound	3.657	4.134	3.657	3.657	3.81
	Upper Bound	5.256	5.761	5.256	5.256	4.92
5% Level	Lower Bound	2.734	2.91	2.734	2.734	3.05
	Upper Bound	3.92	4.193	3.92	3.92	3.97
1% Level	Lower Bound	2.306	2.407	2.306	2.306	2.68
	Upper Bound	3.53	3.517	3.353	3.353	3.39

3. Long-Run and Short-Run Coefficients

The long-run results in <Table 4> indicate that an increase in tourism is associated with reduced CO_2 emissions across all five countries studied, underscoring the positive environmental impact of tourism development in the Middle Eastern region. Specifically, a 1% increase in tourism activity results in reductions in carbon emissions by 0.812%, 0.651%, 0.202%, 0.056%, and 0.137% in Türkiye, Lebanon, Jordan, Cyprus, and Egypt, respectively.

Our findings on the inverse relationship between tourism and carbon emissions in Türkiye align with studies by Direkci and Govdeli (2016) and Kılavuz et al. (2021). Broadly, this reduction in emissions is often attributed to sustainable practices within the tourism sector, such as promoting low-carbon ecotourism initiatives (Balli et al., 2023). However, in Türkiye's case, significant strides by national authorities amplify these results. In collaboration with the Global Sustainable Tourism Council (GSTC), the Turkish government has introduced a green certification system, as well as an Energy Efficiency Action Plan, which emphasizes clean energy initiatives, particularly the use of solar power in coastal regions.

The government has also implemented the Blue Flag certification program to recognize eco-friendly beaches and fostered the development of ecotourism villages in rural settings. Türkiye further promotes low-carbon tourism by supporting electric vehicle rentals and electric bus services for tourists. In addition, the Zero Waste Project, aimed at waste reduction, has been integrated into the tourism industry, enhancing recycling efforts and decreasing single-use plastic reliance. Beyond these measures, Türkiye is making strides in smart tourism through initiatives like digital services for tourists and intelligent waste management systems within tourist areas (Ödemiş, M., 2022). Together, these measures elevate environmental quality, positioning Türkiye as a proactive example of sustainable tourism in the region.

Tourism also plays a significant role in reducing carbon emissions in Cyprus, where green tourism, natural resource conservation, and low-carbon transitions in transport and accommodation are actively promoted. These initiatives are driven by the 2030 National Tourism Strategy and the National Energy and Climate Plan (NECP). Cyprus has established a climate change research center to support green transitions across the Mediterranean and encourages resource-efficient practices in tourism facilities through the

Green Key certification. Ecotourism initiatives are especially prominent in regions such as the Troodos Mountains, where low-carbon travel options are encouraged (Kim & Kim, 2014). Additionally, digital tourism platforms and smart transport systems help optimize travel, reduce emissions, and enhance the visitor experience (Yeniasır & Gökbulut., 2022). In addition to government policies, The private sector has proactively adopted sustainable practices, such as installing solar panels and advanced waste management systems, showcasing a growing commitment to green development. Rising environmental awareness among residents and tourists has increased demand for eco-friendly services, encouraging businesses to adopt sustainable solutions. Academic institutions have supported these efforts through research on sustainable tourism and innovative environmental practices. Local communities also play a vital role through initiatives like eco-trail development and conservation programs, preserving natural resources and reducing tourism's carbon footprint. These findings align with Aslan et al. (2021), who highlight similar trends in Mediterranean coastal countries, including Cyprus.

<Table 4> Results of Long-run Coefficients

Variable	Türkiye	Lebanon	Jordan	Cyprus	Egypt
	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)
lnTOURA	−0.812 (−3.897)***	−0.651 (−3.437)***	−0.202 (−2.647)**	−0.056 (−3.160)***	−0.137 (−2.667)**
lnGDPPC	0.601 (4.030)***	0.589 (3.690)***	−0.039 (−0.780)	0.085 (4.184)***	0.027 (0.256)
lnTRADE	−0.066 (−0.620)	−0.060 (−0.999)	0.043 (0.453)	−0.140 (−4.190)***	0.171 (1.711)*
lnURBAN	2.150 (2.123)*	1.612 (0.584)	−0.708 (−3.483)***	4.640 (5.950)***	−5.850 (−4.097)***

Note: Statistical significance levels, 1% (***), 5% (**), and 10% (*).

While our empirical findings for Egypt contrast with those of Sghaier et al. (2019), they align with El Menyari (2021), despite both studies using panel data models that included Egypt in their datasets. Egypt demonstrates a unique approach to reducing carbon emissions in tourism by leveraging its abundant solar and wind resources and prioritizing clean energy development, particularly in coastal areas like the Red Sea. Initiatives such as Nile River eco-cruises and restrictions in ecologically sensitive areas integrate cultural heritage protection with low-carbon tourism, effectively balancing environmental preservation with tourism growth. While its adoption of smart technologies remains in the early stages, efficiency improvements in energy management and waste processing are already evident. Additionally, technologies like augmented reality (AR) and virtual reality (VR) at tourist sites help minimize physical impacts, while smart energy management systems optimize energy consumption (Rane et al., 2023).

Egypt's carbon reduction efforts are underpinned by key policies and plans. The Renewable Energy Law promotes clean energy expansion, while the National Water Resources Plan (2017-2037) and waste management initiatives strengthen water and waste systems in the tourism sector. Programs such as the Green Pyramidand Green Star certifications support sustainable building and urban development. Natural reserves foster ecotourism, environmental education, and community involvement, all aligned with Egypt's Vision 2030, which integrates sustainable development goals. Collectively, these policies and measures significantly mitigate carbon emissions, underscoring Egypt's commitment to sustainable tourism and environmental conservation (Ibrahim & Elsayeh, 2022).

For Lebanon, our findings align with Voumik (2023), who included Lebanon alongside other Arab countries in the study. The reduction in carbon emissions in Lebanon is driven by its unique geographical diversity, economic challenges, and cultural richness. The country's diverse landscapes, from coastal areas to mountainous regions, naturally support ecotourism, while community-based tourism initiatives in rural areas like Mount Lebanon promote low-impact travel and support local economies (Shim, 2013). Lebanon's reliance on tourism as a key economic driver has incentivized energy-efficient practices and renewable energy adoption to reduce costs and environmental impacts. Additionally, the preservation of its rich cultural and historical heritage has fostered a blend of cultural tourism and environmental protection.

Lebanon's growing ICT sector has further enabled the development of smart tourism solutions, optimizing travel experiences and promoting eco-friendly practices. Improved public transportation infrastructure, driven by the Transport Emission Reduction Program, has reduced reliance on private vehicles, especially in urban areas like Beirut. These efforts, shaped by Lebanon's geographic, economic, and cultural context, collectively contribute to its carbon reduction efforts and underscore the country's commitment to sustainable tourism and environmental conservation. Lebanon also promotes energy efficiency and renewable energy through the National Energy Efficiency Action Plan (NEEAP) and the National Renewable Energy Action Plan (NREAP), which help to reduce energy consumption and carbon emissions within the tourism sector.

Jordan's reduction in carbon emissions is closely tied to its unique environmental and cultural assets, which naturally support sustainable tourism. The country's diverse landscapes, such as Wadi Rum and the Dana Biosphere Reserve, attract ecotourists, while community-driven ecotourism projects foster local engagement and economic benefits. Integration of cultural heritage sites like Petra into ecotourism ensures a balance between conservation and tourism demand.

In a water-scarce country, widespread adoption of ISO 14001 certification has driven water- and energy-saving measures, especially in hotels, while ecological resorts utilize local materials and renewable energy, such as solar power, to minimize environmental impacts. Jordan's abundant solar and wind resources further support renewable energy adoption in tourism hubs, reducing reliance on fossil fuels.

Additionally, the innovative use of digital technologies, such as online booking systems and digital guides, reduces material waste while enhancing visitor experiences (Khwaldeh et al., 2020). Environmental education at major attractions raises awareness, encouraging sustainable behavior among tourists. Jordan's integration of natural, cultural, and technological resources, combined with community participation, underlines its commitment to aligning tourism growth with environmental conservation and sustainability.

Regarding the effects of other control variables on carbon emissions, an increase in GDP per capita is associated with higher CO_2 emissions in Türkiye, Lebanon, and Cyprus. This relationship can be attributed to rising income levels, which increase energy demand and consequently fossil fuel combustion, leading to elevated CO_2 emissions (Razzaq et al., 2023). However, in Egypt and Jordan, GDP per capita is not a significant factor for CO_2 emissions, suggesting a decoupling effect driven by industrial upgrades and economic restructuring. These shifts have reduced the prevalence of high-carbon industries and increased the share of service and high-tech sectors (Mitić et al., 2022).

For trade openness, the results show that in Egypt, a 1% increase in trade openness is associated with a 0.17% increase in CO_2 emissions, while in Cyprus, a 1% increase in trade openness results in a 0.14% decrease in CO_2 emissions. The findings for Cyprus support Caglar's (2022) argument that trade openness can drive technological innovation and the adoption of eco−friendly products, thus reducing CO_2 emissions. In contrast, the relationship between trade openness and CO_2 emissions in Türkiye, Lebanon, and Jordan is not statistically significant.

Regarding the role of urbanization in carbon emissions, the results for Türkiye and Cyprus indicate that urbanization contributes to increased CO_2 emissions, as expected. In contrast, for Jordan and Egypt, urbanization rates are significantly negatively correlated with CO_2 emissions. This may be attributed to smart city developments that enhance energy efficiency and optimize energy structures, thereby reducing carbon emissions (Xiao, 2024). However, in Lebanon, the relationship between urbanization and CO_2 emissions is not statistically significant.

<Table 5> Results of Short−run Coefficients

Variable	Türkiye	Lebanon	Jordan	Cyprus	Egypt
	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)
△lnCO2t−1		−0.567 (−6.033)***			0.537 (3.316)***
△lnCO2t−2		−0.276 (−3.475)***			
△lnTOURA	−0.084 (−4.250)***	0.181 (5.202)***	−0.155 (−4.121)***	−0.043 (−4.37)***	−0.077 (−3.370)***
△lnTOURAt−1	0.638 (8.167)***	0.608 (8.789)***	−0.075 (−2.232)**	−0.014 (−1.369)	0.076 (2.305)**
△lnTOURAt−2	0.472 (8.043)***	0.264 (9.397)***	−0.003 (−0.117)		
△lnTOURAt−3	0.146 (2.887)**		−0.108 (−3.312)***		
△lnGDPPC	0.189 (4.377)***	−0.053 (−0.566)	0.276 (5.032)***	0.146 (4.482)***	−0.020 (−0.313)
△lnGDPPCt−1	−0.348 (−6.938)***	−0.783 (−5.449)***	0.320 (5.066)***	0.134 (4.195)***	0.069 (0.910)

△lnGDPPCt−2	−0.266 (−5.619)***	0.321 (4.289)***	0.151 (2.498)**	−0.060 (−1.967)*	0.227 (2.861)***
△lnGDPPCt−3	−0.119 (−3.996)***		−0.083 (−1.526)		
△lnTRADE	0.039 (0.701)	−0.248 (−10.014)***	0.154 (3.774)***	−0.143 (−4.038)***	0.169 (2.762)**
△lnTRADEt−1	0.001 (0.015)	−0.106 (−3.526)***	0.140 (3.778)***	−0.050 (−1.375)	0.124 (2.318)**
△lnTRADEt−2	−0.121 (−2.522)**			0.218 (5.504)***	0.135 (2.316)**
△lnURBAN	−4.167 (−1.582)	35.007 (4.296)***	1.328 (2.903)***	14.376 (7.049)***	−8.220 (−1.289)
△lnURBANt−1	−4.040 (−1.063)	62.433 (6.712)***		−5.149 (−3.580)***	16.690 (2.317)**
△lnURBANt−2	12.301 (3.716)***			7.042 (6.339)***	
△lnURBANt−3	−16.614 (−7.319)***				
ECMt−1	−1.062***	−0.523***	−0.833***	−1.155***	−1.284***

Note: Statistical significance levels: 1% (***), 5% (**), and 10% (*).

<Table 5> presents the short−run impact of tourism on carbon emissions. The empirical results suggest that substantial growth in tourism leads to increased CO_2 emissions in Türkiye and Lebanon in the short run. However, this effect diminishes over time. In Jordan and Cyprus, the short−term impact of tourism on carbon emissions is relatively minor, while Egypt shows a slightly larger effect. Nevertheless, over time, the initially positive relationship shifts to a negative one, and in the long run, tourism is shown to reduce CO_2 emissions across all five countries, as discussed previously in <Table 4>. Furthermore, the coefficients of the error correction term (ECM) are negative in all five countries, indicating that the model returns to long−run equilibrium effectively after experiencing short−term shocks

(Georgescu and Kinnunen, 2024).

4. The Toda-Yamamoto Approach for Granger Causality Test

The Toda-Yamamoto Granger causality test results, presented in <Table 6>, reveal causal relationships from tourism to CO_2 emissions in all five countries. Specifically, Türkiye, Lebanon, and Jordan exhibit significant bidirectional causality, while Cyprus and Egypt display unidirectional causality from tourism to CO_2 emissions.

<Table 6> Results of the Toda-Yamamoto Granger Causality Test

Türkiye					
Variable	lnCO2	lnTOURA	lnGDPPC	lnTRADE	lnURBAN
lnCO2	-	4.930**	0.123	0.456	2.365
lnTOURA	7.431***	-	0.590	3.128*	0.003
lnGDPPC	1.076	0.075	-	0.054	1.446
lnTRADE	0.716	1.356	3.257*	-	5.337**
lnURBAN	5.464**	7.821***	7.313***	0.219	-
Lebanon					
Variable	lnCO2	lnTOURA	lnGDPPC	lnTRADE	lnURBAN
lnCO2	-	7.284*	2.234	18.797***	4.673
lnTOURA	7.339*	-	25.387***	15.431***	4.672
lnGDPPC	7.845	44.238***	-	22.858***	6.313
lnTRADE	9.151	34.461***	19.921***	-	6.732*
lnURBAN	0.333	22.601***	7.324	5.424	-
Jordan					
Variable	lnCO2	lnTOURA	lnGDPPC	lnTRADE	lnURBAN
lnCO2	-	12.289**	2.318	8.972*	3.951
lnTOURA	21.245***	-	2.229	8.749*	5.232
lnGDPPC	21.031***	1.661	-	5.037	1.765
lnTRADE	7.138	2.303	3.328	-	6.445
lnURBAN	7.262	9.374	2.117	9.600	-

Cyprus					
Variable	lnCO2	lnTOURA	lnGDPPC	lnTRADE	lnURBAN
lnCO2	–	4.345	47.652***	2.418	3.759
lnTOURA	17.779***	–	42.329***	9.755*	2.264
lnGDPPC	6.791	9.746*	–	4.532	4.171
lnTRADE	11.151**	6.670	46.624***	–	2.639
lnURBAN	22.556***	17.709***	56.498***	4.685	–
Egypt					
Variable	lnCO2	lnTOURA	lnGDPPC	lnTRADE	lnURBAN
lnCO2	–	5.400	4.562	112.290***	31.761***
lnTOURA	19.765***	–	23.466***	163.768***	51.947***
lnGDPPC	14.385***	5.170	–	133.684***	29.230***
lnTRADE	6.717	7.519	7.598	–	5.725
lnURBAN	12.798**	1.756	4.830	77.858***	–

Note: Statistical significance levels 1%(***), 5%(**), and 10% (*).

5. Diagnostic Test

To ensure the validity and reliability of the ARDL model's estimation results, a series of diagnostic tests were conducted, as shown in <Table 7>. The insignificance of the LM test indicates an absence of serial correlation in the estimation. The Breusch–Pagan–Godfrey test provides no evidence of heteroscedasticity. The Jarque–Bera test confirms the normal distribution of the residuals at the 5% significance level, and the RESET test suggests that the model is correctly specified. Additionally, the R^2 values for all countries demonstrate a satisfactory goodness of fit for the model.

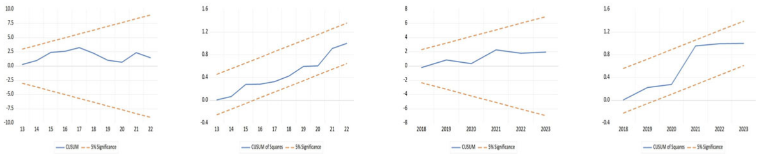
<Table 7> Results of Diagnostic Test

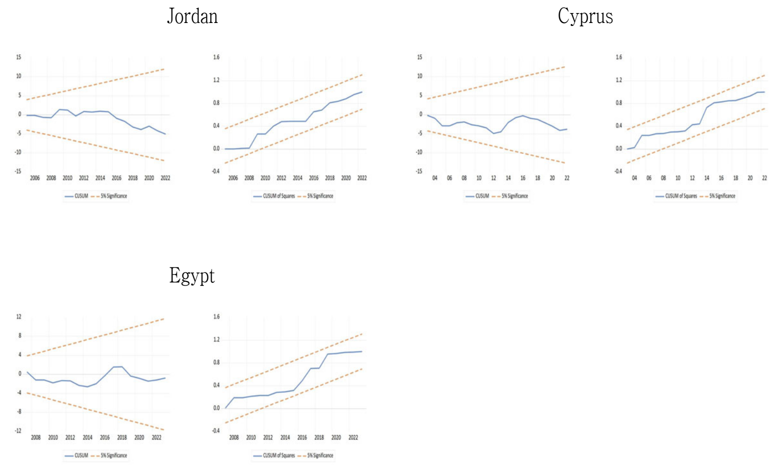
Country	R²	LM	Breusch-Pagan-Godfrey	Jarque-Bera	RESET
Türkiye	0.945	3.740 (0.154)	0.594 (0.859)	1.094 (0.579)	0.402 (0.542)
Lebanon	0.990	2.163 (0.141)	2.165 (0.172)	0.009 (0.996)	1.213 (0.286)
Jordan	0.900	5.671 (0.129)	0.489 (0.938)	4.932 (0.085)	1.132 (0.302)
Cyprus	0.928	1.361 (0.243)	0.755 (0.732)	3.888 (0.143)	0.159 (0.694)
Egypt	0.799	2.671 (0.102)	0.782 (0.697)	0.193 (0.908)	0.004 (0.948)

Note: p-values are presented in parentheses.

Finally, the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUM of square) tests in Figure 2 indicate that the specified models are stable and consistent.

<Figure 2> Results of CUSUM and CUSUM of square


Türkiye
Lebanon


Jordan

Cyprus

Egypt

6. Additional Robustness Checks

Structural breaks can arise from significant events such as policy shifts, economic shocks, or geopolitical developments, potentially affecting key variables such as GDP and tourism. To address this issue, the long-run coefficients from the ARDL model are re-estimated, incorporating the presence of structural breaks. The timing of the structural break is identified using the Zivot-Andrews unit root test. DUMGDP and DUMTOUR represent the structural break dummy variables for GDP per capita and the number of tourists, respectively. The empirical results, presented in <Table 8>, indicate that tourism plays a significant role in reducing carbon emissions across all five countries examined.

<Table 8> Results of Long-Run Coefficients with Structural Break

Variable	Türkiye	Lebanon	Jordan	Cyprus	Egypt
	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)
lnTOURA	−0.716 (−2.783)***	−0.152 (−4.734)***	−0.514 (−3.910)***	−0.061 (−4.801)***	−0.045 (−0.776)
lnGDPPC	0.240 (2.362)**	−0.021 (−1.009)	−0.001 (−0.017)	0.059 (2.049)**	0.184 (3.354)***
lnTRADE	0.436 (3.339)***	−0.070 (−3.278)***	0.240 (1.729)*	−0.171 (−4.894)***	0.120 (1.353)
lnURBAN	3.735 (2.647)**	27.419 (8.579)***	0.622 (1.468)	5.168 (4.351)***	−3.605 (−4.175)***
DUMGDP	0.250 (2.442)**	0.045 (−3.197)***	0.329 (3.318)***	0.033 (1.106)	−0.066 (−1.213)
DUMTOUR	−0.227 (−2.058)***	0.041 (2.383)**	−0.418 (−3.107)***	5.168 (4.351)**	−0.016 (−0.188)

Note: Statistical significance levels, 1% (***), 5% (**), and 10% (*).

This study also examines the potential nonlinear relationship between tourism development and carbon emissions, as postulated by the Environmental Kuznets Curve (EKC) hypothesis, which suggests structural changes over time. To capture this nonlinearity, the squared term of tourism (lnSQTOURA) is included in the estimation model.

<Table 9> Results of Long-Run Coefficients under EKC

Variable	Türkiye	Lebanon	Jordan	Cyprus	Egypt
	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)	Coefficient (t−statistic)
lnTOURA	0.732 (4.742)***	2.036 (2.018)*	3.335 (4.844)***	1.618 (1.978)*	2.352 (2.382)**
lnSQTOURA	−0.140	−0.298	−0.407	−0.144	−0.643

	(−5.881)***	(−2.180)**	(−5.179)***	(−1.866)*	(−2.521)**
lnGDPPC	0.163 (5.720)***	0.017 (0.172)	0.069 (2.739)**	−0.012 (−0.564)	−0.214 (−1.767)*
lnTRADE	0.138 (5.071)***	−0.012 (−0.170)	−0.073 (−1.276)	−0.064 (−0.735)	0.089 (0.287)
lnURBAN	−0.981 (−2.915)***	−0.197 (−0.049)	−0.949 (−7.840)***	−1.607 (−2.611)**	13.441 (1.732)*

Note: Statistical significance levels, 1% (***), 5% (**), and 10% (*).

The empirical results presented in <Table 9> reveal positive coefficients for lnTOURA, while the coefficients for lnSQTOURA are negative. These findings indicate that carbon emissions initially rise during the early stages of tourism development but decline after reaching a specific critical threshold, consistent across all five countries analyzed.

V. Conclusion and Policy Implication

This study systematically examines the impact of tourism on CO_2 emissions in five major Middle Eastern countries, employing the ARDL technique as the primary empirical model and using the Toda-Yamamoto Approach for Granger causality testing to enhance the robustness of the findings. The empirical results indicate that while tourism initially increases carbon emissions in the short run, it reduces carbon emissions in all five countries in the long run. The Toda-Yamamoto Granger causality test and diagnostic checks confirm the model's validity and the reliability of the empirical results. The observed long-run negative relationship between tourism and carbon emissions may be attributed to sustainable tourism practices, advancements in environmental technologies, and innovative policies. Additionally, government policies likely play a substantial role in shaping the relationship between tourism and carbon emissions.

Based on these findings, certain policy recommendations can be made to strengthen the sustainability of tourism in the region:

First, Promote Ecotourism and Environmental Regulations: All five countries should continue investing in ecotourism and enhancing environmental regulations. This includes promoting practices that minimize environmental impact, such as green certifications for tourism facilities and the adoption of low-carbon transportation. Egypt could expand its Blue Flag certificationfor eco-friendly beaches and implement waste management programs along the Red Sea coast to reduce pollution. Jordan can encourage ecotourism in regions like Wadi Rum and the Dana Biosphere Reserve, offering incentives for local businesses to adopt sustainable practices while promoting water-saving measures due to the country's water scarcity. Türkiye could expand its ecotourism villages and promote low-carbon transportation systems, such as electric buses, in popular areas like Cappadocia. Cyprus should strengthen its Green Key certification programsfor tourism facilities and enhance environmental monitoring of its coastal resorts to protect marine ecosystems. Lebanon could establish community-based tourism programs in rural and mountainous areas, such as Mount Lebanon, while introducing stricter regulations on waste disposal and water management in its most-visited cultural heritage sites, like Byblos.

Second, Integrated Tourism Development in Cyprus: Cyprus can advance sustainable tourism by integrating coastal, rural, and urban areas through eco-routes linking the Troodos Mountains, Nicosia, and Limassol, supported by low-carbon transport options like cycling paths and electric buses. Promoting agri-tourism and revitalizing traditional villages with sustainable accommodations and cultural initiatives would diversify tourism and boost rural economies. Expanding renewable energy infrastructure, such as solar-powered resorts, and adopting smart tourism platforms to optimize visitor distribution can reduce congestion and promote inland destinations (Kim, 2023). Establishing a Mediterranean Sustainable Tourism Alliance with countries like Lebanon and Jordan would enable resource sharing, joint marketing, and best practices, reinforcing Cyprus's leadership in integrated sustainable tourism.

Third, Eco-Friendly Infrastructure and Smart Tourism in Egypt and Türkiye: Egypt and Türkiye should prioritize eco-friendly infrastructure and smart tourism to enhance sustainability. Egyptcan expand solar energy in hubs like Sharm El Sheikh and Luxor, develop solar-powered Nile River transportation, and implement modern waste management in Red Sea resorts. Smart energy systems and digital platforms at sites like the Pyramids of Giza would reduce congestion and optimize energy use. Türkiye should integrate solar and wind energy in regions like Antalya and Cappadocia, promote green certifications for hotels, and adopt smart waste management in cities like Istanbul. Digital platforms to monitor tourist density at attractions like Ephesus and expanding eco-mobility options, such as electric vehicles and solar charging stations, would further reduce environmental impact. Both countries should engage in public-private partnerships and collaborate with international organizations to secure investments and technical expertise, ensuring sustainable tourism growth.

Fourth, Focus on Clean Energy and Innovation in Lebanon and Jordan: Lebanon and Jordan should prioritize clean energy and innovation to enhance sustainable tourism. Lebanon can expand solar and wind energy in areas like Byblos and Mount Lebanon, mandate green building standards, integrate smart energy systems in hotels, and use augmented reality (AR) at heritage sites like Baalbek to reduce physical impacts. Jordan should develop solar farms in

Petra and Wadi Rum, adopt energy-efficient technologies, introduce electric buses for low-carbon travel, and establish low-carbon tourism zonesin Aqaba. Public-private partnerships in both countries can accelerate clean energy adoption and innovative solutions, ensuring long-term sustainability.

These recommendations highlight the need for ongoing investment in sustainable tourism infrastructure and policies that reduce tourism's environmental footprint, helping Middle Eastern countries leverage tourism for economic growth while supporting global climate goals.

This study acknowledges certain limitations associated with using the ARDL model to analyze Middle Eastern countries. While the inclusion of region-specific factors, such as energy subsidy policies and levels of infrastructure investment, could potentially improve the model's explanatory power, the unavailability of reliable data for these variables restricted their incorporation as control factors in the analysis.

[Key Words: tourism, carbon dioxide emissions, Middle Eastern countries,
Autoregressive Distributed Lag (ARDL) Model,
Toda-Yamamoto Granger Causality Test]

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