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The impact of tourism on carbon (CO_2) Emissions: An empirical analysis of Turkiye

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Abstract

The study aims to reveal the effects of developments in tourism on CO_2 emissions in Turkey from 1984 to 2021. In this context, the relationship between CO_2 emissions, tourism revenues (TR), and international tourist arrivals (ITA) was analyzed using the autoregressive distributed lag (ARDL) boundary test approach. The results indicate a significant long-term relationship between the variables. The findings reveal that tourism revenues have a decreased effect, and international tourist arrivals have an increased effect on CO_2 emissions in the long run. These results suggest that Turkey needs stronger policies specifically for this subject.

Keywords: *CO_2 emissions, International tourist arrivals, Tourism revenues, ARDL, Turkiye*

1. Introduction

Tourism activity is generally based on clean areas or environments (Yildirim et al., 2008), and nearly no tourist activity does not depend on environmental resources (Rämet et al., 2005). If these activities are not well organized, they can cause negative impacts and endanger the continuity of tourism in the destination (Yildirim et al., 2008). Tourism is a significant catalyst in the economic growth and development of country economies today (Blažević, 2007: 338; Nepal et al., 2018: 2), and it has repeatedly proven itself in this regard (Demir and Bahar, 2021). In this context, the competitive environment in which countries enter to receive a share of international tourism revenue has also brought many debates related to tourism. Undoubtedly, one of the most important issues among these debates is CO_2 emissions, which is a main factor in environmental and climate problems. The significance given to CO_2 emissions compared to other pollutants is since CO_2 emissions are not only local and regional but also on a global scale (Akpan and Akpan, 2012).

Tourism has economic, social, and environmental impacts within the framework of its features (Cooper et al., 1993). CO_2 emissions represent one of these multi-faceted impacts on countries. CO_2 emissions represent one of the many multifaceted effects of tourism on countries. The effects of tourism on CO_2 emissions can be explained by factors such as transportation (Al-Mulali et al., 2015; Howitt et al., 2010; Peeters et al., 2007; Sharif et al., 2017), dependency on fossil fuels (Bohdanowicz et al., 2001; Gössling and Peeters, 2015; UNWTO, 2013), changes in land use due to tourism investments (Al-Mulali et al., 2015; Gossling, 2002), disruption of the ecological balance (Kort, 2002), and visitors' tourism activities (Gossling, 2002; Al-Mulali et al., 2015).

Despite the evaluations of tourism-related developments in connection with climate change and environmental issues (Scott et al., 2012), specific degrees can be approached through other theoretical channels. In the context of tourism, these theoretical channels are explained within the framework of issues such as the significant creation of CO_2 emissions as an important external cost, the Environmental Kuznets Curve (EKC), sustainable tourism, and destination carrying capacity. Therefore, empirical facts are important in discussing the relationship between tourism and CO_2 emissions (Koçak et al., 2020).

The importance of tourism for countries lies in its continuity and impact on the economy, especially in the case of developing countries such as Turkey, where their economy is more intertwined with the tourism sector. This study aims to examine the effects of tourism on CO_2 emissions from the period when tourism started to develop until the present day in Turkey. To this end, the study covers the period from 1984 to 2021 with the help of an ARDL boundary test. The

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study continues: the second section presents a literature review of the relationship between tourism and CO_2; the third section explains the variables and methods used; the fourth section provides analysis and findings; and the fifth and final section presents conclusions and discussions. The study's contribution to the literature is important due to its focus on a specific country regarding the subject matter.

2. Literature review

The rapid growth of tourism worldwide and expectations that this growth will continue globally have led to researchers showing more interest in the tourism industry in all its aspects. However, despite the increased focus on the effects of tourism on CO_2 emissions in recent years, studies in this area still contain certain deficiencies and maintain ambiguity.

Table 1. Literature review

Authors	Period	Country	Method	Results
Katircioglu and Katircioglu (2022)	1990Q1 to 2018Q4	Malta	Autoregressive Distributed Lag Approach	The result showed that tourism has a positive impact on carbon emissions in the short term.
Rahman et al. (2022)	1982-2018	Malaysia	ARDL Test	The result indicated that tourist arrivals have a positive impact on CO_2 emissions.
Salahodjaev et al. (2022)	1990-2015	European and Central Asian Countries	GMM	The result revealed that tourism has a positive impact on CO_2 emissions.
Duran and Bozkaya (2022)	1995-2020	Japan, China, New Zealand, Singapore, and Thailand	Emirmahmutoglu and Köse Panel Granger Causality	The result found that there is a one-way causality from carbon emissions (CO2) to tourism revenues (TG).
Zikirya et al. (2021)	2010-2017	Chinese Provinces	Panel Data Analysis	The result showed that international visitors have a positive impact on CO_2 emissions.
Kılavuz et al. (2021)	1960-2015	Turkey	ARDL Test	The result revealed the existence of a long-term relationship between CO_2 emissions and tourist arrivals.
Kocak et al. (2020)	1995-2014	Most Visitors 10 Countries	CUP-FM and CUP-BC	The result found that tourism development has a positive impact on CO_2 emissions, while tourism revenues have a negative impact.
Lee and Ngyen (2020)	1998-2014	95 Countries	Panel Data Analysis	The result revealed that while tourism increases CO_2 emissions from transportation, the number of tourists increases per capita CO_2 emissions.
Eyuboglu and Uzar (2019)	1960–2014	Turkey	ARDL Test	The results showed that tourism, growth, and energy consumption have a positive impact on CO_2 emissions in the short and long term.
Liu et al. (2019)	1980-2016	Pakistan	ARDL Test and Granger Causality Analysis	The results indicated that tourist revenues have no significant impact on environmental quality.
Gao and Zhang, (2019)	1995–2010	18 Mediterranean Countries	Panel Data Analysis	The results found a two-way causality between tourism and four pollutants (CO_2, NOx, SO_2, and PM2.5).
Sharif et al. (2017)	1972-2013	Pakistan	Gregory and Hansen Structural Break Test.	The results found a one-way causality from tourist development to CO2 emissions.
Dogan et al. (2017)	1995–2010	OECD Countries	Panel Data Analysis	The results found that tourism contributes to carbon emissions levels and there is a long-term relationship between variables.
Zaman et al. (2016)	2003-2015	Mediterranean Coastal Countries	Panel Data Analysis	The results detected tourism-generated emissions and this increases environmental hazards associated with the expansion of tourism.
De Vita et al. (2015)	1960-2009	Turkey	Co-Integration Tests and DOLS Method	The results found that the number of international tourists visiting Turkey is co-integrated with CO_2 emissions and tourist arrivals have a positive and significant impact on CO_2 emissions in the long term.
Katircioglu (2014)	1971–2010	Singapore	DOLS Method and Granger Causality Analysis	A long-term balance relationship between tourism development and carbon emission levels has been found.
Al-Mulali et al. (2014)	1995-2009	48 Tourism Destinations	Panel Data Analysis	A long-term relationship between tourism and CO_2 has been identified in Asia, Africa, America and the Middle East, excluding European destinations, through Panel Data Analysis.
Solarin (2013)	1972–2010	Malaysia	ARDL Test and Granger Causality Analysis	Tourist arrivals actively increase to pollution.
Lee and Brahmasrene (2013)	1988-2009	European Union Countries	Panel Data Analysis	The development of tourism has been found to have increasing impacts on CO_2 emissions.

Studies on the relationship between tourism and CO_2 emissions in the literature generally explain the issue through various variables such as tourism, energy, economic growth, environment (Lee and Brahmasrene, 2013; Katircioglu et al., 2014; Dogan et al., 2017; Liu et al., 2019; Zhang and Zhang, 2021 Rahman et al., 2022; Katircioglu and Katircioglu, 2022; Duran and Bozkaya, 2022), as well as renewable energy and foreign trade (Jebli, 2019; Salahodjaev, 2022). Meanwhile, some studies examine the relevant topic, considering the potential connections between socio-economic factors such as tourism and the environment, in a notably Environmental Kuznets Curve (EKC) framework (Katircioğlu, 2014; De Vita et al., 2015; Zaman et al., 2016; Kılavuz et al., 2021). In specific studies related to the topic in the literature, emphasis is placed on tourism revenue and visitor numbers (Al-Mulali et al., 2015; Sharif et al., 2017; Eyuboglu and Uzar, 2019; Koçak et al., 2020; Le and Nguyen, 2020). In these studies, while it has been found that variables such as energy and economic growth have a significant and positive contribution to CO_2, the same results do not provide a general description of tourism. Furthermore, according to World Tourism Organization (WTO) (2019) predictions before the COVID-19 outbreak, tourism is estimated to account for 5-10% of global emissions. Within this context, national and international studies available in the literature are presented in Table 1 in chronological order.

The literature related to the topic is presented in Table 1 above. The relevant literature review indicates that the effects of tourism on carbon emissions are not homogeneous and that research findings vary by country. However, in studies that include visitor numbers, tourism generally has a significant and increased effect on CO_2. However, only a few studies have focused on the opposite of these results. Based on these explanations, it can be stated that the changes in the findings obtained are due to the economic, geographical, and cultural differences of the countries under analysis. From this perspective, the importance of carrying out research specifically on a country or similar country arises.

3. Model, data, and methodology

Ethics committee approval is not required as the data used in this study is based on the annual data in tourism on CO2 emissions in Turkey from 1984 to 2021. All responsibility belongs to the researchers.

This research primarily aims to examine the effects of tourism on CO_2 emissions in Turkey. In this context, the research was analyzed using the autoregressive distributed lag (ARDL) test developed by Mohammad Hashem Pesaran and Yongcheol Shin in 2001, utilizing annual data between 1984 and 2021. The period taken in the study can be expressed as the years' tourism started to show development in Turkey. The analysis takes tourism revenue and international visitor numbers as independent variables and carbon emission as the dependent variable. The model formed can be expressed as follows:

$$CO_2 = f(TR_t, ITA_t) \quad (1)$$

In the model created above, the data used were obtained from the World Bank, and the explanation of the symbols used for these variables are presented in Table 2.

Table 2. The variables and expressions used in the analysis

TR	Tourism Revenue (USD)
ITA	International Tourist Arrivals (Number)
CO_2	CO_2 Emission (Tons)

Three variables are included in the analysis, and the symbols used for these variables are shown in Table 2. Additionally, there is one dummy variable in the analysis. This dummy variable represents the 2008 Global Financial Crisis. The semi-logarithmic expression of the model created is as follows:

$$lnCO_{2,\ t} = \beta_0 + \beta_1 lnTR_t + \beta_2 ITA_t + \beta_3 D_t + \mu_t, \text{ Here;} \quad (2)$$

$$\beta_1 = \frac{\partial \ln CO_2}{\partial \ln lnTR_t} = \frac{\partial lnCO_2}{\partial CO_2}\frac{\partial CO_2}{\partial \mathrm{TRt}} = \frac{1}{CO_2}\frac{\partial CO_2}{\partial \mathrm{TRt}} = \frac{\partial CO_2/CO_2}{\partial \mathrm{TRt}}, \text{ and} \quad (3)$$

$$\beta_2 = \frac{\partial \ln CO_2}{\partial \ln lnITA_t} = \frac{\partial lnCO_2}{\partial CO_2}\frac{\partial CO_2}{\partial \mathrm{ITAt}} = \frac{1}{CO_2}\frac{\partial CO_2}{\partial \mathrm{ITAt}} = \frac{\partial CO_2/CO_2}{\partial \mathrm{ITAt}}$$

as considered. (4)

The semi-logarithmic model stated above provides β_1 and β_2, which show the effects of a 1-unit change in the related independent variable on the dependent variable. Statistical information about the variables used in the analysis can be provided after preparing the data, creating the model, and presenting it.

Table 3. Statistics Related to the Variables Used in the Analysis

Observation Count:38 Period: 1984-2021				
Variables	*Median*	*Std. Error*	*Min.*	*Max.*
lnCO₂	19.2446	0.431389	18.40795	19.92415
lnITA	16.42849	0.895947	14.95471	17.76193
lnTR	23.22789	1.094622	20.54891	24.34815

Following the presentation of the explanatory statistics of the variables in Table 3 above, the ARDL boundary test approach is used for the analysis. This approach provides the opportunity to explain the variables' short- and long-term relationship. It is a significant advantage because it does not require the used series to be equally stationary. The ARDL form of the model created above (2) can be expressed as follows within the scope of the study.

$$lnCO_{2\,t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i}\, lnCO_{2\,t-i} + \sum_{i=0}^{k} \beta_{2i}\, \Delta lnTR_{\,t-i} + \sum_{i=0}^{k} \beta_{3i}\, \Delta lnITA_{\,t-i} + \beta_4 lnCO_{2\,t-i} + \beta_5 lnTR_{\,t-i} + \beta_6 lnITA_{\,t-i} + \mu_{\,t} \quad (5)$$

The equation (5) created above expresses the ARDL form of the model and Δ represents the first difference of the variables; β_0 represents the slope coefficient; β_1, β_2, β_3 represent the short-term relationship, and β_4, β_5, β_6 represent the long-term relationship. The validity of the analysis is related to the following tested hypothesis:

$H_0 = \beta_4 = \beta_5 = \beta_6 = 0$ and

$H_a = \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$ this is the form.

Following the explanation of the long-term relationship between the variables, the ECM is applied to estimate the short-term coefficients and error correction term, thus enabling the testing of the short-term relationship as follows:

$$\Delta lnCO_{2\,t} = a_0 + \sum_{i=1}^{k} a_{2i}\,\Delta lnCO_{2\,t-i} + \sum_{i=0}^{k} a_{3i}\,\Delta lnTR_{\,t-i} + \sum_{i=0}^{k} a_{4i}\,\Delta lnITA_{\,t-i} + a_1 ECT_{t-i} + \mu_t \quad (6)$$

In the equation mentioned above (6), ECT_{t-1} represents the error correction term. It is expected to be negative and statistically significant. After the formation of the model and its ARDL bound test form and the announcement of valid hypotheses, the effects of tourism on CO_2 emission in Turkey can be revealed, starting from the years in which tourism showed growth. The variables used in the analysis specifically explain the subject's relevance, and the related results are stated below.

4. Analysis and empirical findings

The variables included in the analysis are expected to be stationary in the ARDL boundary test approach used in the study. A significant advantage of the ARDL boundary test approach is that the requirement for the variables to be stationary to the same degree is not required. However, it is impossible to apply the ARDL boundary test model with second-degree stationary variables (Peseran et al., 2001). Therefore, in the analysis where the ARDL boundary test is applied, it is necessary to check the stationary levels of the series. In this regard, to ensure the essential condition for the analysis, the results of the unit root test applied to the variables used in the model are presented in Table 4 with the help of the Augmented Dickey-Fuller (ADF) test.

None of the variables used in the model are second-degree stationary, as seen in Table 4 above. The results of the ADF unit root test show that carbon emissions ($lnCO_2$) are fixed at level I(0); tourism revenue (lnTR) and international tourist arrivals (lnITA) are stationary at first differences I(1), and thus the series used in the analysis meet the necessary condition for the ARDL boundary test. After completing the necessary condition for the analysis, the results of the ARDL model are presented in Table 5.

The results of the ARDL model can be found in Table 5. The results show that the model's significance level (R-Squared) is 99% and the probability value is less than 0.05. Here, a high R-Squared indicates a good explanatory power of the model. The form of the ARDL model results can be presented as follows:

$$lnCO_2 = 11.0417349376 + 0.405949905124*lnCO_2(-1) + 0.146503253625*DlnITA - 0.090941143577*DlnTR - 0.012467168846*D2008 + 0.0225523157038*@TREND \quad (7)$$

In the form generated above (number 7), it shows the results of the ARDL boundary test model. After that, the long-term co-integration between the series is checked. The existence of co-integration between the series is confirmed by the fact that the F-statistic obtained in the long-term form of the analysis is higher than the upper critical value of I(1). The results obtained for the long-term are shown in Table 6.

The long-term results and coefficients of the model where the dependent variable is CO_2, as seen in Table 6 above. The results show that the F-statistic is higher than the critical value I(1) at the 5% and 10% levels, indicating that the long-term form is valid at the 5% and 10% significance levels, and therefore the null hypothesis indicating no co-integration between variables is rejected. This confirms the existence of a long-term relationship between the variables. Additionally, since the t-statistic values of the independent variables are less than 0.05, they are considered significant and interpretable. The direction of the relationship of the coefficients in the results obtained at significance levels of 1%, 5%, and 10% in the long run, when CO_2 is the dependent variable, is seen to be negative for TR and positive for ITA. The long-term findings can be expressed as follows:

$$lnCO_2 = 0.2466*DlnITA - 0.1531*DlnTR + EC \quad (8)$$

Upon finding significant results regarding the long-run forms, the error correction term (ECTt-1) (λ) coefficient is expected to be negative and statistically significant. This indicates the time for the short-term shocks caused by the independent variables to disappear and approach the long-term equilibrium value. The short-term findings obtained in the analysis and the results of the error correction model are displayed in Table 7.

The coefficient of ECT_{t-1} is -0.5940 in Table 7, which can be statistically significant and consistent as it is smaller than 1, negative, and has a probability value of less than 0.05. This means that the results are statistically significant and consistent. The mentioned error correction term indicates that 59.4% of the imbalanced state formed in the short term will disappear from the first year. Therefore, the short-term imbalanced situation will approximately return to balance in 1.7 years (1 / 0.594) in the long term. The results obtained for the error correction model using serial correlation test, functional form specification, normality test, and heteroscedasticity test are shown in Table 8.

The test results for the complementary statistics presented in Table 8 indicate that the estimated models are consistent throughout the sample period, as the probability values are greater than 0.05. CUSUM and CUSUM squares are used after obtaining these consistent results to control the stability of short- and long-term forecasts. The CUSUM test identifies regular fluctuations in the regression coefficients, while the CUSUM squares test indicates rapid fluctuations that can alter the stability of the regression coefficients (Brown et al., 1975). Figure 1 displays the results of the current CUSUM and CUSUM squares tests for the situation where CO_2 is the dependent variable.

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Table 4. ADF Unit Root Results

Variables	*ADF Test Statistic*	*Critical Values*			
		%1	%5	%10	
lnCO_2	-3.958055 [9] (0.0192)	-4.226815	-3.536601	-3.200320	Stationary
lnITA	-2.505464 [9] (0.3239)	-4.234972	-3.540328	-3.202445	Non-Stationary
Δ*lnITA*	-8.586290 [9] (0.0000)				Stationary
lnTR	0.756684 [9] (0.9995)	-4.252879	-3.548490	-3.207094	Non-Stationary
Δ*lnTR*	-5.700082 [9] (0.0002)				Stationary

Note: The lag lengths for the ADF unit root test were determined according to the Schwarz Information Criterion (SC) and the maximum lag length was taken as 9.

Table 5. ARDL model results

Model ARDL (1,0,0)				
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.**
$LCO_2(-1)$	0.405950	0.133067	3.050720	0.0046
DLITA	0.146503	0.056284	2.602946	0.0141
DLTR	-0.090941	0.052047	-1.747300	0.0905
K2008	-0.012467	0.024854	-0.501621	0.6195
C	11.04173	2.462944	4.483144	0.0001
@TREND	0.022552	0.005049	4.466396	0.0001
R-squared	0.991624			
Prob.	0.000000			
F-statistic	733.9795			

Table 6. Long-term form and boundary test

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
DLITA	0.246618	0.063955	3.856097	0.0005
DLTR	-0.153087	0.067028	-2.283924	0.0294
EC = $\ln CO_2$ - (0.2466*DlnITA - 0.1531*DlnTR)				
F-Bounds Test				
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	8.705619		n=40	
k	2	10%	4.477	5.42
		5%	5.387	6.437
		1%	7.527	8.803

Table 7. ARDL error correction model

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	11.04173	2.084689	5.296586	0.0000
@TREND	0.022552	0.004452	5.066054	0.0000
K2008	-0.012467	0.024726	-0.504208	0.6177
CointEq(-1)*	-0.594050	0.112664	-5.272743	0.0000
R-squared	0.474419			
Prob(F-statistic)	0.000082			
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	8.705619	10%	4.19	5.06
k	2	5%	4.87	5.85
		2.5%	5.79	6.59
		1%	6.34	7.52

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Table 8. Complementary statistics

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.532113	Prob. F(2,29)	0.5930
*Obs*R-squared*	1.309742	Prob. Chi-Square (2)	0.5195
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.760208	Prob. F(5,31)	0.5853
*Obs*R-squared*	4.041215	Prob. Chi-Square (5)	0.5435
Ramsey Reset Test			
	Value	df	Probability
t-statistic	0.144614	29	0.8860
F-statistic	0.020913	(1, 29)	0.8860
Histogram – Normality Test			
Mean	5.89e-15	*Jarquea-Bera*	0.54291
Median	-0,003484	*Probability*	0.742936
Max.	0.095772		
Min	-0.077385		

Figure 1. Cusum Test Results

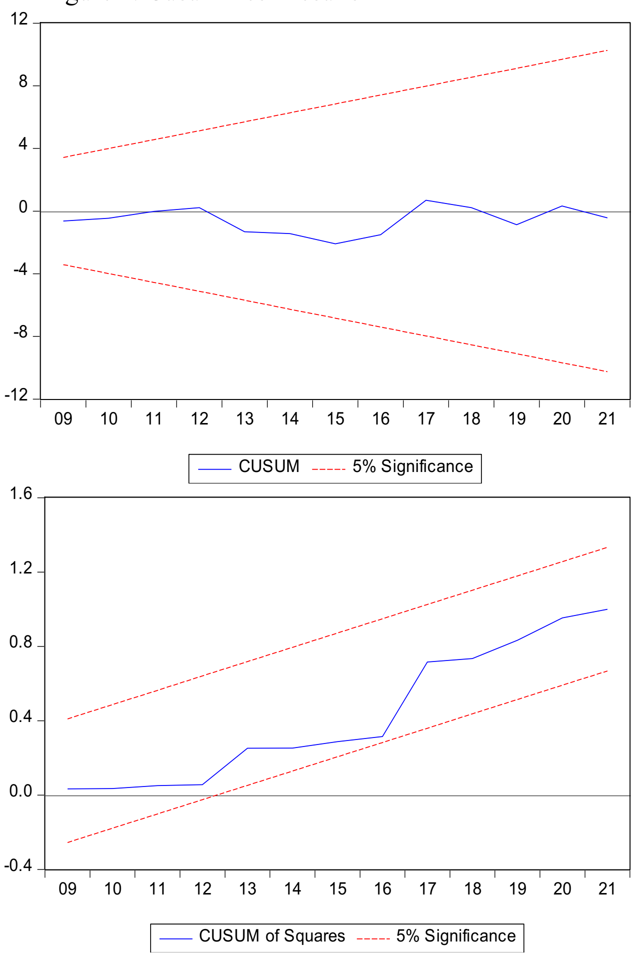

Figure 1 presents the results of the CUSUM and CUSUM squared test, which do not suggest a structural break regarding international tourist arrivals and tourism revenue being the independent variable and CO2 emissions being the dependent variable. The graphs of both statistics related to CUSUM tests are seen to be within the critical boundaries that confirm the stability of coefficients in the error correction model, and it is observed that there are no structural breaks within the period frame included in the analysis. Thus, the results obtained from the analysis with the relevant model are meaningful and consistent.

5. Conclusion

This study analyzed the effects of tourism on carbon emissions in Turkey over the period 1984-2021, using the ARDL boundary test developed by Peseran et al. (2001) with annual data. In the study, carbon emissions were considered as the dependent variable, and tourism revenue and international tourist arrivals were considered as independent variables, and a dummy variable was used for the effects of the global crisis. The short and long-term relationship between these series was studied using the ARDL boundary test, and the findings showed a significant relationship between tourism revenue, international tourist arrivals, and carbon emissions in both the short and long term. In the long term, a decreased effect of tourism revenue on carbon emissions and an increased effect of international tourist arrivals on carbon emissions were identified. The flexibility of these statements is that a 1% increase in tourism revenue has an effect in a decrease in carbon emissions by 0.15%, and a 1% increase in international tourist arrivals has an effect in increasing carbon emissions by 0.24%. The results show that the error correction term is effective, and 59.4% of the imbalance formed in the short term disappears from the first year. This analysis demonstrates that the short-term imbalance reverts to balance approximately 1.7 years later in the long term.

The findings of this research are quite significant in terms of the gains in literature with a specific focus on a single country and the reliability of the empirical application. Specific studies in the literature can support the findings from the research. These studies include Kocak et al. (2020), Solarin (2013), De Vita et al. (2015), Zikirya et al. (2021), and Rahman et al. (2022). However, the research findings do not align with the results of Liu et al. (2019).

Turkey is one of the world's leading tourist destinations due to its numerous advantages. Therefore, tourism is a highly important sector of the Turkish economy; however, its economic contributions are primarily based on the sector's sustainability. Research findings indicate that Turkey needs stronger policies in this context. Strategic practices such as renewable energy incentives, fossil fuel taxes, technology development efforts, appropriate or horizontal urban planning, expert reports, local community education in destination areas, R&D studies, and regulatory mechanisms are crucial. These policies should be based on local, regional, and national practices that reduce the impact of tourism development on CO_2 emissions under the state's leadership and in collaboration between the public and private sectors. This issue and the required policies retain their current importance to alleviate concerns about the sustainability of tourism, increase tourism revenues, and gain competitiveness in tourism.

Author contributions

The authors declare that they equally contributed to the design and implementation of the research, the analysis of the results, and the writing of the article.

Disclosure statement

The authors reported no potential competing interest.

Ethics committee approval

All responsibility belongs to the researchers. Ethics committee approval is not required as the data used in this study is based on the annual data in tourism on CO2 emissions in Turkey from 1984 to 2021.

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