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Economic Growth and Carbon Emission Nexus: the Function of Tourism in Brazil

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ABSTRACT

The impact of international tourism on emerging markets has been overwhelmingly beneficial. Despite the obvious benefits of tourism, it comes at a high price for the environment in the form of pollution. Brazil's annual tourist influx has the potential to boost economic development and damage the country's ecosystems. The objective of this investigation is to analyze, using time series data ranging from 1990 to 2019, the effects of tourism and economic growth (GDP) on carbon dioxide (CO_2) emissions in Brazil. The stationarity of the data was examined by employing unit root tests, and an autoregressive distributed lag (ARDL) technique was used to investigate the link between the factors, taking both the long- and the short-run into consideration. This research shows that there are long-term and short-term ties between Brazil's tourism industry, GDP, and CO_2 emissions. Yet, both tourism and economic expansion have had serious negative effects on Brazil's ecology. These results indicate that in order to maintain environmental quality in Brazil, policymakers need to pursue more eco-friendly economic expansion as well as environmentally conscious tourist regulations.

KEYWORDS

Tourism; Economic growth; CO_2 emissions; Environmental degradation; Sustainable development; Brazil

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1. Introduction

The exponential development in tourism demand over the course of the last several decades has resulted in remarkable changes within the global tourism industry (Raihan et al., 2023a). This pattern ultimately contributes to the deterioration of the natural environment as well as an increase in the amount of energy that is consumed at the tourist site (Raihan and Tuspekova, 2022a). The end outcome of having a high energy consumption is contamination of the surrounding environment, most commonly in the form of CO_2 emissions (Raihan et al., 2019; Begum et al., 2020; Raihan et al., 2023b). Researchers are becoming increasingly concerned about the CO_2 emissions that have occurred over the past few decades as a direct outcome of global warming (Jaafar et al., 2020; Raihan et al., 2022a; Voumik et al., 2022a; Sultana et al., 2023). Since the beginning of the 1960s, the quantity of CO_2 emissions has roughly doubled, making it the primary cause of global warming (Raihan et al., 2018; Raihan et al., 2021a; Raihan and Said, 2022). The effects of global warming will have a negative impact on many aspects of society, including the economy, government, way of life, and the evolution of geopolitics (Raihan et al., 2021b; Ali et al., 2022; Raihan et al., 2022b). Millions of people have been put at risk of starvation, sickness, flooding, and a lack of access to clean water as a direct result of global warming and changes in the environment (Raihan et al., 2022c; Isfat and Raihan, 2022). Yet, CO_2 emissions are seen as a cost of tourist industry due to the many activities that are associated with tourism (Raihan and Tuspekova, 2022b). As a result, it sparked worries regarding the negative repercussions that may result from the excessive use of energy in the tourism business (Raihan et al., 2022d; Voumik et al., 2022b). Consequently, it is of the utmost importance to conduct research on the possible long-term effects that tourism could have on the condition of the environment, in particular for those nations in which tourism is a key contributor to the GDP.

The tourism industry has become a key factor in the advancement of the economy for equally industrialized and emerging states during the past four decades, demonstrating a tremendously beneficial effect on economic expansion around the globe (Raihan, 2023a). Blake et al. (2006) found that the tourist industry had a significant positive influence on economic development when evaluating the influence of the competitiveness of various tourist sectors on economic growth. The autonomous economic growth hypothesis was applied by Liu et al. (2018), who assumed that productivity was exogenous and that the rate of return on capital was decreasing. This was done to verify hypotheses in the theory. They illustrated the extrinsic tourism output boost to economic growth with the island of Mauritius. Their research suggests that tourism has a favorable effect on the economy as a whole since it creates jobs, brings in new capital, enhances infrastructure, helps the manufacturing, agricultural, and service sectors grow, and boosts hotel profits (Zaman et al., 2017; Kocak et al., 2020). In spite of the fact that tourism is good for the economy, it is also responsible for a number of negative repercussions, such as the problem of pollution. Tourism is one of the most significant contributors to an economy's CO_2 emissions due to the increased number of economic activity and the amount of energy it consumes (Raihan and Tuspekova, 2022c). As a result, tourism is a significant component that can either straight or deviously influence the regional ecology alongside the universal ecosystem (Raihan, 2023b). Consistent with the numbers provided by the UNWTO, the number of foreign tourists who visited a country in 2018 climbed by 6%, while the revenue generated by international tourism increased by 4%. Revenues from international passenger transport services are anticipated to rise to 309 billion US dollars by 2026, up from 277 billion US dollars in 2021. Tourism is one of the industries that contributes to this growth. In addition, when it comes to the amount of money made from exporting goods throughout the world, tourism is in third place, behind the chemical and fuel industries and the automobile sector.

Many countries, such as France, Turkey, Thailand, Italy, China, Spain, Mexico, the USA, the UK, Germany, and Malaysia, have been the focus of previous research that investigated the negative effects that tourism activities have on the ecosystem of the host state. According to their conclusions, tourism appears to have a negative impression on the overall attribute of the ecosystem (Aziz et al., 2020; Raihan and Tuspekova, 2022d; Raihan et al., 2023c). Despite the fact that it is beneficial to the transport, food preparation, and lodging industries in the nation that is hosting the event (Raihan et al., 2022e). The development process, industrialization, and economic expansion are all circumstances that contribute to environmental deprivation as a complementary phenomenon (Raihan et al., 2022f). The tourism industry in Brazil is one that is expanding, and it is making a considerable role to the total progression of the economy. In 2019, Brazil welcomed close to 6.5 million international visitors. In addition to this, Brazil is the third greatest prevalent tourist terminus in all of Latin America, coming in behind only Mexico and Argentina. In 2019, Brazil's tourism industry was responsible for around 7.7% of the country's overall economic progression and almost 3.3% of the country's total occupation. Mass tourism is a relatively modern phenomena in Brazilian circle, despite the fact that tourism itself has been around for quite some time.

The aim of this assessment is to evaluate the liaison amongst economic progression, tourism, and CO_2 emissions using Brazil as a case study in order to evaluate the effects of financial and tourist performances on the excellence of the environment. Brazil is an incredibly important nation in the BRICS group, and its enormous economic progress and tourism industry contribute to the country's elevated stage of power utilization and carbon dioxide emissions. As a result, it is of the utmost importance to investigate the connection that exists in Brazil between GDP, CO_2, and tourism. This work makes several important contributions to the body of previously published research. The stationarity and series stability of the variables was confirmed by utilizing three unit root tests, and their connections to long- and short-term dynamics were verified using the ARDL strategy. The conclusions of the analysis might be advantageous to policymakers in making policies that are acceptable in order to pursue more eco-friendly economic expansion as well as environmentally conscious tourist regulations.

2. Methodology

2.1. Data and empirical model

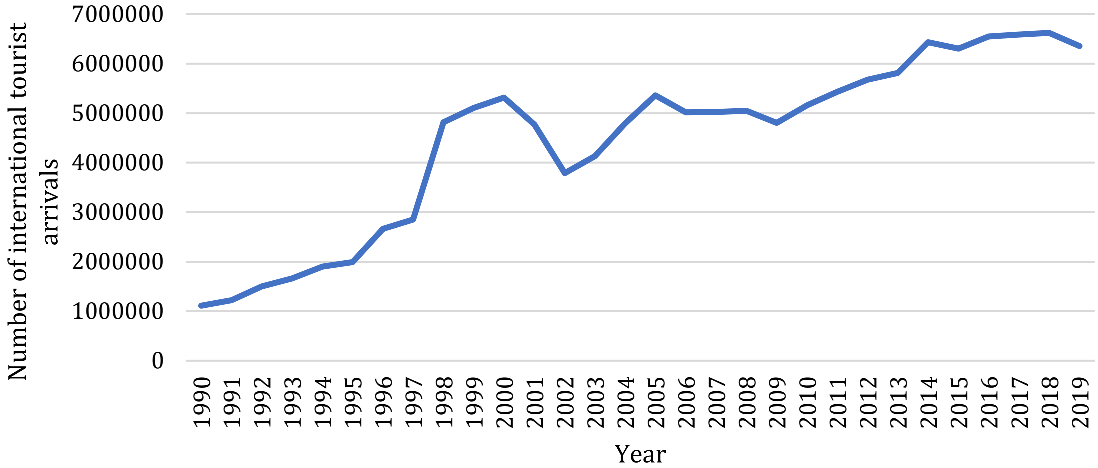
In order to validate the hypothesis regarding the relationship between the variables, the ARDL bounds analysis strategy was combined thru a cointegrating regression scrutiny. The World Development Indicators (WDI) was operated to accumulate all of the variable time series data, and the years covered by these data range from 1990 to 2019. Study variables include tourism (measured as the number of international tourist arrivals), gross domestic product (measured in constant 2015 USD), and CO_2 emissions (measured as kilotons). Figure 1 is a plot that displays the patterns of the variables over time.

This study specified the following model at time t in order to demonstrate the association between variables.

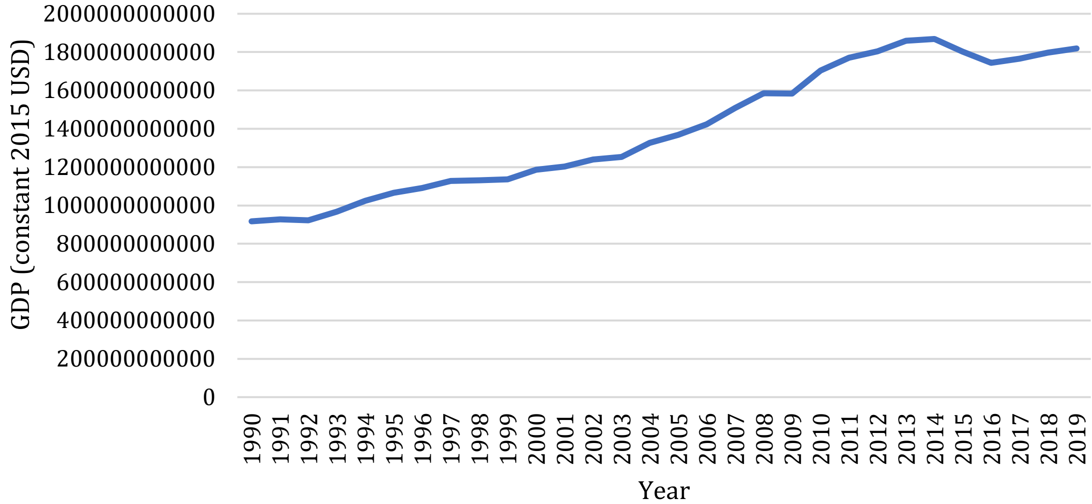
$$C_t = \tau_0 + \tau_1 T_t + \tau_2 Y_t + \varepsilon_t \quad (1)$$

Here, C, T, and Y are CO_2 emissions, tourism, and GDP, respectively. In addition, τ1 and τ2 are the coefficients, whereas ε is the error term. The variables were employed by following the logarithmic to clarify smooth data. data.

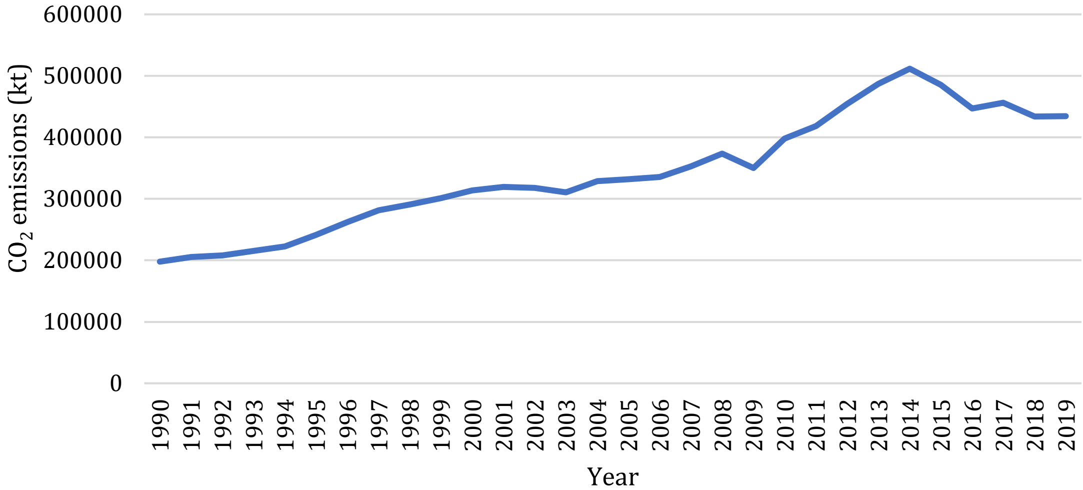
$$LC_t = \tau_0 + \tau_1 LT_t + \tau_2 LY_t + \varepsilon_t \quad (2)$$



(a) Tourism



(b) GDP



(c) CO_2 emissions

Figure 1. The yearly trends of tourism, GDP, and CO_2 emissions in Brazil.

2.2. Stationarity check

To determine whether the dataset is unified at I (0) or I (1), this study first looks at the associations between the answer variable and its explanatory components. Second, not all regressors need to have a seasonal influence or be included by order one (Raihan et al., 2022g). In addition, trying to steer clear of the I (2) sequence is invalid and may produce misleading results (Raihan and Tuspekova, 2022e). In addition, if any variable is nonstationary, the result may be erroneous (Raihan and Tuspekova, 2022f). However, the switch to I (2) is unparalleled and causes concern for the small sample size (Raihan and Tuspekova, 2022g). The Augmented Dickey-Fuller (ADF), the Dickey-Fuller generalized least squares (DF-GLS), and the Phillips-Perron (P-P) unit root tests are used in this inquiry to ensure that no variables are I (2).

2.3. ARDL approach

To analyze the long-term link between the parameters, the ARDL bounds testing method of cointegration purported by Pesaran et al. (2001) was utilized. With respect to the sequence of integration, this cointegration test has various advantages over more conventional methods (Raihan and Tuspekova, 2022h; Voumik et al., 2023). If the parameters are found to be unchanging at either the I(1) or I(0) level, or the I(1)/I(0) level, then this approach can be used (Raihan, 2023c). The ARDL bounds testing econometric analysis makes use of a sufficient number of lags inside a general-to-specific modelling framework to accurately represent the creation of data (Raihan and Tuspekova, 2022i). Under the ARDL framework, the ARDL F-statistic can be calculated to test for the presence of cointegration between factors by using a diverse ideal number of lags for each variable (Raihan and Voumik, 2022a). If the ARDL F-statistic is larger than a predetermined upper critical value, then it is demonstrated that the factors are cointegrated. If the ARDL F-statistic is less than the lower critical bound, then the variables do not exhibit cointegration (Raihan and Tuspekova, 2022j). When the ARDL F-statistic falls in the middle of the two critical values—the upper critical bound and the lower critical value—the empirical conclusions will be unconvincing (Raihan, 2023d). The following is the approximate model for the ARDL bounds analysis method of examining cointegration:

$$\Delta LC_t = \tau_0 + \tau_1 LC_{t-1} + \tau_2 LT_{t-1} + \tau_3 LY_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LC_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LT_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LY_{t-i} + \varepsilon_t \quad (3)$$

where Δ is first difference operator; q indicates the length of the lag that is optimal.

ARDL bounds testing can be transformed linearly to obtain the error correction model (ECM). This method yields trustworthy empirical results even with relatively tiny samples (Raihan, 2023e). To preserve the long-term picture, the ECM integrates the short-run subtleties with the long-term stability. This method isolates the cointegrating vectors that emerge from the empirical model as a consequence of the presence of several cointegrating vectors (Raihan and Voumik, 2022b). The coefficient of ECM is displayed by the representation θ. There is almost never an ECM below 0, and it never goes over 1. In instances where ECM is negative and statistically significant, it is essential that the variance be corrected to reach equilibrium. This research computed the short-run coefficients of the parameters using Equation (4) after establishing the long-term relationship between the series.

$$\Delta LC_t = \tau_0 + \tau_1 LC_{t-1} + \tau_2 LT_{t-1} + \tau_3 LY_{t-1} + \sum_{i=1}^{q} \gamma_1 \Delta LC_{t-i} + \sum_{i=1}^{q} \gamma_2 \Delta LT_{t-i} + \sum_{i=1}^{q} \gamma_3 \Delta LY_{t-i} + \theta ECM_{t-1} + \varepsilon_t \quad (4)$$

3. Results and discussion

Tabulated in Table 1 below are descriptive statistics. Based on the data collected and analyzed, it has been determined that the median and mean values of all variables are very similar. All of the variables exhibit a normal distribution, as shown by the skewness values near zero, the kurtosis values below 3, and the Jarque-Bera test statistics below their thresholds.

Table 1. Descriptive statistics.

Variables	LC	LT	LY
Mean	12.70782	15.19753	27.93716
Median	12.70715	15.42924	27.92895
Maximum	13.14534	15.70576	28.25614
Minimum	12.19552	13.92077	27.54460
Std. Dev.	0.281860	0.336539	0.244938
Skewness	-0.275546	-0.287164	-0.134151
Kurtosis	2.056305	2.389465	1.596807
Jarque-Bera	1.492828	1.777965	1.551172
Probability	0.474063	0.337043	0.279267

The first step is to get certain that order one, I (1), contains the entire dataset, and more specifically the response variables. This is done by analyzing the strength of correlation that exists between the response variables and the predictor parameters. Next, it is not appropriate to include all of the regressors of order one or to demonstrate temporary unit roots. Both of these approaches are flawed. To evaluate the order of the parameters and ensure compliance with the prerequisite, the ADF, DF-GLS, and P-P three-unit root tests were employed. The conclusions of the unit root tests are shown in Table 2. The data disclosed that all the tested parameters are stationary at the initial difference. The data are consequently appropriate for ARDL estimator.

Table 2. The results of unit root examinations.

Logarithmic form of the variables	ADF		DF-GLS		P-P	
	Log levels	Log first difference	Log levels	Log first difference	Log levels	Log first difference
LC	-1.883	-4.251***	-0.354	-4.329***	-1.780	-4.288***
LT	-0.499	-4.577***	-0.817	-4.323***	-0.512	-4.362***
LY	-0.376	-4.673***	-0.296	-4.634***	-0.252	-4.651***

*Notes: *** denotes significance at 1% level.*

After establishing the reliability of the variable's unit roots, this probe devoted the ARDL bounds experiment to inspect the nature of the long-term connection that exists between the variables. The empirical conclusions of using the ARDL bounds testing approaches to cointegration are shown in Table 3. As the estimated F-statistic was higher than the values of the upper critical bound, the empirical data presented evidence that long-term cointegration did, in fact, exist among the variables in question.

Table 3. Results of ARDL bounds analysis.

F-bounds test		Null hypothesis: No degrees of relationship		
Test statistic	Estimate	Significance	I(0)	I(1)
F-statistic	8.677235	At 10%	2.63	3.35
K	2	At 5%	3.10	3.87
		At 2.5%	3.55	4.38
		At 1%	4.13	5.00

Once the long-term connection has been established, this study will proceed to estimate the long-term and short-term parameters. Tabulated in Table 4 are the findings of both the long- and short-run studies. The empirical findings from the ARDL estimation exhibit that tourism exhibits a positively significant weight on CO_2 emissions over the long and short terms. A 1% upswing in tourist arrivals precedes CO_2 emissions by 1.12% (in the short run) and 0.24% (in the long run), assuming GDP remains constant. According to ARDL outcomes, GDP has both a positive and a significant influence on the CO_2 emissions both in the short run and in the long run. To be more specific, an intensification of 1% in GDP results in an expansion of 1.83% in the CO_2 releases in the short-run and 0.31% in the long-run. However, the conclusions of the ARDL investigation demonstrated that the long run influences of tourism and economic expansion on CO_2 releases are less than the short run impacts. This is because of the raising of environmental awareness, environment friendly technology development, renewable energy usage, green lifestyle, eco-friendly tourism development, and sustainable tourism policy implementation, in accordance with higher economic growth (specially the revenue from tourist industry) in the long run (Raihan and Tuspekova, 2023a; Raihan, 2023f).

Table 4. ARDL results over the long and short term.

Variables		Long-run			Short-run	
	Coefficient	t-Statistic	p-value	Coefficient	t-Statistic	p-value
LT	0.241***	4.862	0.000	1.124***	3.783	0.007
LY	0.309***	7.412	0.000	1.832***	4.155	0.003
C	12.503	1.334	0.147	-	-	-
ECM (-1)	-	-	-	-0.611***	-3.835	0.000
R2	0.9861					
Adjusted R2	0.9725					

*Notes: *** denotes significance at 1% level.*

This study's evaluation of ECM is negative at the 1% level of significance. How quickly a system moves from a state of short-run disequilibrium to one of long-run equilibrium can be inferred from the magnitude and sign of the estimate of the equilibrium correlation matrix (ECM). This result demonstrates that the long-run equilibrium is reached once short-run errors are adjusted by 61 percent. Furthermore, the long-run evaluation R^2 and adjusted R^2 are 0.9861 and 0.9725, correspondingly, demonstrating that the proposed regression model fits the data remarkably well. This points out that the independent aspects can explain nearly 97% of the variability in the dependent factor. Table 5 exhibits the empirical calculations of several diagnostic statistics. To ensure uniformly distributed residuals, the Jarque-Bera test can be utilized. The Lagrange multiplier (LM) procedure was utilized in the investigation of the serial correlation issue. Model-free of serial correlation problem, as shown by the LM test result. The Breusch-Pagan-Godfrey analysis was utilized in the forecast model to investigate the heteroscedasticity issue. The conclusions of the Breusch-Pagan-Godfrey analysis designate that the predictable model does not suffer from heteroscedasticity. The model was determined to be well-founded using the Ramsey reset test.

Table 5. The findings obtained as of diagnostic examinations.

Diagnostic probes	Coefficient	p-value	Conclusion
Jarque-Bera analysis	1.556126	0.4592	The residuals have a normal distribution.
Breusch-Godfrey LM analysis	0.179326	0.8379	There is no serial correlation
Breusch-Pagan-Godfrey analysis	0.645327	0.7553	There is no heteroscedasticity.
Ramsey RESET analysis	0.468687	0.6465	The model is precisely described

Summation cumulative of recursive residuals (CUSUM) and squares of the recursive residuals' cumulative sum (CUSUMSQ) functions were to evaluate the structural steadiness of the model in this study. The CUSUM and CUSUMQ analysis are graphically represented in Figure 2. Model parameters are stable if, for example, scatter plots don't deviate from the critical bound by more than 5%. As can be seen from the graphs, both the CUSUM and CUSUMSQ values stayed inside the allowable span of +/- 5% throughout the duration of the study.

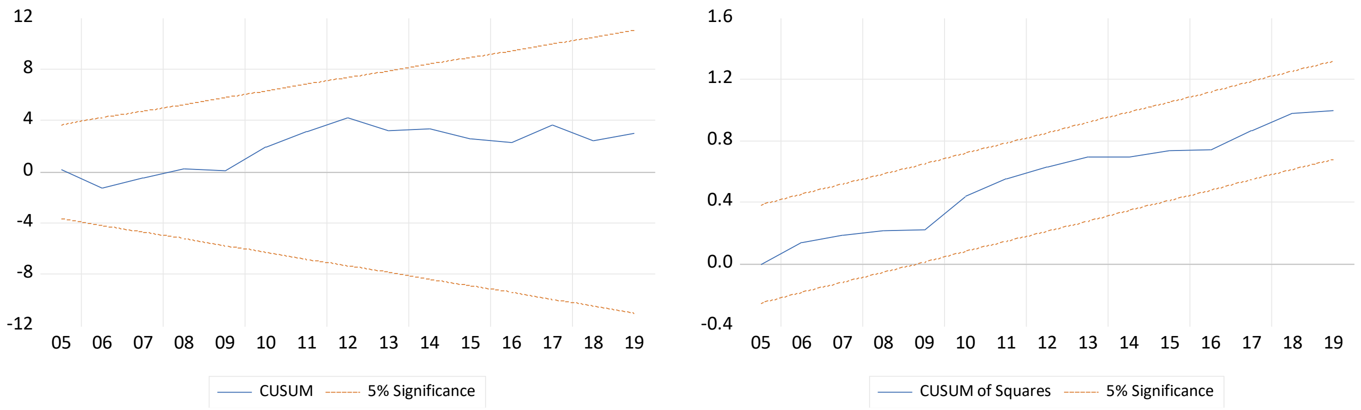


Figure 2. The findings of both the CUSUM and CUSUMQ analyses.

Economic expansion in Brazil is being hampered by efforts to save energy and cut down on pollution. It is critical that Brazil has a workable plan for reducing carbon emissions. Because the majority of tourism-related services rely on fossil fuels for power, massive CO_2 emissions ensue (Raihan et al., 2022h), there will inevitably be environmental effects because of the decarbonization process (Raihan and Tuspekova, 2023b; Raihan, 2023g). Because of this, the purpose of this research is to determine if tourism helps with cutting down on CO_2 emissions. The increasing number of tourists has a major influence on Brazil's CO_2 emissions in the long run, as demonstrated by the ARDL test results. It's additional evidence that the climbing digit of travelers visiting Brazil is giving a negative sway on the nation's ecosystem. The finding is in agreement with Raihan and Tuspekova (2022k); who discovered that economic progress and tourism enhances CO_2 emissions in Brazil. The tourism industry has a sizable effect on global warming due to the widespread use of transportation, which in turn is a direct outcome of increasing CO_2 emissions caused by increased energy consumption (Raihan et al., 2022i; Raihan, 2023h). One of the most important components of the global warming argument is the connection between rising carbon emissions, rising energy use, and expanding economic development (Raihan et al., 2023d; Raihan, 2023i). The principal causes of environmental degradation are economic development and energy use, which serve as significant transmission channels (Raihan, 2023j).

The predicted results show that in the short run, carbon emissions in Brazil are positively and significantly impacted by tourist arrivals and the GDP. This makes sense given the long-term and short-term nature of the influence of tourism and economic expansion on CO_2 emissions and climate change. So, this study draws the inference that Brazil's CO_2 emissions will rise in the long run if tourism and GDP continue to grow. This is consistent with prior research (Zaman et al., 2017; Liu et al. 2018; Kocak et al., 2020; Aziz et al., 2020) that discovered both a short- and long-term effect. However, boosting tourism activities through technology improvement increases economic growth (Raihan, 2023k) which might lead to the degradation of natural ecosystems (Raihan, 2023l). To achieve the current emissions targets and advance toward decarbonization or a low-carbon economy, Brazil must exert considerable effort to alter its tourism structure to lessen burdens on the ecosystem ascending after that cause and capitalize in low-carbon technologies.

Moreover, as COVID-19 pandemic had negative impacts on the society (Raihan and Himu, 2023) as well as the tourism sector, the Brazilian government needs to take necessary steps for uplifting the tourism industry. The tourism industry needs credible measures from the government to generate market confidence and recover the loss due to COVID-19 pandemic. The government needs to provide funding for promoting tourist destinations (Raihan et al., 2023e). In order to safeguard the ecological equilibrium in the face of tourism, governmental bodies may contemplate several measures. These measures include intensifying their efforts and financial allocations towards capacity building and training initiatives, implementing sustainability taxes targeted at tourists, safeguarding vulnerable community and Indigenous People's territories from exploitative practices, and incorporating scientific frameworks into policy-making processes.

4. Conclusions and policy implications

Brazil has the biggest economy in Latin America and is liable for a significant segment of the CO_2 emissions that are produced in the region. These emissions have a significant impact on a variety of social and environmental variables. Throughout the course of the research period, Brazil saw an overall growth in the number of tourists visiting the country, despite several years of stagnant performance. Both having an economy that is expanding at a high rate and having a large number of tourists arrive each year have a significant negative influence on the nation's overall environmental quality. Therefore, by utilizing data series spanning from 1990 to 2019, the objective of this analysis was to explore whether or not there is a dynamic connection between tourism, GDP, and CO_2 emissions in Brazil. The stationarity of the data was examined applying unit root assessments such as ADF, DF-GLS, and P-P. Additionally, the ARDL methodology was utilized to investigate the link between the factors using both long-run and short-run scrutiny. According to the findings, an increase of one percent in both tourism and GDP will result in an increase of 0.24% and 0.31% in CO_2 emissions over the long term, in addition to an increase of 1.12% and 1.83% over the short term. The decisions of the assessment might be advantageous to policymakers in making policies that are acceptable in order to pursue more eco-friendly economic expansion as well as environmentally conscious tourist regulations.

The research's conclusions revealed that the legislature should support the UNWTO's carbon-neutral policy at the regional level. In this scenario, Brazil may implement a variety of policies in order to lower the amount of pollutant emissions produced by the economy. To begin, the transportation industry is the primary contributor to the production of carbon dioxide (CO2) emissions. This is due to the fact that the primary fuel requirements of transport automobiles (air, road, railway, and water) are primarily convened by fossil fuels. As a result, the government can decide to promote the utilization of alternate energies and fusion machineries, notably in the transportation sector. Second, the government has the ability to enact rules that are clearly defined regarding environmental quality. For instance, tourist destinations that have a greater negative impact on the ecosystem must set aside adequate finances for ecological refurbishment to maintain ecological value. Thirdly, the communal segment might make use of subsidies or tax exemptions to encourage the generation of renewable and clean energy throughout the economy, remarkably in areas that are popular tourist attractions. Fourthly, the quality of the environment can be improved by putting into place policies that allow for the accumulation of certified carbon credits, as well as by encouraging initiatives such as tree planting campaigns, the production of renewable energy, and energy savings, as well as by providing operative ecological schooling and mindfulness. The application of these solutions has the prospective to create noteworthy developments to the ecosystem and contribute to the reduction of CO_2 emissions in Brazil.

However, the research does have certain restrictions due to the fact that it was only conducted in a single nation. In addition, it is limited in scope, as it only covers the years 1990–2019 because data for earlier years were not readily available. This research has the potential to be expanded into many more dimensions. It will be fascinating to watch how CO_2 emissions in popular tourist locations affect the healthiness of the indigenous inhabitants that resides in these areas. Yet, it might be intriguing to employ tools for anticipating for instance the neural system to estimate the long-term influence that tourist industry would have on the ecological feature of a nation. The current investigation has a number of shortcomings; therefore, in the future, researchers ought to take both developed and developing regions into consideration, in addition to possibly including other essential factors like the effects of globalization and cultural influences, in order to provide a more compelling explanation for this relationship.

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Conflict of interest

The author claims that the manuscript is completely original. The author also declares no conflict of interest.

Author contributions

Conceptualization, visualization, methodology, data curation, formal analysis, writing: Asif Raihan.

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