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The dynamic nexus among carbon dioxide emissions, energy consumption, and tourism development in Sri Lanka

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ABSTRACT

The study examines the dynamic nexus among carbon dioxide emissions, energy consumption, and tourism development in Sri Lanka. The tourism sector is one of the fastest-growing industries throughout the globe. This sector significantly contributes to the national development of a country in various ways, not only in developed countries but also in developing countries. However, activities related to the tourism sector contribute to environmental damage, such as transportation, establishing tourism destinations, discouraging wages, high presume on endangered species, and developing foreseeing fire, etc. Scholars for various studies have found conflicting results about the relationship between growing tourism and environmental degradation. Therefore, based on the ARDL cointegration analysis for the period 1990-2019 in Sri Lanka, this paper examines whether the tourism development has contributed to environmental damage, energy consumption, and economic growth. Statistical analysis of the data demonstrates that CO_2 emissions in Sri Lanka are negatively correlated with tourist arrival (TR) but positively correlated with tourism receipt (TR) and energy consumption (EC) in the long term. Further, the findings highlight that there is no significant relationship between CO_2 emissions and economic growth in Sri Lanka. The findings of this research ensure that the tourism industry can adjust to shifting energy conditions and economic dynamics by pointing policymakers in the direction of workable strategies that strike a balance between energy efficiency, economic growth, and sustainable tourism development.

Contribution/ Originality: This study represents a valuable contribution to the proposal and assessment of sustainable tourist development plans that strike a balance between environmental preservation and economic growth. Additionally, it urges that Sri Lanka's tourist industry adopt sustainable practices, energy-efficient technologies, and renewable energy sources to improve the energy efficiency of tourism-related activities and infrastructure.

1. INTRODUCTION

About 7.6% of global Gross Domestic Product (GDP)and exports are directly attributable to the travel and tourism sector(WTTC, 2022). Tourism visitors and revenues have been increasing at a rate of 3-5% annually, and it outperforms the development of international trade. It indicates that expanding economies are detrimental to ecological sustainability(WTTC, 2022). According to Tugcu and Topcu (2018), tourism is one of the global contributing factors to environmental deterioration. Lenzen et al. (2018) ascribed that nearly 8% of global greenhouse gases came from tourism, and it has increased from 3.9 to 4.5 $GtCO_2e$ between 2009 and 2013 because of some significant contributors such as food, shopping, and transport. Though tourism and travel have made important contributions to economic growth, they have entailed significant environmental costs, such as deterioration (Khan, Basit, Khan, & Khan, 2022). Commonly, transport is essential for tourism, and it relies heavily on energy consumption, intensifying the environmental damage. Further, the tourism industry will be affected by severe future changes and adaptation to increased risk due to climate change (Balli, Sigeze, Manga, Birdir, & Birdir, 2019; Dogru et al., 2020; Jebli, Ben Youssef, & Apergis, 2019). Increasing energy consumption causes increased environmental degradation but diminishes environmental degradation while increasing renewable energy consumption. The massive rise in tourist arrivals is significantly overwhelming the emissions reduction of tourism-related technology (Lenzen et al., 2018). The same source indicates that the high carbon intensity and continued growth of tourism will contribute to an increasing amount of greenhouse gas emissions in the global atmosphere.

Sri Lanka attracts many tourists since it is rich in nature, such as natural beaches, hills, waterfalls, ample sunshine, and more. Though the tourism sector heavily contributes in the direction of job creation, FOREX remunerations, and a stable supply of foreign income in direct and indirect ways, further, the tourism industry contributes nearly 12 percent to the GDP (Annual Report, 2022), and it is the major source of foreign exchange reserves, behind worker remittances and the apparel industry. However, by the end of 2019, it was reported that it would be shut down due to the Easter attack and COVID-19. However, a sizable influx of tourists into the nation's burgeoning energy consumption and service sector activities further causes the tourism industry to put a strain on environmental quality through natural resource degradation (Ali, Sadiq, et al., 2020).

It was shown that only a handful of studies, including those by Uddin, Bidisha, and Ozturk (2016); Muhammad, Long, Salman, and Dauda (2020) and Gamage, Hewa Kuruppuge, and Haq (2017) were undertaken to assess Sri Lanka's CO_2 emissions and economic growth, and those studies did not consider the tourism sector. Furthermore, considering Sri Lanka's tourism industry is growing rapidly, it is more important to examine the impact of CO_2 emissions from this sector as well. Since no attempt has been made yet to evaluate the CO_2 emission potential of this significant industry, this work is especially significant. Using the ARDL Cointegration method, this paper looks at how tourism affected CO_2, energy consumption, and economic growth in Sri Lanka from 1990 to 2019.

The research is organized as follows: Following the introduction section, extensive literature was presented. Part three covers the study's data and methodology, while part four gives the empirical findings. Similarly, conclusions and policy recommendations are presented in the last section.

2. REVIEW OF LITERATURE

Liu, Kumail, Ali, and Sadiq (2019) analyzed the connection between tourism revenue, GDP growth, energy use, and CO_2 emissions in Pakistan using ARDL and the Granger causality technique for the period from 1980 to 2016. Ali, Rahman, Zahid, Khan, and Kumail (2020) examined the effects of structural change, energy use, tourist arrivals, and GDP growth on environmental degradation in Pakistan between 1981 and 2017 by using an ARDL bound test and confirmed the existence of a long-run relationship between the variables. Further, the Granger causality approach showed that increases in energy use, tourism, and GDP were the primary contributors to global warming. Researchers in the European Union (Leitão & Lorente, 2020) investigated the correlation between GDP growth, renewable energy use, trade openness, tourist arrivals, and carbon dioxide emissions. Pedroni and Kao's residual cointegration test has proven the long-term cointegration between the variables, and carbon dioxide levels were found to rise in tandem with economic development. It also found that the number of visits had a negative correlation with the amount of carbon dioxide released. Hussain, Ullah, Khan, Syed, and Han (2023) used quarterly data from 1995 to 2019 to examine the dynamic relationship among tourism, transportation energy consumption, and carbon dioxide emissions in the United States. The wavelet coherence approach's findings confirm that tourism increases transportation energy consumption, whereas both tourism and energy consumption increase carbon emissions in the United States.

Ullah et al. (2022) examined how tourism affected Brazil's GDP and CO_2 emissions using a nonlinear ARDL method. They confirmed both short-run and long-run associations between the variables from 1995-2018. Further, they have proved that the Brazilian ecology is suffering from the country's rapid economic and tourist growth. Using the Johansen and Juselius ARDL bound test approach and the Gregory and Hansen structural break test, Sharif, Afshan, and Nisha (2017) analyzed CO_2 emissions, tourist visits, and GDP growth in Pakistan between 1972 and 2013. Long-term CO_2 emissions and visitor numbers go hand in hand. Furthermore, variance decomposition analysis supported their findings that an increase in tourism leads to elevated CO_2 emissions. Using dynamic ordinary least squares (DOLS) and fixed effects multilevel modeling (FMOLS), Ozturk, Aslan, and Altinoz (2022) analyzed CO_2 emissions, energy consumption, economic growth, and pilgrimage tourism in Saudi Arabia. They found that a combination of higher oil prices, more tourists, and increased energy consumption positively impacted CO_2 emissions. Further, oil prices were found to have a bidirectional causal relationship with both pilgrimage tourism and GDP, but carbon dioxide was only found to have a unidirectional causal relationship.

Dogan and Aslan (2017) employed a panel estimate approach to examine energy use, tourism, real income, and carbon emissions across several member states of the European Union (EU) between 1995 and 2011. Lagrangian Multiplier (LM) bootstrap panel cointegration confirmed the long-term relationships between the variables. The use of higher energy was found to raise CO_2 emissions despite GDP and tourism's ability to reduce emissions. Granger causality analysis confirmed that tourism and carbon emissions are only connected in one way, whereas real income and CO_2 emissions are connected in two directions. To measure how the rise in tourism development had affected CO_2 emissions, Jiaqi, Yang, Ziqi, Tingting, and Teo (2022) analyzed panel data for the top 70 tourist nations from 2000 to 2017. Researchers discovered that tourism had a direct positive effect on CO_2 emissions. From 1995-2010, Jebli et al. (2019) looked at the relationships among GDP growth, renewable energy use, tourism, and carbon dioxide emissions in Central and South American countries. Long-term findings reveal that renewable energy boosts CO_2 emissions by attracting more visitors, contradicting the short-term unidirectional causation that suggests the opposite. Since tourism, renewable energy, and foreign direct investment (FDI) have all contributed to higher resource consumption and waste, CO_2 emissions have increased.

The consequences of carbon emissions through tourism and globalization were studied by Muhammad et al. (2020). They found positive and negative effects of carbon emissions in South Asian countries. Furthermore, they found the environmental impact of tourism is mostly positive in Nepal and Sri Lanka but detrimental in Bangladesh, India, and Pakistan. Increased tourism in the world's most visited countries has been linked to higher levels of carbon dioxide (CO_2) emissions, which in turn contribute to climate change and global warming Koçak, Ulucak, and Ulucak (2020). Further, they concluded that tourism arrivals raise carbon dioxide (CO_2) emissions, but the revenue generated from these trips helps reduce emissions. With a panel Granger causality test, Akadiri, Lasisi, Uzuner, and Akadiri (2020) looked into the connection between tourism, GDP growth, and carbon emissions. Despite the findings supporting the hypotheses that pollution is concentrated in high-traffic locations, as well as the supply-led and demand-driven hypotheses.

Dogan, Seker, and Bulbul (2017) used Lagrangian multiplier bootstrap cointegration to examine long-term correlations, and they found increased trade is beneficial to the environment, but increased energy use and tourism are contributors to greenhouse gas emissions. For the Brazil, Russia, India, China, and South Africa (BRICS) economies between 1995 and 2014, Danish and Wang (2018) studied the impact of tourism on GDP growth and carbon dioxide emissions. While tourism is essential for the growth of the economy, which is linked to an uptick in greenhouse gas emissions. The Environment Kuznets Curve (EKC) hypothesis was tested using data on energy usage and the expansion of the tourism industry in Sri Lanka by Gamage et al. (2017) and confirmed that there is long-term cointegration among carbon emissions, income, tourism development, and energy consumption. Eyuboglu and Uzar (2020) looked into the connection between CO_2 emissions, tourist arrivals, energy consumption, and economic growth in Turkey from 1960 to 2014 and found more energy usage has decreased carbon dioxide emissions both in the short run and long run.

The connection between tourism arrivals, GDP growth, and carbon emissions was examined by Paramati, Alam, and Chen (2017) for both developed and developing countries. The finding corroborates the conventional wisdom that tourism is beneficial to the economies of both industrialized and developing nations, which supports the environmental Kuznets curve (EKC) theory. This theory posits that an increase in the number of tourists does not result in a corresponding increase in greenhouse gas emissions. Chen, Thapa, and Yan (2018)measured the impact of tourism on China's GDP and CO_2 emissions between 2001 and 2015. The results showed that increasing tourist arrivals are responsible for an increase in energy usage and carbon dioxide emissions. Lenzen et al. (2018) determined the carbon footprints of the tourism industries in 160 different countries. According to their investigation of data from a number of different sources, the tourism industry's global carbon footprint quadrupled between 2009 and 2013.

Tugcu and Topcu (2018)utilized the panel ARDL technique to analyze the correlation between carbon emissions and tourism revenue in the top ten global destinations. They found emissions from gaseous fuels have a positive impact on tourism revenues over the period of 1995–2010, while total emissions from solid fuels (only in the short term) and emissions from liquid fuels have negative impacts. Raihan, Ibrahim, and Muhtasim (2023)investigated the effects of economic growth, fossil fuel energy consumption, renewable energy consumption, tourism, and agricultural productivity on CO2 emissions in Egypt for the period from 1990 to 2019 and proved that economic growth, usage of fossil fuel energy, and tourism contribute to CO2 emissions in Egypt. Khan and Hou (2021) examined the impact of energy consumption and tourism growth on the ecological footprints and economic growth of 38 International Energy Agency (IEA) countries over the 1995–2018 period. The findings of the study indicate that energy consumption boosts economic growth but negatively impacts environmental quality, while tourism growth enhances environmental quality and stimulates long-term economic growth.

Kadir, Nayan, Mat Noor, and Zakaria (2019) demonstrate that the level of CO2 emissions significantly affects economic growth in 30 selected nationals from 1996 to 2014. The findings also supported the EKC hypotheses that the total number of tourists and energy use had a major impact on CO2 emissions. Using the vector error correction model and the Granger causality technique, Zhang and Zhang (2021) studied the correlation between tourism, GDP, energy usage, and CO2 emissions for 30 provinces in China between 2000 and 2017. The panel cointegration tests showed that the variables were related over time, and the Granger causality test showed that there was a short-term, two-way cause-and-effect link between GDP and tourism, carbon dioxide emission and GDP, and tourism and carbon dioxide emissions. Balli et al. (2019) investigated the impact of tourism on GDP growth in a number of Mediterranean countries, accounting for CO2 emissions by manipulating panel data. Long-run cointegration analyses revealed that the tourism industry, carbon emissions, and economic growth are positively correlated.

Between 1991 and 2018, Jayasinghe and Selvanathan (2021) used the autoregressive distributed lag and vector error correction model to investigate the relationship between India's energy consumption, carbon dioxide emissions, GDP, and the number of international tourists visiting the country. Electricity generation and transportation contribute to rising atmospheric carbon dioxide levels, resulting in linear growth in energy consumption, GDP, GDP2, and tourism. Khan et al. (2022) applied panel ARDL to study the effect of tourism, GDP growth, energy use, and oil consumption on carbon emissions from 1995 to 2019. The findings implied that endogenous variables have a significant and positive impact on environmental degradation, both in the long run and in the short run. Zhang and Zhang (2021) analysed the relationship between CO2 emissions, tourism, fossil fuels, and GDP growth from 1970 to 2019 by applying the inverse U-shaped EKC and the ARDL model in China. Their study concluded that a sophisticated GDP has a negative effect on CO2 emissions during the early stages of development, while a higher GDP has a favorable effect on CO2 emissions later on. While the use of petrol and electricity has little effect on CO2 emissions, the growth of the tourism industry, the usage of fossil fuels (coal and oil), and population increases all exhibit significant influences on CO2 emissions. Raihan and Tuspekova (2022) investigated the dynamic impacts of economic growth, energy use, urbanization, and tourism on CO2 emissions in Singapore by applying time series data from 1990 to 2019 and employing the dynamic ordinary least squares (DOLS) approach. The findings show that the long-run coefficient of economic growth is negative and significant. Furthermore, the coefficient of energy use is positive and significant. Moreover, the coefficient of tourism is positive and significant in the long run.

Using the bootstrap panel cointegration method and the augmented mean group estimator, Dogru et al. (2020) analyzed the impacts of GDP, renewable energy utilization, and tourism receipts on carbon dioxide emissions in Organisation of Economic Co-operation and Development (OECD) countries. Research shows that an increase in tourism has a beneficial impact on carbon dioxide emissions in Italy, Luxembourg, and the United Kingdom, but it has the opposite effect in Canada, the Czech Republic, and Turkey.

In conclusion, from empirical literature, the scholars found the relationship between CO_2 and its determinants may be positive or negative in various countries for different periods of time. Therefore, the impact of CO2 on tourism, energy consumption, and economic growth is still a debatable issue all over the globe. Scholars from Sri Lanka have conducted several research studies in this area, but they have not considered the impact of tourism on energy consumption, and economic growth. Thus, a study on the impact of CO2 emissions on tourism, energy consumption and economic growth in Sri Lanka is essential to explain the relationship between the above variables and enhance the existing knowledge of the field.

3. DATA AND METHODOLOGY

Using time-series data from 1990 to 2019, this study examines the nexus among CO_2 emissions, energy use, and tourism growth in Sri Lanka. Against this backdrop, the ARDL cointegration test was used to analyze the interdependent nature of the variables. The environmental degradation of the country is used as a proxy for CO_2 emissions throughout the study, and tourism arrival, GDP growth, energy use, and tourism revenue are serving as exploratory variables. All the data considered for this study are taken from the World Bank database and all variables are transformed into log form.

Table 1. Variables and description.

Variables	Description
CO_2 emissions (CO_2)	CO_2 total mt
Tourist arrival (TA)	International tourism, number of arrivals
Tourism receipt (TR)	Tourism receipt US$ Mn
Energy consumption (EC)	Primary energy consumption per capita (kWh/person)
Economic growth (EG)	GDP (Constant 2015 US$)

Table 1 presents the dependent and independent variables selected for the study and their measures. The variables are selected based on the previous scholar's research findings. Table 1 covers the annual series that spans from 1990 to 2019.

3.1. Unit Root Test

A unit root test is an essential tool in time series analysis because it determines the stationarity of the series. Also, it helps to choose the model and methods. The following assumptions were established for the use of ADF and PP methods to determine the stationarity of the selected variables:

$H_0 = \beta_1 = 1$ (Non-Stationary).

$H_0 = \delta_1 = 0$ (Stationary).

In general, a p-value of less than 1%, 5%, and 10% rejects the null hypothesis that a unit root exists.

3.2. ARDL Bounds Test

Autoregressive Distributed Lag (ARDL) approach to co-integration was employed to investigate the existence of long-run relationship between the variables due to the variables are in I(1) and I(0) which was developed by Pesaran, Shin, and Smith (2001). The method is based on a rough approximation of the following equation.

$$\Delta LnCO_{2t} = \alpha_0 + \sum_{i=1}^{p} \propto_i \Delta LnCO2_{t-i} + \sum_{i=1}^{q1} \propto_2 \Delta LnTA_{t-i} + \sum_{i=1}^{q2} \propto_3 \Delta LnTR_{t-i} + \sum_{i=1}^{q3} \propto_4 \Delta LnEC_{t-i} + \sum_{i=1}^{q4} \propto_5 \Delta LnGDP_{t-i} + \delta_1 LnCO2_{t-1} + \delta_2 LnTA_{t-1} + \delta_3 LnTR_{t-1} + \delta_4 LnEC_{t-1} + \delta_5 LnGDP_{t-1} + u_t \quad (1)$$

In the equation above, the short-run dynamic coefficients are denoted by $\alpha 1, \alpha 2, \alpha 3, \alpha 4$ and $\alpha 5$ and the long-run coefficients are represented by $\delta 1, \delta 2, \delta 3, \delta 4$ and $\delta 5$. The optimal lag lengths for each variable are p, q1, q2, q3, and q4 accordingly. The model's error term is ut. The following hypothesis will be applied to examine whether co-integrating relationships exist between the variables based on the F-test.

H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ - No cointegration among the variables.

H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$ - Cointegration among the variables.

3.3. Error Correction Model (ECM)

After investigating the cointegrating relationship between the variables, the study employed the error correction term with one period lagged (ECT_{t-1}) to examine the long-run and short-run dynamics of the variables by transforming Equation 1. The value of Error Correction Term(ECT) might b variesas positive or negative. In the positive range, the equilibrium is probably not stable. If it is negative, the equilibrium is stable. Further, because the value of ECM is small, the system is always stable, assuming there are no transient disturbances. Also, the value of the ECT (percentage) represents the rate changes towards the long-run equilibrium. Finally, the post-estimation diagnostics are test performed to determine how the model (1) fits with the data.

$$\Delta LnCo_{2t} = \delta_0 + \sum_{i=1}^{p} \delta_1 \Delta LnCO2_{t-i} + \sum_{i=0}^{q1} \delta_2 \Delta LnTA_{t-i} + \sum_{i=0}^{q2} \delta_3 \Delta LnTR_{t-i} + \sum_{i=0}^{q3} \beta_4 \Delta LnEC_{t-i} + \sum_{i=0}^{q4} \beta_5 \Delta LnEG_{t-i} + \lambda \Delta ECT_{t-1} + v_t$$

4. RESEARCH FINDINGS

Table 2 presents the outcomes of the unit root tests of the present study. According to the ADF and PP tests, variables considered for the study, such as carbon dioxide emission (CO_2), Tourism Arrival (TA), Tourism Receipt (TR), Economic Growth (EG)and Energy consumption (EC) are stationary in the first difference I (1) at 5% and 1% significant levels.

Table 2. Unit root test result.

Variables tests	Carbon dioxide emission	Tourism arrival (TA)	Tourism receipt (TR)	Energy consumption (EC)	Economic growth (EG)
Augmented Dickey-Fuller test (ADF)					
Level I(0)	0.526	0.875	0.922	0.836	0.908
1st Difference I(1)	0.000***	0.012**	0.023**	0.001***	0.015**
Phillips-Perron test (PP)					
Level I(0)	0.140	0.941	0.970	0.790	0.909
1st Difference I(1)	0.000***	0.013**	0.023**	0.000***	0.015**

Note: ** and *** indicate cointegration at 10%, and 5% respectively.

The variables' stationarity was assessed by the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, as shown in Table 3. According to Table 3, all the variables are non-stationary at the 5% level of significance. After a test at the first difference, the results showed that all of the variables are integrated of order I(1) and stationary at the first difference.

Further, the appropriate lag lengths were selected on the basis of the Schwarz Criterion (SC), and it suggested using the ARDL (2, 3, 1, 0, 3) model, as the best model among the top 20 models, for this analysis.

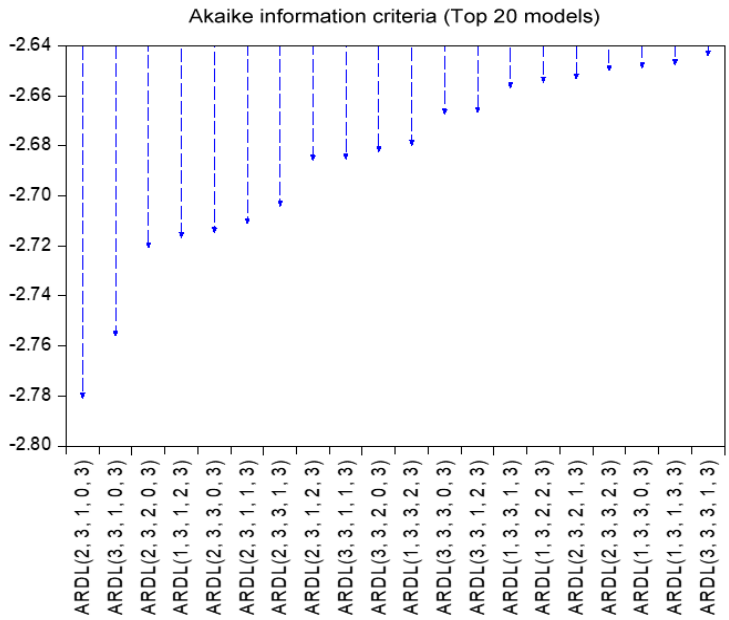

Figure 1. Model selection criteria.

The above Figure 1 explains the best ARDL model of 2,3,1,0,3 for the present study.

4.1. Estimation of ARDL Bounds Test

Table 3 explains the outcomes of the ARDL Bounds test. The computed value of F-statistic (10.029) is greater than 5% of the upper value (3.49), which means the null hypothesis of no cointegration is rejected at the 5% level of significance and indicates the existence of a long-run relationship between the variables.

Table 3. Results of ARDL bound test.

Critical values	Value	Significant	Level of significance	
			Lower bound I(0)	Upper bound I(1)
ARDL	2, 3, 1, 0, 3	10%	2.2	3.09
F-bounds test	10.029	5%	2.56	3.49
K	4	1%	3.29	4.37

4.2. Estimation of Long Run Relationship

The present study investigated the relationship between carbon dioxide emission (CO_2), Tourism Arrival (TA), Tourism Receipt (TR), Economic Growth (EG)and Energy consumption (EC) for the period from 1990 to 2019 using ARDL approach. The estimated long-run findings are explained in Table 4.

Table 4 presents the long-run relationship between the dependent variable and the independent variables. In the long-run tourist arrival (TA) has a strong negative and statistically significant impact on carbon dioxide emissions (CO_2). This implies that higher tourist arrivals reduce the CO_2 emissions in Sri Lanka during the period of 1990- 2019.These results corroborate the findings of Liu et al. (2019). But tourist receipt (LTR) and energy consumption (LEC) have a strong positive and statistically significant impact on carbon dioxide emission (CO_2), which suggests higher tourist receipt and higher energy consumption increase the CO_2 emission in Sri Lanka.

Table 4. Estimation of long run relationship.

Variable	Coefficient	Std. error	t-statistic	Prob.
AR	-4.453	1.978	-2.251	0.042
TR	2.750	1.314	2.092	0.056
EC	1.515	0.523	2.892	0.012
EG	-0.349	0.573	-0.609	0.552
C	41.420	28.706	1.442	0.172

These findings are similar to those of Ullah et al. (2022); Raihan et al. (2023) and Raihan and Tuspekova (2022). Furthermore, the majority of researchers discovered a positive correlation between environmental deterioration (CO2) and economic growth (EG) (Khan et al., 2022; Raihan et al., 2023; Ullah et al., 2022). However, the present study indicated a negative correlation, but it was not a statistically significant relationship between CO2 and economic growth. Furthermore, during the study period, a strong positive correlation was observed between energy consumption and CO2 emissions in Sri Lanka. With the exception of Eyuboglu and Uzar (2020) finding in Turkey, subsequent research (Hussain et al., 2023; Khan et al., 2022; Khan & Hou, 2021; Raihan et al., 2023) has supported this findings.

4.3. Estimation of Short Run Relationship of the Coefficients

In Table 5, the negative and statistically significant Error Correction Model (ECM) indicates that the disequilibrium is being corrected annually towards a long-run equilibrium by 56 percent. Tourist arrivals have a significant negative impact on CO_2 emissions in Sri Lanka in the short run and long run, except for the lag length of two. Tourist receipts and energy consumption also show a strong positive and significant impact in the long run and short run. In addition, the higher the Durbin-Watson statistic than the R squared, the more likely it is that the model is free from spuriousness problems.

Table 5. Findings of the error correction model.

Variable	Coefficient	Std. error	t-statistic	Prob.
C	0.030	0.050	0.602	0.558
D(CO2(-1))	0.316	0.133	2.360	0.037
D(CO2(-2))	0.332	0.106	3.116	0.009
D(AR)	-1.447	0.315	-4.596	0.000
D(AR(-1))	-0.773	0.238	-3.239	0.007
D(AR(-2))	0.156	0.084	1.854	0.090
D(AR(-3))	-0.540	0.080	-6.742	0.000
D(TR)	0.700	0.225	3.108	0.009
D(TR(-1))	0.846	0.178	4.756	0.000
D(EC)	0.000	7.080	3.870	0.002
D(EG)	1.975	0.469	4.202	0.001
D(EG(-1))	-3.196	0.560	-5.697	0.000
D(EG(-2))	-1.106	0.582	-1.899	0.084
D(EG(-3))	1.495	0.636	2.351	0.038
ECT(-1)	-0.563	0.276	-2.036	0.046
R-squared	0.924	Durbin-Watson stat		1.987
Adjusted R-squared		0.858		

Table 6. Diagnostic tests.

Diagnostic test	Prob. value
Heteroskedasticity test: ARCH	0.267
Breusch-Godfrey serial correlation LM test	0.100
Jarque-Bera test	0.884
Ramsey's RESET test	0.083

As illustrated in Table 6, the Breusch-Godfrey serial correlation LM test value (0.100) is greater than the 5% significant level, indicating that the error term follows a normal distribution and the derived model shows no serial correlation. There is no inhomogeneity problem since the ARCHLM test is 0.267. There are no missing variables in the short-run model, and the model has a valid function form, as shown by the Ramsey's RESET test (0.083).

Given that the Jarque-Bera value (0.244) is less than 3 and probability value (0.8848)) is higher than at a 5% significant level, the Normality test - Histogram (shown in Figure 2a) suggest that the error follows a normal distribution.

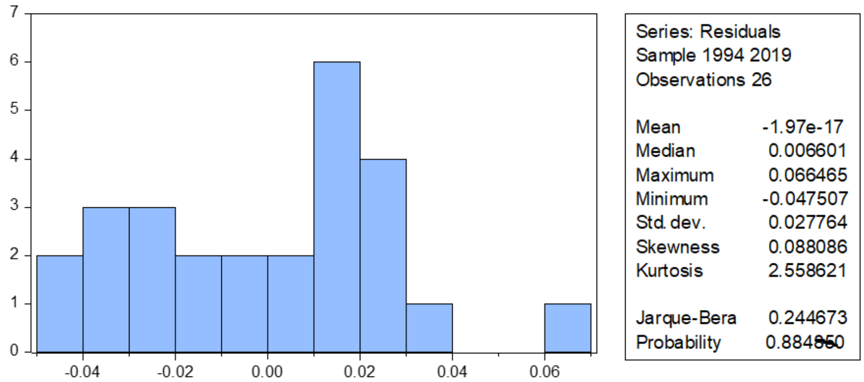

Figure 2a. Normality test.

4.3. Stability Test

By applying the CUSUM test, the stability of the long-run coefficients and the short-run dynamics are evaluated.

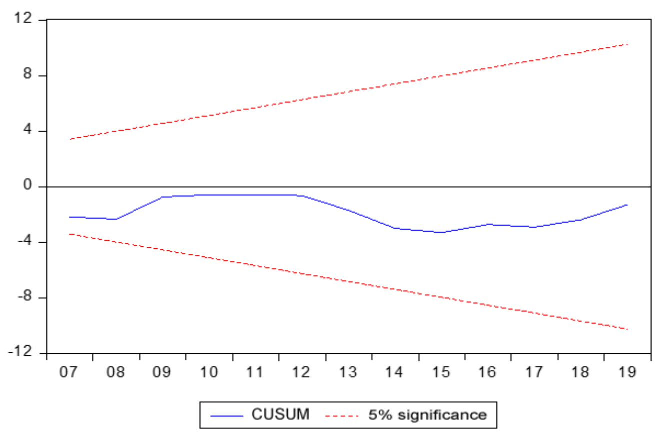

Figure 2b. Stability of the model.

As shown in Figure 2b, the plots of the CUSUM test lie within the critical bounds of the 5 percent significance level. These tests indicate that the model was stable during the study period.

5. CONCLUSION

The purpose of this analysis was to identify the associations among carbon dioxide emissions, tourist arrivals, tourist receipts, economic growth, and energy consumption in Sri Lanka from 1990 to 2019. The ARDL cointegration findings revealed existence of a long-run relationship between CO_2 emissions and their drivers in Sri Lanka. The VAR model was used to forecast the short- and long-run output of the study. The study found a positive impact on environmental quality, indicating that an increase in the number of arrivals could decrease CO_2 emissions. It has been shown that an increase in a country's tourist income is also accompanied by an improvement in environmental quality due to positive link between CO_2 emissions and tourist receipts, which indicate that increasing tourist income improves environmental quality. Given that the majority of the country's economic activities are energy-related and generate substantial amounts of CO_2 emissions, which are harmful to the environment. The findings are similar to the work of Ullah et al. (2022) for Brazil; (Ozturk et al., 2022) for Saudi Arabia; (Jiaqi et al., 2022) for the top 70 tourist countries. Therefore, it is essential to develop comprehensive energy and tourism development strategies that are required to achieve long-term sustainable growth. It means action should be taken to promote and raise the proportion of renewable energy sources in the nation's overall energy mix.

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Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by Sarojini Maheswaranathan.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

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