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Dirty Dance: Tourism and Environment

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Dirty Dance: Tourism and Environment

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Abstract

Tourism was one of the fastest-growing sectors before the COVID-19 pandemic, accounting for about 10 percent of global GDP. But it has also created a number of challenges including environmental degradation, especially in small island countries where the carbon footprint of tourism constitute substantial share of carbon dioxide (CO_2) emissions. This study empirically investigates the impact of tourism on CO_2 emissions in a relatively homogenous panel of 15 Caribbean countries over the period 1960–2019. The results show that international tourist arrivals have a statistically and economically significant effect on CO_2 emissions, after controlling for other economic, institutional and social factors. Therefore, managing tourism sustainably requires a comprehensive set of policies and reforms aimed at reducing its impact on environmental quality and curbing excessive dependency on fossil fuel-based energy consumption.

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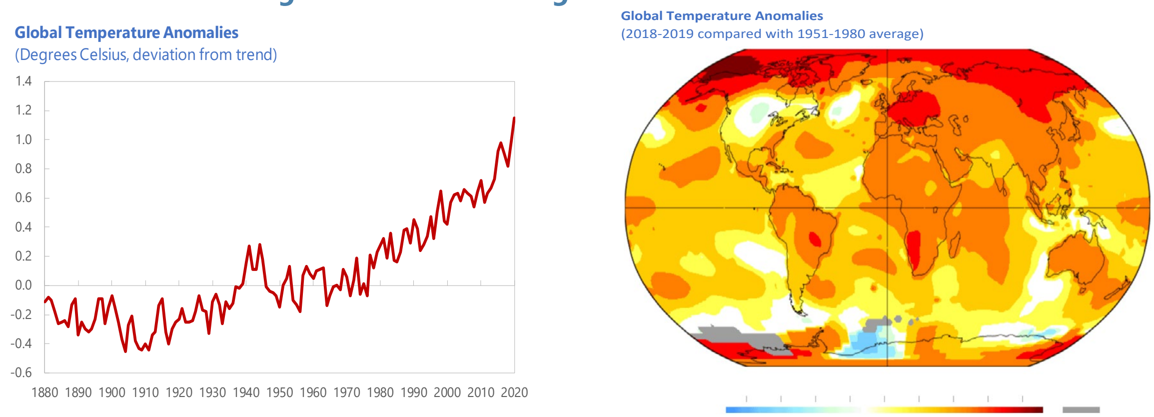
I. Introduction

Climate change is one of the most significant threats to people's health and living standards, especially in countries with limited economic diversification. Earth's global surface temperature has already increased by about 1.1 degrees Celsius (°C) compared with the preindustrial average, heightening the intensity and frequency of extreme weather events (Figure 1). Looking forward, the risk of destructive climate shocks, including heat waves, forest fires, large-scale flooding and severe storms, is projected to increase with global warming by as much as 4°C over the next century and rising sea level by at least 35 centimeters above the level recorded in 2000 (IPCC 2007, 2014, 2019; 2021; Stern 2007). If greenhouse-gas (GHG) emissions continue increasing at the current rate, global warming is projected to reach 4-6°C by 2100, an unprecedented shift with irreversible environmental changes unseen in millions of years (Hansen and others, 2013). These developments therefore pose a significant challenge to developing countries with limited economic diversification.

This paper explores the relationship between tourism and environment. Before the COVID-19 pandemic, tourism was one of the fastest-growing sectors across the world, accounting for 10 percent of global GDP and acting as a catalyst for economic development, especially in small island states. While it benefits greatly from clean environment, tourism contributes to GHG emissions and other environmental problems (Lenzen and others, 2018). This contradiction is even greater in the Caribbean, where tourism accounts for as much as 90 percent of GDP and 80 percent of energy-related carbon dioxide (CO_2) emissions (Figure 2). This is why the relationship between tourism and CO_2 emissions is critical for sustainable economic development as well as the protection of natural resources that are the main point of attraction for international tourists coming to the Caribbean with low-lying islands and cays spread within the Atlantic Hurricane Belt.[2] Recent research shows that climate change vulnerability already has a significant negative

Figure 1. Climate Change and Weather Anomalies



Source: NOAA.

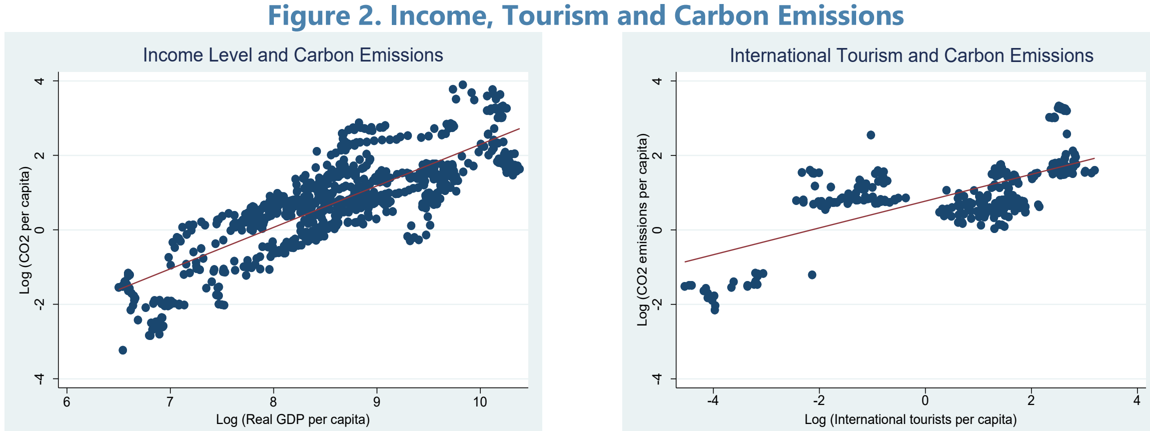
[2] Small island states are particularly vulnerable to weather-related disasters. In the Caribbean, the cost of Hurricane Ivan for Grenada in 2004 amounted to 148 percent of GDP and Hurricane Maria for Dominica in 2017 reached 260 percent, reflecting both the intensity of hurricane damage and the small size of these economies.

effect on international tourism revenues across the Caribbean (Cevik and Ghazanchyan, 2021). For example, a 10 percentage-point increase in climate change vulnerability leads to a decline of 9 percentage points in tourism earnings per visitor (or a reduction of 10 percentage points in tourism revenues as a share of GDP), even after controlling for conventional macroeconomic and social factors. But tourism also contributes to environmental degradation and global warming.

There is growing interest on the relationship between tourism and environment, and this study contributes to the literature by empirically analyzing the impact of international tourism on CO_2 emissions in a relatively homogeneous panel of 15 tourism-dependent Caribbean countries over the period 1960–2019 and thereby providing robust estimates based on alternative specifications and estimation methodologies. The results show that international tourism has an statistically and economically significant detrimental effect on the environment by increasing CO_2 emissions across the Caribbean. An increase of 10 percent in international tourist arrivals is associated with an increase of as much as 8 percent in CO_2 emissions, after controlling for the level of economic development and other economic, institutional and social factors. The impact of tourism on CO_2 emissions occurs through several channels in Caribbean countries, including carbon-intensive energy production and consumption of material resources in accommodation, transportation and other tourist activities, and changes in land use associated with tourism-related investments.

From a global perspective, there is no doubt that large carbon-emitting countries are responsible for the great majority of emissions correction the world needs. This creates a policy tension between climate change mitigation and adaptation in smaller countries with potentially high marginal returns to adaption (due to greater physical risks) and smaller marginal returns to mitigation (as they are not large emitters). While there are trade-offs between investing in climate change mitigation and adaptation, these investments could be complementary elements of a broader strategy to respond to climate change. All countries including small island states need to pursue policies and reforms aimed at reducing energy-related CO_2 emissions, as well as adapting to the worst effects of climate change. An important illustration of mitigation-adaptation interlinkages in the Caribbean is energy supply and consumption, which is

Figure 2. Income, Tourism and Carbon Emissions



Source: GCA; IMF; World Bank; author's calculations.

determined to a great extent by tourism-related activities. Aligning mitigation and adaptation strategies would in turn provide diverse ecological, economic and social benefits and opportunities. It is therefore critical for sustainability and well-being to focus on the impact of tourism on environment, which consequently has an adverse effect on the Caribbean's attractiveness as a high-end destination. Managing tourism sustainably requires reducing its impact on environmental quality and curbing excessive dependency on fossil fuel-based energy consumption—the main source of CO_2 emissions. To this end, Caribbean countries could reduce CO_2 emissions by: (i) decarbonizing the energy sector with very high shares of renewables; (ii) electrifying mobility and transportation; and (iii) developing sustainable land-use practices and smarter urbanization. Finally, although cutting CO_2 emissions is necessary for sustainable tourism and climate change mitigation, small island states in the Caribbean also urgently need to invest in climate-resilient infrastructure against stronger and more destructive hurricanes and rising sea levels, which pose an existential threat.

The remainder of this study is organized as follows. Section II provides an overview of the related literature. Section III describes the data used in the analysis. Section IV introduces the salient features of our econometric strategy. Section V presents the empirical results, including a series of robustness checks. Finally, Section VI offers concluding remarks with policy implications.

II. A Brief Review of the Literature

This paper brings together a number of fast-growing branches of the literature. The first strand of research examines the relationship between economic growth and CO_2 emissions—the so-called Environmental Kuznets Curve (EKC) hypothesis that posits an inverted U-shaped pattern. Empirical findings in this area, however, remain inconclusive. While some studies obtain evidence in support of the EKC hypothesis (Hettige, Lucas, and Wheeler, 1992; Cropper and Griffiths, 1994; Selden and Song, 1994; Grossman and Krueger, 1995; Dinda, Coondoo, and Pal, 2000; Galeotti, Lanza, and Pauli, 2006; Narayan and Narayan, 2010), others conclude that greenhouse gas emissions are driven by economic cycles and monotonically increasing with per capita income levels (Shafik, 1994; Holtz-Eakin and Selden, 1995; Ang, 2008; Sharma, 2011; Doda, 2014; Feng and others, 2015; Gonzalez-Sanchez and Martin-Ortega, 2020). Harbaugh, Levinson, and Wilson (2002), Millimet, List, and Stengos (2003), and Stern (2004) question the technical reliability of these estimates and point out that most studies on the EKC hypothesis are not econometrically robust owing to the problem of multicollinearity.

The second strand of the empirical literature investigates the link between tourism and economic growth, yielding inconsistent results. Some studies, using time-series data from tourism-dependent countries, show a strong relationship between tourism activity and economic development (Hazari and Sgro, 1995; Lanza and Pigliaru, 2000; Balaguer and Cantavella-Jorda, 2002; Durbarry, 2004; Gündüz and Hatemi-J, 2005; Kim, Chen, and Jang, 2006; Lean and Tang, 2010). Others, however, find no significant impact of tourism on economic growth, including in the Caribbean (Modeste, 1995; Oh, 2005; Gökovali and Bahar, 2006; Lee and Chang, 2008; Katircioglu, 2009; Payne and Mervar, 2010; Brida, Punzo, and Risso, 2011; Antonakakis, Dragouni, and Filis, 2015).

The third strand focusses on the relationship between tourism and environment. While tourism benefits from environmental quality and has a positive effect on economic growth in many advanced and developing countries, it is also found to contribute to environmental degradation and natural habitat loss. First, as the tourism sector grows, the exploitation of natural resources increases the risk of environmental damage due partly to changes in land use associated with tourism (Tovar and Lockwood, 2008; Özturk, Al-Mulali, and Saboori, 2016; Bilgili and others, 2017; Raza and others, 2017; Katircioglu, Gökmenoglu, and Eren, 2018). Second, the rise in tourism increases energy consumption and consequently leads to higher levels of GHG emissions in the environment, especially in small island states (Gössling, 2000; 2002; 2013; Becken, Frampton, and Simmons, 2001; Dwyer and others, 2010; Hall, Scott, and Gössling, 2013; Lee and Brahmasrene, 2013; Katircioglu, Feridun, and Kilinc, 2014; Gössling and Peeters, 2015; Zaman and others, 2016; Paramati, Alam, and Chen, 2017; Koçak, Ulucak, and Ulucak, 2020; Gao, Xu, and Zhang, 2021; Tian, Bélaïd, and Ahmad, 2021). This study, however, contributes to the literature by analyzing the impact of international tourism on CO_2 emissions in a relatively homogeneous panel of small island states in the Caribbean with the latest data covering a long period and thereby providing robust estimates based on alternative specifications and methodologies.

III. DATA OVERVIEW

This study focuses on a sample of 15 Caribbean countries and employs an unbalanced panel of annual observations over the period over the period 1960–2019.[3] Economic and financial statistics are assembled from the IMF's International Financial Statistics (IFS) and World Economic Outlook (WEO) databases, the World Bank's World Development Indicators (WDI) database, the Global Carbon Atlas (GCA) database, and the International Country Risk Guide (ICRG) database. The dependent variable in this paper is territory-based CO_2 emissions in metric tons per capita as an indicator of overall GHG emissions in a given country.[4] The main explanatory variable of interest in the empirical analysis is tourism activity as measured by the number of international tourist arrivals. To make sure that estimations are not biased by omitted variables, I include both the linear and quadratic terms of real GDP per capita measured in constant 2010 US$[5], real GDP growth, trade openness, population, the share of urban population, a composite index of government effectiveness as control variables, which are widely used in the literature.

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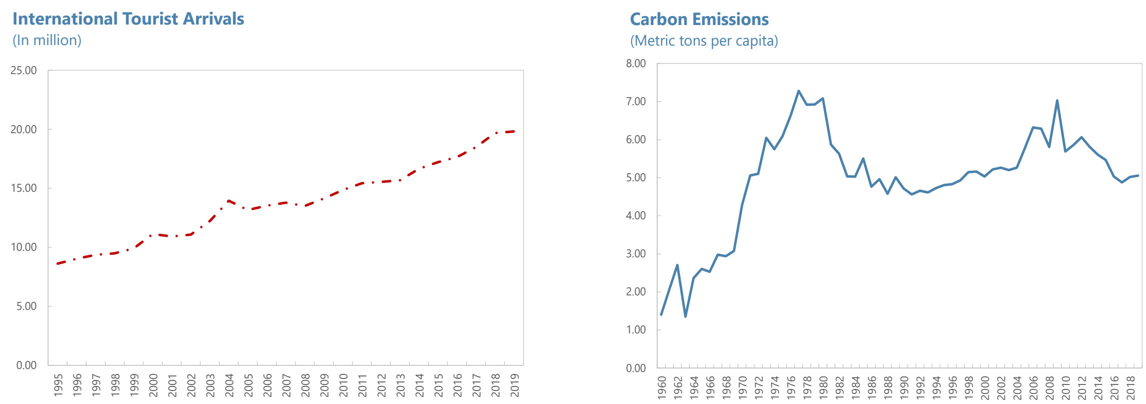
[3] The countries in the sample are Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Dominica, Dominican Republic, Grenada, Guyana, Haiti, Jamaica, St Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Suriname. Although the emissions data is available since 1960, tourism statistics become available only after 1990 for most countries in the sample. Similarly, the inclusion of government effectiveness as a control variable further reduces the size of the sample due to uneven data availability.

[4] Territorial CO_2 emissions are from the use of coal, oil and gas (combustion and industrial processes), the process of gas flaring, and the manufacture of cement. Accordingly, the data includes CO_2 emissions from domestic flights, but not from bunker fuels associated with international aviation and maritime operations.

[5] The logarithm of real GDP per capita may be collinear with its squared term; thus I demean the logarithm of real GDP per capita to reduce collinearity.

Summary statistics for the main variables used in the analysis are presented in Table 1. Although the Caribbean is a relatively homogenous region, there is still a significant degree of dispersion across countries and over time in terms of CO_2 emissions and considerable heterogeneity in the number of international tourist arrivals. CO_2 emissions per capita, the dependent variable in this study, has a sample mean of 4.55 tons and ranges from a minimum of 0.02 tons to a maximum of 49.26 tons during the period 1960–2019. On average, CO_2 emissions per capita increased by over 260 percent from 1.40 tons in 1960 to 5.06 tons in 2019, but the pace of growth slowed down in the mid-1990s and especially after the global financial crisis in 2008. Similarly, with regards to the main variable of interest, the Caribbean attracts more than 1.26 million international tourists on average during the sample period, with a minimum of 43,000 and a maximum of 7.6 million. The number of foreign visitors to the Caribbean recorded a significant increase from 8.6 million in 1995 to 19.8 million in 2019, but the pace of growth slowing from 5.3 percent in the second half of the 1990s to 2.9 percent in the 2000s and 3.6 percent in the 2010s. Control variables show similar patterns of variation among countries, with an upward trend in the level of economic development over time across the region.

Figure 3. International Tourism and Carbon Emissions



Source: World Bank; GCA; author's calculations.

Table 1. Summary Statistics

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
CO_2 emissions per capita	880	4.55	6.81	0.02	49.26
Tourism arrivals	403	1,255,450	1,533,166	43,000	7,600,000
Real GDP per capita	843	8,494	7,627	666	32,237
Real GDP growth	827	1.9	4.9	-19.1	27.3
Trade openness	617	100.4	35.1	31.1	275.0
Government effectiveness	492	2.1	1.1	0.0	3.0
Population	728	1,374,275	2,717,864	40,259	11,000,000
Urbanization	728	44.8	16.6	15.6	83.1

Source: IMF; World Bank; ICRG; author's calculations.

Table 2. Correlation Matrix

	CO_2 emissions	Tourism arrivals	Real GDP per capita	Real GDP growth	Trade openness	Government effectiveness
CO_2 emissions per capita	1.00					
Tourist arrivals	0.41	1.00				
Real GDP per capita	0.89	0.50	1.00			
Real GDP growth	-0.13	0.03	-0.20	1.00		
Trade openness	0.42	-0.42	0.25	-0.11	1.00	
Government effectiveness	0.82	0.16	0.82	-0.15	0.52	1.00

Source: Author's calculations.

Table 3. Variable Inflation Factor

Variable	VIF
Real GDP per capita	3.97
Government effectiveness	3.56
Tourist arrivals	2.58
Trade openness	2.38
Real GDP growth	1.02

Source: Author's calculations.

The correlation matrix, presented in Table 2, is the first step in analyzing the nature of the relationship between dependent and explanatory variables used in this study. Although multicollinearity does not lead to biased results, it could affect the reliability of estimated coefficients due to large standard errors in the related independent variables, which consequently leads to larger confidence intervals. The problem of multicollinearity becomes likely when the correlation coefficient among independent variables exceeds 0.7, which is not the case for international tourist arrivals and real GDP per capita as well as other explanatory variables. The absence of multicollinearity is also confirmed by performing the variable inflation factor (VIF) test. As presented in Table 3, none of the independent variables has a VIF above 10 and thus shows signs of potential multicollinearity.

IV. Empirical Methodology

The objective of this paper is to empirically investigate the impact of international tourism on CO_2 emissions by applying alternative specifications. The baseline empirical model is estimated in the following specification:

$$ln(car_{c,t}) = \beta_1 + \beta_2 \ln(car_{c,t-1}) + \beta_3 \ln(tur_{c,t}) + \beta_4 X_{c,t} + \eta_c + \mu_t + \varepsilon_{c,t}$$

where $car_{c,t}$ denotes CO_2 emissions per capita in country c and time t; $tur_{c,t}$ is the number of international tourist arrivals; $X_{c,t}$ is a vector of control variables including the logarithm of real GDP per capita and its quadratic term, real GDP growth, trade openness, and a measure of government effectiveness.[6] The η_c and μ_t coefficients denote the time-invariant country-specific effects and the time effects controlling for common shocks that may affect CO_2 emissions across all countries in a given year, respectively. $\varepsilon_{c,t}$ is the idiosyncratic error term. To account for possible heteroskedasticity, robust standard errors are clustered at the country level.

I estimate and present the standard fixed effects model as a point of reference, but it is also important to capture persistence in CO_2 emissions over time with a dynamic model. The presence of the country-specific effect in conjunction with the lagged dependent variable may cause a bias in the conventional least squares estimator when the time dimension is fixed, due to a correlation between the error term and the lagged dependent variable in the transformed model. Accordingly, I also use the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) to confirm the results and take into account inertia in CO_2 emissions. The system GMM approach involves constructing two sets of equations, one with first differences of the endogenous and pre-determined variables instrumented by suitable lags of their own levels, and one with the levels of the endogenous and pre-determined variables instrumented with suitable lags of their own first differences. The one-step version of the system GMM estimator is applied to ensure the robustness of the results, as the standard errors from the two-step variant of the system GMM method are known to be downward biased in small samples.

The use of all available lagged levels of the variables in the GMM estimation leads to a proliferation in the number of instruments, which reduces the efficiency of the estimator in finite samples, and potentially leads to over-fitting. A further issue is that the use of a large number of instruments significantly weakens the Hansen *J*-test of over-identifying restrictions, and so the detection of over-identification is hardest when it is most needed. Conversely, however, restricting the instrument set too much results in a loss of information that leads to imprecisely estimated coefficients. Estimation of such models therefore involves a delicate balance between maximizing the information extracted from the data on the one hand, and guarding against over-identification on the other. To this end, I follow the strategy suggested by Roodman (2009) to deal with the problem of weak and excessively numerous instruments. The system GMM identification assumptions are also validated by applying a second-order serial correlation test for the residuals and the Hansen *J*-test for the overidentifying restrictions. The values reported for AR(1) and AR(2) in Table 1 for baseline results and Table 2 for robustness checks are the *p*-values for first- and second-order autocorrelated disturbances in the first-differenced equation. As expected, there is high first-order autocorrelation, but no evidence for significant second-order autocorrelation. Similarly, the Hansen *J*-test result indicate the validity of internal instruments used in the dynamic model estimated via the system GMM approach.

V. Estimation Results

The baseline empirical findings, displayed Table 4, indicate a strong fit of the model to the dataset, with the expected signs across all specifications. The static models are presented in

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[6] For robustness, the empirical model is also estimated including demographic variables such as population and the share of urban population as additional control variables.

columns [1] and [2], starting with a basic specification to show the relationship between economic development and CO_2 emissions in Caribbean countries. The results indicate that the elasticity of CO_2 emissions per capita with respect to real GDP per capita is positive but becomes negative with the quadratic term of real GDP per capita. This is consistent with the EKC hypothesis, which suggests a nonlinear relationship between real GDP per capita and CO_2 emissions per capita. Following an inverted U-shaped pattern, increases in the level of per capita income initially leads to higher levels of CO_2 emissions, but then lower CO_2 emissions per capita after reaching a certain level of economic development. Similarly, there is a strong positive relationship between real GDP growth and CO_2 emissions as expected. Higher rates of growth leads to an increase in CO_2 emissions per capita, irrespective of the level of real GDP per capita.

Trade openness, on the other hand, has a statistically significant negative effect on CO_2 emissions, implying that greater trade openness improves environmental quality in the Caribbean, where countries tend to import even basic necessities due to the limited capacity for

Table 4. Tourism and Carbon Emissions: Baseline Estimations

	Fixed Effects		**System GMM**	
	[1]	**[2]**	**[3]**	**[4]**
CO2 emissions per capita$_{t-1}$	0.865***	0.737***	0.947***	0.737***
	[0.044]	[0.136]	[0.010]	[0.113]
Tourist arrivals		0.077***		0.066***
		[0.030]		[0.025]
Real GDP per capita	0.363***	1.047**	0.272***	1.030***
	[0.045]	[0.231]	[0.124]	[0.227]
Real GDP per capita squared	-0.016**	-0.059**	-0.013**	-0.063**
	[0.026]	[0.033]	[0.007]	[0.013]
Real GDP growth	0.003***	0.002***	0.004***	0.001**
	[0.002]	[0.006]	[0.002]	[0.001]
Trade openness		0.001***		0.048
		[0.040]		[0.039]
Government effectiveness		-0.076		-0.056***
		[0.024]		[0.017]
Number of observations	807	172	807	172
Number of countries	15	15	15	15
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj R^2	0.89	0.71		
AR1 p -value			0.002	0.002
AR2 p -value			0.647	0.225
Hansen J -test p -value			0.245	0.188

Note: The dependent variable is CO2 emissions per capita. Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

domestic manufacturing. Globalization as captured by greater trade openness may also lead to stronger adherence to international environmental protocols and thereby lower CO_2 emissions. The coefficient on government effectiveness, a proxy measure for the quality of policies and institutions, turns out to be negative, implying that governments play a role in lowering CO_2 emissions. Although this effect is not statistically significant at conventional levels, it indicates that reforms aimed at improving government effectiveness may also contribute to environmental quality in the Caribbean.

As for the key explanatory variable of interest, the results show that the elasticity of CO_2 emissions with respect to the number of international tourist arrivals is positive and statistically significant, after controlling for conventional factors. This implies that an increase in international tourism is associated with higher level of CO_2 emissions per capita in the Caribbean during the sample period. The estimated coefficient on international tourist arrivals is 0.077 in the static empirical specification, which is statistically and economically highly significant. This is not an surprising result, as more foreign visitors create additional demand for energy, which in turn leads to an increase in CO_2 emissions and consequently undermines environmental quality in Caribbean countries that are largely dependent on fossil fuels in electricity generation.

The standard fixed effects model provides as a point of reference, but it is also important to capture persistence in CO_2 emissions over time with a dynamic model estimated via the system GMM approach. These results, presented in columns [3] and [4] of Table 4, indicate that the lagged dependent variable (CO_2 emissions per capita) has a statistically and economically significant coefficient. With regards to the main explanatory variable of interest, the results indicate that international tourist arrivals remain a significant factor in determining the trajectory of CO_2 emissions in Caribbean countries. The estimated coefficient remains positive and statistically significant, albeit with a marginally lower magnitude in dynamic modelling (0.066 compared to 0.077 in static modelling). In other words, an increase of 10 percent in the number of international visitors is associated with an increase of about 7 percent in CO_2 emissions. This confirms that the impact of tourism is critical in determining the trajectory of CO_2 emissions in the Caribbean, even after taking into account conventional factors and persistence in CO_2 emissions over time.

Likewise, the behavior of control variables remain unchanged, with some small changes in the magnitude and significance of estimated coefficients. The system- GMM estimations confirm the inverted U-shaped pattern between the level of real GDP and CO_2 emissions per capita, which is in line with the EKC hypothesis across the Caribbean region. One notable change in estimation results with the dynamic modelling is that the coefficient on government effectiveness becomes statistically significant, strengthening the assessment that governance reforms could help better manage environmental challenges.

A series of robustness checks are conducted to validate the main findings based on the fixed-effects model. First, I exclude the lagged dependent variable to avoid a potential bias in estimations and find that these results, with larger coefficients for explanatory variables, remain consistent with the baseline findings. Second, I truncate the sample at the 5^{st} and 95^{th} percentiles

Table 5. Tourism and Carbon Emissions: Robustness Checks

	Fixed Effects			
	Excluding the lagged dependent variable	Truncated sample	Additional control variables	Nonlinear effects of tourism
CO2 emissions per capita$_{t-1}$		0.849***	0.697***	0.729***
		[0.066]	[0.202]	[0.182]
Tourist arrivals	0.235***	0.048***	0.063***	0.075***
	[0.088]	[0.031]	[0.035]	[0.032]
Tourist arrivals^2				0.005*
				[0.020]
Real GDP per capita	2.061***	0.516***	1.828***	0.918***
	[0.135]	[0.120]	[0.238]	[0.232]
Real GDP per capita squared	-0.123***	-0.031*	-0.110**	-0.057**
	[0.035]	[0.066]	[0.043]	[0.035]
Real GDP growth	0.002***	0.001*	0.001**	0.001**
	[0.005]	[0.002]	[0.002]	[0.002]
Trade openness	-0.001***	-0.001***	-0.001***	-0.001***
	[0.002]	[0.001]	[0.002]	[0.003]
Government effectiveness	-0.125	-0.062	-0.125	-0.051
	[0.083]	[0.041]	[0.083]	[0.083]
Population			0.380	
			[0.427]	
Urbanization			-0.002	
			[0.006]	
Number of observations	172	151	149	172
Number of countries	15	15	15	15
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj R^2	0.47	0.79	0.70	0.71

Note: The dependent variable is CO2 emissions per capita. Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

to exclude outliers and find that the results remain intact, with marginal changes in the magnitude of estimated coefficients. Third, I introduce additional control variables—population and the share of urban population. Although these the estimated coefficients have the expected signs for these variables, they are not statistically significant at conventional levels. Larger population appears to contribute to higher environmental pollution (due probably to greater electricity and fuel consumption), while urbanization is associated with lower CO_2 emissions per capita (due probably to efficiency gains in cities). Finally, I explore nonlinear effects of international tourism on CO_2 emissions by introducing the quadratic term of tourist arrivals and find that there is indeed some evidence of nonlinearity with higher levels of tourism causing further emissions increase in Caribbean countries. The diseconomies of scale in tourism to a large extent reflects the heavy dependence on fossil fuels in the energy matrix as well as geographic conditions. These robustness checks, presented in Table 5, confirm the baseline results and show that the positive relationship between tourism and environmental pollution remains unchanged in the context of 15 Caribbean countries over the period 1960–2019, with some minor changes in the magnitude of estimated coefficients.[7]

VI. Conclusion

Climate change is a critical challenge of our times. The latest analysis indicates that global warming is likely to reach more than 1.5°C above the preindustrial average, triggering runaway climate change with widespread catastrophic effects. Every additional increase in the global average temperature will heighten the intensity and frequency of extreme weather events in some regions of the world more than others. In the Caribbean with low-lying islands and cays spread over the Atlantic Hurricane Belt, climate change is an existential threat that is already having a significant negative effect on international tourism—the most important economic sector accounting for as much as 90 percent of GDP in some countries. But tourism is also a significant contributor to environmental degradation and global warming, as its carbon footprint may constitute as much as 80 percent of CO_2 emissions in these small island countries.

Empirical results presented in this paper show that international tourism has a statistically and economically significant effect on CO_2 emissions in a relatively homogenous panel of 15 tourism-dependent Caribbean countries over the period 1960–2019. After controlling for economic, institutional and social factors, I find that an increase of 10 percent in the number of international visitors is associated with an increase of as much as 8 percent in CO_2 emissions, which is consistent with the findings in previous studies focusing on small island states. The negative impact of tourism on environmental quality occurs through several channels in Caribbean countries including carbon-intensive energy production and consumption of material resources in accommodation, transportation and other tourist activities, and changes in land use associated with tourism-related investments.

These findings provide valuable insights for policymakers facing complex environmental challenges that transcend national boundaries. In order to optimize welfare-enhancing economic growth, policy priorities must take into account climate change and environmental quality while promoting sustainable and inclusive economic development and financial resilience. Accordingly, managing tourism sustainably requires reducing its negative impact on the environment and curbing excessive dependency on fossil fuel-based energy consumption, which is the main source of CO_2 emissions in the Caribbean. To this end, countries could reduce GHG emissions by: (i) incentivizing decarbonization throughout the economy; (ii) developing a low-carbon energy sector; (iii) electrifying mobility and transportation; (iv) strengthening land-use practices and smarter urbanization with better and stronger building codes; and (v) decarbonizing the tourism industry.

[7] Additional sensitivity checks are presented in Appendix Table A1 and include the following specifications: (i) without the quadratic term of real GDP per capita; (ii) with the number of international tourists per capita; (iii) excluding real GDP growth; and (iv) excluding trade openness and government effectiveness that have more limited observations compared to other variables.

- *Incentivizing decarbonization with fiscal measures*. Even a modest carbon price can mobilize investment in renewable energy, encourage greater energy efficiency, and thereby induce significant abatement in CO2 emissions within a short period (IMF, 2020a; Black and others, 2021; Gugler, Haxhimusa, and Liebensteiner, 2021; Parry, Black, and Roaf, 2021). As long as CO2 emissions remain free, there is no effective incentive for the emitters to alter behavior. In contrast, imposing a price on CO2 emissions relays a powerful signal throughout the economy. Therefore, to meet the NDC commitments under the Paris Agreement, Caribbean countries should introduce a broad-based carbon tax that is set to gradually increase to US$50 per metric ton of CO_2 by 2030.[8] It is important to note that the level of carbon tax needed to achieve NDC for Caribbean countries might vary according to the ambitiousness of targets and responsiveness of the energy sector on pricing. In this context, countries should also consider "feebates"—fees on products with high emissions combined with rebates on products with low emissions—in carbon-intensive sectors such as agriculture, tourism and transportation. While politically challenging, these measures would incentivize households and firms to use energy more efficiently and shift to lower-carbon sources of energy than fossil fuels. During the green transition, additional revenue from carbon taxes can be used to increase the acceptability of the reforms by reducing other types of taxation, developing insurance instruments and social safety nets to mitigate the immediate impact of climate shocks on vulnerable households, and funding public investment in sustainable and resilient infrastructure.

- *Developing a low-carbon energy sector*. Most emissions are generated by the energy sector, which accounts for more than 70 percent of CO_2 emissions in the Caribbean due to heavy dependence on imported fossil fuel for electricity generation. As a result, with limited utilization of renewable energy sources, Caribbean countries are not only completely reliant on imported fossil fuels that leave it vulnerable to global price fluctuations, but the energy mix is also highly damaging to the environment. To decarbonize the economy, countries need to change the composition of energy supply from a primary energy mix dominated by fossil fuels to mainly renewables, complemented by expanded storage capacity and smart transmission grids. Transitioning towards sustainable energy by decarbonizing the energy system and decentralizing electrification technologies can build resilience to natural disasters, increase energy efficiency, strengthen energy security, and reduce energy-related CO_2 emissions.

- *Electrifying mobility and transportation*. Transportation accounts for more than one-third of oil consumption and energy-related CO_2 emissions in the Caribbean, implying a great potential for policy interventions and technological improvements that can help reduce emissions and mitigate climate change. Most countries in the region could easily take advantage of electrifying mobility and transportation systems thanks to shorter distances

[8] The IMF proposes a differentiated range of carbon taxes for advanced, high-income emerging markets and low-income emerging markets—$75, $50 and $25 per metric ton of CO_2 emissions, respectively (Black and others, 2021). However, it should be noted that CO_2 emissions associated with international aviation and maritime transport (including cruise tourism) destined to the Caribbean could be taxed at a regional level. However, it should be noted that a carbon tax on international aviation would "induce a shift from long flights to medium distance one and a shift from medium distance flights to short distance holidays, [and thereby] disproportionally hit island nations [if] the tax is applied regionally rather than globally" (Tol, 2007).

compared to other geographies. Electrification brings many benefits, including diversifying the fuel portfolio, reducing dependence on fossil-based sources, lowering total cost of ownership, improving price stability, strengthening energy independence, and attaining a healthier environment (Gay, Rogers, and Shirley, 2018). Furthermore, with a vehicle-to-grid approach, the electrification of the transportation system creates a significant opportunity to bring more renewable energy onto the grid by managing and leveling periods of intermittency in solar and wind.

- *Strengthening land-use and building regulations.* Restoration of natural capital, especially forests and coastal ecosystems, can make countries resilient to extreme weather events, as well as slow onset changes like desertification and sea level rise. Transition to low-carbon economy therefore requires smarter urbanization with zoning practices and building codes, especially in tourism-dependent areas, which are designed to reduce vulnerability to climate change, expand green areas, strengthen CO_2 emission management in new projects, and improve energy efficiency in buildings. To this end, policymakers can implement fees and feebates to promote energy savings in the stock of commercial and residential buildings and reduce deforestation in the forestry and land-use sectors.

- *Decarbonizing the tourism industry*. The shift to more sustainable forms of tourism, combined with stronger protection and restoration of ecosystems, can be a powerful climate solution, while creating millions of jobs and diversifying the tourism sector. Countries could consider sector-specific fiscal instruments, such as a carbon tax on foreign visitors earmarked for climate change mitigation, to decouple tourism growth from CO_2 emissions. These would help better manage the carbon footprint of international tourism and support greater access to international green finance for climate change adaptation and mitigation.

Finally, although cutting CO_2 emissions is necessary for sustainable tourism and climate change mitigation, small island states in the Caribbean also urgently need to invest in climate-resilient infrastructure against stronger and more destructive hurricanes and rising sea levels, which pose an existential threat. There will of course be upfront fiscal cost of climate change adaptation, but the lack of inaction on the climate front would have even a greater macro-fiscal cost for generations, and investing in structural resilience would yield long-run socioeconomic benefits. Furthermore, investing in climate-resilient infrastructure would reduce damages from natural disasters and increase expected returns to private investment in tourism and other sectors. In this context, climate change mitigation and adaptation measures should not be considered as strict policy trade-offs, but complementary elements of a broader strategy to respond to climate change. An important illustration of mitigation-adaptation interlinkages in the Caribbean is energy supply and consumption, which is determined to a great extent by tourism-related activities. Balancing mitigation and adaptation strategies would in turn provide diverse ecological, economic and social benefits and opportunities.

Appendix Table A1. Additional Sensitivity Checks

	Fixed Effects			
	without the quadratic term of real GDP per capita	with international tourists per capita	excluding real GDP growth	excluding trade and governance that have limited number of observations
CO2 emissions per capita$_{t-1}$	0.739***	0.698***	0.738***	0.648***
	[0.133]	[0.191]	[0.134]	[0.086]
Tourist arrivals	0.065***	0.061***	0.066***	0.075***
	[0.031]	[0.037]	[0.034]	[0.037]
Real GDP per capita	0.958***	0.934***	0.972***	0.881***
	[0.121]	[0.176]	[0.113]	[0.081]
Real GDP per capita squared				
Real GDP growth	0.001***	0.001***		0.001***
	[0.002]	[0.001]		[0.002]
Trade openness	0.001***	0.001***	0.001***	
	[0.010]	[0.010]	[0.006]	
Government effectiveness	-0.062	-0.055	-0.060	
	[0.021]	[0.018]	[0.020]	
Number of observations	172	149	172	384
Number of countries	15	15	15	15
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Adj R^2	0.70	0.69	0.69	0.62

Note: The dependent variable is CO2 emissions per capita. Robust standard errors, clustered at the country level, are reported in brackets. A constant is included in each regression, but not shown in the table. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

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