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# Does Causality Between Tourism and Environmental Pollution Depend on Economic Development Level? A Novel Evidence From JKS's Panel Granger Non-causality Method


## Abstract

This study explored the causal link between tourism and CO2 emissions using bivariate and multivariate causality approaches to analyse data from 134 countries. Employing JKS's Panel Granger non-causality method, we established that tourism significantly Granger-causes environmental pollution. The multivariate model exhibited more robust causality than the bivariate model, yet this causality remains consistent regardless of a country's economic development level. This emphasizes the urgent need to address the interplay between tourism and environmental concerns.


*Keywords:* tourism, CO2 emission, causality

## 1. Introduction

Starting with Bach and Gößling (1996), tourism and environmental economists have devoted significant attention to examining the connection between tourism and environmental pollution. The interest in the connection between tourism and environmental pollution is born out of the fact that tourism is not only a driver of economic growth but also affect environmental quality (Raifu, 2024; Raifu & Afolabi, 2024a, b; Koçak et al., 2020). The literature provides four distinct ways in which tourism can affect environmental quality. First, during tourism, travel involves using various modes of transportation (air, rail, sea, and road) that generate emissions that can lead to environmental pollution. Second, tourism development requires significant investment in infrastructure, which entails land reclamation, deforestation, habitat destruction and land degradation. This contributes to ecosystem destruction, soil erosion, and flooding. Third, tourist destinations generate a lot of waste, such as parking lot debris, food scraps and disposable items, which can lead to environmental contamination. Fourth, hotels, resorts, and other tourism-related facilities use a lot of energy, which, if improperly managed, can lead to increased CO2 emissions (Eyuboglu & Uzar, 2020). This suggests that tourism activities can generate a significant amount of pollution. In other words, tourism can contribute significantly to (or Granger-cause) environmental pollution.

However, some scholars argue that environmental pollution can be detrimental to the development of the tourism industry. This is because environmental pollution prevents travellers from travelling to a destination, reducing tourist arrivals (Zhang & Zhang, 2021). For tourist destination countries, the implication is that environmental pollution that drives tourists away will reduce tourism receipts or foreign exchange earnings, which in turn can affect their economies (Zhang et al., 2020). This suggests that environmental pollution can have a considerably negative influence on tourism. In other words, tourism can also be Granger-caused by environmental pollution.


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A substantial body of research has explored the causal relationship between tourism and environmental pollution, focusing on time series and panel analyses (e.g., Azam et al., 2018 for Malaysia, Singapore, and Thailand). Many of these studies employed bivariate causality methods that solely consider the causal relationship between tourism and pollution, often overlooking other contributing factors like economic growth and energy consumption, which can also jointly influence environmental pollution (Paramati et al., 2017). In this context, our study contributes to the existing studies by reevaluating the causal link between tourism and environmental pollution using panel data from 134 countries. We provide two key contributions. First, we investigate the causality between tourism and pollution from bivariate and multivariate perspectives. The bivariate approach focuses solely on tourism and pollution, whereas the multivariate perspective considers economic growth and energy consumption as additional drivers of pollution. Some researchers have used Konya's (2006) bootstrap panel Granger causality method to analyse multivariate causality (Akadiri et al., 2020). However, most of these studies, including Konya's (2006), have treated the third variable as an auxiliary variable rather than a joint predictor that works with the second variable to affect the first variable (Konya, 2006, p. 979, 982). However, our study treats economic growth and energy consumption as joint predictors of pollution with tourism, not as auxiliary variables. In other words, economic growth, energy consumption, and tourism collectively predict pollution (Xiao et al., 2023).

We utilise a novel panel causality method developed by Juodis et al. (2021) (hereafter referred to as JKS) to achieve our objectives. This method not only facilitates bivariate causality testing but also extends to multivariate causality analysis, making it superior to existing panel causality methods, including Dumitrescu and Hurlin's (2012) approach (DH) and Konya's (2006) method. Like DH's panel causality method, JKS's Granger non-causality test accounts for panel data heterogeneity and cross-sectional dependence. Moreover, it accommodates both homogeneous and heterogeneous alternatives and cross-sectional heteroscedasticity in the panel data.

Second, we assess whether the causality between tourism and CO2 emissions depends on the economic development level. We apply the same estimation method for bivariate and multivariate causality analyses. Thus, we divided our dataset into developed and developing countries based on the United Nations Development Programme (UNDP, 2014) classification (Human Development Index).

Section 2 presents the methodology and data sources. The results are presented in section 3, and section 4 concludes the study.

# 2. Methodology and data sources

Following Xiao et al. (2023), we specify a bivariate JKS Granger non-causality between tourism and CO2 emissions. We assume that we have the following dynamic linear panel data model:

$$CO2_{i,t} = \alpha_{0,i} + \sum_{p=1}^{P} \alpha_{p,i} CO2_{i,t-p} + \sum_{p=1}^{P} \beta_{p,i} tor_{i,t-p} + \varepsilon_{i,t} \tag{1}$$

Where *tor* denotes tourism. In this study, we use tourist arrivals, tourism exports, and tourism receipts as proxies for tourism. Following Raifu et al. (2021), we compute the tourism index from these three measures of tourism using the Principal Component Analysis (PCA). *CO2* represents carbon emission which is used to proxy environmental pollution. In Equation 1, *tor* is assumed to be a scalar. $\alpha_{0,i}$ denote the individual-specific effects. $\alpha_{p,i}$ represent the heterogeneous autoregressive coefficients $p = 1,\ldots,P$ and $\beta_{p,i}$ represent the heterogeneous feedback coefficients or Granger-causality parameters.

The null hypothesis that tourism does not Granger cause *CO2* emission is formulated as a set of linear restrictions on the parameters in equation 1 and it is specified as:

$$H_0 : \beta_{p,i} = 0, \quad \text{for all } i \text{ and } p \tag{2}$$

The alternative hypothesis can be specified as:

$$H_0 : \beta_{p,i} \neq 0, \quad \text{for some } i \text{ and } p \tag{3}$$

Failure to reject the null hypothesis is interpreted as tourism, not Granger, causing emission. In the multivariate version above, we account for economic growth and energy consumption as joint drivers of CO2 emission.[1] Thus, the same rule applies to the multivariate model when the null hypothesis is rejected, meaning that tourism, economic growth (GDP per capita), and energy consumption do not cause CO2 emissions. The inclusion of GDP per capita and energy consumption stems from insight drawn from the study by Selvanathan et al. (2021).

This study uses the data of 134 countries from 1995 to 2020. CO2 and energy consumption are obtained from Our World in data (Ritchie & Roser, 2020). CO2 captures all fossil emissions (Coal, oil, gas, cement and flaring). Tourism and GDP per capita are sourced from the World Development Indicators (WDI). GDP per capita and energy consumption are used to capture the level of economic development and primary energy consumption. The measurements of the variables are presented in Table 1

# 3. Empirical findings

Using JKS's Granger non-causality test requires preliminary tests. Therefore, we conducted three distinct tests: descriptive statistics, unit root tests (using Maddala and Wu's first-generation (1999) and Pesaran's second-generation (2007) methods) and the Breusch-Pagan LM test of independence for cross-sectional dependence, applied to both bivariate and multivariate models. The Appendices A and B, provide the unit root and cross-sectional dependence test results. Concisely, unit root tests indicate the presence of unit roots in some variables, especially tourist arrivals, CO2 emissions, GDP per capita, and energy consumption. Additionally, the statistically significant Breusch-Pagan LM test at the 1% level rejected the null hypothesis of cross-sectional independence. As presented in Table 1, descriptive statistics reveal mean values of 10.6 million tourists, \$6.81 billion in tourism receipts, and \$6.49 billion in tourism exports. CO2 emissions, GDP per capita, and energy consumption stood at 212 billion metric tonnes, \$13,098.25 and 939.38 TWh, respectively.

**Table 1**
***Descriptive statistics***

| Variables | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| Tourist arrivals (millions) | 3484 | 10600000 | 26500000 | 4800 | 2.200e+08 |
| Tourism receipts (billion (USD)) | 3484 | 6.810e+09 | 1.760e+10 | 100000 | 2.400e+11 |
| Tourism exports (billion (USD)) | 3484 | 6.490e+09 | 1.720e+10 | 2300000 | 1.900e+11 |
| CO2 (billion metric tonnes) | 3484 | 2.120e+08 | 8.400e+08 | 76944 | 1.096e+10 |
| GDP per capita (thousand (USD)) | 3484 | 13098.25 | 18004.007 | 217.625 | 112418 |
| Energy consumption (TWh) | 3484 | 939.379 | 3349.072 | .257 | 41513.813 |

*Source:* Authors.

Table 2 presents JKS's Granger non-causality results for both bivariate and multivariate models. We selected three maximum lags using the Bayesian Information Criterion (BIC) during the estimation process. In two-way causal relationships, our results support tourism as a Granger-causal factor for CO2 emissions, except

[1] For simplicity, we specify bivariate causality between tourism and air pollution. However, the multivariate version of equation 1 can be specified as follows:

$$CO2_{i,t} = \alpha_{0,i} + \sum_{p=1}^{P} \alpha_{p,i} CO2_{i,t-p} + \sum_{p=1}^{P} \beta_{p,i} tor_{i,t-p} + \sum_{p=1}^{P} \lambda_{p,i} ec_{i,t-p} + \sum_{p=1}^{P} \gamma_{p,i} gdppcap_{i,t-p} + \varepsilon_{i,t}$$ where $ec$ and $gdppcap$ denote energy consumption and GDP per capita respectively.

for the model that looks at tourism exports and $CO_2$ emissions. The results of multivariate analysis closely mirror those of bivariate the causality between. This underscores tourism's predictive role in environmental pollution, economic growth, and energy consumption. However, the coefficients in the multivariate test compared to the bivariate test show that the combined impact of tourism, economic development and energy consumption more significantly contributes to pollution than tourism alone. This finding aligns with prior studies like Koçak et al. (2020) and Eyuboglu and Uzar (2020).

We further investigated the causality between tourism indicators and $CO_2$ emissions to understand whether causality depends on economic development. We divided our dataset into developed and developing countries. Table 2 presents the results of both bivariate and multivariate causality tests. Our findings consistently show that, regardless of economic development level, all tourism indicators exhibit a Granger-causal relationship with $CO_2$ emissions. This suggests tourism's capacity to predict environmental pollution irrespective of economic development level. The same trend is observed in the multivariate causality analysis, where we examined the combined impacts of tourism, GDP per capita and energy consumption on $CO_2$ emissions. We found that all three variables (tourism indicators, GDP per capita, and energy consumption) Granger-cause $CO_2$ emissions imply their joint prediction of environmental pollution.

**Table 2**
***JKS's Granger non-causality results***

| | All countries | | Developed countries | | Developing countries | |
|---|---|---|---|---|---|---|
| | Bivariate | Multivariate | Bivariate | Multivariate | Bivariate | Multivariate |
| Tourist arrivals (HPJ Wald test) | 23.18*** (0.000) | 34.09*** (0.000) | 48.20*** (0.000) | 44.30*** (0.000) | 40.83*** (0.000) | 53.84*** (0.000) |
| Tourism receipts (HPJ Wald test) | 7.12*** (0.008) | 15.19*** (0.002) | 16.64*** (0.000) | 54.68*** (0.000) | 38.32*** (0.000) | 43.78*** (0.000) |
| Tourism exports (HPJ Wald test) | 0.11 (0.738) | 4.65 (0.199) | 8.36*** (0.004) | 33.03*** (0.000) | 7.10*** (0.008) | 23.45*** (0.000) |
| Overall tourism (HPJ Wald test) | 7.23*** (0.007) | 14.98*** (0.002) | 16.63*** (0.000) | 54.67*** (0.000) | 38.28*** (0.000) | 43.43*** (0.000) |

Note. Bivariate model includes only tourism variables and co2 while multivariate model, apart from tourism variables and co2, includes economic growth and energy consumption.
*** p<0.01. ** p<0.05. * p<0.1.

# 4. Conclusion

Recently, the link between tourism and environmental pollution has gained attention. Some argue that tourism contributes to pollution, while others suggest pollution negatively affects the tourism industry. These connections have been examined through impact and causal analyses. However, prior causal studies often focused only on the direct causality between tourism and pollution, neglecting other factors like economic growth and energy consumption. This study employs a novel JKS's Granger non-causality method to analyse data from 134 countries between 1995 and 2020. Results indicate that tourism, economic growth, and energy consumption contribute to environmental pollution regardless of economic development level. Thus, addressing the interplay between tourism and pollution necessitates sustainable measures.

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# Appendix A

## The results of unit root tests

| | Maddala and Wu (1990) | Pesaran (2007) | Maddala and Wu (1990) | Pesaran (2007) |
|---|---|---|---|---|
| | Level | | First difference | |
| Tourist arrivals | 250.84<br>(0.767) | -3.83***<br>(0.000) | 585.32***<br>(0.000) | -16.43***<br>(0.000) |
| Tourism receipts | 368.96***<br>(0.000) | -5.44***<br>(0.000) | 747.13***<br>(0.000) | -16.63***<br>(0.000) |
| Tourism exports | 338.78***<br>(0.002) | -4.29***<br>(0.000) | 762.36***<br>(0.000) | -15.59***<br>(0.000) |
| CO2 | 298.76*<br>(0.095) | -5.42***<br>(0.000) | 1554.38***<br>(0.000) | -19.09***<br>(0.000) |
| GDP per capita | 288.67<br>(0.184) | -4.37***<br>(0.000) | 748.76***<br>(0.000) | -8.89***<br>(0.000) |
| Energy consumption | 285.48<br>(0.221) | -5.39***<br>(0.000) | 1420.74***<br>(0.000) | -18.93***<br>(0.000) |

*** p<0.01. ** p<0.05. * p<0.1.

# Appendix B

## Cross-section dependence test results

| Test | Bivariate model | Multivariate model |
|---|---|---|
| Breusch-Pagan LM test of independence: chi2(8911) | 68643.59***<br>(0.000) | 48385.02***<br>(0.000) |
| Breusch-Pagan LM test of independence: chi2(8911) | 75884.84***<br>(0.000) | 52213.167***<br>(0.000) |
| Breusch-Pagan LM test of independence: chi2(8911) | 75052.32***<br>(0.000) | 52179.29***<br>(0.000) |
| Breusch-Pagan LM test of independence: chi2(8911) | 75948.62***<br>(0.000) | 52214.87***<br>(0.000) |

*Note*. Bivariate model includes only tourism variables and co2 while multivariate model, apart from tourism variables and co2, includes economic growth and energy consumption.
*** p<0.01. ** p<0.05. * p<0.1.