Empirical Research Article

Air Pollution and Tourism: Evidence from G20 Countries

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Abstract

Theoretically, it is well argued that environmental factors affect the growth of the tourism industry; however, from an empirical perspective, some gaps still exist in the literature. We empirically examine the effect of carbon dioxide (CO_2) and particulate matter (PM2.5) emissions on tourist arrivals in a panel of G20 countries. Using annual data from 1995 to 2014 and a series of panel data models, our results suggest that the growth of both CO_2 and PM2.5 emissions adversely affects international tourist arrivals. The results also show that the observed effect of CO_2 emissions is more pronounced in developed economies, while the effect of PM2.5 emissions is stronger for developing economies. Given these findings, our study provides and discusses a number of policy and practical implications.

Keywords

CO_2 emissions, PM2.5 emissions, tourist arrivals, the G20

Introduction

The growth of the tourism industry is not homogenous across countries as it fails in some countries but thrives in others. As a result, a growing literature attempts to explain tourism growth by examining various factors including climate change and carbon tax regulations (see, e.g., Dwyer et al. 2013; Gössling, Peeters, and Scott 2008; Mayor and Tol 2010; Pentelow and Scott 2010; Tol 2007), transport infrastructure (see, e.g., Khadaroo and Seetanah 2007, 2008; Prideaux 2000), income and price (see, e.g., Athanasopoulos and Hyndman 2008; Crouch 1992; Garín-Muñoz 2009), culture (see, e.g., Felsenstein and Fleischer 2003), terrorism (see, e.g., Arana and León 2008; Pizam and Smith 2000), and environmental conditions (see, e.g., Agnew and Viner 2001; Amelung, Nicholls, and Viner 2007; Moore 2010), among others.

Further, evidence suggests that environmental conditions rank very highly among factors that tourists take into account when making decisions about where to vacation or visit (see, e.g., Hu and Ritchie 1993; Lise and Tol 2002). Tourism by its very nature is expected to represent pleasure and satisfaction for people, and thus demand for tourism is largely dependent on the satisfaction that it provides (Moore 2010). Environmental conditions considerably impact the perception of satisfaction and thus play significant roles in determining where people choose as tourist destination.

However, there are some gaps in the existing literature that examines the association between the environment and tourism. Specifically, with regard to the association between environmental factors and tourism, much of the literature tends to focus on the impact of tourism on the environment (see, e.g., Al-Mulali, Fereidouni, and Mohammed 2015; Gössling 2002; Katircioglu 2014; Paramati, Alam, and Chen 2017a; Paramati, Shahbaz, and Alam 2017b; Tabatchnaia-Tamirisa et al. 1997). Although a growing body of literature examines the effects of environmental factors on tourism, most of these studies focus on the impact of climate change with emphasis on shifts in seasonal temperature averages and other dimensions of climate change (see, e.g., Agnew and Viner 2001; Amelung, Nicholls, and Viner 2007; Harrison, Winterbottom, and Sheppard 1999; Sajjad, Noreen, and Zaman 2014). Further, these studies are limited in scope as they tend to focus on single countries or specific geographic areas (Ceron and Dubois 2005; Harrison, Winterbottom, and Sheppard 1999; Yeoman and McMahon-Beattie 2006).

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In this study, we argue that differences in environmental conditions, specifically air pollution, proxied by CO_2 emissions and particulate matter (PM2.5), play significant roles in explaining cross-country differences in tourism growth. Air pollution affects the attractiveness of tourist destinations and is likely to affect the extent to which tourists are attracted to specific locations. Thus, our study attempts to explain cross-country differences in tourism growth by focusing on two common air pollutants, CO_2 and PM2.5 emissions. PM2.5 emissions encompass liquid and solid waste particles that are suspended in air. They tend to reduce visibility and pose significant health risks (Sánchez-Soberón et al. 2015). In contrast, although CO_2 emissions are not visible, they are responsible for about 75% of the greenhouse effect (Atasoy 2017; Awaworyi Churchill et al. 2018), and also the most widely studied air pollutant in the literature (see, e.g., Ang 2007; Apergis and Payne 2009; Awaworyi Churchill et al. 2019; Awaworyi Churchill et al. 2020; Bhattacharya, Churchill, and Paramati 2017; Friedl and Getzner 2003; Ivanovski and Awaworyi Churchill 2020; Lean and Smyth 2010).

We focus on a panel of G20 countries drawing on annual data from 1995 to 2014 to examine the effects of CO_2 and PM2.5 emissions on tourism. We find that an increase in CO_2 and PM2.5 emissions adversely affects international tourist arrivals. Further, a comparative analysis between developed and developing countries suggests that the effect of CO_2 emissions on tourism is relatively stronger for developed countries than developing countries, while the negative effect of PM2.5 emissions is more pronounced in developing countries.

Our study contributes to several strands of literature. Notably, our study relates to those in the literature that examine the impact of tourism on the environment (see, e.g., Alam and Paramati 2017; Al-Mulali, Fereidouni, and Mohammed 2015; Katircioglu 2014; Paramati, Alam, and Chen 2017a; Paramati, Shahbaz, and Alam 2017b). For instance, Alam and Paramati (2017) examine the impact of tourism investment on economic growth and carbon emissions across a panel of countries, while Paramati, Shahbaz, and Alam (2017b) compares the effects of tourism on environmental quality in Eastern and Western European Union countries. Al-Mulali, Fereidouni, and Mohammed (2015), Katircioglu (2014), and Paramati, Alam, and Chen (2017a) also examine the impact of tourism on carbon emissions in different contexts. The findings from these studies generally suggest that tourism is associated with higher CO_2 emissions. Our study differs from these as we do not examine how tourism influences the environment but rather how the environment, specially air pollution, influences tourism. Put differently, unlike these studies, which focus on tourism as an antecedent to poor environmental quality, we consider tourism as our outcome variable, and in addition to focusing on CO_2 emissions as the determinant of tourism, we also use PM2.5.

The closest in the literature to ours are those studies that examine the effects of a wide range of environmental factors on tourism (see, e.g., Agnew and Viner 2001; Amelung, Nicholls, and Viner 2007; Ceron and Dubois 2005; Harrison, Winterbottom, and Sheppard 1999; Sajjad, Noreen, and Zaman 2014; Yeoman and McMahon-Beattie 2006). We differ from these studies given the scope of our study. We contribute to the existing literature by presenting an extensive study that focuses on a panel of G20 countries instead of focusing on a single country. On the policy front, focusing on the G20 countries allows us to contribute to existing discussion on the implications of high emissions produced by G20 countries. Specifically, evidence suggests that G20 countries are responsible for approximately 75% of global greenhouse gas emissions and, between 1995 and 2014, CO_2 emissions for these countries increased by more than 50% (Climate Transparency 2016). G20 members such as China and Saudi Arabia also emit the highest levels of PM2.5. Further, on the methodological front, the use of panel data approaches presents us with the advantage of improved estimates.

The remainder of the article is organized as follows. The second section provides a brief overview of the relevant literature. The third section discusses the data, model and estimation techniques. The fourth section presents the empirical results and discussion, while in the fifth section we conclude and provide some policy suggestions.

Brief Overview of Related Literature

A large body of literature examines tourism demand, focusing on various factors. However, early reviews of the literature on tourism demand (see, e.g., Crouch 1995; Lim 1997) conclude that the majority of studies estimating tourism demand tend to focus on economic factors. Similarly, a review by Pike (2002) which reviewed 142 studies that examined the features of tourist destinations revealed that there is a lack of empirical evidence on the importance of the environment on tourism and destination choice decision making by tourists. For instance, of the 142 studies examined, Pike's (2002) review revealed that only one study, Lohmann and Kaim (1999), specifically examined the weather. Lohmann and Kaim (1999) focused on a single country, Germany. The study examined the importance of tourist destination characteristics, and found that landscape was the most important characteristic that influences tourism, even before price. Other important characteristics that were identified include weather and bio-climate.

The theoretical literature on tourism argues in favor of a set of factors that motivate people to make decisions about tourism, especially where to go. These set of factors have been explained by the "Push-Pull" framework (Amelung, Nicholls, and Viner 2007; Dann 1977, 1981; Hamilton, Maddison, and Tol 2005; Kozak 2002). Push factors are those that motivate people to travel while the pull factors are qualities and characteristics of destinations that attract tourists. Klenosky (2002) reviewed various "push–pull" studies and found that the environment is among the pull factors identified in several studies that used factor analysis to reduce the attributes of tourist destinations into a set of pull factors. Other pull factors identified include cultural attractions, infrastructure, and sports, among which the environment ranks very highly when tourists make decisions about destinations (Hu and Ritchie 1993; Lise and Tol 2002). This points to the need for studies that examine, more rigorously, the association between the environment and tourism.

While the tourism industry influences the environment, the industry is also impacted by the state of the environment. Thus, research on the relationship between tourism and the environment focus on both dimensions, more so on the impact of tourism on environmental pollution. As an industry dependent on the weather and other environmental factors, it is expected that tourism would be affected by changing weather and environmental conditions. A growing literature thus examines the impact of the environment on tourism, focusing largely on various dimensions of climate change.

A number of arguments can be advanced for why the environment affects tourism. For instance, the environment has been identified to have psychological effects (see, e.g., Hamilton, Maddison, and Tol 2005; Parker 2000), which influence the decisions on destination choice. Further, where the environment is polluted or characterized by extreme weather conditions, individuals may have health concerns, which could affect their decisions. In particular, research has shown that regions with excessive rain, and previous patterns of extreme weather conditions such as hurricanes and snowstorms tend to experience significant loss in tourism revenue given that such weather conditions negatively influence tourist satisfaction (see, e.g., Becken and Wilson 2013; Kim et al. 2017; Jeuring and Peters 2013). Accordingly, climate change may have a direct impact on tourism. Changes in the environment and weather associated with climate change such as droughts, increase in sea level, and extreme weather events as well as warmer summers and winters directly affect tourism (Sajjad, Noreen, and Zaman 2014).

Studies have thus sought to examine the impact of climate change on tourism using both qualitative methods and quantitative methods (see, e.g., Agnew and Viner 2001; Amelung, Nicholls, and Viner 2007; Elsasser and Bürki 2002; Gable 1997; Harrison, Winterbottom, and Sheppard 1999; Nicholls and Hoozemans 1996; Wall 1998). However, most of these studies focus on single countries and usually examine the impact of changes in temperature. One of the earliest studies on the subject, Koenig and Abegg (1997), examines the impact of changes in temperature on Swiss ski tourist destinations. Using temperature as the measure of climate change, Lise and Tol (2002) also argue that the preferred temperature of tourists visiting the Organisation for Economic Co-operation and Development (OECD) countries is approximately 21° Celsius, and thus given current changes to the climate, tourism in these destinations is likely to suffer. Harrison, Winterbottom, and Sheppard (1999) also focuses on Scotland and examines how spatial patterns of potential changes in the Scottish climate relate to aspects of tourism such as winter skiing. Other studies (see, e.g., Ceron and Dubois 2005; Uyarra et al. 2005; Yeoman and McMahon-Beattie 2006) also focus on single countries or dimensions of climate change such as temperature and clear waters. While these studies provide useful inferences about specific countries, and on limited dimensions of the impact of climate change, they do not provide a holistic picture of the impact of environmental factors on tourism. Accordingly, to capture the impact of a broader dimension of climate change, some studies (see, e.g., Amelung, Nicholls, and Viner 2007; Amelung and Viner 2007; Scott and McBoyle 2001) also adopt indices such as the tourism climatic index (Mieczkowski 1985), which is expected to allow for a quantitative analysis of climate for the purpose of tourism-related activities.

On the other hand, some studies focus on multiple countries (see, e.g., Agnew and Viner 2001; Moore 2010). However, these studies are limited in various ways including limitations in terms of methods, scope, or measures of environmental characteristics. For instance, Agnew and Viner (2001) examines the potential impact of climate change for 10 tourist destinations. The study focuses on factors such as sea-level rise, flooding, and coral bleaching, among others. However, this study, like others, does not adopt rigorous quantitative techniques in a panel framework; neither does it focus on air pollution. Moore (2010) adopts relevant econometric techniques but focuses solely on Caribbean destinations.

A more comprehensive study, which focuses on several dimensions of climate change, including environmental pollution, and thus is similar to our study in that regard, is Sajjad, Noreen, and Zaman (2014). However, our study differs in terms of the sample used and measures of tourism. Specifically, Sajjad, Noreen, and Zaman (2014) examines the relationship between climate change, proxied by several gas emissions including hydrofluorocarbons, nitrous oxide, and sulphur hexafluoride, among others on tourism development indicators in selected regions in the world. We investigate the impacts of air pollution measured by CO_2 and PM2.5 emissions on tourism for G20 countries.

Overall, the literature examining the impact of the environment on tourism is relatively scant and as Amelung, Nicholls, and Viner (2007) put it, only very few tourist demand models have examined climate as a factor. Although a growing literature has begun exploring the effects of environmental factors in the last decade, majority of these studies focus on the impact of climate change. These studies also tend to be limited in scope as they focus on specific geographic areas or single countries. Further, the effects of CO_2 emissions, one of the major causes of climate change, and PM2.5 air pollution, the leading environmental cause of poor health and premature death, have not received much attention in the literature. The current study seeks to bridge the gap in the literature by examining the effects of CO_2 and PM2.5 emissions on international tourist arrivals in G20 countries and thus provides some useful policy suggestions.

Data and Methodology

Data and Measurement

This study uses annual data for 15 G20 countries from 1995 to 2014.[1] We further split our sample into developed and developing countries based on the World Bank classification[2] to examine if differences exist in the observed effect by country type. The developed country sample consists of nine countries, namely, Australia, Canada, France, Germany, Italy, Japan, Saudi Arabia, United Kingdom, and United States, while the developing country sample includes Brazil, China, Korea, Rep., Mexico, Russia, and South Africa.[3]

In this article, tourism arrival (TA) is measured by the number of tourist arrivals, carbon dioxide emissions per capita (CO_2) are expressed in metric tons, mean population exposure to particulate matter (PM2.5) is in micrograms per cubic, GDP per capita (RGDP) is measured in 2011 purchasing power parity (PPP) international dollars, trade openness (TO) is total exports and imports as a percentage of GDP, and real effective exchange rate (REER) is the nominal exchange rate index (expressed on the base 2010 = 100) divided by a price deflator. The required data on the above variables are obtained from the World Development Indicators (WDI) online database published by the World Bank except for PM2.5 emissions data, which are drawn from the OECD statistics database.[4]

We transform the data series into natural logarithms to ensure that the estimated coefficients in the model can be interpreted as elasticities. Furthermore, the transformation also helps to avoid problems associated with distributional properties of our variables since the measurement differences are substantial.

Model Specification

To examine the impact of pollution on tourism, we follow the literature in specifying a model for tourist arrivals, which includes real GDP per capita, real effective exchange rate and trade openness as covariates (see, e.g., Qiu and Zhang 1995; Sharma and Pal 2019), and augmented to include pollution as follows:

$$\mathrm{TA}_{it} = f(\mathrm{POLLUT}_{it}, \mathrm{RGDP}_{it}, \mathrm{REER}_{it}, \mathrm{TO}_{it}), \qquad (1)$$

where POLLUT stands for air pollution and is proxied by per capita CO_2 and PM2.5 emissions. The above equation can be parameterized as below:

$$\mathrm{TA}_{it} = \mathrm{POLLUT}_{it}^{\beta_{1i}} \mathrm{RGDP}_{it}^{\beta_{2i}} \mathrm{REER}_{it}^{\beta_{3i}} \mathrm{TO}_{it}^{\beta_{4i}}. \qquad (2)$$

Equation (2) can further be derived by taking natural logarithms, which is shown as follows:

$$\begin{aligned}\ln\mathrm{TA}_{it} &= \beta_{1i}\ln\mathrm{POLLUT}_{it} + \beta_{2i}\ln\mathrm{RGDP}_{it} \\ &\quad + \beta_{3i}\ln\mathrm{REER}_{it} + \beta_{4i}\ln\mathrm{TO}_{it} + \varepsilon_{it},\end{aligned} \qquad (3)$$

where ε_{it} is the error term, countries are denoted by i ($i = 1, \ldots, N$), and t stands for time span ($t = 1, \ldots, T$).

We employ fully modified ordinary least squares (FMOLS) to estimate equation (3). The FMOLS method enables us to examine the long-run relationship between tourist arrivals, CO_2 and PM2.5 emissions. Moreover, the estimator yields unbiased and asymptotically efficient estimates of long-term relationship. We also estimate the short-run effect using the system generalized method of moments (GMM) approach.

Empirical Analysis and Discussion

Summary and Descriptive Statistics

We begin our preliminary analysis by presenting descriptive statistics and relevant information on the basic time series properties of our variables in Table 1. As shown in Table 1, the level of per capita CO_2 emissions ranges from 1.59 to 20.18 metric tons. The annual mean value of PM2.5 concentration during the sample period is 23.86 $\mu g/m^3$ with large variations across countries. The average annual tourist arrivals is 24.3 million and also varies significantly within the G20 group. The mean value of real GDP per capita is 29,026.29 international dollars with a standard deviation of 13,049.71. There are also significant variations in trade openness across countries.

In Table 2, we show the relative standing of the G20 countries in the world by presenting the percentage of tourist arrivals (TA), total CO_2 emissions (CO_2), total GDP (GDP), and total population (POP) of the G20 countries in the world.[5] This table suggests that the G20 countries account for 52%, 74%, 78%, and 64% of the global tourist arrivals, CO_2 emissions, GDP, and population in 1995, respectively. Over the period, the share of international tourist arrivals in the G20 countries has slightly declined. However, the G20 countries still account for a relatively large share of international tourist arrivals globally, and this is also the case for emissions, GDP, and population.

Next, we present the compounded annual growth rates on selected variables in Table 3. The growth rates of tourist arrivals show that only Canada has a negative growth rate while all other countries have positive growth rates. Among the G20 countries, Saudi Arabia has the highest positive growth rates in tourist arrivals while Mexico has the lowest positive growth rates. Likewise, a number of G20 countries such as Italy, the United Kingdom, Canada, the United States, France, and Germany have shown negative growth rates in CO_2 emissions. On the other hand, countries like China and Brazil have shown tremendous positive growth rates in CO_2 emissions. Interestingly, we find that the per capita income growth rates are positive for all of the sample countries. Finally, among the sample countries, the per capita income has higher growth rates in China, while the lowest was in Italy. Overall, these growth rates suggest that all of the G20 countries have positive growth rates in tourist arrivals (except Canada). We also find that many of the developed

Table 1. Summary Statistics across Countries.

Variable	Mean	Std. Dev.	Min	Max
International tourism, number of arrivals (TA)	24,300,000	20,700,000	1,991,000	83,700,000
CO_2 emissions in metric tons per capita (CO_2)	9.95	5.02	1.59	20.18
PM2.5 in micrograms per cubic meter (PM2.5)	23.86	19.87	7.31	91.46
Real GDP per capita, purchasing power parity (GDP)	29,026.29	13,049.71	2,556.61	52,080.79
Trade openness as % of GDP (TO)	51.55	18.82	15.64	110
Real effective exchange rate index (REER)	99.56	16.38	47.95	165.88

Table 2. Percentage of G20 Key Indicators in the World.

Year	TA	CO_2	GDP	POP
1995	52.35	73.52	78.14	64.15
1996	53.05	74.29	78.07	64.03
1997	52.27	73.53	78	63.9
1998	51.9	72.79	77.92	63.78
1999	51.65	74.2	77.94	63.64
2000	52.78	74.68	77.87	63.5
2001	51.36	73.05	77.71	63.35
2002	51.12	73.54	77.66	63.2
2003	50.11	73.47	77.63	63.03
2004	49.09	73.97	77.33	62.86
2005	48.52	73.28	77.21	62.69
2006	47.87	73.39	76.95	62.51
2007	47.94	73.82	76.72	62.32
2008	47.93	73.4	76.55	62.13
2009	47.64	73.7	76.51	61.94
2010	47.09	74.5	76.67	61.74
2011	47.52	75.08	76.81	61.52
2012	47.12	75.23	76.98	61.32
2013	46.45	74.87	77.09	61.12
2014	46.82	75.12	77.64	61.18
Average	49.53	73.97	77.37	62.7

Note: Authors' calculation. TA = tourism arrival; CO_2 = total carbon dioxide emissions; GDP = total gross domestic product; POP = total population.

Table 3. Compounded Annual Growth Rates (Percent).

Country	TA	CO_2	PM2.5	RGDP	REER	TO
Australia	2.87	0.25	−0.56	1.92	1.95	0.42
Brazil	5.8	2.35	−0.5	1.78	−0.07	2.29
Canada	−0.28	−0.86	−0.56	1.54	1.12	−0.57
China	5.53	5.45	0.05	8.81	2.11	1.55
France	1.76	−0.78	−0.96	1.06	−0.52	1.65
Germany	4.05	−0.63	−1.06	1.38	−0.98	3.58
Italy	2.29	−1.46	−0.7	0.12	0.71	1.01
Japan	6.13	0.18	−0.55	0.75	−2.6	3.84
Korea	6.39	1.86	−0.44	3.76	−0.84	3.41
Mexico	0.93	0.67	−0.21	1.29	1.8	1.78
Russia	5.94	0.66	−0.77	3.64	3.19	−0.77
Saudi Arabia	8.54	1.9	−0.25	0.62	−0.57	1.26
South Africa	4.05	0.08	0.07	1.59	−1.61	2.04
United Kingdom	1.9	−1.37	−0.88	1.58	0.81	1.06
United States	2.56	−0.86	−0.76	1.51	−0.03	1.59
Average	3.9	0.5	−0.54	2.09	0.3	1.61

Note: Growth rates were calculated using before log conversion data. TA = total arrival; CO_2 = total carbon dioxide emissions; PM2.5 = mean population exposure to particulate matter; RGDP = GDP per capita; REER = real effective exchange rate; TO = trade openness.

economies have shown significant negative growth in CO_2 emissions.

Table 4 displays summary statistics on individual countries over the sample period. Among the G20 countries, only France and the United States have more than 50 million international tourist arrivals during the sample period. On average, Australia, Brazil, Japan, and Korea have less than 10 million international tourist arrivals per year. The average per capita CO_2 emissions are significantly higher in countries like the United States, Australia, Canada, Saudi Arabia, and Russia, while China and Mexico have the lowest. China and Saudi Arabia emit much higher levels of PM2.5 than other countries. Further, Saudi Arabia and the United States have per capita income of more than $40,000 international dollars, whereas China has less than $10,000 international dollars. Korea has the highest real effective exchange rate, while the lowest is Russia. In terms of the trade openness, only Korea and Saudi Arabia are above 70%. Finally, we report that the contribution of total tourism to GDP (TGDP) is more than 10% in countries such as Australia, Germany, Italy, Mexico, and Saudi Arabia, while only the United Kingdom has less than 5%. Overall, the summary statistics imply that tourism plays an important role in the economic development of the G20 nations.

Before proceeding to our main results, we first provide some preliminary results and plots to examine the basic time series properties of our variables. Panel A of Figure 1 shows that there is a negative correlation between per capita CO_2 emissions and tourism arrivals whereas panel B indicates a negative correlation between PM2.5 emissions and tourism arrivals. We report the results from different models below as a step to a more rigorous causality analysis.

Preliminary Analysis

As a prerequisite for panel analysis, we first perform panel unit root tests and cointegration tests. We use panel unit root tests to

Table 4. Summary Statistics on Individual Countries.

Country	TA	CO_2	PM2.5	RGDP	REER	TO	TGDP
Australia	5.21	17.04	10.48	37970.57	85.88	40.94	12.83
Brazil	4.7	1.97	15.69	12789.43	85.22	23.59	9.16
Canada	17.8	16.4	8.22	38784.87	87.34	69.57	5.9
China	41.6	4.63	64.78	6416.17	95.5	46.57	8.53
France	75.4	5.75	14.65	35386.98	102.11	53.49	9.93
Germany	22.1	9.8	14.85	38404.6	104.84	67.61	11.85
Italy	40.3	7.38	19.31	36016.54	99.32	49.99	11.31
Japan	6.53	9.5	14.22	34906.6	102.49	25.44	8.49
Korea	6.8	10	29.73	24979.07	118.55	77.52	6.3
Mexico	21.6	4.13	26.63	15909.35	103.38	55.49	14.72
Russia	22	11.28	18.88	18731.88	81.48	54.22	5.63
Saudi Arabia	10.6	16.57	84.45	45382.74	106.4	79.31	11.51
South Africa	7.17	8.91	26.39	10835.05	97.17	55.62	8.41
United Kingdom	26.4	8.49	12.38	34968.36	116.74	53.59	2.62
United States	53.3	18.68	9.34	47183.46	108.38	25.79	8.12
Average	24.1	10.04	24.67	29244.38	99.65	51.92	9.02

Note: TA = international tourist arrivals, in million; CO_2 = CO_2 emissions in metric tons per capita; PM2.5 = particulate matter emissions in micrograms per cubic meters; RGDP = real GDP per capita in 2011 purchasing power parity international dollars; REER = real effective exchange rate index, 2010 = 100; TO = trade openness is total trade as a percentage of GDP; TGDP = total tourism contribution to the GDP.

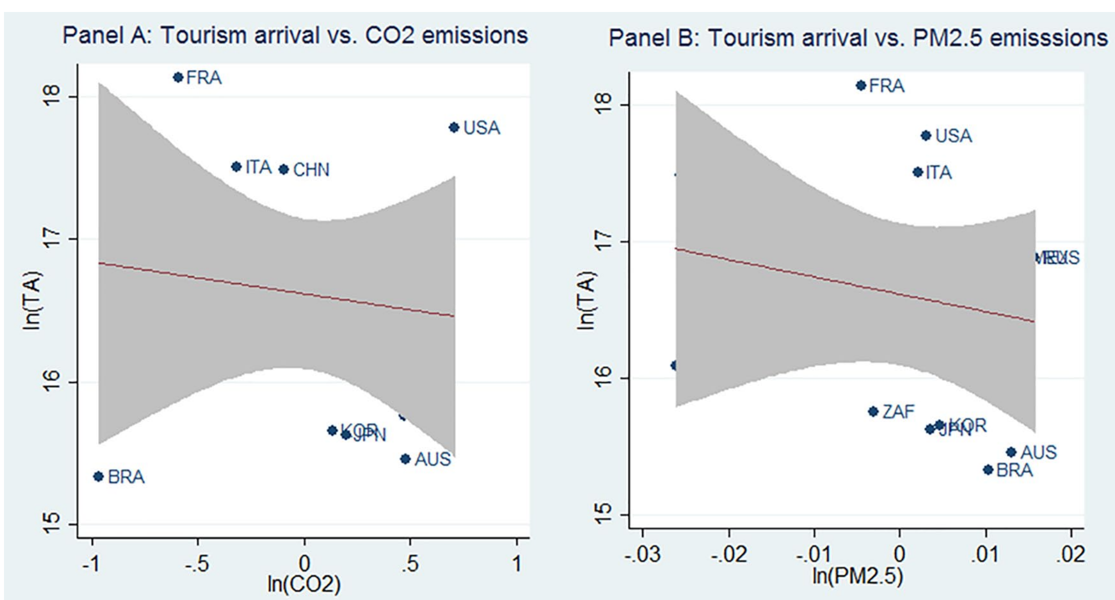

Figure 1. Association between tourism and air pollution.

determine the order of integration of our variables prior to estimating the long-run effects and short-run dynamics. We apply three panel unit root tests including the IPS test (Im, Pesaran, and Shin 2003), the Fisher-Augmented Dickey-Fuller (ADF) test (Maddala and Wu 1999), and Fisher-Phillips-Perron (PP) test (Choi 2001). Unlike the IPS test, the Fisher-ADF and Fisher-PP tests can adopt various lag lengths for the individual ADF regressions and are used for unbalanced panel data (Li and Lin 2016). The panel unit root test results with intercept and trend are displayed in Table 5. At level, the IPS and Fisher-ADF test statistics show that all the variables are nonstationary. The Fisher-PP test results show that all the variables except international tourism arrivals are nonstationary. At first difference, the results of the panel unit root tests show that the test statistics for all the variables are significant at the 1% level, which suggests that all the variables are stationary.

Table 5. Panel Unit Root Test Results.

Variables	Im, Pesaran, and Shin (2003)	Maddala and Wu (1999)	Choi (2001)
	Test		
Level			
TA	−0.35	−0.44	−1.52*
CO_2	1.92	2.06	1.29
PM2.5	1.65	2.99	2.42
GDP	−0.75	−0.7	1.33
TO	−0.47	0.91	−0.87
REER	−0.73	−1.22	−0.26
First difference			
TA	−3.42***	−3.68***	−9.47***
CO_2	−5.52***	−5.29***	−10.57***
PM2.5	−5.10***	−2.79***	−4.53***
GDP	−4.01***	−4.03***	−7.24***
TO	−4.42***	−4.72***	−10.27***
REER	−3.14***	−3.50***	−5.72***

Note: TA = tourist arrivals; CO_2 = CO_2 emissions per capita; PM2.5 = particulate matter emissions; GDP = gross domestic product; TO = trade openness; REER = real effective exchange rate. * and *** indicate the significance at the 10% and 1% levels, respectively.

We then employ the Pedroni (2004) and Kao (1999) cointegration tests to examine the existence of long-run effects. All variables need to be of the same order before implementing cointegration tests (Lin, Zhang, and Wu 2012). Because of the stationarity of all variables at first difference as shown in Table 5, the Pedroni (2004) and Kao (1999) cointegration tests can be used to investigate the existence of long-run effects of carbon and PM2.5 emissions on tourism arrivals. The results of the Pedroni (2004) and Kao (1999) cointegration tests are presented in Table 6. The Panel PP, Panel ADF, group PP and group ADF test statistics are significant, suggesting that the null hypothesis of no cointegration is rejected. Moreover, the significant statistics of the ADF also indicates that the null hypothesis of cointegration is rejected. The results of the two cointegration tests therefore provide strong evidence of the existence of long-run effects of both carbon and PM2.5 emissions on tourist arrivals.

Baseline Results

To get some sense of the magnitude of the long run effects of carbon and PM2.5 emissions on tourism arrivals, we estimate the cointegrating relationship using fully modified ordinary least-squares (FMOLS) as a benchmark exercise. The estimation results from the FMOLS model are shown in Table 7. According to the Akaike Information Criterion (AIC), the time lag selected in the long run model equals to one, which is in line with studies in the literature (see, e.g., Böhringer et al. 2017; Schleicha, Walza, and Ragwitza 2017). Our results show that there is a significant negative correlation between CO_2 emissions and tourist arrivals. Specifically, the results in column (1) of Panel A in Table 7 suggests that a 1% increase in carbon emissions is associated with a decline in tourism arrivals by 0.12%. Moreover, we find that PM2.5 emissions also have a significant negative impact on tourism arrivals. As shown in column (1) of Panel B, a 1% increase in the level of PM2.5 emissions in the atmosphere causes a decrease in tourism arrivals by 0.92%.

One may be concerned that international tourists may have different sensitivity to air pollution when considering developed or developing countries as their destinations. To address this concern, we further split our sample into developed and developing countries based on the World Bank classification to examine if differences exist in the observed effect by country type. The results, reported in columns (2) to (3) of Panel A in Table 7, show that carbon emissions negatively impact tourist arrivals in both developed and developing countries. In particular, a 1% increase in per capita CO_2 emissions is associated with a decrease in tourism arrivals in developed and developing countries by 0.49% and 0.37%, respectively. The results in columns (2) to (3) of Panel B show that the coefficients of PM2.5 emissions are negative and statistically significant at a 5% level or better, implying PM2.5 emissions have a detrimental effect on tourism arrivals. Our results also imply that real GDP per capita and trade openness have a significant positive effect on international tourism.

Overall, the above findings indicate that the growth in CO_2 and PM2.5 emissions adversely affect the tourist arrivals in developed and developing economies. The results also show that the effect of CO_2 emissions is more pronounced in the case of developed economies than developing economies, while the effect of PM2.5 emissions is stronger for developing economies. These results have significant policy implications. More specifically, our analyses imply that international tourists are very sensitive to the level of air pollution in the visiting country, be it a developed or developing economy. The G20 nations account for about three-fourths of the global CO_2 emissions, while the highest emissions in PM2.5 are also reported in some G20 countries. This points to the need for policies that can sustain the tourism industry given the persistent increase in CO_2 and PM2.5 emissions.

Given these findings, we propose the need for the G20 nations to implement effective environmental policies such as increase in the share of renewable energy consumption, adopt more emission-controlling and energy-efficient technologies, which can all significantly help to reduce the growth of CO_2 and PM2.5 emissions. Without adequate control of the level of CO_2 and PM2.5 emissions, the tourism industry across the G20 countries is likely to suffer further detrimental effects. Further, given the job prospects and other benefits associated with the growth of the tourism industry, it is important to keep CO_2 and PM2.5 emissions in check.

Table 6. Pedroni (2004) and Kao (1999) Cointegration Test Results.

Method	Statistic	(1) Full Sample	(2) Developed Countries	(3) Developing Countries
Panel A: CO_2 on TA				
Pedroni residual cointegration test	Panel v statistic	4.08***	3.15***	2.58***
	Panel rho-statistic	2.77	2.02	1.83
	Panel PP statistic	−3.58***	−4.21***	−1.39*
	Panel ADF statistic	−3.39***	−1.94**	−2.69***
	Group rho statistic	3.95	2.8	2.82
	Group PP statistic	−6.63***	−6.07***	−3.05***
	Group ADF statistic	−3.24***	−2.24**	−2.38***
Kao residual cointegration test	ADF stat	−2.11**	−2.33**	−2.7***
Panel B: PM2.5 on TA				
Pedroni residual cointegration test	Panel v statistic	1.54*	1.64*	0.72
	Panel rho-statistic	2.3	2.22	1.25
	Panel PP statistic	−3.33***	−2.8***	−2.04**
	Panel ADF statistic	−4.85***	−6.58***	−2.03**
	Group rho statistic	3.5	2.8	2.1
	Group PP statistic	−8.59***	−8.29***	−3.44***
	Group ADF statistic	−7.16***	−6.78***	−3.02***
Kao residual cointegration test	ADF stat	−7.9***	−5.92***	−5.67***

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 7. FMOLS Results.

	(1) Full Sample	(2) Developed Countries	(3) Developing Countries
Panel A: CO_2 on TA			
Per capita CO_2 emissions	−0.12*	−0.49***	−0.37*
	(–0.07)	(–0.15)	(–0.19)
Real GDP per capita	0.63***	2.79***	0.83***
	(–0.07)	(–0.42)	(–0.15)
Trade openness	0.92***	0.29*	0.76***
	(–0.07)	(–0.16)	(–0.15)
Real effective exchange rate	0.05	0.20	0.02
	(–0.07)	(–0.20)	(–0.15)
Panel B: PM2.5 on TA			
Per capita CO_2 emissions	−0.92***	−0.51**	−1.9***
	(0.26)	(0.22)	(0.37)
Real GDP per capita	0.56***	0.50**	0.64***
	(0.08)	(0.24)	(0.08)
Trade openness	0.92***	0.26*	0.81***
	(0.1)	(0.14)	(0.13)
Real effective exchange rate	0.01	−0.30**	0.04
	(0.12)	(0.14)	(0.13)

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Endogeneity

The existing literature suggests the existence of a reverse causality relationship between environmental quality and tourism. To ensure that our results are robust to endogeneity, which may arise from reverse causality, we use the system generalized method of moments (GMM) estimation proposed by Arellano and Bover (1995) and Blundell and Bond (1998) to control for endogeneity.[6] Moreover, given that our data exhibit relatively large cross-sectional components compared with time-series components, the system GMM method is preferred as it is specifically designed for this type of data set. The GMM estimation results are presented in Table 8. The results in column (1) of Panel A in Table 8 show that the coefficient on CO_2 emissions is negative and statistically significant, with an effect size of 0.69, implying that a 1% increase in CO_2 emissions is associated with a 0.69% decrease in tourist arrivals. The results in columns (2) to (3) of panel A show that an increase in CO_2 emissions is negatively associated with tourism arrivals, where the effect is stronger for developed countries. Specifically, on average, a 1% increase in carbon emissions is associated with a 1.71% and 0.87% reduction in tourist arrivals in developed and developing countries, respectively. The coefficient of PM2.5 emissions in column (1) of panel B is negative and statistically significant at the 10% level, indicating that PM2.5 emissions have a negative effect on tourist arrivals. The results in columns (2) to (3) of panel B show that the negative effect of PM2.5 emissions is stronger for developing countries. In particular, on average, a 1% increase in PM2.5 emissions causes a decrease in tourism arrivals about 0.5%. The effect by country type reveal that a 1% rise in PM2.5 emissions leads to 0.71% and 0.73% fall in tourist arrivals in developed and developing countries, respectively.

Table 8. System GMM Results.

	(1) Full Sample	(2) Developed Countries	(3) Developing Countries
Panel A: CO_2 on TA			
Per capita CO_2 emissions	−0.69**	−1.71***	−0.87***
	(–0.3)	(–0.46)	(–0.22)
Real GDP per capita	0.74**	2.32*	0.12
	(–0.28)	(–1.1)	(–0.17)
Trade openness	0.40	−0.08	2.07***
	(–0.33)	(–0.67)	(–0.35)
Real effective exchange rate	0.18	−0.13	1.90***
	(–0.22)	(–0.6)	(–0.36)
Observations	296	176	120
AR(2) *p* value	0.09	0.15	0.93
Hansen test *p* value	1	1	1
Panel B: PM2.5 on TA			
Per capita CO_2 emissions	−0.50*	−0.71**	−0.73*
	(0.24)	(0.30)	(0.41)
Real GDP per capita	0.01	0.73	0.61***
	(0.24)	(1.65)	(0.12)
Trade openness	0.73***	0.70**	0.30**
	(0.24)	(0.27)	(0.15)
Real effective exchange rate	0.78**	1.08*	0.13
	(0.31)	(0.56)	(0.12)
Observations	296	176	120
AR(2) *p* value	0.9	0.3	0.25
Hansen test *p* value	1	1	1

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

The validity of the GMM estimates relies on the assumption that the exclusion restriction holds, $E\left(X^{f}u\right)=0$. That is, the independent variables are assumed to be exogenous and therefore uncorrelated with the error term in the second-stage regression. Following a common diagnostic test procedure in the literature, we report the Hansen test of overidentifying restrictions and the second-order, autoregressive, AR(2) tests. The Hansen test provides evidence of the validity of the instruments by evaluating the entire set of moment conditions in satisfying the exclusion restriction.

The AR(2) test and the Hansen test reported in Table 8 do not reject the null hypothesis of no second-order serial correlation and the validity of the overidentifying restrictions, respectively. The *p* value for the second-order serial correlation in the system GMM estimation is greater than 5% in all specifications, which is unable to reject the null hypothesis of no second-order serial correlation at the conventional levels of significance (1% and 5%). Furthermore, for the Hansen test, we do not reject the null hypothesis of the validity of the overidentifying restrictions at the conventional levels of significance. Overall, the AR(2) test for second-order serial correlation and the Hansen test of overidentifying restrictions are both satisfied, suggesting that our GMM estimates are consistent and efficient.

Conclusions

This study provides an empirical analysis on the effects of CO_2 and PM2.5 emissions on tourism. While a number of theoretical studies have argued that environmental factors influence the growth of the tourism industry, there is a lack of empirical studies that examine the effects of air pollution on tourist arrivals. This study therefore contributes to the literature by providing empirical evidence on the role of CO_2 and PM2.5 emissions on tourist arrivals in G20 countries. We utilized annual data from 1995 to 2014 on 15 countries of the G20 group, and for the purpose of comparison, explore the differential effects on developed and developing countries of the G20. The G20 countries have played an important role not only in terms of economic development but also in attracting international tourists. However, the G20 countries are also responsible for three-fourths of the global CO_2 emissions and the member countries are also the world's largest emitters of PM2.5, making this an issue of concern for both individuals and policy makers.

We find evidence of a negative effect of CO_2 and PM2.5 emissions on tourism. This effect of CO_2 emissions is more pronounced for developed countries, while the effect of PM2.5 emissions is stronger for developing countries. Given this evidence, we propose the need for appropriate policies that aim at reducing both CO_2 and PM2.5 emissions. We first propose taxation as an important policy intervention. Fiscal policy is an important determinant of economic choices. Taxes on corporate income are particularly powerful drivers of tourism growth. Subsidies and tax provisions therefore should favor firms that produce green tourism goods. Taxes outside energy can also influence CO_2 and PM2.5 emissions. In particular, property taxes and related instruments, especially in countries with rapidly growing urban areas, can affect future CO_2 and PM2.5 emissions. These policies should be considered in light of the broader economic benefits of such tax measures, and in country-specific contexts.

Second, the implementations and investments into low-carbon innovations can also serve as important policy instruments. Clear and credible government commitment to ambitious core climate policy instruments is important for low-carbon innovation. Along these lines, it is important for governments to promote innovations that ensure sustainable tourism by creating new tourism businesses as well as restructure unsustainable businesses. Such a venture can only be achieved with the emergence of innovative technologies and the right support frameworks for carbon-curbing innovations to be widely adopted. This includes addressing potential skills gaps through education, training, and labor market policies. Indeed, the achievement of such goals require sustainable low-carbon investment and finance. The global economy requires around US$90 trillion of investment in infrastructure between 2015 and 2030 to support sustainable economic development.[7] Investing in low-carbon, climate-resilient infrastructure could put the world on a 2°

Celsius trajectory and deliver significant co-benefits, including improvements in environmental quality, energy savings, and better mobility.

It is also important for government to invest toward sustainable urban mobility. Current transport systems that rely largely on fossil fuels impose very high environmental costs (climate change, noise, air pollution), particularly in urban settings. Policy intervention is needed to provide more energy-efficient and less carbon-intensive mobility. Aligning policy action across levels of governments and between stakeholders could do much to deliver lower-carbon mobility.

Given the evidence on the negative effects of tourism on the environment, the promotion of sustainable tourism investments would help the tourism industry to minimize its contribution to environmental degradation. Increased investment in sustainable tourism can promote the tourism industry across developed and developing countries and may help them to adopt more renewable energy sources as well as energy-efficient and emission-controlling technologies. Failure to ensure growth in tourism investment and a reduction in CO_2 and PM2.5 emissions could severely limit the performance of the tourism industry in the near future, and this could have negative implications on economic factors such as employment, tax revenues, and foreign exchange reserves, among others.

One limitation of our study is that we focus only on CO_2 emissions among the greenhouse gases. While CO_2 emissions are responsible for a significant portion of the greenhouse effect, future research can shed more light on the relationship between tourism and other greenhouse gases. Importantly, it would be interesting to empirically test the channels through which air pollutants work to influence tourism. Understanding the mechanisms of influence is relevant and can contribute toward more targeted policies that will aim at mitigating the negative effects of air pollutants on tourism. Future research can also examine the impact of other indicators of environmental pollution besides air pollutants on tourism. This research can focus on the impact of polluted waterways, solid waste, and litter, among others, on tourism. This can provide insights that can support more holistic environmental policies to promote tourism. Another limitation of our study is that we focus on G20 countries. While the G20 countries make for an interesting case study given trends in pollution and tourism, it will be useful to understand the dynamics of the relationship we study in other cross-country contexts, and thus, future research can focus on an extended sample to examine this relationship.

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Notes

1. Our analysis starts at 1995 and ends at 2014 given that data on tourism are only available from 1995 while data on carbon emissions are unavailable beyond 2014.
2. Following the World Bank classification of countries, the G20 economies are grouped based on their income levels using gross national income (GNI) per capita, in US dollars, converted from local currency. The classifications data are available online at https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries
3. The European Union (EU) is also part of the G20, so we only consider the individual countries of the G20 group. Data on real effective exchange rate index is unavailable for Argentina, India, Indonesia, and Turkey, and are thus, excluded.
4. Data on PM2.5 are only available until 2010, and thus, we use linear interpolation to fill in the missing observations.
5. We do not report the percentage of total PM2.5 emissions as the data for world PM2.5 emissions is only available from 2010 onward.
6. The system GMM approach produces more efficient dynamic panel data estimators than the GMM in differences approach proposed by Arellano and Bond (1991) since the system GMM estimator reduces the potential biases arising from the instruments.
7. See OECD (2015).

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