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# The Impact of Long Haul Destinations on Carbon Emissions: The Case of Mauritius

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*With the continual increase in tourism and travel activities globally, there are serious allegations that the industry is significantly contributing towards climate change through its impact on $CO_2$ emissions. There are, to date, no empirical studies investigating the relation between tourism development and carbon emissions, which are debated to cause climatic changes. This article studies the impact that tourism and travel has on climate change for the case of Mauritius, a long-haul tourist destination. Assessing climatic change requires a significant amount of data over time. However, in the short term, the impact and contribution of tourism and travel-related activities on $CO_2$ emissions can be assessed given that time series data are available. Using an autoregressive distributive lag approach, we specifically examine the dynamic relationship between tourism activities and carbon dioxide emissions as a proxy of environmental degradation using data from the period 1978–2011. The estimated long-run and short-run parameters revealed that an increase in tourist arrivals has significantly and positively affected $CO_2$ emissions. This implies that the tourism and travel industry will have to adopt cleaner technologies to reduce $CO_2$ emissions to avoid climatic changes.*

*KEYWORDS climate change, $CO_2$ emissions, time series, autoregressive distributed lag*

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## INTRODUCTION

It is well acknowledged that one of the serious environmental challenges facing the tourism and travel industry is the issue of climatic change (Hall & Higham, 2005; Patterson, Basstianoni, & Simpson, 2006). Fiorello and Bo (2012) posited that tourism can negatively affect the host communities as well as their natural environment. They also discussed the changing attitude of society toward the environment, particularly that of travelers who are becoming increasingly responsible. Although responsible travel—by land, water, or air—will certainly have an impact on environment through the emissions of $CO_2$, the ultimate question remains as to how to minimize those emissions. A forecast from the World Tourism Organization, *Tourism 2020,* revealed that international tourist arrivals would reach nearly 1.6 billion by the year 2020 (378 million being long-haul travelers). Air travel is predicted to grow significantly over the next two decades, around 5% to 5.2% (Airbus, 2003, cited in Cooper & Hall, 2008). Although it is usually argued that tourism may be a victim of environmental degradation, tourism activities also contribute to greenhouse emissions and this is expected to rise further with increasing tourism demand globally; the latter is the current focus of this article. However, a scant amount of literature has attempted to analyze tourism development and emissions in individual nations or regions (Dubois & Ceron, 2006; Gössling, 2002; Peeters, Gössling, & Becken, 2007). In addition, as far as we are aware, no empirical relation between tourism development and carbon emission (the proxy for environmental and climatic degradation) exists.

As reported by Seetanah and Sanassee (2011), Mauritius is strongly and increasingly dependent on fossil fuels as far as its energy needs are concerned (a reported amount of 82%). As such, the carbon dioxide emissions associated with fossil fuels have risen; according to the Central Statistical Office (2010), figures on per capita carbon dioxide emission reached around 2.8 tons. On the other hand, the island has also been registering honorable growth in its tourism, averaging 7% over the years 2000 to 2010 (tourist arrivals in 2011 were 964,642). It is believed that related tourism activities (such as increased air travel, inland traffic, food production, and construction, among others) may have exacerbated per capita carbon dioxide emissions. Given the location of Mauritius being far from its many tourist-originating countries, Mauritius is almost inevitably condemned to be highly dependent on fossil fuels, resulting in higher carbon dioxide emissions and thus, an increased climatic challenge for the Mauritian economy.

This article attempts to supplement the scant literature by examining the empirical link between tourism and carbon dioxide emissions, using annual data between 1978 and 2011 for the case of Mauritius. It takes into account the time series properties of the data together with the possibility of dynamic effects and thus proposes an autoregressive distributed lag (ARDL) framework. The econometric model employed is based on the determinant of $CO_2$ emissions for the case of Mauritius.

The article is organized as follows: In Section 2, we review the literature discussing related articles on climate change. In Section 3, we specify the model and discuss the time series properties of the data. Section 4 contains our findings, and Section 5 concludes the article.

## LITERATURE REVIEW

### Tourism Development: A Vector of Climate Change

Tourism appears first and foremost as a victim of climatic change. However, it is also a nonnegligible vector of the changes that are taking place and it contributes, sometimes through overexploitation, to the global warming process. There are several studies that have analyzed the risks of climate change on the tourism sector (e.g., Moreno, 2011; Moreno & Belda, 2011). Moreno and Belda (2011) found that in the case of Ibiza, as many as 70% of respondents acknowledged that tourism on the island depends highly on weather and climate and that little is being done to adapt to projected climatic changes.

Oomah, Mamode Khan, Emmambokus, and Heenaye (2011) used a Poisson regression model to analyze the economic impacts of climate change on the tourism demand in Mauritius. It is believed that climate change may push away tourists due to rising sea levels (e.g., in the case of Maldives Islands), biodiversity loss, increased natural hazards (such as heavy storms, coastal flooding, and erosion) and increasing incidence of diseases, which will adversely impact tourism. However, in the case of Mauritius, Oomah et al. (2011) found that a rise in temperature as a measure of climate change will lead to a rise in tourism in Mauritius. This result has to be interpreted with some reservations, as the model is ad hoc and lacks theoretical rigor. However, Hamilton and Tol (2007) also revealed that with climate change, as the Northern hemisphere gets warmer, tourists from Western European origins might tend to stay home and will, therefore, demand less international travel. From this, it is clear that the effect of climate change is obvious; however, the main question we wish to understand is whether tourism and travel activities significantly contribute to climate change.

Undeniably, as Gössling (2002) and Peeters (2005) posited, the transport sector remains the major component of both the tourism industry and greenhouse gas emissions, particularly air transport, and is increasingly linked with climate change. Peeters (2005) further stated that air travel, with over 1,000 million passengers currently being transported per year, is estimated to account for one fifth of carbon dioxide emissions, while the World Tourism Organization (2012) estimated that air travel is related to over half of all greenhouse gas emissions from tourism. The report also highlighted that air transport also is likely to impact the skies (e.g., through the formation of cirrus clouds). In addition, tourist transportation via road (e.g., train travel from the residence to the destination) also contributes, though to a far lesser extent, to tourist-related $CO_2$ emissions.

Gössling (2002) further pointed out that in addition to transportation, the operation of accommodations—related mainly to heating and cooking, among others—also accounts for carbon dioxide emissions. The author added that this is also probably the case with other tourism activities/entertainment related to the operation of restaurants, bars, nightclubs, cinemas, tours, and motorized sports, among others. Gössling (2002) and Peeters, Szimba, and Dunijinisveld (2007) posited that nearly 90% of all emissions were caused by transport, with 9% caused by accommodations in regards to tourism activities.

From the aforementioned literature, it hence seems important that we examine the extent to which tourism and travel activities contribute to climate change through their greenhouse gas emissions, in particular, $CO_2$ emissions. Mauritius presents an interesting case to consider, as over 90% of tourist arrivals are by air and are mainly from European origins.

## METHODOLOGY AND ANALYSIS

### Modeling the Effect of Tourism on $CO_2$

To assess the impact of tourism and travel on climate change we specify an econometric model to analyze the effects of tourism and travel on the environment as measured by carbon dioxide emissions. The model employed is a variant of the model used by Seetanah and Sannassee (2014) and Khadaroo and Seetanah (2007), with an emphasis on tourism. The model is specified as follows:

$$CO_2 = f\,(\text{GDP}, \text{IVT}, \text{POP}, \text{VEHICLES}, \text{TOUR}) \tag{1}$$

Where $CO_2$ is the carbon dioxide emissions per head of the population, GDP is the gross domestic product per head of the population and is a measure economic development, IVT is the investment ratio, POP reflects the population, VEHICLES is the number of vehicles on road, and TOUR is the number of tourist arrivals in Mauritius (reflective of tourism development. Except $CO_2$, which was obtained from the CDIAC, our data was obtained from the Central Statistical Office and spans over the years 1978 to 2011.

### The Econometric Model and Preliminary Tests

From the specification in Equation 1, we specify an econometric model (in double log form) as follows:

$$co_2 = \beta_0 + \beta_1 gdp + \beta_2 ivt + \beta_3 pop + \beta_4 vehicles + \beta_5 tour + \varepsilon \qquad (2)$$

We preliminarily investigate the data series properties with respect to stationarity and cointegration. The augmented Dickey-Fuller (1979) unit-roots test confirms that all our variables are integrated of Order 1 (I[1]) with the exception $CO_2$, which is I(0). The Phillips-Perron test (Phillips & Perron, 1988) confirmed the above and the results from both tests are summarized in Table 1 and 2. For stationarity tests, also refer to Tables 1 and 2.

## ARDL Model

Given the existence of both I(0) and I(1) variables, the ARDL bounds cointegration technique has been our preferred methodology for both test of cointegration and estimation of model, as well (see Pesaran, Shin, & Smith, 2001).

*Testing for Cointegration Using the ARDL.* Using an approach similar to Seetanah (2006, 2008) and Pesaran and Shin (1997), we investigate the existence of a long-term relationship in our model. For the specification at (1),

**TABLE 1** Summary results of unit root tests in level form: Dickey-Fuller and Phillips/Perron Test

| Variables (in log) | Lag selection | Aug. Dickey Fuller | Phillips Perron | Critical value | Variable type | Aug Dickey Fuller (time trend [*t*]) | Critical value | Variable type |
|---|---|---|---|---|---|---|---|---|
| $CO_2$ | 1 | +3.42 | +3.557 | −2.9 | *I(0)* | −4.26 | −3.5 | *I(0)* |
| *gdp* | 1 | −1.65 | −2.135 | −2.9 | *I(1)* | −2.27 | −3.5 | *I(1)* |
| *ivt* | 1 | −2.23 | −2.87 | −2.9 | *I(1)* | −3.17 | −3.5 | *I(1)* |
| *pop* | 1 | +0.97 | +2.97 | −2.9 | *I(1)* | −1.17 | −3.5 | *I(1)* |
| *vehicles* | 1 | −1.34 | −0.75 | −2.9 | *I(1)* | −0.77 | −3.5 | *I(1)* |
| *tour* | 1 | −1.75 | −0.65 | −2.9 | *I(1)* | −0.73 | −3.5 | *I(1)* |

**TABLE 2** Summary results of unit root tests in first difference: Dickey-Fuller and Phillips/Perron Test

| Variables (in log) | Lag selection | Aug. Dickey Fuller | Phillips Perron | Critical value | Variable type | Aug Dickey Fuller (time trend [*t*]) | Critical value | Variable type |
|---|---|---|---|---|---|---|---|---|
| $\Delta CO_2$ | 0 | −8.51 | −8.74 | −.2.9 | *I(0)* | −8.64 | −3.5 | *I(0)* |
| $\Delta gdp$ | 0 | −5.21 | −4.33 | −.2.9 | *I(0)* | −5.34 | −3.5 | *I(0)* |
| $\Delta ivt$ | 0 | −7.73 | −5.64 | −.2.9 | *I(0)* | −8.74 | −3.5 | *I(0)* |
| $\Delta pop$ | 0 | −4.34 | +3.77 | −.2.9 | *I(0)* | −4.42 | −3.5 | *I(0)* |
| $\Delta vehicles$ | 0 | +4.46 | −2.92 | −.2.9 | *I(0)* | −5.07 | −3.5 | *I(0)* |
| $\Delta tour$ | 0 | −4.76 | +3.76 | −.2.9 | *I(0)* | −4.41 | −3.5 | *I(0)* |

the error correction version of the ARDL model with variables *$co_2$, gdp, ivt, pop, vehicles,* and *tour* is given by:

$$\begin{aligned}\Delta co2 = \beta_o + \sum_{i=1}^{n} b_i \Delta co2_{t-i} + \sum_{i=1}^{n} c_i \Delta qdp_{t-i} + \sum_{i=1}^{n} d_i \Delta ivt_{t-i} \\ + \sum_{i-1}^{n} e_i \Delta pop_{i-1} + \sum_{i-1}^{n} f_i \Delta vehicles_{t-i} + \sum_{i=1}^{n} g_i tour_{t-1} + \delta_1 co2_{t-1} \\ + \delta_2 gdp_{t-1} + \delta_3 \mathrm{i}vt_{t-i} + \delta_4 pop_{t-1} + \delta_5 vehicles_{t-1} + \delta_6 tour_{t-1} + \varepsilon_1\end{aligned} \tag{3}$$

The maximum order of the lags in the ARDL model, using the final prediction error due to the Schwartz Bayesian criterion (SBC), was one.

For Equation 3, the hypothesis being tested is the null of "the absence of a long run relationship" defined by:

*H0:* $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = 0$

With the alternative hypothesis being:

*H1:* $\delta_1 \neq 0, \delta_2 \neq 0, \delta_3 \neq 0, \delta_4 \neq 0, \delta_5 \neq 0, \delta_6 \neq 0$

We use the *F*-statistic to test for the joint significance of $\delta_1$, $\delta_2$, $\delta_3$, $\delta_4$, $\delta_5$, and $\delta_6$. To computation of the *F*-statistic, the following regression is run:

$$\begin{aligned}\Delta \mathrm{co2_t} = \beta_0 + \mathrm{b}\Delta \mathrm{co2_{t-1}} + \mathrm{c}\Delta \mathrm{gdp_{t-1}} + \mathrm{d}\Delta \mathrm{ivt_{t-1}} + \mathrm{e}\Delta \mathrm{pop_{t-1}} \\ + f\,\Delta \mathrm{vehicles_{t-1}} + \mathrm{g}\Delta tour_{\mathrm{t-1}} + \varepsilon_t\end{aligned} \tag{4}$$

Subsequently, we have to perform a variable addition test and this includes the following:

$$\delta_1\, co_{2\mathrm{t-1}}, \delta_2\, gdp_{\mathrm{t-1}}, \delta_3\, ivt_{\mathrm{t-1}}, \delta_4\, pop_{\mathrm{t-1}}, \delta_5\, vehicles_{\mathrm{t-1}}, \delta_6\, tour_{\mathrm{t-1}}$$

The *F*-statistic, *F*(*co2,gdp, ivt, pop, vehicles, tour*) was reported to be 6.87 and exceeds the upper bound of the critical value band (provided in Pesaran, Shin, & Smith, 1996). The null hypothesis of the absence of a long run link between the variable, despite being I(0) and I(1), was rejected. The test results thus validated the presence of a long run relationship between our variables.

## ESTIMATION AND RESULTS

We subsequently estimate the short and long coefficients and alongside the error correction model (ECM). The SBC confirmed a lag order of 1; the ARDL (1,0,1,0,1,0) and the long run estimated coefficients are reported in the Table 3.

From the results, it is found that in the long run, a 1% increase in the arrival of[1] in the country is associated with a 0.08% increase in $CO_2$ emissions. Although it is a reportedly small but significant coefficient, this would imply that tourism has an adverse effect on $CO_2$ emissions in the country, and can be allegedly argued to be a potential contribution to climatic change by extension. It should be noted that its contribution is relatively small as compared to the other explanatory variables, with the number of vehicles on the roads and level of investment being the two most important polluters as per our model. It should also be noted that one has to be careful about these results, as our tourist variable probably captures other elements of tourism environmental degradation than that of inland vehicle (road transport) emissions. This is because part of the tourism transport environmental effect has been captured by the vehicles variable. However, the overall results imply that tourism, at least in the long run, affects $CO_2$ emissions and, most likely, climate change.

In the short run, it is reported that an increase in tourist arrivals does not have a significant impact on $CO_2$ emissions. One would argue that the impact of tourism on emissions and climatic change is indeed essentially a long-term phenomenon. The other short-term determinants behave as per theoretical underpinnings and the smaller reported coefficient, relative to the long-run estimates, would imply that it takes times to have the full effect on $CO_2$ emissions. The negative and significant coefficient of the error correction variable, ECM(-1; see Table 4) implies the presence of a stable long-run relationship between variables. In fact, the error-correction term is an indication of the speed of adjustment, following a shock, to restore equilibrium. From our results, the reported coefficient is around −0.40; this means that there is a 40% correction to the long-run equilibrium following a short-run shock.

**TABLE 3** Estimated long run coefficients based on ARDL approach: Dependent variable is $co_2$

| Regressor | Coefficient (SBC 1,0,1,0,1,0) | *t*-ratio |
|---|---|---|
| *gdp* | 0.283*** | 2.45 |
| *Ivt* | 0.473*** | 2.78 |
| *pop* | 0.15*** | 2.56 |
| *vehicles* | 0.56* | 1.98 |
| *tour* | 0.08* | 1.92 |
| *Constant* | 7.22*** | 5.15 |

*Significant at 10%. **Significant at 5%. ***Significant at 1%.

**TABLE 4** Error correction representation for the selected ARDL model: Dependent variable *co2*

| Regressor | Coefficient AIC (1,0,1,0,1,0) | $t$-ratio |
|---|---|---|
| $\Delta gdp$ | 0.174*** | 3.23 |
| $\Delta ivt$ | 0.188** | 1.94 |
| $\Delta pop$ | 0.064** | 1.48 |
| $\Delta vehicles$ | 0.162** | 2.03 |
| $\Delta tour$ | 0.036 | 1.18 |
| *ECM(-1)* | −0.403*** | 4.04 |
| $R^2$ | 0.656 | |
| DW | 1.91 | |

*Significant at 10%. **Significant at 5%. ***Significant at 1%.

The cointegration test results of the ARDL model reveal that our series are cointegrated, thus Granger causality will exist at least in one direction between different pairs of the variables included in the model. However, the ARDL cointegration results do not reveal the direction of the causality, for example, between $CO_2$ and *tour* in particular. A Granger causality test was performed and it yielded evidence of a one-way directional causality from $CO_2$ and *tour*, implying that tourist arrivals contribute to emissions (and not vice versa, at least for the case of Mauritius which has relatively low level of emissions).

## CONCLUSION

With increasing tourism activities, the impact of tourism and travel on climate change will become more and more pronounced. There are, however, practically no empirical studies to measure the impact of tourism and travel on climate change. This is due to a few reasons: (a) climate change is a difficult phenomenon to quantify (many variables that might be considered as good candidates are changes in temperature, amount of rainfall, duration of drought, and rising sea level, among others); (b) the nature of these variables makes it difficult to collect reliable data; and (c) there is no theory that enables econometric testing to quantify the relationship.

To overcome the difficulty of measuring the effect of tourism and travel on climate change, we first use $CO_2$ emissions as a proxy to reflect climate change. As is widely documented in the literature, increasing $CO_2$ emissions result in climate change. Data on $CO_2$ emissions are readily available and measureable. Travel, in particular, long-haul travel, is a significant contributor to $CO_2$ emissions.

We use a simple model to empirically measure the impact of tourism and travel on $CO_2$ emissions, which in turn provides an indication on climatic change. Mauritius, being a destination that is far from its major tourist originating countries, certainly has some contribution to $CO_2$ emissions. This study tests an empirical model to examine the relationship between tourism and travel activities and carbon dioxide emissions using data for the period 1978–2011. An ARDL model is used to confirm the long-run impact of tourism on $CO_2$ emission (and climate change). We found that a 1% increase in the tourist arrivals in the country is associated with 0.08% increase in $CO_2$ emissions in the long run. Although the impact is relatively small, it is, however, significant. Interestingly as well, in the short run, we found that an increase in tourist numbers does not have a significant impact on $CO_2$ emissions, although half of the long run impact. These tend to indicate that the impact of tourism on emission and climatic change is indeed essentially a long-term phenomenon.

The study hence reports for the first time the impact of tourism and travel on climatic change through its effect on $CO_2$ emissions. Policymakers should promote the use of cleaner energies and technologies to minimize $CO_2$ emissions. Given that travel, in particular, for long-haul destinations, is a significant contributor of carbon dioxide in the atmosphere, there is a high need to boost the use clean energies for this type of travel.

## NOTE

1. We have also used tourist receipts as an alternative to tourist arrivals, and the results do not differ greatly (with a coefficient of 0.07 obtained).

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