

Using Quantile Mediation Analysis to Explore the Effect of Tourism Development on Carbon Dioxide Emissions in Taiwan

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Abstract: This paper aims to investigate the effect of tourism development on carbon dioxide emissions whether through economic growth or not by using quantile mediation analysis, which combines a quantile regression and mediation analysis from 1990 to 2019 in Taiwan. The results of this innovative approach indicate that Taiwan's tourism development affects carbon dioxide emissions through the partial mediation effect of economic growth at below 0.5 distributions of carbon dioxide emission. Moreover, there is no any effect from tourism development to carbon dioxide emission at above 0.6 distributions of carbon dioxide emission.

Keywords: Quantile Mediation Analysis, Tourism Development, Carbon Dioxide Emissions, Economic Growth

JEL Classification Number: O10, O44

1. Introduction

Studies examining the relationship between tourism development and carbon dioxide (CO₂) emissions have become the important issues for researchers. Many empirical results indicated that tourism development and CO₂ emissions exists causal relationship in several nations, but seems to have mixed effects on CO₂ emissions. For example, Solarin (2014) explored the effects of tourist arrivals and macroeconomic determinants of CO₂ emissions in Malaysia during the period 1972–2010 by using autoregressive distributed lag, cointegration and Granger causality approaches. Results demonstrated that tourist arrivals have a positive effect on CO₂ emissions. Zhang and Gao (2016) applied panel cointegration and panel causality analyses to investigate the relationship between international tourism receipt, energy consumption, economic growth and CO₂ emissions in 30 provinces of China in the period of 1995–2011. They found that international

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tourism receipt has a decreasing effect on CO₂ emissions in Western and Eastern China, while it has no significant effect in Central China. Nepal, et al. (2019) analyzed the effect of tourist arrivals on CO₂ emissions in Nepal for the period of 1975–2014. Their results demonstrated that tourism is a significant contributor to CO₂ emissions. Le and Nguyen (2021) explored the impact of tourism on carbon dioxide emissions: insights from 95 countries international evidence during the period 1998–2014. The empirical results showed that tourism receipts or tourism arrivals can reduce total CO₂ emissions.

In the tourism research area, some empirical results also indicated that tourism development and economic growth exists causal relationship in several nations. For example, Balaguer and Cantavella-Jorda (2002) showed that there is a long run equilibrium relationship between tourism development and economic growth. They conducted a standard Granger causality test and showed that there is one-way causal relationship between tourism development and economic growth with Spanish data. Gunduz and Abdunnasser (2005) employed the leveraged bootstrap causality to examine the impact of tourism on the Turkey economy and also support the tourism-led growth hypothesis. However, using data of South Korea, Oh (2005) found that by using the co-integration analysis, there is no long-run relationship between tourism receipts and economic growth in South Korea over the period from 1975 to 2001. On the other hand, Dritsakis (2004), Kim, et al. (2006), and Rasool, et al. (2021) found a bi-directional relationship between tourism expansion and economic development.

On the other hand, Grossman and Krueger (1995) provided a systematic explanation for the relationship between gross domestic product (GDP) and environmental pollutants. They found that the economic development has three effects on environmental quality, which include scale effect, composition effect, and technique effect. The scale effect asserts that economic growth causes a negative effect on environmental quality. Balsalobre-Lorente, et al. (2018) explored the relationship between economic growth and CO₂ emissions in the European Union – Germany, France, Italy, Spain, and the United Kingdom for the period 1985–2016. They proved that economic growth indeed has a positive impact on CO₂ emissions.

The purpose of this paper is to investigate either if there is the direct relationship from tourism development to carbon dioxide emissions in Taiwan, or there is the indirect relationship from tourism development to carbon dioxide emissions through economic growth in Taiwan, or if there exist both an indirect and indirect relationship. Moreover, in this study we employed an innovative methodology proposed by Hsu (2020), which is totally different from the past research studies and called quantile mediation analysis. This innovative method combines a quantile regression proposed by Koenker and Bassett (1978) and mediation analysis proposed by Baron and Kenny (1986) to investigate the

dynamic short-run causal impact of tourism development on CO2 emissions across different conditional CO2 emissions from 1990 to 2019 in Taiwan.

The remainder of this paper is simply organized as follows. Section 2 explains research methodology. Section 3 describes data collection and results from empirical analysis. Section 4 shows the concluding discussion and further comments.

2. Methodology

This paper uses an innovative method that integrates a quantile regression and mediation analysis, to examine the impact of tourism development on CO2 emissions, whether through economic growth or not for the period 1990-2019 in Taiwan.

A quantile regression proposed by Koenker and Bassett (1978) considers the skewness of distributions and gives a more complete picture the performance affected by various independent variables. First, a quantile regression is more robust in response to large outliers because the estimated coefficient vector is not sensitive to outlier observations on the dependent variable. Second, it estimates the median and the full range of other conditions, rather than ordinary least squares regression to estimate the mean. Third, a quantile regression objective function is a weighted sum of absolute deviations, which gives a robust measure of location. Fourth, a quantile regression demonstrates a more efficient approach than the ordinary least squares method when the disturb term is non-normal. Lastly, a further advantage of quantile regression is that any quantile can be estimated when we have enough data.

An integrated method combines a quantile regression and meditation analysis which provides a useful supplement to the standard constant-parameter regression estimate (only one b or c or d) for studying all possible parameters (for all quantiles) varying across high dependent variable and low dependent variable. This novel method also leads to a more dynamic and complete understanding of what might really underlie the stories of great effect or non-effect for tourism development on CO2 emissions. The quantile regression minimizes a weighted sum of the positive and negative error terms in equations 1 to 3.

$$\min_{\theta} \sum |CO2_t - b_0 - b_1 TOURM_t| + (1 - \theta) \sum |CO2_t - b_0 - b_1 TOURM_t| \quad (1)$$

$$\min_{\theta} \sum |GROW_t - c_0 - c_1 TOURM_t| + (1 - \theta) \sum |GROW_t - c_0 - c_1 TOURM_t| \quad (2)$$

$$\min_{\theta} \sum |CO2_t - d_0 - d_1 TOURM_t - d_2 GROW_t| + (1 - \theta) \sum |CO2_t - d_0 - d_1 TOURM_t - d_2 GROW_t| \quad (3)$$

Here, the tourism development (TOURM) is measured as the real receipts of international tourism. The variable of CO2 is carbon dioxide emissions in metric tons. Economic growth (GROW) is measured as the real gross domestic product.

We use mediation analysis to investigate the causality from tourism development to CO₂ emissions through economic growth and the direct relation between tourism development and CO₂ emissions in Equations 1 to 3. According to Baron and Kenny (1986), mediation analysis of economic growth processes comprises the following steps:

Step 1: The independent variable TOURM should relate to the dependent variable CO₂, such that b_1 is significant in Equation 1. This condition is used to establish that there is a direct relationship between TOURM and CO₂ to be considered.

Step 2: The independent variable TOURM should relate to the mediator variable GROW, such that c_1 is significant in Equation 2. This condition establishes the first stage of the mediated effect.

Step 3: The mediator variable GROW should relate to the dependent variable CO₂, such that d_2 is significant in Equation 3. This condition establishes the second stage of the mediated effect.

Step 4: The independent variable TOURM should no longer relate to the dependent variable CO₂ after the mediator variable GROW is controlled, such that d_1 is not significant in Equation 3. This condition shows that the relationship between TOURM and CO₂ examined under the first condition disappears when the mediated effect transmitted through GROW is considered.

Satisfying all four steps provides evidence for complete mediation. However, only satisfying the first three steps indicates partial mediation if d_1 is still significant in Equation 3 and is smaller than b_1 in Equation 1.

3. Empirical Results

This study uses annual Taiwan data that covers the period 1990-2019. The data of the real gross domestic product is taken from the Taiwan Economic Journal, and the real receipts of international tourism from Tourism Bureau, the Ministry of Transportation and Communications. The data on carbon dioxide emissions is from Bureau of Energy, the Ministry of Economic Affairs. All variables are in logarithmic form.

Regarding the causal relationship between tourism development and carbon dioxide emissions, and tourism development and economic growth in equations 1 and 2, we demonstrate the causality test results in Table 1. For example, the notation of $\text{TOURM} \nrightarrow \text{CO}_2$ means that the variable tourism development does not affect the variable carbon dioxide emissions.

We find out some remarkable results as follows. First, there is the direct relationship from tourism development to carbon dioxide emissions by using traditional ordinary least

square method (OLS). Second, by using a quantile approach, there also exists causality running from tourism development to carbon dioxide emissions at below 0.5 distributions of carbon dioxide emissions, but no direct running from tourism development to carbon dioxide emissions at above 0.6 distributions of carbon dioxide emissions. Lastly, there exists causality running from tourism development to economic growth by using traditional OLS method and at any distributions of economic growth in Table 1. This result establishes the first stage of the mediated effect. It asserts that we consider the mediated effect at below 0.5 distributions of carbon dioxide emissions.

Table 1: Results from TOURM to CO2 and from TOURM to GROW at Different Quantiles

Quantile	TOURM	≠> CO2	TOURM	≠> GROW
	b1	p-value	c1	p-value
0.2	0.946	0.000	0.992	0.000
0.4	0.934	0.000	1.009	0.000
0.5	0.654	0.010	0.949	0.000
0.6	0.465	0.096	0.929	0.000
0.8	0.226	0.467	0.698	0.000
OLS	0.822	0.000	0.944	0.000

The table 2 shows that d2 is significant both by using traditional OLS and a quantile approach in Equation 3, that is, the mediator variable GROW relates to the dependent variable CO2. This result establishes the second stage of the mediated effect. Moreover, through the OLS method and a quantile analysis, the variable TOURM still relates to the dependent variable CO2 after the mediator variable GROW is controlled, such that d1 is significant in Equation 3, but is smaller than b1 in Equation 1. This result evidences the partial mediation because of only satisfying the first three steps in equations 1 to 3.

Table 2: Results from TOURM and EXPO to GROW at Different Quantiles

Quantile	TOURM	≠> CO2	GROW	≠> CO2
	d1	p-value	d2	p-value
0.2	-0.784	0.000	1.688	0.000
0.4	-0.610	0.000	1.521	0.000
0.5	-0.597	0.000	1.516	0.000
OLS	-0.640	0.000	1.727	0.000

4. Conclusions

Several empirical literatures have examined the causal relationship from tourism development to CO2 emissions. Most research results found a directly positive effect of tourism development on CO2 emissions by using the ordinary least square method.

However, in this paper we not only investigate if there is the direct relationship from tourism development to carbon dioxide emissions in Taiwan, but also if there is the indirect relationship from tourism development to carbon dioxide emissions through economic growth in Taiwan.

Moreover, in this study we employed an innovative methodology, which combines a quantile regression and mediation analysis, and provided a comprehensive picture of tourism development to CO₂ emissions in Taiwan over the period of 1990 to 2019. The results of this innovative analysis demonstrated that Taiwan's tourism development affects CO₂ emissions through the partial mediation effect of economic growth at below 0.5 distributions of CO₂ emissions, but at above 0.6 distributions of CO₂ emissions, there is no direct and indirect effect from tourism development to CO₂ emissions. These results suggest that Taiwan's government focus on economic growth if she wants to reduce CO₂ emissions at below 0.5 distributions of CO₂ emissions. Since we only examine the impact of tourism development on carbon dioxide emissions and other factors which affect carbon dioxide emissions are not investigated. In the future research, we could use this method to further analyze the effect of other factors.

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