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The Global Nexus of Tourism, Economy, Renewable Energy and Carbon Emissions in the Last 20 Years

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Abstract:

The nexus between tourism, economy, renewable use, and carbon emissions is rarely discussed on a global scale by extensive published literature. To fill this gap, this study aims to examine the bidirectional relationships among tourism and other analyzed variables in terms of impulse response and Granger causality from the global perspective. This study uses a panel vector autoregressive model estimated using the system generalized method of moments based on panel data for 114 countries for the years 1995 to 2015. To explore the regional heterogeneity of these relationships, we further divide these countries into 5 regions, namely Asia, Africa, Europe and Oceania, North America, and South America. The results demonstrate that tourism contributes to both global economic growth and carbon emissions. Also, tourism is affected by the economy, renewable energy and carbon emissions. The relationships among the four analyzed variables vary significantly across the regions. Carbon emissions have a longer impact on tourism, relative to the economy. A two-way causal relationship between tourism and renewable energy was not found in this study.

Keywords: *Tourism, Gross domestic product (GDP), Renewable energy, Carbon emissions, Panel vector autoregression*

I. INTRODUCTION

The dual pressures of economic growth and climate change make low-carbon tourism increasingly important. The rapid growth of tourism, the desire for economic growth and concerns about climate change have made the nexus of tourism, economic growth and carbon emissions gradually become the forefront of current developments in the tourism field. In this process, a growing number of scholars are looking at energy as an additional important variable due to the close relationship between energy consumption and carbon emissions. Therefore, numerous efforts have been devoted to exploring the relationship among

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tourism development, economic growth, energy consumption and carbon emissions. These studies have confirmed the existence of the relationships between tourism and these variables.

Besides, in terms of data selection, empirical research on one or several countries or regional or international organizations is dominant; however, we rarely find global studies, thus leading to the limited universality of research conclusions. Two exceptions are Gulistan, Tariq and Bashir (2020) [1], who examined the nexus of tourism, economic growth, energy and carbon emissions globally. In terms of variable selection, scholars are increasingly aware of the importance of multivariate research, from tourism and carbon to tourism and the economic growth, energy and carbon. The nexus of tourism-economic growth-energy-carbon dominates this tourism sub-field. However, few studies focus on renewable energy use, despite the vital importance of renewable energy for the decarbonization of tourism and global low-carbon development.

Due to limitations or differences in research methods and data, these studies did not develop robust or consistent conclusions, especially concerning the nexus between tourism and other variables. In addition, the utilization of renewable energy is a key variable in the global low-carbon transition. From the previous studies, the existing single-equation model does not solve the problem of endogeneity or explain the two-way relationship between analysis variables. Therefore, this study draws on the panel vector autoregression (PVAR) model. The PVAR model has three prominent characteristics suitable for this research. First, the PVAR model establishes an endogenous system and processes all variables without restriction, which is more suitable for the case of strong correlation and interaction between variables. This correlation and interaction may exist in the nexus between tourism, economy, renewable energy, and carbon emissions, which have been explored in extensive prior studies (see Literature review). Second, unlike the time series VAR model, the PVAR model also considers the heterogeneity of the cross-section, which helps to identify the heterogeneity between different regions. Third, the PVAR model can easily capture variable relationships' temporal changes, such as impulse response.

However, the existing PVAR model has not overcome the inherent coefficient estimation bias and inconsistency. The fixed effect is related to the independent variable because of the lag of the dependent variable in the PVAR model. Using the standard mean difference operation to remove fixed effects may lead to deviations and inconsistencies in the estimated coefficients. In order to obtain a consistent and valid estimate in this situation, we apply the mean forward difference and maintain the orthogonality between the lagging independent variable and the transformed variable. Therefore, we use the Generalized System Method of Moments (GMM) to estimate these coefficients.

In this context, this study contributes to examine the bidirectional relationships among tourism, economic growth, renewable energy and CO_2 emissions by using a robust GMM-PVAR technique with panel data from a global sample of 114 countries during the time spanning from 1995 to 2015. This research has contributed to the fields of tourism, energy and the environment in several ways. First, we investigate the relationship between tourism and the other three key economic and environmental variables (i.e. the economic growth, renewable energy use, and CO_2 emissions) from the global perspective. The

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introduction of renewable energy into the model also contributes to grasping tourism's role in the global economic and environmental system. Secondly, we use the GMM method to estimate the PVAR model, which effectively overcomes the problems of endogeneity and inaccurate estimation coefficients in the existing models and obtains more robust results. Third, different from Gulistan, Tariq and Bashir (2020) [1], who discussed the differences among different income groups, we examine the regional comparisons of the relationship between tourism and the other three analyzed variables, contributing to the understanding of the regional heterogeneity of this relationship [2].

We structure this paper as follows: Section 2 contains the literature review. Section 3 explains the methodology and data collection for this study. We report the empirical results for impulse response functions and Granger causality in Section 4 and discuss them in Section 5. The last section concludes.

II. LITERATURE REVIEW

2.1 Tourism and Economic Growth

Mainstream studies asserted that the tourism had positive effect on economic growth (Nunkoo et al., 2019) [3]. A large number of empirical researches measured the causal relationship between tourism and economic growth. The casual relationship between tourism and economic growth can be divided into four categories: (1) tourism-driven growth; (2) economic-led tourism growth; (3) bidirectional positive relationship between tourism and economic growth; (4) no causal relationship. The majority of studies support a one-way causal relationship from tourism to economic growth. In addition to direct economic income growth, some studies also argue that tourism is conductive to local infrastructure construction and human capital development [4]. Economic-driven tourism growth means economic growth causes tourism development. Tourism sectors could benefit from economic growth through tourism infrastructure [5], destination safety & security and relevant investment [6]. On the other side of the coin, a shock to GDP have generated a significant impact on tourism industry. Besides, the bidirectional positive relationship between tourism and economic growth is confirmed by Roudi et al. (2019) [7] for a few small island developing countries. However, due to various data sources, estimation methods and regional characteristics, the positive effect does not exist in developing countries.

2.2 Tourism and Energy Consumption

Plenty of theoretical and empirical studies have found that an increase in the outcomes of tourism-related activities affects energy consumption. Tourism was identified as one of the major energy consuming sectors at the World Summit on Sustainable Development in 2002. Nepal (2008) pointed out the diverse energy consumption patterns in tourism [9]. Conversely, Eyuboglu and Uzar (2019) [10] found that the increase in energy consumption positively affected tourism in Turkey. However, Nepal et al. (2019) proved the negative effect of energy consumption on tourism in Nepal [11]. Additionally, Roudi et al. (2019) [7] found the bidirectional relationship between tourism and energy consumption in the top 10 international tourism destinations. On the contrary, Dogan and Aslan (2017) [12] found no causality

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between tourism and energy consumption. Above all, these studies advocated the formulation of energy conservation policies and cleaner energy penetration in tourism consumption.

2.3 Tourism and CO_2 Emission

In recent years, voluminous studies have focused on the relationship between tourism and CO_2 emission. Tourism sector is facing a rapid increase in carbon emissions [13]. Peeters and Dubois (2010) asserted that tourism is responsible for 5% of global carbon emissions all around the world [14]. However, there are three different viewpoints regarding the relationship between tourism and carbon emissions. The first point is that tourism development enhances CO_2 emission for the study area. Notwithstanding most studies concluded tourism industry had a positive effect on carbon emission, some studies found tourism was conducive to reducing carbon emissions [15]. Also, tourism does not affect carbon emissions in Pakistan [16]. The bidirectional causality between tourism and carbon emissions is confirmed by Danish and Wang (2018) [17] in BRICS economies, Eyuboglu and Uzar (2019) in Turkey [18]. In conclusion, the existing studies have pluralistic results for the casual relationship between two sectors (i.e. tourism and CO_2 emission).

Our literature review shows that these studies have not reached an agreement on the relationship between tourism and the economic growth or energy or carbon emissions subject to different analytical techniques, data and regional characteristics. Compared to studies on tourism and economic growth, carbon emissions energy consumption, or, fewer studies have focused on tourism and renewable energy use. Some exceptions include Ali et al. (2018), who found that tourism is conducive to increasing renewable energy use in Asia countries [19]. While Jebli et al. (2019) confirmed the bidirectional dynamic causality between tourism and renewable energy use in Mediterranean countries [18].

Despite increasing interest, relative studies still contain some shortcomings. Concerning the analytical techniques, panel analysis techniques have prevailed, and only a few studies have used time series methods. The ARDL model is widely employed among these panel analysis tools to examine the relationship between tourism and other variables. However, this single equation approach contains a potential endogeneity problem. To solve this problem, some scholars have adopted the GMM estimation method. However, this single equation model cannot explain the feedback relationships between tourism and other variables. Therefore, multi-equation analysis methods such as panel VAR and panel VEC models have captured more scholars' attention. Since the panel VAR model has too many parameters (the same is true in the panel VEC model), only when few variables can obtain satisfactory estimates by the OLS and maximum likelihood estimations. This paper involves tourism, economic growth, renewable energy, and carbon emissions. Therefore, traditional estimation methods may lead to biased and inconsistent estimators. We thus need a robust estimation method applied to the panel VAR model.

Besides, most of the existing empirical studies focus on countries with similar space such as Mediterranean countries, Caribbean countries and European Union countries, an economic organization such as BRICS economies and OECD countries, or a single country such as China, Turkey and Korea. As

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a result, it is difficult to identify the regional heterogeneity of the relationship between tourism and other variables. Moreover, the relationship between tourism and other variables is rarely discussed globally by extensive published literature. In addition, few studies concentrate mainly on the nexus of tourism, economic growth, renewable energy use, and CO_2 emissions. To fill this gap, this study, based on the panel data for 114 countries worldwide from 1995-2015, applies the GMM-PVAR approach to examine the global and regional relationships among tourism and other analyzed variables.

III. DATA AND METHODOLOGY

3.1 Data Source

Similar to existing studies, the proxies of tourism, economic growth, renewable energy use, and CO_2 emissions in this study are international tourism, gross domestic product (GDP) per capita, the proportion of renewable energy use to total energy consumption, and carbon emissions per capita, respectively. These four variables are measured by the number of international tourist arrivals (T), GDP per capita (current US dollar) (GDPpc), percentage of total energy use (RE), and metric tons of CO_2 emissions per capita (carbon), respectively. All the data on these variables are derived from the World Bank open data (https://data.worldbank.org/indicator). Since in the database, the earliest date of international tourism data is 1995, and the latest date of renewable energy use data is 2015, we span the data from 1995 to 2015.

We finally selected 114 countries as the sample subject to the data availability. The other countries are excluded because of a significant lack of data on one or more variables. To account for regional heterogeneity, we further divide the 114 countries into five regions: Asia, Africa, Europe and Oceania (i.e. Australia and New Zealand), North America, and South America. Oceania's sample size is too small to meet the GMM estimation. Another reason is that Australia and New Zealand have so much in common with European countries regarding socio-economic development. Therefore, our classification is more conducive to studying regional heterogeneity globally.

3.2 Methods

First, we build the following panel VAR model

$$\mathbf{y}_{i,t} = \boldsymbol{\alpha} + \sum_{j=1}^{p} \mathbf{A}_j \mathbf{y}_{i,t-j} + \boldsymbol{\mu}_i + \boldsymbol{\xi}_{i,t} , \qquad (1)$$

Where $\mathbf{y}_{i,t}$ =(tourismi,t, economic growthi,t, renewable-energyi,t, carboni,t)', μi represents the individual heterogeneity and fixed-effects, $\mathbf{A}_j$ is a 4×4 coefficients matrix, j denotes the lag period, $\boldsymbol{\mu}_i$ and $\boldsymbol{\xi}_{i,t}$ are 4×1 vectors. $\boldsymbol{\xi}_{i,t}$ denotes the stochastic error term.

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The system GMM is an extension of the earlier difference GMM and uses the lags of both the variables and the difference variable as the instrumental variables, which can effectively avoid the shortcoming of the weak instrumental variables in difference GMM. This study estimates the PVAR model by performing a robust system GMM technique. Thus, we obtain the following equation (2).

$$\begin{aligned} \Delta \mathbf{y}_{1,i,t} &= \sum_{j=1}^{k}\sum_{h=1}^{m} \boldsymbol{\gamma}_{1h}^{j} \Delta \mathbf{y}_{1h,i,t-j} + \xi_{1,i,t} \\ &\vdots \\ \Delta \mathbf{y}_{m,i,t} &= \sum_{j=1}^{k}\sum_{h=1}^{m} \boldsymbol{\gamma}_{mh}^{j} \Delta \mathbf{y}_{mh,i,t-j} + \xi_{m,i,t} \end{aligned} \qquad (2)$$

The left-hand side of each equation is the first difference of an endogenous variable. The right-hand is the k lagged first difference of all endogenous variables and no constant.

Table I reports the descriptive statistics of the four analyzed variables. Considering the large variation in the magnitude of the different variables, we take tourism and GDP per capita separately as natural logarithms in the GMM-PVAR model.

Table I: Descriptive statistics of the economic growth, environment, energy, renewable energy and tourism

	Tourism	GDPpc	Re	Carbon
Mean	6312358.	11804.38	8.397041	4.578336
Median	1869000.	3973.020	3.530000	3.479000
Maximum	83701000	118823.6	55.57700	24.82500
Minimum	700.0000	102.5980	0.000000	0.017000
Std. Dev.	11959442	17174.17	10.77315	4.377570
Observations	2279	2279	2279	2279

IV. RESULTS

Before establishing the PVAR model, we performed the stationary test on the panel data. However, we use the system GMM method to estimate the PVAR model, and then output the impulse response function to study the dynamic impact of shocks on certain system variables. Furthermore, this study also conducts the GMM-PVAR Granger causality test to study the causal nexus between tourism and other variables.

4.1 Stationary Test

Here, the stationary test includes the cross-section dependence test and the panel unit root test. The results are respectively shown in Tables II and III. Table II indicates that the null hypothesis of no

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cross-section dependence regarding each variable is rejected, implying that all the variables are cross-section dependent. This further indicates that currently, there are connections among countries worldwide concerning tourism, economic growth, and environmental change.

Table II: Cross-section dependence test

Test	LnTourism	LnGDPpc	RE	Carbon
Breusch-Pagan LM	79735.10***	105313.0***	32370.64***	42738.96***
Pesaran scaled LM	645.7693***	871.1275***	228.4572***	319.8089***
Bias-corrected scaled LM	642.7693***	868.1275***	225.4572***	316.8089***
Pesaran CD	251.2038***	321.8939***	37.27188***	19.26438***

The results in Table III show that tourism, GDP per capita, renewable energy use and CO_2 emissions include unit root at their levels. However, their first differences variables become stationary at the 1% significance level. These four variables are integrated at order 1 to create the GMM-PVAR model according to Equations (1) and (2). Section 4.2 reports the impulse response functions, and section 4.3 presents the Granger causality.

Table III: Results for panel unit root tests (individual intercept and trend)

Method	LnTourism		LnGDPpc		RE		CO_2	
	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference
Null: unit root (assumes common unit root process)								
LLC	-6.25*	-17.94***	-4.62***	-12.98***	-1.76**	-17.39***	-1.83	-11.14***
Breitung	-0.82	-10.41***	-0.35	-13.75***	7.94	-8.12***	7.84	-5.94***
Null: unit root (assumes individual unit root process)								
IPS	-3.05***	-15.03***	-1.31	-6.77***	0.86	-17.64***	2.71	-14.62***
ADF	306.42	620.36***	231.13	371.49***	285.29	733.25***	210.83	637.13***
PP	323.50	1170.32***	166.71	600.62***	360.78*	1538.96***	230.59	1454.13***

It is noteworthy that the results for the stationary test for each region also show that the five variables are cross-section dependent and integrated at order one. This paper does not present these results subject to the limited space.

4.2 Impulse Response Analysis

In this section, the results focus mainly on tourism from two facets: the impact of tourism shock on other variables and the impact of other variables' shock on tourism. We ignore the interaction among the other three variables. Figure 1 shows the global impulse response function, while Figures 2-6 shows Asia, Africa, Europe and Oceania, North America, and South America, respectively.

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Figure 1 shows that a positive shock to tourism has the largest positive impact on GDP per capita in the first period. The effect gradually weakens and converges to 0 in the fifth period. This proves that tourism positively affects global economic growth. Likewise, a positive shock to tourism also has the largest positive impact on carbon emissions in the first period. The effect gradually weakens and converges to 0. Besides, a positive shock to tourism exerts the maximum negative effect on renewable energy use in the third period. Then the effect weakens and becomes slightly positive and converges to 0 in the sixth period.

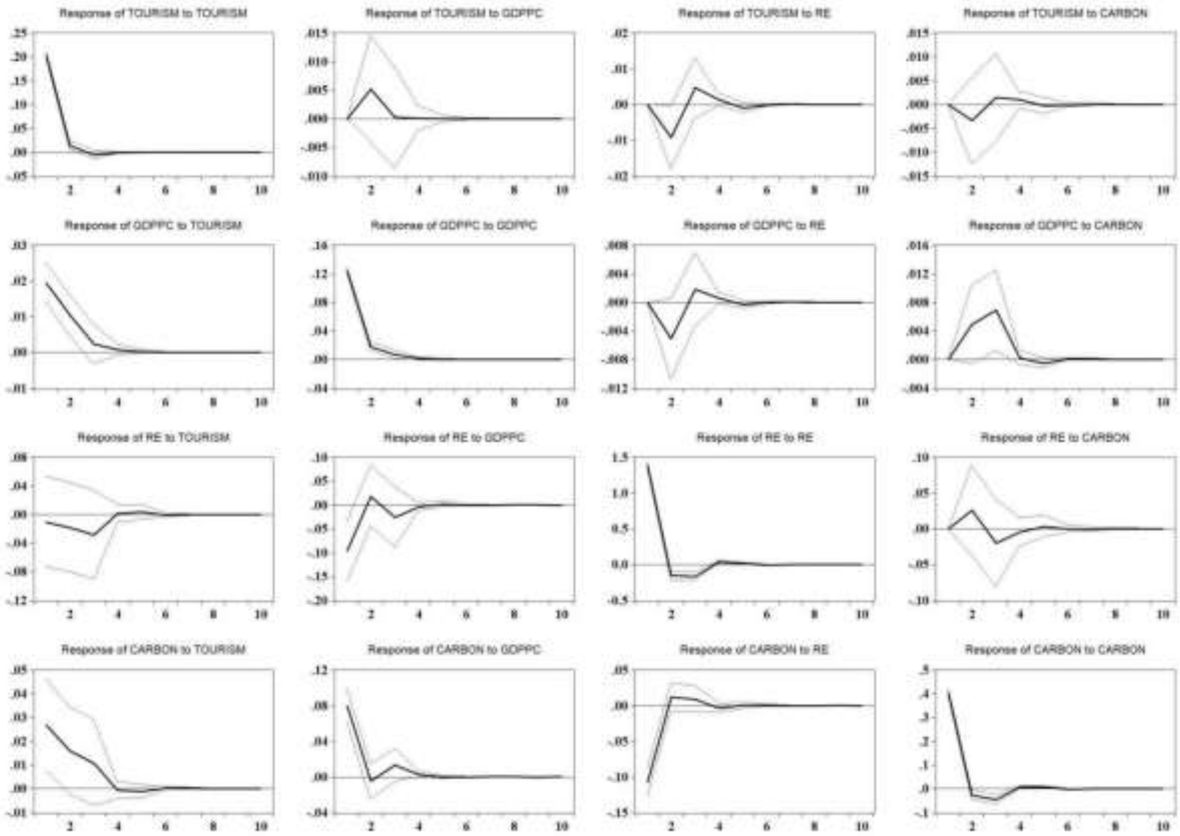

Fig 1: Global impulse response functions (lag order selected by the Schwarz information criterion is 1)

Figure 1 also shows that given a positive shock to GDP per capita, tourism has the largest positive response in the second period, which converges to 0 in the third period. In response to a positive shock to renewable energy, tourism fluctuates during the first six periods and then converges. Similarly, in response to a positive shock to carbon emissions, tourism fluctuates during the first seven periods and then converges. This implies that relative to GDP per capita, the increase in renewable energy and carbon emissions has a longer effect on tourism.

Figure 2 displays that a positive shock to tourism in Asia has the largest positive impact on GDP per capita in the first period, which gradually declines and converges to 0 in the fourth period. Responding to a

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positive shock to tourism, renewable energy use fluctuates during the first six periods and then converges. A positive shock to tourism has a greater positive impact on Asian carbon emissions than GDP per capita. Responding to a positive shock to GDP per capita, tourism fluctuates during the first eight periods; however mostly increases and then converges. Figure 2 also illustrates that a positive shock to renewable energy has a negative impact on tourism. Such an effect reaches the extreme value in the second period and becomes a slight positive, and converges to 0 in the fifth period. The impact of carbon emissions' shock on tourism possesses the longest persistence and converges to 0 in the ninth period.

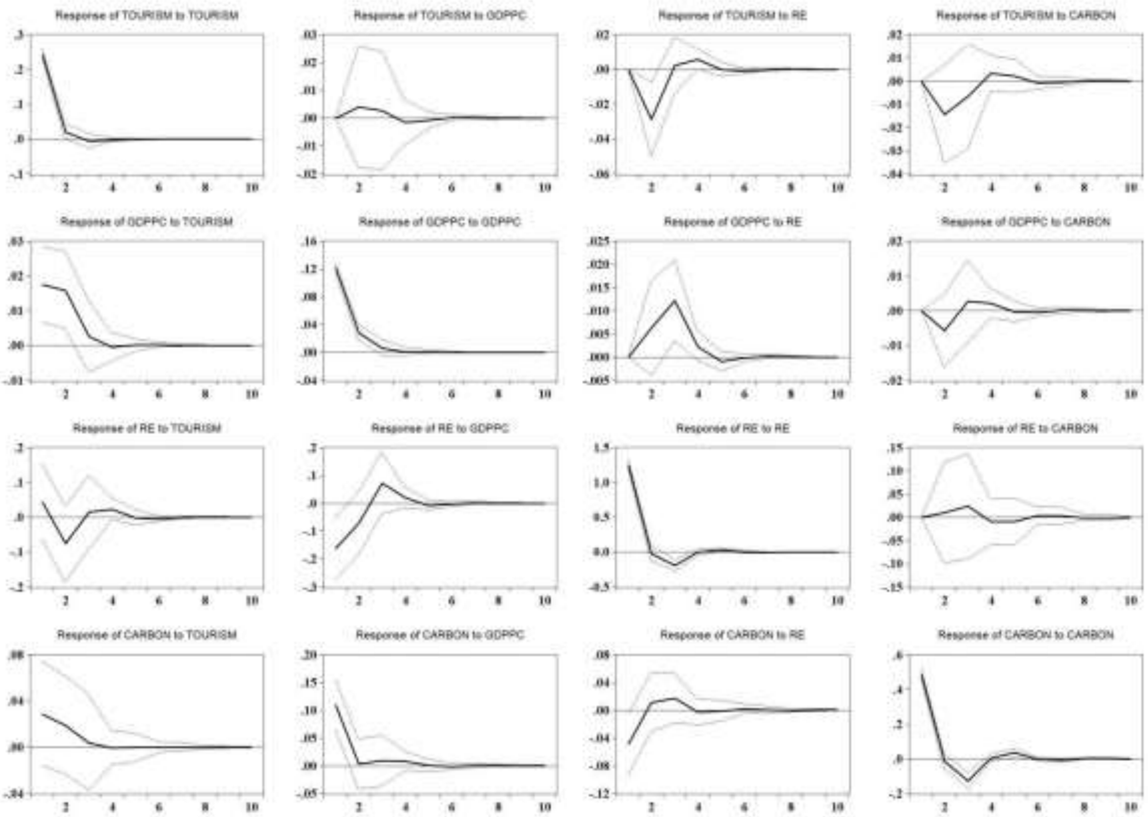

Fig 2: Asian impulse response functions (lag order selected by the Schwarz information criterion is 1)

In Africa, Figure 3 shows that regarding a positive shock to tourism, GDP per capita peaks in the first period and then fluctuates slightly and converges in the fifth period. We note that this fluctuation is always positive. Responding to a positive shock to tourism, renewable energy use fluctuates during the first six periods and then positively converges. Likewise, the increase in tourism mostly positively affects carbon emissions and this effect converges to 0 in the fifth period. A positive shock to GDP per capita exerts the greatest positive impact on tourism in the second period and the biggest negative effect on tourism in the third period. The effect converges to 0 in the fourth period. The increase in renewable energy use exerts a slight effect on tourism. The increase in carbon emissions mostly affects tourism negatively.

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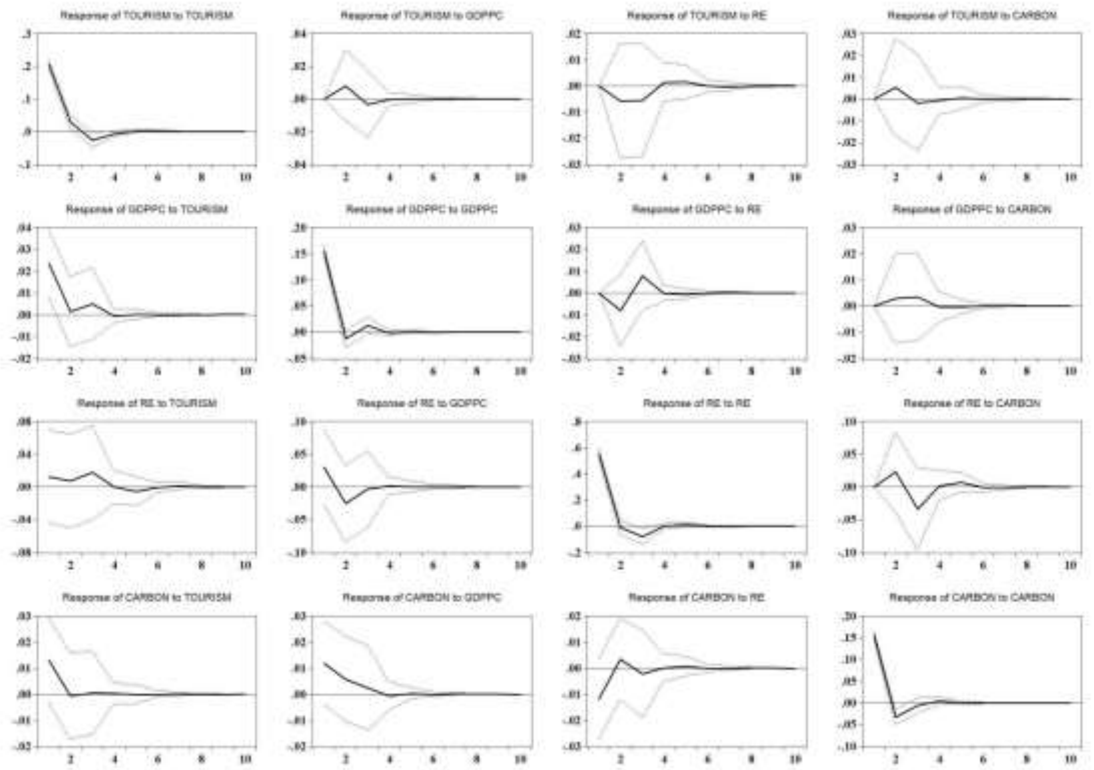

Fig 3: African impulse response functions (lag order selected by the Schwarz information criterion is 1)

Figure 4 illustrates that in Europe and Oceania, a positive shock to tourism exerts the greatest positive effect on GDP per capita in the first period, which gradually declines and becomes negative in the third period and converges to 0 in the fifth period. In response to a positive shock to tourism, renewable energy use fluctuates during the first six periods and then converges. The increase in tourism on carbon emissions is always positive and peaks in the first period and converges to 0 in the fourth period. Given a positive shock to GDP per capita, tourism fluctuates during the first five periods. In the case of a positive shock to renewable energy, tourism fluctuates during the first six periods and then converges. The increase in carbon emissions exerts a slight long negative effect on tourism.

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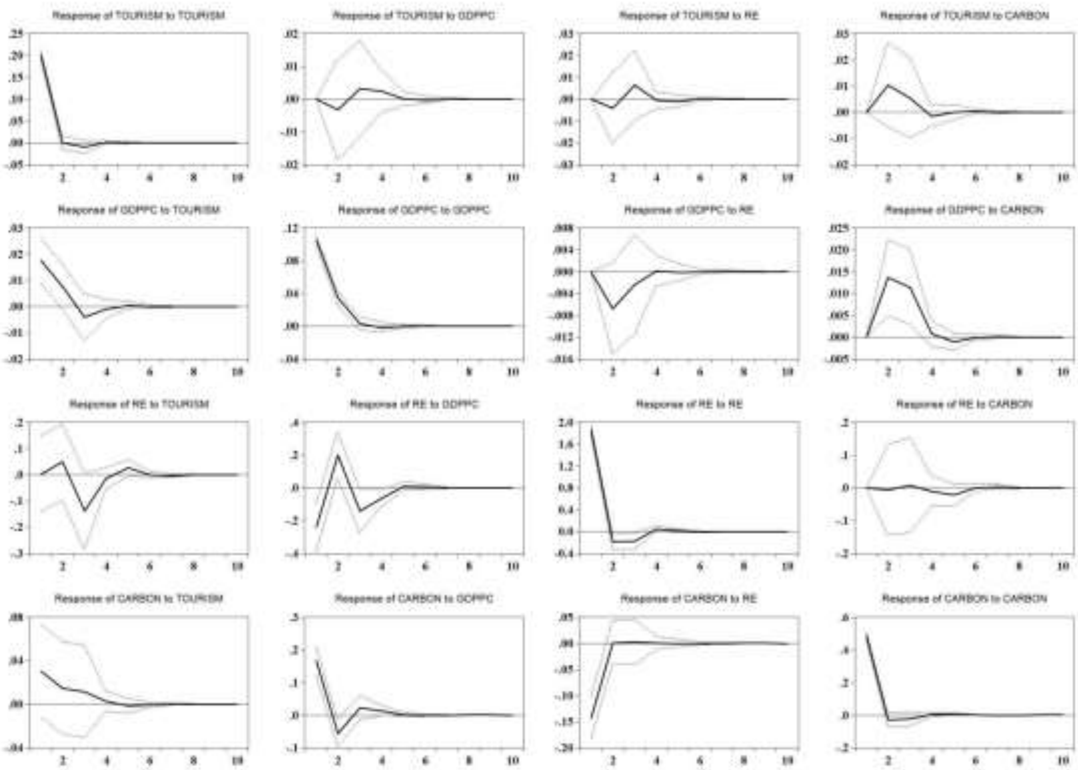

Fig 4: European and Oceanian impulse response functions (lag order selected by the Schwarz information criterion is 1)

In North America, Figure 5 shows that a positive shock to tourism has a short positive effect on GDP per capita. To cope with a positive shock to tourism, renewable energy use declines and negatively converges in the third period. The increase in tourism on carbon emissions is positive and converges to 0 in the third period. Tourism shock has a similar impact on GDP per capita and carbon emissions. Figure 5 shows that tourism always fluctuates during the simulation period, given a positive shock to GDP per capita. However, in general, economic growth exerts a positive impact on tourism. In response to a positive shock to renewable use, tourism positively fluctuates and peaks in the third period as well. Tourism fluctuates and converges in the tenth period, giving a positive shock to carbon emissions. The results demonstrate that in North America, the increase in economic growth and carbon emissions has a longer impact on tourism than in other regions.

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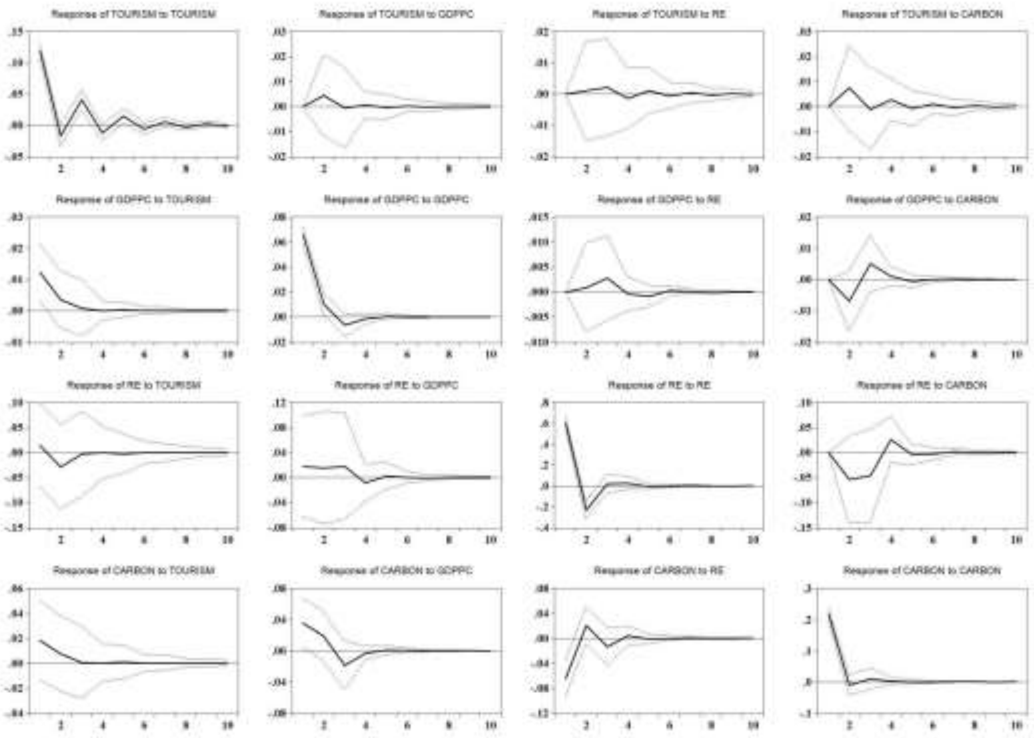

Fig 5: North American impulse response functions (lag order selected by the Schwarz information criterion is 1)

Figure 6 exhibits that in South America, a positive shock to tourism exerts the largest positive impact on GDP per capita in the first period. The effect gradually weakens and converges to 0 in the sixth period. To deal with a positive shock to tourism, renewable energy use fluctuates during the first five periods and converges in the sixth period. Given a positive shock to tourism, carbon emissions increase and peak in the third period and converge in the fourth period. Given a positive shock to GDP per capita, tourism fluctuates during the first six periods and converges. Given a positive shock to renewable energy use, tourism fluctuates during the first eight periods. The increase in carbon emissions negatively affects tourism during the first three periods and positively affects tourism. This effect negatively converges to 0 in the fifth period.

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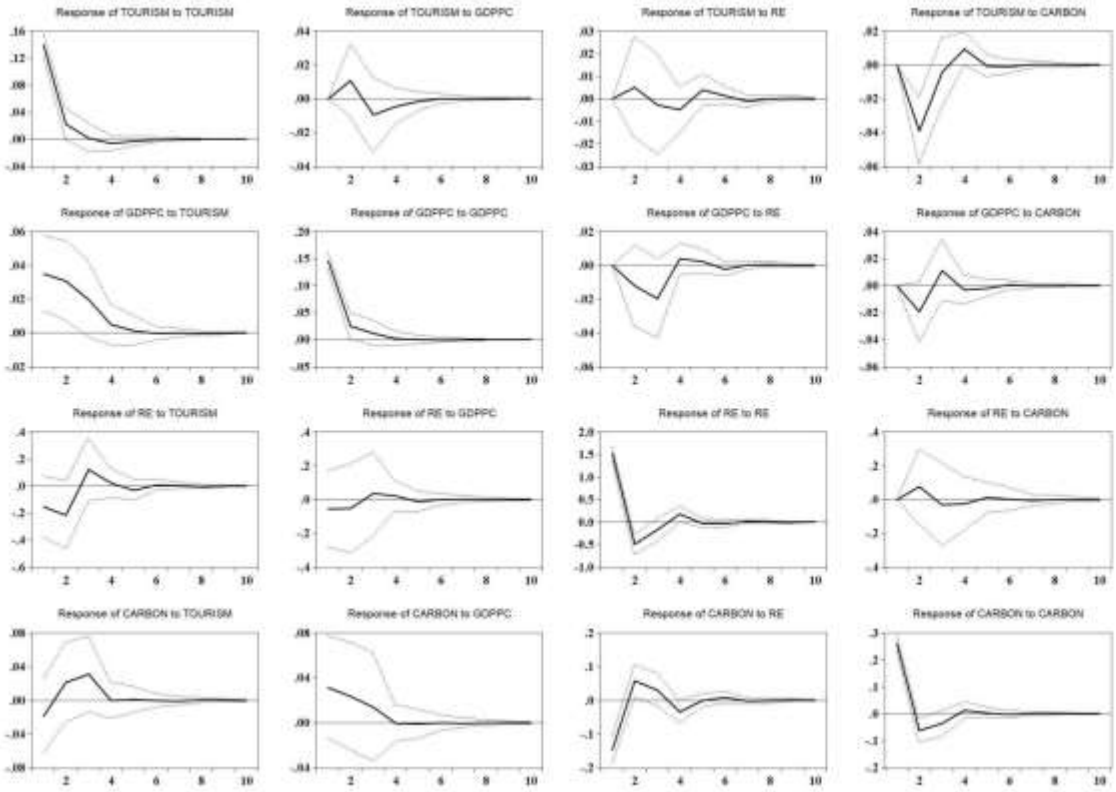

Fig 6: South American impulse response functions (lag order selected by the Schwarz information criterion is 1)

4.3 Granger Causality

Table IV reports the GMM-PVAR Granger causality tests for all the samples. The results show that for the global sample, the lnTourism equation rejects the null hypothesis that GDP per capita, renewable energy and carbon emissions are not the Granger cause for tourism. The lnGDPpc equation rejects the null hypothesis at the 5% significance level that tourism is not the Granger cause for GDP per capita. This reveals that tourism is the Granger cause for economic growth globally. The RE equation accepts the null hypothesis that tourism is not the Granger cause for renewable energy use, indicating that tourism cannot Granger cause renewable energy use. Tourism rejects the null hypothesis at the 10% significance level in the carbon equation, indicating that tourism has a significant Granger impact on carbon emissions.

Table IV: Results for GMM-PVAR Granger causality

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Full sample		Asia	Africa	Europe and Oceania	North America	South America
Dependent variable: lnTourism						
Excluded			Chi-sq			
lnGDPpc	0.5672**	0.4808**	1.1951	1.2563**	1.1050	2.0385
RE	5.5805*	9.6980***	0.1223	1.2741	3.8026	1.0197
CO_2	4.1415**	1.9148**	0.7190	0.3681	2.0341	14.5233***
Dependent variable: lnGDPpc						
Excluded			Chi-sq			
LnTourism	7.1144**	5.1459*	0.2395	2.7049***	0.1957**	3.9251
RE	5.0451*	10.5003***	2.4515	0.2561	2.6341	2.1013
CO_2	5.6300***	1.1502*	0.3805	7.6287**	2.6335	6.8697**
Dependent variable: RE						
Excluded			Chi-sq			
LnTourism	1.4649	1.6674	0.5195	1.6299	0.5736	4.1667
lnGDPpc	1.2420	2.0581	0.8074	9.2346***	1.8872	0.5524
CO_2	0.4691	0.0326	1.8728	0.3248	3.6348	1.1447
Dependent variable: CO_2						
Excluded			Chi-sq			
LnTourism	3.2303*	0.6870*	0.6054	1.4912**	0.1952	1.3657
lnGDPpc	3.0283**	1.5156	1.8200	4.9288*	3.3040	2.2637
RE	0.1269	0.71530	0.1355	0.9929	2.6521	3.0408

*, **, and*** indicate the 10%, 5%, and 1% significance level, respectively.

For the Asian subsample, GDP per capita, renewable and carbon emissions are the Granger causes for tourism at 5%, 1%, and 5% significance levels. Tourism is the Granger cause for GDP per capita and carbon emissions at the 10% significance level but is not the Granger cause for renewable energy. For the African subsample, tourism cannot Granger cause all the GDP per capita, renewable energy and carbon emissions. For the European and Oceanian subsample, GDP per capita is the Granger causes for tourism at the 5% significance level. Tourism Granger causes GDP per capita and carbon emissions at the 1% and 5% significance levels. For the North American subsample, GDP per capita has not had a Granger effect on tourism. Tourism Granger causes GDP per capita at the 5% significance level while it is not the Granger cause for renewable energy use and carbon emissions. For the South American subsample, carbon emissions unidirectionally Granger cause tourism at the 1% significance level. There is no Granger causality between tourism and the economic growth.

V. DISCUSSION

For the global sample, all variables are the Granger causes for tourism, which indicates that the change in any variable will cause changes in tourism. Therefore, tourism relies on the whole economic and environmental systems. This confirms the highly dependent industrial characteristics of tourism. In various regions apart from North America, we also find this result. Therefore, tourism is endogenous to the

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economic and environmental systems. The sustainable growth of tourism depends on the sustainable development of the economic growth and environment. We also find that carbon emissions exert a longer effect on tourism for both global and regional samples relative to the economic growth. It should be noted that this effect is negative.

Tourism significantly affects economic growth for the global sample, and Granger causes economic growth. This result contradicts the findings of Antonakakis et al. (2019), who investigated the nexus between tourism and economic growth based on the sample data of 113 countries [8]. However, Antonakakis et al. (2019) found the positive effects of tourism on economic growth in developing countries [8]. This result also accords with extensive empirical evidence found by, for example, Paramati et al. (2017) [6]. As indicated by the UNWTO (United Nations World Tourism Organization), tourism is already the world's most dynamic and greatest comprehensive economic industry. It has made important contributions to global economic growth. Therefore, it is feasible to promote global economic growth by developing tourism. For different regions, impulse response functions show that tourism positively affects economic growth. Tourism in Asia, Europe and Oceania, and North America is the greater cause for economic growth than Africa and South America. There is a bidirectional Granger causality between tourism and economic growth in Asia, Europe, and Oceania. This reveals that tourism contributes to economic growth, and conversely, economic growth also contributes to tourism development. Understandably, the reforming of the tourism environment, peculiarly the hardware such as transportation, accommodation, and entertainment facilities, brought by economic growth act a significant role in enhancing the attractiveness of tourism. The impulse response results also show that economic growth positively impacts tourism globally and in each region. This result provides support for Antonakakis et al. (2019) [8].

Contrary to tourism and the economic growth, the nexus between tourism and renewable energy use presents distinct characteristics. For the global sample, tourism negatively affects renewable energy use, indicating that global renewable energy use decreases as tourism increases. Consequently, past practice suggests that renewable energy use is declining within tourism. This finding is inconsistent with the results found by Ali et al. (2018) [2]. We further find that tourism is not the Granger cause for global renewable energy use. Furthermore, renewable energy use unidirectionally Granger causes tourism. This contradicts the findings of Ali et al. (2018) as well [2]. For different regions, tourism positively affects renewable energy use in Africa while a negative effect in North America. This effect fluctuates between positively and negatively in the other regions. This shows that the proportion of renewable energy use in African tourism is relatively high, while in North America, it is relatively low. We also find the significant adverse effect of renewable energy use on Asian tourism, and the significant positive effect in North America. In Asia, renewable energy use is the Granger cause for tourism, while tourism does not Granger cause renewable energy use in any region. Therefore, no bidirectional Granger causality was found between tourism and renewable energy use in either the global or regional samples.

Tourism significantly affects carbon emissions for the global sample, and Granger causes carbon emissions. This implies that tourism-related carbon emissions are increasingly growing worldwide. It is in

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part consistent with Ghosh (2020), who respectively examined the nexus between tourism and carbon emissions from the global perspective of 112 and 95 countries. This conclusion also supports the findings of the extensive published literature such as Alam and Paramati (2017), Sharif et al. (2017) and Zhang and Liu (2019) [19-20]. We also find that carbon emissions negatively affect tourism and Granger causes tourism. This indicates that the environmental changes caused by carbon emissions are threatening global sustainable tourism development. This also accords with the findings of Azam et al. (2018), Danish and Wang (2018), Ghosh (2020) [17,19]. Finally, we discover the bidirectional Granger causality between tourism and carbon emissions globally. For different regions, tourism positively affects carbon emissions as well. Moreover, except for North America, carbon emissions exert a significant negative effect on tourism. In Asia and Europe and Oceania, tourism is the Granger cause for carbon emissions, while in Asia and South America, carbon emissions are the Granger causes for tourism.

Based on the above findings and discussion, we underline our policy implications. Firstly, it is a good choice to boost the economic growth by developing tourism in the context of sluggish global economic growth. However, we note that tourism also contributes to global carbon emissions. Therefore, the condition sine qua non of achieving the double dividends of the economic growth and environment is to promote the decarbonization of tourism. It is well known that improving the utilization of renewable energy will help achieve a low-carbon transition. Our results reveal that renewable energy utilization does not significantly negatively affect tourism and is not the Granger cause for tourism. Thus, it is suggested to enhance the use of renewable energy worldwide to replace traditional fossil fuels in the tourism industry. Our results also indicate that economic growth contributes to tourism. Hence, globally, tourism and the economic growth are mutually reinforcing.

Secondly, in Asia, Europe and Oceania, and North America, promoting economic growth by developing tourism is feasible. Moreover, Asian economic growth has contributed to the development of tourism. We note that increasing renewable energy use in Asia is not conducive to tourism. However, given the importance of renewable energy use to energy conservation and emission reduction, increasing the proportion of renewable energy use is an irreversible trend. Therefore, tourism needs to respond positively to accelerate its low-carbon transformation. For Europe and Oceania, increasing renewable energy use could effectively promote tourism. Furthermore, there is a positive unidirectional causal relationship between tourism and carbon emissions. Accordingly, we recommend increasing investment in renewable energy and low-carbon technology applications in tourism. In North America, carbon emissions do not significantly negatively affect tourism. Therefore, promoting tourism in North America by increasing energy consumption is feasible. Renewable energy use also contributes to the development of tourism. Therefore, we recommend enhancing the use of renewable energy in this region. Increasing carbon emissions helps promote tourism; however, our results demonstrate that tourism does not dedicate to African economic growth. Therefore, policy-making Africa's economic growth dependent on tourism should be cautiously implemented. The same is true in South America.

VI. CONCLUSION

This study examines the endogenous nexus among tourism, economic growth, renewable energy, and carbon emissions from the global perspective by employing a GMM-PVAR technique based on the panel data from 114 countries over the period 1995-2015. To explore the regional heterogeneity of these relationships, we have further divided these countries into 5 regions, namely Asia, Africa, Europe and Oceania, North America, and South America.

We arrive at the following conclusions: (1) For the global sample, tourism contributes to economic growth and carbon emissions, and vice versa. Tourism exerts a negative effect on renewable energy use. The economic growth, renewable energy, and carbon emissions significantly affect tourism. The economic growth is positively affected, while carbon emissions negatively affect tourism. Tourism is endogenous to the economic and environmental systems. (2) The relationships among the four analyzed variables vary significantly across the regions. Our results do not support the causality from tourism to economic growth in Africa and South America. This study finds a bidirectional causality between tourism and economic growth in Asia, Europe, and Oceania. Tourism positively affects renewable energy use in Africa while negatively affecting North America. The causal link from tourism to carbon emissions exists only in Asia, Europe and Oceania. (3) Carbon emissions have a longer effect on tourism relative to the economic growth. We do not examine the bidirectional causality between tourism and renewable energy.

Despite the findings indicated above, we address some future directions. This study measured the interaction between tourism, economic growth, renewable energy use, and carbon emissions through the impulse response analysis and PVAR Granger causality test. However, we did not quantify the effects of tourism on the other three analysed variables. Future studies can focus on tourism-induced economic and environmental changes and investigate the linear and non-linear relationships between tourism and other variables based on the Kuznets hypothesis. In addition, due to limited data availability, our sample period ends on 2015. This limits the timeliness of the article to a certain extent. If there are new data in the future, we are willing to redo this research.

REFERENCES

[1] Gulistan A, Tariq Y B, Bashir M F, "Dynamic relationship among economic growth, energy, trade openness, tourism, and environmental degradation: fresh global evidence." Environmental Science and Pollution Research, vol. 27, no. 12, pp. 13477-13487, 2020.

[2] Ali, Q., Khan, M. T. I., Khan, M. N., "Dynamics between financial development, tourism, sanitation, renewable energy, trade and total reserves in 19 Asia cooperation dialogue members. Journal of Cleaner Production," vol. 71, no. 9, pp. 114-131, 2018.

[3] Nunkoo, R., Seetanah, B., Jaffur, Z. R. K., Moraghen, P. G. W., & Sannassee, R. V, "Tourism and economic growth: A meta-regression analysis," Journal of Travel Research, vol. 59, no.3, pp. 404-423, 2020.

[4] Fayissa, B., Nsiah, C., & Tadasse, B, "Impact of tourism on economic growth and development in Africa," Tourism Economics, vol. 14, no.4, pp. 807-818, 2008.

[5] Aratuo, D. N., & Etienne, X. L, "Industry level analysis of tourism-economic growth in the United States," Tourism Management, vol. 70, pp. 333-340, 2019.

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[6] Paramati, S. R., Alam, M. S., & Lau, C. K. M, “The effect of tourism investment on tourism development and CO_2 emissions: empirical evidence from the EU nations,” Journal of Sustainable Tourism, vol. 26, no.9, pp. 1587-1607, 2018.
[7] Roudi, S., Arasli, H., & Akadiri, S. S, “New insights into an old issue–examining the influence of tourism on economic growth: Evidence from selected small island developing states,” Current Issues in Tourism, vol. 22, no.11, pp. 1280-1300, 2019.
[8] Antonakakis, N., Dragouni, M., Eeckels, B., & Filis, G, “The tourism and economic growth enigma: Examining an ambiguous relationship through multiple prisms,” Journal of Travel Research, vol. 58, no.1, pp. 3-24, 2019.
[9] Nepal, S. K, “Tourism-induced rural energy consumption in the Annapurna region of Nepal,” Tourism Management, vol.29, no.1, pp. 89-100, 2008.
[10] Eyuboglu, K., & Uzar, U, “The impact of tourism on CO_2 emission in Turkey,” Current Issues in Tourism, vol.23, no.13, pp. 1631-1645, 2020.
[11] Nepal, R., al Irsyad, M. I., & Nepal, S. KTourist arrivals, energy consumption and pollutant emissions in a developing economic growth–implications for sustainable tourism. Tourism Management, vol.72, pp. 145-154, 2019.
[12] Dogan, E., & Aslan, A, “Exploring the relationship among CO_2 emissions, real GDP, energy consumption and tourism in the EU and Candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence,” Renewable & Sustainable Energy Reviews, vol.77, pp. 239-245, 2017.
[13] Scott, D., Peeters, P., & Gössling, S, “Can tourism deliver its “aspirational” greenhouse gas emission reduction targets?” Journal of Sustainable Tourism, vol.18, no.3, pp. 393-408, 2010.
[14] Peeters, P., & Dubois, G, “Tourism travel under climate change mitigation constraints,” Journal of Transport Geography, vol.18, no.3, pp. 447-457, 2010.
[15] Akadiri, S. S., Akadiri, A. C., & Alola, U. V, “Is there growth impact of tourism? Evidence from selected small island states,” Current Issues in Tourism, vol.22, no.12, pp. 1480-1498, 2019.
[16] Lin, V. S., Yang, Y., & Li, G, “Where can tourism-led growth and economic growth-driven tourism growth occur?” Journal of Travel Research, vol.58, no.5, pp.760-773, 2019.
[17] Danish, & Wang, Z. Dynamic relationship between tourism, economic growth, and environmental quality. Journal of Sustainable Tourism, vol.26, no.11, pp.1928-1943, 2018.
[18] Jebli, M. B., Youssef, S. B., & Apergis, N, “The dynamic linkage between renewable energy, tourism, CO_2 emissions, economic growth, foreign direct investment, and trade,” Latin American Economic Review, vol.28, no.1, pp.1-19, 2019.
[19] Ghosh, S, “Tourism and the environmental Kuznets Curve: A panel estimation,” International Journal of Tourism Research, vol.22, no.6, pp.839-852, 2020.
[20] Alam, M. S., & Paramati, S. R, “The dynamic role of tourism investment on tourism development and CO2 emissions,” Annals of Tourism Research, vol.66, pp.213-215, 2017.