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The roles of international tourism and renewable energy in environment: New evidence from Asian countries

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ABSTRACT

Northeast and Southeast Asian region is one of the fastest growing regions in CO_2 emissions, real GDP, energy consumption, and international tourism. However, the relationships among emissions, real GDP, energy consumption, and tourism are little known. The purpose of present paper is to explore the linkage among CO_2 emissions, real GDP, non-renewable and renewable energy, and tourism in panel of ten Northeast and Southeast Asian (NSEA-10) countries covering the period of 1995–2014. Environmental Kuznets curves are examined by fully modified ordinary least squares (FMOLS) and augmented mean group (AMG) based on individual country and panel data. Moreover, heterogeneous panel non-causality test is employed to analyze the causality among variables based on regional data. The empirical results reject the existence of the environmental Kuznets curve (EKC) hypothesis in whole samples (NSEA-10), Northeast Asian countries (NEA-4), and Southeast Asian countries (SEA-6). Non-renewable energy is the big source of emissions, while renewable energy can reduce emissions in panel data. The development of tourism may lead to the environmental degeneration. The findings based on heterogeneous causality test are mixed in different regions.

1. Introduction

Climate change and global warming are affecting human life. The average temperature in the earth surface increased 0.5 °C taking more than 100 years (from −0.19 °C in 1880 to 0.31 °C in 1994). Shockingly, it makes such an “achievement” only using 20 years (0.9 °C in 2017).[1] The main culprit of global warming is greenhouse gas (GHG), especially, carbon dioxide (CO_2) emissions [1,2]. But nowadays, the emissions have been alleviated by increasing utilization of renewable energy and the efficient use of energy [3–6]. Renewable energy has experienced rapid worldwide development in the past few decades [7], which accounted for nearly 19.1% of global total energy use in 2013 and provided nearly half of all new power generation capacity in 2014.[2]

Tourism is an important sector for the growth of economy (10.2% of world economy in 2016) and job creation (10% of world jobs in 2016) throughout the world. Moreover, the contribution of tourism on GDP growth in 2016 is 3.1%.[3] Although enriching national income, tourism is one of the significant contributors on emissions [8], which contributes nearly 5% of global CO_2 emissions, including transportation sector (75%), accommodation sector (20%), and other sector (5%).[4]

Northeast and Southeast Asian (NSEA) regions are expected to be at two of the fastest growing regions, not only for their CO_2 emissions and economic growth, but also for their energy consumption and international tourism. Fig. 1 presents the share of CO_2 emissions, real GDP, non-renewable and renewable energy use, as well as international tourism in selected Asian countries in 2014. From the chart, we can get the share of each selected sector in global total. The percentage of carbon emissions and non-renewable energy is around 40%, while the share of real GDP and renewable energy is around 30%, and the international tourism

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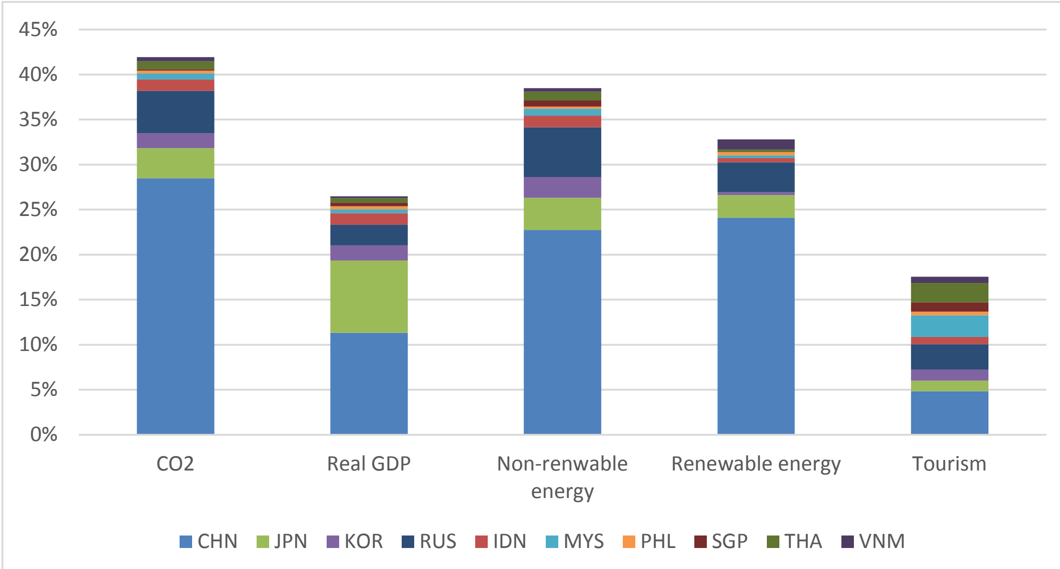


Fig. 1. Share of each variable in world total in 2014.

contributes more than 15% of the global total. Individually, China contributes the most in this region, following with Russia and Japan, while in international tourism, the ranking is changed, following with Russia and Malaysia.

Recently, NSEA region has been experiencing a rapid growth in CO_2 emissions, real GDP, energy use, and international tourism. However, little is known about the dynamic linkages among the above variables in the region. The aim of the present paper is to explore the linkages among the selected variables, which may enrich the existing literature in the regions. The main contributions are as follows: 1) This paper focuses on renewable and non-renewable energy use rather than the total energy consumption which is used in many previous papers. The development of renewable energy use is very remarkable in Asian countries, but the relationship among renewable energy, international tourism, and emissions is little known in this region. 2) We investigate causality in the complete sample (NSEA-10) and two separated regions (four Northeast Asian countries (NEA-4) and six Southeast Asian countries (SEA-6)), respectively. The results may better reflect the relationship among international tourism, energy consumption, economy, and environment in regions. 3) By using fully modified ordinary least squares (FMOLS) [9] and augmented mean group (AMG) [10], environmental Kuznets curves (EKCs) are examined based on individual and panel data, which may have idiosyncratic characteristics on different countries and regions. 4) The latest causality test, named heterogeneous panel non-causality [11], is used to investigate the linkages among selected variables. 5) To our knowledge, this paper is the first study to analyze the linkages among CO_2 emissions, GDP, non-renewable and renewable energy use, and tourism in the Asian region, which may enrich existing literature. Through this paper, the intention is to provide advice to the authorities.

The rest of this paper is structured as follows. Section 2 presents the literature review. Section 3 describes the empirical model and data, and Section 4 considers the empirical results and discussion. Section 5 offers conclusions and policy implications.

2. Literature review

The causality of CO_2 emissions, renewable and non-renewable energy consumption have been extensively studied by numerous scholars over the last few decades, but the results are mixed (Table 1, A and B). Along with the growth of tourism and related industries, the relationships between tourism and other related variables are investigated by many tourism economists. Some studies investigate the linkage of tourism and economic growth (Table 1, C). By employing bivariate Vector Auto-regression (VAR) model in Korean tourism and economy, Oh [12] finds that only unidirectional causality from economy to tourism is found, and indicates that Korean economy is not tourism-led economy. The findings of Lee and Chang [13] reveal that international tourism development plays more significant role in economic development in non-Organization for OECD countries than that in OECD countries. The results indicate one-way causal linkage from tourism to the economy in OECD countries, feedback linkage in non-OECD countries, but only weak linkage in Asian countries. Additionally, based on the panel of ten transition countries, the results of Chou [14] are mixed. Only in Estonia and Hungary, he finds the feedback hypothesis between tourism and economic development. By using the data of 24 countries in Middle East and North African region, Tang and Abosedra [15] employ the methodology of static (ordinary least square, OLS; random effect; fixed effect) and dynamic (generalized method of moments, GMM) to examine the linkage of tourism and economic growth. The results indicate that tourism contributes to the region's economic growth significantly, which supports the tourism-led growth hypothesis.

With climate change and global warming, numerous studies focus on the linkages among tourism, economic development, and environment (Table 1, C). Taking Turkey as an example, Katircioglu [39] examines the long-run linkages among tourism, energy use, and carbon dioxide emissions in Turkey. The long-run ARDL estimation indicates that all independent variables take a positive impact on emissions significantly. Based on heterogeneous panel estimation technology, Dogan and Aslan [40] examine the linkages between emissions, GDP, and tourism in 25 European Union and candidate countries covering from 1995 to 2011. The empirical results suggest that economic growth and tourism reduce the emissions. Additionally, bidirectional causality between economic growth and emissions, and unidirectional causality from tourism to emissions are found, respectively. Using the same methodology,

Table 1
Summary of some selected literature on energy, tourism, economic growth and emissions.

Authors	Time periods	Countries	method	Long-run linkage
A. Renewable energy and emissions				
Apergis et al. [16]	1984–2007	19 developed and developing countries	ECM Granger causality	RE→CO2
Ozbugday and Erbas [17]	1971–2009	36 countries	Heterogeneous panel analysis	RE→CO2
Sebri and Ben-Salha [18]	1980–2005	G7 countries	FMOLS, DOLS	RE←CO2
Shakouri and Khoshnevis Yazdi [19]	1992–2014	10 countries	FMOLS, DOLS	RE→CO2
Zeb et al. [20]	1975–2010	SAARC countries	FMOLS, Multivariate Granger-causality	RE→CO2 (India and Pakistan) RE←CO2 (Bangladesh) RE≠CO2 (Nepal and Sri Lanka)
Bilgili et al. [21]	1977–2010	19OECD	FMOLS,DOLS	RE→CO2
hahbaz et al. [22]	1960–2016	United States	ARDL,VECM	BIO↔CO2
Dogan and Inglesi-lotz [23],	1985–2012	22 countries	FMOLS	BIO→CO2
Liu and Bae [24]	1970–2015	China	ARDL,VECM	SRE→CO2
Zhang [25]	1971–2013	South Korea	ARDL,VECM	NFF→CO2
B. Non-renewable energy and emissions				
Bildirici and Bakirtas [26]	1969–2011	BRICTS	ARDL,FMOLS,DOLS, Granger causality	CO→CO2 (BRCTS) OIL→CO2(CITS) OIL↔CO2(BR)
Bloch et al. [27]	1965–2008	China	VECM	CO↔CO2
Lotfalipour et al. [28]	1967–2007	Iran	Toda-Yamamoto Granger causality	OIL→CO2 NG→CO2 FF≠CO2
Saboori and Sulaiman [29]	1980–2009	Malaysia	VECM	OIL↔CO2 NG↔CO2 CO↔CO2
Ahmad et al. [30]	1971–2014	India	ARDL,VECM	OIL↔CO2 NG↔CO2 CO→CO2
Dong et al. [31]	1970–2016	14 Asia-Pacific countries	AMG, VECM	NG↔CO2
C. Tourism, economic growth, and emissions				
Isik et al. [32]	1995–2012	7 countries	Bootstrap Granger causality	TOUR→Growth
Dogru and Bulut [33]	1996–2014	7 Mediterranean countries	Panel DH Granger causality	TOUR↔Growth
Du et al. [34]	1995–2011	109 countries	OLS, quantile regression	TOUR→Growth
Turan et al. [35]	1970–2009	Cyprus	ARDL, conditional Granger causality	TOUR→CO2
Shakouri et al. [36]	1995–2013	12 Asia-Pacific countries	GMM, Granger causality	TOUR→CO2
Zhang and Gao [37]	1995–2011	China	FMOLS	TOUR→CO2 (Central and Western regions) TOUR↔CO2 (Eastern region)
Zaman et al. [38]	1995–2013	11 transition Economies	FE,	TOUR→CO2

Note: ECM-error correction model; RE-renewable energy; DOLS-dynamic ordinary least squares; FMOLS-fully modified ordinary least squares; G7- Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States; BRICS-Brazil, Russia, India, China, and South Africa; ARDL-autoregressive distributed lag; SAARC-South Asian Association for Regional Cooperation; OECD- Organization for Economic Cooperation and Development; VECM-vector error correction model; BIO-biomass; SRE-share of renewable energy in total energy; NFF-non fossil fuel; BRICTS- Brazil, Russia, India, China, Turkey, and South Africa; NG-natural gas; OIL-oil; AMG-Augmented Mean Group; OLS-ordinary least squares; FE-fixed effect; GMM-generalized method of moments; TOUR-international tourism; DH-Dumitrescu and Hurlin; CO-Coal.

Ben Jebli et al. [41] examine the relationships between real income, emissions, and tourism in Tunisia from 1990 to 2010. The ARDL results show that the tourism increases Tunisian CO_2 emissions and his real income. Moreover, Granger causality suggests that feedback relationship between real income, emissions, and tourism in the long-run. By using methodologies of panel co-integration and pooled mean group, Sherafatian-Jahromi et al. [42] explore the linkages of international tourism and CO_2 emissions in the five Southeast Asian countries. The results reveal that the hypothetical EKC is discovered between tourism and emissions, and between the economy and emissions. Moreover, economic growth and energy use increase emissions significantly. Similarly, Sharif et al. [43] argue that economic development and tourism increase emissions in Pakistan significantly, based on FMOLS and DOLS. Three co-integration tests are used, such as ARDL bounds test, Johansen co-integration, and Gregory and Hansen test, which confirm that the existence of co-integrating linkage of emissions and tourist arrivals. Moreover, the results of variance decomposition method exhibit the unidirectional causality running from tourist arrival to CO_2 emission. Rational development of tourism mitigates emissions, and increases the impact on economic development in Pakistan.

Compared with these existed studies, the present paper employs international tourism, renewable and non-renewable energy, real GDP, and CO_2 emissions with panel data on 10 Asian countries. Moreover, the latest causality test, named heterogeneous panel non-causality is used to examine the linkage between variables. Additionally, EKC hypothesis is revealed by FMOLS methodology in the whole sample and two groups of different regions.

3. Methodology, model, and data

3.1. Empirical model

The goal of the present paper is to explore the linkages among CO_2 emissions, real GDP, non-renewable and renewable energy use, and international tourism in a panel of ten Asian countries from 1995 to 2014. Following the model used by Zhang and Gao [37] and Dogan and Aslan [40], the relationship can be written as follows:

$$CO_{it} = f\left(GDP_{it}, GDP_{it}^2, NRE_{it}, RE_{it}, TOUR_{it}\right) \tag{1}$$

Here, the natural logarithmic form of Eq. (1) is formulated as:

$$LCO_{it} = \alpha_0 + \alpha_1 LGDP_{it} + \alpha_2 LGDP_{it}^2 + \alpha_3 LNRE_{it} + \alpha_4 LRE_{it} + \alpha_5 LTOUR_{it} + \varepsilon_{it} \tag{2}$$

where i, α, t, and ε stand for each country in the panel, the parameters of independent variables, the time period, 1995–2014, and the error term, respectively. CO stands for total CO_2 emissions, measured by million metric tons. GDP and GDP^2 are real GDP and its square, based on constant 2010 US$. NRE and RE denote total non-renewable and renewable energy use, measured by million tons oil equivalent (Mtoe). TOUR represents the international tourism, number of arrivals. The data of CO, GDP, and TOUR are from World Development Indicators,[5] while NRE and RE are from British Petroleum Statistical Review of World Energy.[6]

3.2. Methodology

Firstly, four types of panel unit root tests are calculated so as to check the order of integration and stationarity of the time series at diverse level and first difference. These techniques are named as the Levin-Lin-Chu (LLC) [44], the Im-Pesaran-Shin (IPS) W [45], the Fisher augmented Dickey-Fuller (ADF) and the Fisher Phillips-Perron (PP) tests [46]. These tests can be grouped into two sectors. The first sector contains LLC t-statistic test, which assumes a common unit root process across the cross section. The second sector is composed by the IPS W-statistic, the Fisher-ADF χ^2, and the Fisher-PP χ^2 tests, which assume an individual unit root process across the cross section. Besides, the cross-sectional augmented IPS (CIPS) [47] is used. For all these tests, the null hypothesis is that there is a unit root, while the alternative hypothesis of no unit root.

Secondly, for sake of checking long-run associations in a heterogeneous panel, Johansen Fisher co-integration tests [46] are used. Such techniques perform better than the conventional panel co-integration tests, for their more reliable findings on the long-run linkages of time series data [48–50]. Such methodology employs two ratio tests (trace and maximum eigenvalue test), based on individual co-integration test [51]. The Johansen-Fisher test combines the individual statistics (p-values) together for panel analysis. The results of both methods can be used to propose the existence of co-integrating vectors. If p_i is the p-value from an individual co-integration test for cross-section i, under the null hypothesis the test statistic for the panel:

$$-2\sum_{i=1}^{n}\log(p_i) \sim \chi^2_{2n} \tag{3}$$

where χ^2 is based on Mackinnon et al. [52]. Moreover, Durbin-Hausman panel cointegration test [53] is employed, which takes the cross-sectional dependence and slope homogeneity into consideration. There are two evaluation indicators, including Durbin-Hausman panel test (DHp) and Durbin-Hausman group test (DHg). The null hypothesis of each indicates no cointegration between variables.

If time series data are co-integrated, this step is to estimate the associated long-run co-integration parameters of Eq. (2). The dependent variable is CO_2 emissions, while the independent variables are real GDP, the square of real GDP, non-renewable and renewable energy use, and international tourism. In this step, we use FMOLS [9], allowing for estimating heterogenous co-integrated vector for panels members. The main advantage of the FMOLS technique is that it rectifies both serial correlation and simultaneous bias. Because selected time series data come in natural logarithmic forms, the parameters estimated from the long-run co-integration linkage can be interpreted as long-run elasticity. Moreover, AMG [10] estimators are employed considering cross-sectional dependence and heterogeneity.

Next step is to test bivariate panel causality among emissions, GDP, non-renewable and renewable energy use, as well as international tourism in selected countries. The causality linkages of the time series data are investigated by allowing for heterogeneity in the dynamic models across the cross-sections. Dumitrescu and Hurlin [11] put forward a simple method to examine the hypothetical homogeneous non-causality (HNC) against the alternative of heterogeneous non-causality (HENC). The linear heterogeneous model is as follows:

$$y_{i,t} = \alpha_i + \sum_{k=0}^{K}\gamma_i^{(k)}y_{i,t-k} + \sum_{k=1}^{K}\beta_i^{(k)}x_{i,t-k} + \varepsilon_{i,t} \tag{4}$$

where K stands for the lag length, x and y denote each variable under consideration variables observed for i individuals in t periods in model, α_i represents constant term for i individual effect, while $\gamma_i^{(k)}$ and $\beta_i^{(k)}$ denote lag parameter and coefficient slope based on k lag and i individual, respectively.

Null hypothesis (H_0) and alternative hypothesis (H_1) are defined as following:

$$\begin{aligned} &H_0 : \beta_i = 0 \quad \forall i = 1, \ldots, N \quad with \beta_i = \left(\beta_i^1, \beta_i^2 \ldots \beta_i^k\right) \\ &H_1 : \beta_i = 0 \quad \forall i = 1, \ldots, N_1 \\ &\quad\ \beta_i \neq 0 \quad \forall i = N_1 + 1, N_1 + 2, \ldots, N \end{aligned} \tag{5}$$

where N_1 meets condition $0 \le N_1 < N$. According to the null hypothesis, no causal association for all the units of the panel (H_0). The alternative hypothesis (*HENC*, H_1) can be specified into two segments. A causality from x to y is observed in the first segment, but not in the second segment. In the second segment, no causality from x to y suggests us to employ heterogeneous panel data model by assuming fixed estimates of the group for empirical analysis. The average statistics $W_{N,T}^{HNC}$ is proposed, which is related to the *HNC* hypothesis, as follows:

$$W_{N,T}^{HNC} = \frac{1}{N}\sum_{i=1}^{N} W_{i,T} \tag{6}$$

Where $W_{i,T}$ stands for the individual Wald statistics for the ith cross section unit. Under the null hypothesis of non-causality, each individual Wald statistic converges to a Chi-squared distribution with K degrees of freedom for $T \to \infty$. The standardized test statistic converges to a normal distribution under the homogeneous non-causality hypothesis, and is as follows:

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}}\left(W_{N,T}^{HNC} - K\right) \to N(0,1) \tag{7}$$

where T, $N \to \infty$ denotes the fact that $T \to \infty$ first and then $N \to \infty$.

3.3. Data and descriptive statistics

This study uses annual data of 10 Northeast and Southeast Asian countries (NSEA-10) from 1995 to 2014. The countries are China (CHN), Japan (JPN), and South Korea (KOR) in Northeast Asia, together with Russia (RUS) (NEA-4); Indonesia (IDN), Malaysia (MYS), the Philippines (PHL), Singapore (SGP), Thailand (THA) and Vietnam (VNM) in Southeast Asia (SEA-6). The criterion for selection of countries is on account of the availability of data and the interest of the empirical results.

Fig. 2 shows the average growth rate of every variable for each country between 1996 and 2014. The growth rate of CO_2 emissions

[5] World Bank, 2017. https://data.worldbank.org/.
[6] British Petroleum, 2017 https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

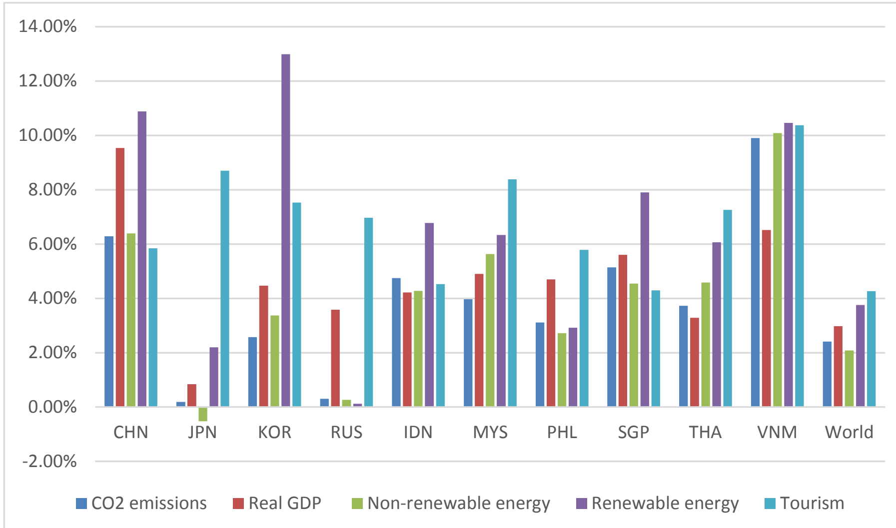


Fig. 2. The average growth rate of each variable for each country from 1996 to 2014.

ranges from a low of 0.19% (Japan) to 9.90% (Vietnam). Compared with the world total, only growth rates of Japan and Russia's emissions are below the global level. Growth rates of regional economy are all above the average of world except Japan, which suggests that the Asia-Pacific region is one of world most dynamic place in world economy. China has the highest growth rate of GDP in recent two decades of 9.54%, followed by Vietnam of 6.52%. The growth rates of non-renewable energy consumption in this region are also fast for its rapid growth, only Japan with negative growth averagely. Moreover, Asia-Pacific region also pays more attention to the development of renewable energy. The growth rates of China, South Korea and Vietnam in renewable energy are above 10%. Compared with world international tourism, the growth rate in this region is much quicker, while the rate has been above 10% in Vietnam.

For comparison, Fig. 3 also shows the average growth rate based on the regions (four Northeast Asian countries (NEA-4), six Southeast Asian countries (SEA-6), and total sample (NSEA-10)) and the world total. Along with the regional prosperity, the corresponding industries are increasing accordingly. The growth rate of each variable in the selected region is two times faster than the world average. Moreover, the average rates in SEA-6 are larger than that in NEA-4 except renewable energy.

For the sake of finding the essential characteristics of selected data and appreciating the data's homogeneity, Table 2 shows summary statistics under natural logarithm. Statistical indexes selected for dispersion are mean, median, maximum, minimum and standard deviation (Std. Dev.). For all chosen variables, the values of mean and median are close. Similarly, the Std. Dev. of variables are all similar, making clear that the variables are relatively homogeneous. To avoid cross-sectional dependence between countries, we also use Pesaran [54] CD test in Table 2. The results indicate that the null hypothesis of cross section independence is rejected uniformly.

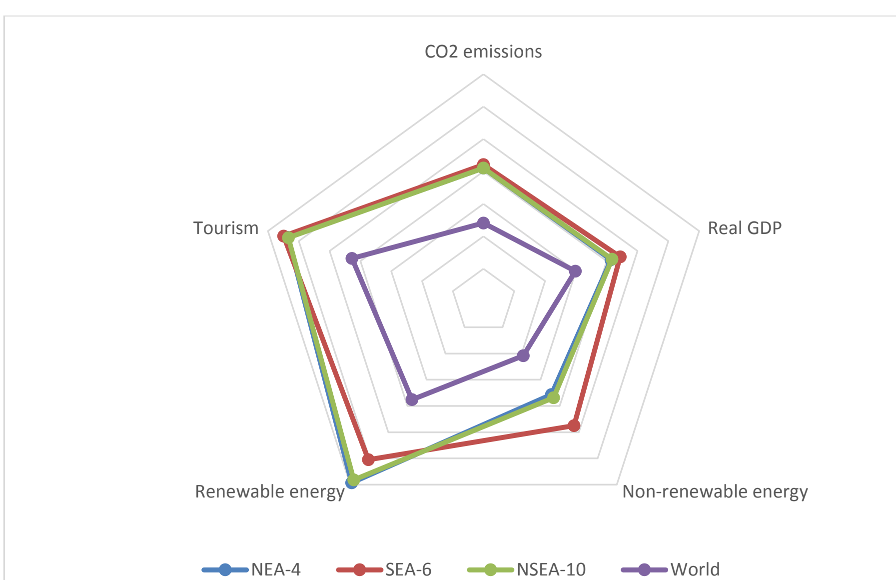


Fig. 3. The average growth rate of each variable for regions and world from 1996 to 2014.

Table 2
Summary statistics (after natural logarithm).

	co	*gdp*	*nre*	re	*tour*
Mean	12.72166	26.97269	4.850761	1.457317	15.95727
Median	12.51689	26.72698	4.556627	1.342889	15.82754
Maximum	16.14687	29.75128	7.894317	5.665058	17.8712
Minimum	9.899805	24.50053	2.082467	−2.892501	14.11636
Std. Dev.	1.488756	1.366523	1.391438	1.913282	0.881135
Pesaran *CD*	16.47030***	29.08079***	18.22528***	20.17477***	26.44977***

Notes: *** indicates statistical significance at the 1% level.

4. Empirical results and discussions

In order to examine the relationship among CO_2 emissions, real GDP, the square of real GDP, non-renewable and renewable energy use, and international tourism for a panel of ten Asian countries, the methodologies, such as panel unit roots, co-integration, and causality are employed. The detailed procedures are as follows.

4.1. Panel unit root tests

Table 3 presents the estimated results of unit root tests at various levels and the first differences for all six variables in our data set. The results are computed by employing four panel unit root tests, LLC, IPS, Fisher-ADF, and Fisher-PP, on each time series data. They show that for each variable by levels, and the null hypothesis of a unit root cannot be rejected at the 5% level. While by first difference, the alternative hypothesis of no unit root is accepted. Thus, we reject the null hypothesis of non-stationarity at the 1% level of significance and indicate that the selected variables are integrated of order one, I(1).

4.2. Panel co-integration test

Table 4 displays the Johansen-Fisher and Durbin-Hausman panel co-integration test based on total sample (NSEA-10), NEA-4, and SEA-6. The results based on Trace and Maximum eigenvalue statistics indicate that the null hypothesis of no co-integration is strongly denied for the three groups of sample countries at a 1% significance level, suggesting evidence of a long-run equilibrium association among emissions, real GDP, the square of real GDP, non-renewable and renewable energy use, and international tourism. Moreover, the results of DH_p and DH_g suggest that existence of cointegration relationship between selected variables in the three models.

4.3. Long run equilibrium

Results for individual and panel FMOLS and AMG long run

Table 3
Panel unit roots test.

	co	*gdp*	*gdp²*	*nre*	re	*tour*
Level						
LLC	−2.19758	−0.75787	−0.49248	−2.48077	0.65231	0.99326
IPS	0.91034	3.53592	3.75267	1.84115	1.79748	3.26708
ADF-Fisher	15.1267	12.1818	11.8223	10.1797	14.9694	16.3200
PP-Fisher	25.3494	12.8233	11.0371	33.7779	19.8347	12.2823
CIPS	−2.544	−2.402	−2.450	−2.938	−3.091	−1.760
First difference						
LLC	−7.79525***	−17.965***	−17.6362***	−8.23586***	−12.2994***	−9.99345***
IPS	−8.17317***	−12.0326***	−11.873***	−8.46416***	−10.5338***	−10.1696***
ADF-Fisher	98.7196***	309.878***	283.172***	103.061***	125.651***	122.485***
PP-Fisher	143.989***	115.24***	113.514***	125.522***	404.764***	135.77***
CIPS	−3.810***	−3.413***	−3.406***	−3.997***	−3.997***	−3.997***

Notes: *** indicates statistical significance at the 1% level.

Table 4
Co-intergation test.

	NSEA-10		NEA-4		SEA-6	
Fisher-type Johansen co-integration test						
Hypothesized No. of CE(s)	Fisher Statistic		Fisher Statistic		Fisher Statistic	
	Trace	Max-eigen	Trace	Max-eigen	Trace	Max-eigen
None	133.100***	133.100***	39.610***	39.610***	93.490***	93.490***
At most 1	415.200***	290.700***	183.400***	126.500***	231.800***	164.200***
At most 2	214.000***	150.400***	100.500***	75.830***	113.500***	74.530***
At most 3	91.590***	69.220***	38.610***	34.240***	52.980***	34.980***
At most 4	42.540***	41.670***	13.070	11.320	29.470***	30.350***
At most 5	25.440	25.440	12.900	12.900	12.550	12.550
Durbin-Hausman co-integration test						
	Statistic		Statistic		Statistic	
DH_g	−1.532*		−1.237*		−1.245*	
DH_p	−1.680**		−1.439*		−1.532*	

Note: ***, **, and * stands for rejecting the null hypothesis of no co-integration at 1%, 5%, and 10% significance level, respectively.

Table 5
Long-run estimates based on individual and panel data.

Variables	*gdp*	*gdp²*	*nre*	re	*tour*
FMOLS					
CHN	−8.526**	0.148**	1.100***	−0.019	−0.092
JPN	−113.363	1.945	0.329*	0.205*	−0.081
KOR	−29.654***	0.558***	1.07**	0.017	0.182**
RUS	−5.612*	0.100*	1.188***	−0.096	0.044*
IDN	72.546**	−1.337**	1.002***	−0.230*	0.667**
MYS	−6.658	0.153	−0.401	−0.215**	0.145
PHL	−19.309**	0.376**	1.139***	0.121*	−0.150**
SGP	−141.832***	2.717**	2.640**	−0.468*	−0.864
THA	9.388	−0.177	0.787***	0.065**	−0.071
VNM	0.178	0.012	0.773***	−0.151*	−0.174
NEA-4	−4.682***	0.084***	0.730***	0.017	0.034**
SEA-6	−5.452***	0.098***	1.046***	−0.182***	0.251***
NSEA-10	−4.047***	0.070***	1.058***	−0.148**	0.222***
AMG					
NEA-4	−7.461**	0.126*	0.823***	−0.003	0.010*
SEA-6	−5.538**	0.095*	0.524***	−0.137*	0.034
NSEA-10	−5.467**	0.095**	0.680***	−0.088**	0.056*

Notes: ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

parameters based on Eq. (2) are displayed in Table 5. The results indicate that the groups of NEA-4, SEA-6, and NSEA-10, reject the hypothetical EKC in the FMOLS and AMG. Such result may depend on that Asian region, as the most economically active area in the world, needs more energy to stimulate the economic development, accompanied by an increase in emissions. The finding is similar with Liu et al. [3] of four Association of Southeast Asian Nations (ASEAN-4), and differs from Cerdeira Bento and Moutinho [55] of Italy, Zhang [25] of Korea, and Zhang et al. [56] of ten newly industrialized countries. According to the FMOLS estimators, the results also present that a 1% augment in non-renewable energy may lead to 0.730% in NEA-4, 1.046% in SEA-6, and 1.058% in NSEA-10 increasing in emissions in the long run, respectively, which are supported by Liu et al. [57] and Dong et al. [58] of BRICS countries. Such results may depend on more efficient use and more technological input in non-renewable energy in Northeast Asia. While a 1% augment in renewable energy may reduce emissions by 0.182% in SEA-6 and 0.148% in NSEA-10. Such results are supported by Hu et al. [59], and Liu and Bae [24] based on share of renewable energy in 25 developing countries and China. In NEA-4, the finding of insignificance indicates that, although the development of renewable energy is very fast, the share of renewable energy in total energy use is very limited in this region. Thus, the main approach is to increase energy efficiency, especially non-renewable energy efficiency. Besides, a 1% increase in international tourism can increase 0.034% in NEA-4, 0.251% in SEA-6, and 0.222% in NSEA-10 in carbon emissions. As the world's fastest growing tourism market, environmental pollution is unavoidable in the Asia-Pacific region, especially CO_2 emissions. More tourism needs more energy consumption input, which is as the result presents.

From individual, there is an interesting finding that all selected countries do not support the inverted U-shaped EKC expect Indonesia. Such findings warn governments that the development of regional economy should turn to lower-economic growth to protect the environment, so as to meet the turning point of carbon emissions. Non-renewable energy plays a positive role in emissions in all selected countries except no significance in Malaysia. Non-renewable energy has created both the economic boom and the problem of regional environment. Energy substitution and efficiency should be considered by governments. With regard to the impact of renewable energy on emissions, the present study finds a negative and significant impact in Indonesia, Malaysia, Singapore, and Vietnam, while positive and significant impact in Japan, the Philippines, Thailand. Such results are interesting, which indicate that whether renewable energy does positive or negative on emissions, does not merely depend on country's economic strength [21]. Moreover, positive impact of tourism on emissions is found in Indonesia, Korea, and Russia, while negative impact in the Philippines.

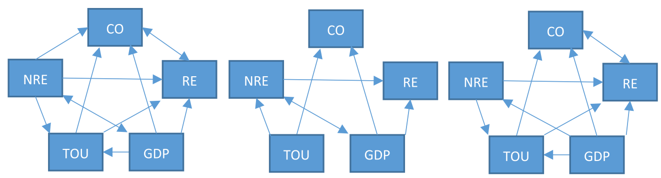
4.4. Heterogeneous panel non-causality tests

Table 6 reports the homogeneous causality among the selected variables based on ten Northeast and Southeast Asian countries (NSEA-10), four Northeast Asian countries (NEA-4), and six Southeast Asian countries (SEA-6). For sake of expressing the linkages among the selected variables, Fig. 4 is presented based on results of Table 6. In the whole sample (Fig. 4 (a)), bidirectional

Table 6
Homogeneous causality among the selected variables.

Null Hypothesis:	NSEA-10			NEA-4			SEA-6		
	W-Stat.	Zbar-Stat.	Prob.	W-Stat.	Zbar-Stat.	Prob.	W-Stat.	Zbar-Stat.	Prob.
gdp does not homogeneously cause co	5.255	3.219***	0.001	8.138	4.066***	0.000	2.387	1.687*	0.092
co does not homogeneously cause gdp	3.745	1.538	0.124	3.236	0.614	0.539	0.569	−0.778	0.437
nre does not homogeneously cause co	3.888	1.697*	0.090	4.079	1.207	0.227	2.342	1.626	0.104
co does not homogeneously cause nre	1.994	−0.412	0.681	2.403	0.028	0.978	1.050	−0.126	0.900
re does not homogeneously cause co	4.414	2.282**	0.023	4.232	1.315	0.188	2.977	2.486**	0.013
co does not homogeneously cause re	4.680	2.578***	0.010	3.348	0.693	0.489	3.287	2.906***	0.004
tour does not homogeneously cause co	5.465	3.453***	0.001	6.844	3.154***	0.002	4.691	4.809***	0.000
co does not homogeneously cause tour	2.359	−0.006	0.996	1.393	−0.684	0.494	0.847	−0.401	0.689
nre does not homogeneously cause gdp	4.638	2.532**	0.011	5.206	2.001**	0.045	0.992	−0.204	0.838
gdp does not homogeneously cause nre	6.664	4.787***	0.000	10.583	5.786***	0.000	3.193	2.779***	0.005
re does not homogeneously cause gdp	3.513	1.279	0.201	1.544	−0.577	0.564	2.307	1.578	0.115
gdp does not homogeneously cause re	8.125	6.413***	0.000	6.023	2.577***	0.010	4.616	4.708***	0.000
tour does not homogeneously cause gdp	1.711	−0.727	0.467	1.704	−0.464	0.643	1.199	0.076	0.939
gdp does not homogeneously cause tour	3.841	1.644*	0.100	1.134	−0.866	0.387	4.014	3.892***	0.000
re does not homogeneously cause nre	3.362	1.111	0.266	3.318	0.672	0.502	2.282	1.544	0.123
nre does not homogeneously cause re	6.954	5.110***	0.000	5.295	2.064**	0.039	4.521	4.580***	0.000
tour does not homogeneously cause nre	3.483	1.246	0.213	6.805	3.127***	0.002	1.659	0.699	0.484
nre does not homogeneously cause tour	5.999	4.047***	0.000	4.503	1.506	0.132	3.105	2.660***	0.008
tour does not homogeneously cause re	4.454	2.327**	0.020	4.095	1.219	0.223	3.243	2.846***	0.004
re does not homogeneously cause tour	2.361	−0.003	0.998	2.907	0.383	0.702	1.053	−0.122	0.903

Notes: ***, **, * indicate statistical significance at the 1%, 5%, and 10% level, respectively.



a) NSEA-10 b) NEA-4 c) SEA-6

Fig. 4. Heterogeneous causality test based on different regions in Asian countries.

linkages of renewable energy and emissions, and of non-renewable energy and GDP are found. Such results indicate that any change in renewable energy may affect emissions, while any change in non-renewable energy may affect GDP, vice versa, which are in line with Liu et al. [3] for feedback result between renewable energy and emissions for ASEAN countries, and Charfeddine et al. [60] for feedback linkage of non-renewable energy and emissions in Qatar. Evidences of one-way linkages exist from GDP, non-renewable energy, and international tourism to emissions, not vice versa. The findings reveal that any change in emissions would not affect economic development, the use of non-renewable energy, and international tourism. Therefore, carbon reduction can be implemented without economic recession by governments. Moreover, one-way linkages from GDP, non-renewable energy, and international tourism to renewable energy are found. The linkage running from non-renewable energy and GDP to tourism also is found, respectively.

In the group of NEA-4 (Fig. 4 (b)), feedback causal linkage of non-renewable energy and GDP indicates that economic development heavily depends on non-renewable energy, and vice versa. The finding is inconsistent with Bhattacharya et al. [61] only from non-renewable energy to economy for top 38 renewable energy use countries and Liu [62] for China, but supported by Kahia et al. [63] for MENA net oil importing countries. Only unidirectional causality from GDP and tourism to emissions, and no causality between energy and emissions, reveal that emissions can be controlled by sustainable tourism and economy, and emissions reduction can be implemented by regional governments. One-way causalities from GDP and non-renewable energy to renewable energy, and from tourism to non-renewable energy are found, respectively.

In the group of SEA-6 (Fig. 4. (c)), feedback causal linkage of renewable energy and emissions shows that the development of renewable energy is effective for environmental improvement. There are evidences of unidirectional causalities from GDP and tourism to emissions, and from non-renewable energy, tourism, and GDP to renewable energy. International tourism can stimulate the development of renewable energy consumption in Southeast Asian countries. The causal linkage of renewable energy and GDP is different from Liu et al. [64] of Asia-Pacific region. The linkages from GDP and non-renewable energy to international tourism suggest that tourism industries' development needs non-renewable energy input, as well as economic input. Only one-way causal linkage from GDP to non-renewable energy indicates that energy reduction would not affect the economic growth. No causality from non-renewable energy to emissions indicates that the exchange of non-renewable energy would not affect the emissions in the short run in NEA-4 and SEA-6. Thus, governments should consider the long-term issue of non-renewable energy.

5. Conclusions and implications

The present paper explores the relationship among CO_2 emissions, real GDP, non-renewable and renewable energy, and tourism in panel of ten Northeast and Southeast Asian countries covering the period of 1995–2014. Environmental Kuznets curves are examined by FMOLS and AMG based on individual country and panel data. Moreover, heterogeneous panel non-causality test is employed to analyze the causality among variables based on regional data. The empirical results reject the existence of the EKC hypothesis in whole samples (NSEA-10), Northeast Asian countries (NEA-4), and Southeast Asian countries (SEA-6). Compared with the coefficient of renewable energy (-0.148), non-renewable energy makes great effect on emissions, with coefficient of 1.058 on emissions in total panel data set. Moreover, one percentage increasing in tourism may lead to increasing 0.222% emissions in this region. Therefore, enlarging renewable energy consumption, making non-renewable energy more efficient, and developing smart tourism should be promoted. The findings based on heterogeneous causality test are mixed in different regions.

Based on the empirical results, some implications are suggested as following:

1) Based on causality between emissions and GDP, economic growth should be developed actively, especially green economy, so as to accelerate the arrival of the turning point of inverted U-shaped hypothetical EKC. Asian development does heavily depend on resources input, especially the overuse of fossil fuels, which inevitably result in environmental damage, such as degrading air quality and eco-systems. Policymakers should shift the economic growth to be inclusive and sustainable by enforcing clean technology, recycling waste, and advocating resource-saving consumed mode. Moreover, existing green development regulations or designing better laws should be implemented practically.
2) Renewable energy should be energetically developed, while non-renewable energy should be curbed. As the main source of emissions, the consumption of non-renewable energy, especially fossil fuels, should be reduced. Based on the condition of energy structure in Asia, coal should be used as little as possible for its massive emissions. Such measure can be achieved by developing new energy extraction technologies in the sea or on land. One of renewable energy's most vexing issues is the sheer variability of wind and solar power, therefore, the storage or conversion of renewable energy technologies should be improved, as well as surplus non-renewable energy. Additionally, the cost of renewable energy should be reduced by technologies.
3) Developing green tourism is conducive to environmental improvement and economic development. Ecotourism, low carbon tourism, and sharing tourist economy should be encouraged and popularized by government. The technology of energy intensity reduction should be developed in the tourism process. Tourism industries and destinations need to play a leading role in specific implementation and measures to alleviate environmental pollution throughout the tourism value chain. Moreover, infrastructure and public transportation should be improved by local government. According the UNWTO, transportation sector in tourism contributes 75% of all tourism emissions. Therefore, technological innovation in transportation needs to be strengthened, such as using energy-efficient airplanes and high-speed rails. Construction of tourism infrastructure should be invested by the government. According to Asian Development Bank,[7] Asia needs $8.4 trillion transport

[7] Asian Development Bank, 2017. https://www.adb.org/news/features/what-infrastructure-does-asia-need-and-why.

investment through 2030. Additionally, some governmental policies should be put into effect. Visa-free travel between regional countries should be encouraged, which may reduce carbon emissions in the process of handling. Environmental awareness and smart tourism should be strengthened in everyone's mind by our governments.

Besides, international cooperation should be strengthened in intra-region or extra-region, not only in technological cooperation, but also information sharing. Such actions may reduce unnecessary waste and increase the ability to combat climate change jointly. The tourism environment should be maintained not only by society but also by individuals.

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