Economics Development Analysis Journal 9 (3) (2020)

Economics Development Analysis Journal

http://journal.unnes.ac.id/sju/index.php/edaj

Renewable Energy Consumption in Emerging Countries and Developed Countries

Tiurma Melissa Rakhel✉

Faculty of Economics and Business, Universitas Indonesia

Article Information

Hisrtory of Article
Received April 2020
Accepted June 2020
Pusblished August 2020

Keywords:
Renewable Energy Consumption, Panel Cointegration, PMG-ARDL

Abstract

Resources of non-renewable energy are limited, and energy consumption is known to worsen major environmental problems in the world. To reach a balance between energy needs and environmental problems, using renewable energy is one of the best options for many countries. Given this state of affairs, this study addresses the long-term relationship of renewable energy consumption with respect to output, pollutant emissions and international trade. It uses a panel cointegration technique, along with the Pooled-Mean Group Auto Regressive Distributed Lag (PMG-ARDL) method, to compare a group of emerging countries with a group of developed countries. The study shows that the consumption of renewable energy is positively related to real Gross Domestic Product (GDP) per capita and international trade for both emerging countries and developed countries, while it is negatively associated with CO_2 per capita with a large magnitude. This result suggests that international trade and economic growth will promote the consumption of renewable energy in the long-run future. However, whether an increase in the percentage of renewable energy consumed solves the environmental problems depends a great deal on the future trajectory of CO_2 emissions along with economic development. Overall, the empirical analysis in the present study demonstrates that international trade leads to the promotion of the consumption of renewable energy as a long-run relationship. It means that, in the future, economic development along with international trade and advances in environmental technology are expected to further facilitate and promote the consumption of renewable energy in every country.

✉Corresponding author :
Address: MPKP FEB UI, UI Salemba Campus
Salemba Raya No.4, Senen, Jakarta Pusat 10430
E-mail: melissa.rakhel@gmail.com

ISSN 2252-6560

INTRODUCTION

An increase in energy consumption is a feature of the advancement of civilization, such as population growth, economic growth, and technological development in industrial sectors. At present, fossil fuels are the dominant energy source in the world. Using this type of energy is a problem for conservation and environmental carrying capacity related to climate change and the greenhouse effect. Therefore, to create energy security without worsening environmental problems such as climate change, using renewable energy as an alternative energy is considered one of the best options for both emerging countries and developed countries. This type of energy can fulfil the needs of the current generation without sacrificing the ability of future generations to meet their energy needs. In recent decades, both emerging countries and developed countries have experienced massive industrialisation and trade liberalisation, which have led to increases in exports and imports of goods and services. Liberalisation of trade between nations is predicted to cause an increase in consumption of both non-renewable energy and renewable energy. Given this state of affairs, this study addresses the long-term relationships between the consumption of renewable energy and economic output, the emission of pollutants, and international trade.

Many scholars in the fields of energy economics and energy policy have discussed and developed models regarding the relationships between the consumption of renewable energy and economic output and the emission of pollutants. Two approaches have been used to investigate these relationships, namely supply-side and demand-side approaches. The supply-side approach examines the contribution of the consumption of renewable energy to economic activity, which is combined with a standard production function. Meanwhile, the demand-side analysis studies the correlation between economic activity and the determination of the usage of renewable energy. Chien and Hu (2008) analysed the effects of renewable energy on Gross Domestic Product (GDP) in 116 countries by using Structural Equation Modelling (SEM). Their results showed a positive correlation between renewable energy and Gross Domestic Product (GDP) through the increase in capital formation. In line with this, Soava et al. (2018) used panel data techniques to demonstrate that an increase in the consumption of renewable energy has enormous positive impacts on economic growth in 28 European Union countries from 1995 to 2015. Other studies using the supply-side approach related renewable energy to CO_2 emissions. Bekun, Alola and Sarkodie (2019) demonstrate that there is a long-term relationship and a causal interaction among non-renewable energy, renewable energy, and economic growth in carbon function.

On the other hand, Apergis and Payne (2015) and Salim and Rafiq (2012) conducted empirical studies using a demand-side approach. Their studies used panel cointegration techniques to reveal a positive and significant long-term elasticity among the consumption of renewable energy per capita, GDP per capita, and oil prices. Nguyen and Kakinaka (2019) also using panel cointegration techniques, study 107 countries based on their phases of country development. They discover that the consumption of renewable energy in low-income countries has a positive relationship with carbon emissions and a negative relationship with output. By contrast, the consumption of renewable energy in high-income countries has a negative relationship with carbon emissions and a positive relationship with output. These results indicate that the best energy policy depends on the level of economic activity in each country.

Although much attention has been given to this topic, there are still very few studies that focus on the relationship between international trade and renewable energy. Sadorsky (2011), Sadorsky (2012) and Lean and Smyth (2010) see only the relationship between trade openness between countries and energy consumption. Omri, Daly and Nguyen (2015) examined the determinant factors of the consumption of renewable energy in 64 countries using a static approach and dynamic panel data. They find that CO_2 emissions per capita and Gross Domestic

Product (GDP) per capita has a positive and significant impact on the consumption of renewable energy in all countries, except in low-income countries. The result of the Generalized Metthod of Moments (GMM) approach shows that CO2 emissions, national income, and international trade also play an important role in the usage of renewable energy. Nevertheless, none of the studies have focused on analysing the long-term relationship between output, the emission of pollutants and international trade on the usage of renewable energy in two different groups, emerging countries and developed countries.

For that reason, the main purpose of this study is to answer the following question: Is there a long-run relationship between the ratio of the consumption of renewable energy, Gross Domestic Product (GDP) per capita, CO2 emissions per capita and international trade in emerging countries and developed countries in the period 1990-2014. Furthermore, if such relationships exist, what are the long-run elasticity estimates between variables? This study employs a panel cointegration technique using the Pooled-Mean Group Auto Regressive Distributed Lag (PMG ARDL) approach. It is hoped that findings from this study will be beneficial for policy makers who are concerned with the demand for renewable energy by forecasting the determinants of renewable energy and possible trajectories of environment along with economic growth and international trade.

RESEARCH METHODS

This study used a panel cointegration analysis to investigate whether the consumption of renewable energy is affected by Gross Domestic Product (GDP) per capita, CO_2 emissions, and international trade. This study examines data from two groups of countries, emerging countries and developed countries, defined by country income (see Table 1). This study analyze secondary data, panel data series from 1990-2014, from the International Energy Agency and the World Bank. The ratio of consumption of renewable energy is the dependent variable, while CO_2 emissions per capita, Gross Domestic Product (GDP) per capita, and ratio of international trade are independent variables (Key World Energy Statistics (2017) and *World Development Indicators 2017* (2017)).

Table 1. List of Sample Countries

Emerging Countries			Developed Countries		
1	BDG	Bangladezh	1	ARG	Argentina
2	BGR	Bulgaria	2	AUS	Australia
3	BRA	Brazil	3	AUT	Austria
4	CHN	China	4	CAN	Canada
5	COL	Columbia	5	CHE	Switzerland
6	ECU	Ecuador	6	CHL	Chile
7	EGY	Egypt	7	DEU	Germany
8	IDN	Indonesia	8	DNK	Denmark
9	IND	India	9	ESP	Spain
10	LKA	Sri Lanka	10	FIN	Finland
11	MAR	Marroco	11	FRA	France
12	MEX	Mexico	12	GBR	United Kingdom
13	MYS	Malaysia	13	IRL	Irland
14	PAK	Pakistan	14	ISL	Iceland
15	PER	Peru	15	ISR	Israel
16	PHL	Philiphines	16	ITA	Italy
17	ROU	Roumania	17	JPN	Japan
18	THA	Thailand	18	KOR	South Korea
19	TUR	Turkey	19	NDL	Netherland
20	VEN	Venezuela	20	NOR	Norway
21	VNM	Vietnam	21	NZL	New Zealand
			22	POR	Poland
			23	PRT	Portugal
			24	SGP	Singapore
			25	SWE	Sweden
			26	USA	USA

Before performing econometric estimation using panel data time series, some stages must be done (see Figure 1). Panel data analysis starts by testing the stationarity of the to determine whether there is any unit root in those variables. The test is conducted to eliminate any doubt that the variables are integrated over order I (1). The stationarity tests used in the present study are Levin, Lin and Chu (LLC), Im, Peseran and Shin (IPS), Augmented Dickey Fuller-Fisher (ADF-Fisher) and Philip Pheron-Fisher (PP-Fisher). A probability less than 10% indicates that the variable is stationary. Levin, Lin and Chu (2002), Breitung (2000) and Im, Pesaran and Shin (2003) have developed panel-based unit root tests similar to a time series data test. However, a panel unit root test is stronger and more reliable than a unit root test applied on time series data because information in time series data is equipped with available cross-section data.

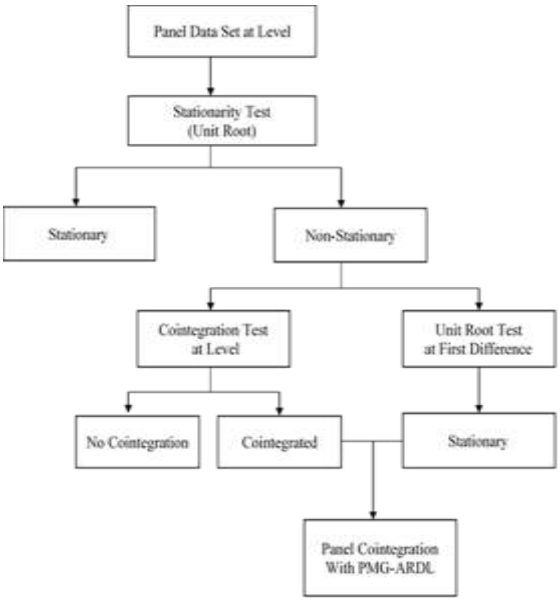

Figure 1. The Stages of Panel Cointegration Analysis

Stationarity Test (Unit Root Test), there are two types of unit root panel testing: the common unit root, consisting of Levin, Lin and Chu and Breitung test statistics and unit root individuals, consisting of Im Pesaran and Shin and PP-Fisher test statistics. Unit root test for panel data is:

$y_{it} = \rho_i \, y_{it-1} + X_{it}\delta + \varepsilon_{it}$ ……………………1

where i is an individual unit, t is a time series, X_{it} is an exogenous variable, ρi are atoregressive coefficients, and ε_{it} is an error term. If $|\rho_i| \leq 1$, then there is a unit root in the y_i variable. There are two related assumptions ρ_i:

Parameters are common across the cross section, so $\rho_i = \rho$ for all i. Levin, Lin and Chu (LLC), and Breitung use this assumptions in the unit root panel test. The Levin, Lin and Chu (LLC) and Breitung methods analyze the unit root with the equation as follows:

$$\Delta y_{it} = \propto y_{it-1} + \sum \beta_{ij} \, \Delta y_{it-1} + X_{it}\,\delta + v_{it}$$

Assuming $\alpha = 1 - \rho$. The hypothesis can be written as H0 : $\alpha = 0$ and H1 : $\alpha < 0$, Where H0 there is a unit root, while H1 there is no unit root. Assume ρi freely in all cross sections. Im, Paseran and Shin (IPS), Fisher-ADF and Fisher-PP use this assumption in testing unit root. They analyze unit root with the following equation:

$\Delta y_{it} = \propto y_{it-1} + \sum_{j=i}^{\rho i} \sum \beta_{ij} \Delta y_{it-1} + X'_{it}\,\delta + v_{it}$.......2

With the following hypothesis: H0 : $\alpha i = 0$, for all i; H1 : $\alpha i = 0$, untuk i = 1,2,3 … . . N; $\alpha i = 0$, untuk i = N + 1, N + 2, … .N

Cointegration Test, in the second stage, the panel cointegration tests can be proceeded after testing the unit root. Cointegration test is used to see whether there is any long-term relationship between variables which are not stationary but have stationary linear combination among the variables. The cointegration tests used in this study are Johansen Cointegration test with Pedroni and Kao Residual Cointegration Test methods. A probability less than 10% indicated that the variables in the current study were cointegrated or have long-term balance.

Pedroni, similar to panel unit root tests, panel cointegration tests are much more powerful than the normal time series cointegration. This study uses the Pedroni test to examine whether a long-run relationship exists between the variables. Pedroni made several tests of the null hypothesis of no cointegration in the panel data model. These statistics are panel v-statistics, panel p-statistics, panel PP-statistics, panel Augmented Dickey Fuller (ADF) statistics, group p-statistics, group PP-statistics and group Augmented Dickey Fuller (ADF)-statistics. The first four cointegration statistics appoint to the within-dimension and the last three appoint to the between-dimension.Kao, Similar to Pedroni's panel cointegration approach, the Kao test requires cross-section-specific intercepts and homogenous coefficient on the regressor in the first stage estimation. Kao test examines the asymptotic null distribution of residual-based cointegration in panel data by conducting Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests. The current study conducts two panel cointegration tests for robustness, checking to ensure the existence of cointegration.

Panel Cointegration Estimation, Autoregressive Distributed Lag (ARDL) is a selection modelling approach developed by Pesaran and Pesaran (1997), Pesaran and Smith (1998), and Pesaran, Shin and Smith (2001). The purpose of using ARDL in this study is to answer the key question whether long-term consumption of renewable energy was affected by Gross Domestic Product (GDP) per capita, CO_2 emissions, and international trade. Eviews provides an application to estimate and test models using Autoregressive Distributed Lag (ARDL). ARDL is a fairly popular method in econometrics because it can test long-term relationships and short-term relationships among variables, and it avoids problems due to non-stationary data Pesaran, Shin and Smith (1999). The model accepts variable integration at I (1) and I (0), but it cannot be applied when the series are integrated to I (2). Moreover, the method is a consistent and efficient estimator because it inserts lags into independent and dependent variables, thus removing the problem of endogeneity—a correlation between the independent variable and the error term in a model. According to Pesaran, Shin and Smith (1999), the Autoregressive Distributed Lag (ARDL) (p, q) model is as follows:

$$\Delta Y_{l,it} = \alpha_{li} + \gamma_{li} Y_{l,it-1} + \sum_{l=2}^{k} \gamma_{li} X_{l,it-1} + \sum_{j=1}^{p-1} \delta_{lij} \Delta Y_{l,it-j} + \sum_{j=0}^{q-1} \sum_{l=2}^{k} \delta_{lij} \Delta X_{l,it-j} + \varepsilon_{l,it} \quad \ldots\ldots 3$$

Where Yl is the dependent variable and Xl is the independent variable, with l= 1,2,3,4. εt is the error term, and Δ is the difference operator. For example, if RREC is the dependent variable, the empirical ARDL model to be estimated can be written as follows:

$$\Delta RREC_{l,it} = \alpha_{li} + \gamma_{1i} RREC_{it-1} + \gamma_{2i} LRGDPPC_{it-1} + \gamma_{3i} LCO2PC_{it-1} + \gamma_{4i} Trade_{it-1} + \sum_{j=1}^{p} \delta_{1i} \Delta RREC_{it-j} + \sum_{i=0}^{q} \delta_{2i} \Delta LRGDPPC_{it-j} + \sum_{i=0}^{q} \delta_{3i} \Delta LCO2PC_{it-1} + \sum_{i=0}^{q} \Delta Trade_{it-1} + \varepsilon_{l,it} \quad \ldots\ldots 4$$

The selection of a lagged variable in this study is based on the Akaike Information Criterion (AIC), where RREC is Ratio Renewable Energy Consumption; LRGDPPC is the logarithm of real Gross Domestic Product (GDP) per capita; LCO2PC is the logarithm of CO_2 per capita and Trade is total export import per GDP. In this equation, real GDP is expected to show a positive relationship with RREC, while CO_2 per capita is expected to have a negative relationship. For variable trade, the results will differ according to the type of panel of the country's income. Developed countries will have a positive relationship between trade and RREC, but emerging countries will show a negative relationship between trade and RREC.

RESULTS AND DISCUSSION

A panel cointegration analysis is chosen to evaluate the long-term relationships between the consumption of renewable energy and GDP per capita, CO_2 per capita and international trade.

The first required step before performing the cointegration test is testing the stationarity of each variable. Table 2 shows the stationarity at zero difference or level using Eviews on both dependent and independent variables. The present study uses five unit root test methods, i.e., LLC (Levin, Lin & Chu), IPS (Im, Pesaran & Shin), Breitung, ADF-Fisher, and PP-Fisher. The results show that the majority of the observed variables are stationary at zero difference or level for most methods. The exceptions are trade and RREC in Breitung and PP-Fisher test methods in which it is stationary at the level.

Next, differentiating by first difference is performed on all variables. Table 5 shows that all observed variables are differenced once and successfully rejected the Null Hypothesis (H0), meaning that the variables are stationary or no unit root. This is evident in the fact that nearly all variables have probabilities less than 1%. It is concluded that the variables are qualified for the cointegration test because all variables are non-stationary at level but are integrated at order one at first difference.

Cointegration Test, the cointegration test aimed to see whether, in the long term, there was any similar movement in or stability of the relationships between two or more variables. If time series data had unit root and were integrated at the same order, the cointegration test would show if the time series data were cointegrated. The current study examined long-term relationships using the Johansen Cointegration Test developed by Pedroni and Kao. From the test of the variables of the model, it was assumed that if there were a deterministic trend component at the data level, then the null hypothesis was rejected, meaning there was cointegration between variables in the equation. Description of the two approach methods of cointegration test is given below:

Pedroni, in the approach method developed by Pedroni, there are seven statistics to test the null hypothesis (see Table 3). The seven statistics are divided into panel statistics (within dimension) and individual statistics (between dimensions). Within-dimension tests calculate common autoregressive coefficients, while between-dimension tests assume individual autoregressive coefficients of each country in the panel. For both the emerging country panel and the developed country panel the four within-dimension statistics rejected the null hypothesis (no cointegration) at the 1% significance level. Furthermore, two of the three between-dimension statistics also rejected the null hypothesis and indicated that there is cointegration among variables. Because the majority of the test results do not accept the null hypothesis, it reveals that there is cointegration or long term relationship between among the variables.

Kao Test, this study also uses the Kao method to strengthen the results or to test the validity of the Pedroni method. The difference between this method and Pedroni is that the Kao method requires intercept and cross-section homogeneous regression parameters specific cross-section. The result of the Kao cointegration test in Table 4 shows that the null hypothesis is rejected at 1% significant level in emerging countries and at a significant 5% level in developed countries. These results prove that there is a long-term equilibrium relationship between RREC and the independent variables.

Table 2. Kao Test

	Statistic	P-value
Emerging Countries		
ADF	-2.342***	0.009
Residual Variance	2.105	
HAC Variance	1.436	
Developed Countries		
ADF	1.609*	0.054
Residual Variance	2.321	
HAC Variance	1.621	

Notes: *,**,and *** represent the 10%, 5% and 1% significance, respectively

Long Run Estimate, the panel data processing method has undergone various developments to produce better and more consistent estimations. However, OLS analysis, which is commonly used, provides a biased and inconsistent estimate when applied to a cointegration panel model. Two approaches that address weaknesses of standard OLS estimators are Fully Modified OLS (FMOLS), which was developed by Pedroni (2000), and Dynamic OLS (DOLS), which was proposed by Phillips and Loretan (1991). However, the current study used the Pooled-Mean Group Auto Regressive Distributed Lag (PMG-ARDL) approach, developed by Pesaran, Shin and Smith (1999). The PMG-ARDL technique could be a solution to prevent inconsistencies from heterogeneous short-run dynamic relationships. Moreover, ARDL has become popular due to some advantages over other single equation cointegration procedures because it can predict long- and short-term parameters simultaneously and it does not require variables to have the same integration sequence.

Table 3. Long Run Estimate

Dependent Variable : RREC		
Variable	Coefficient	Prob
Emerging Countries		
LRGDPPC	0.5682***	0.0000
LCO2PC	-2.2593***	0.0000
TRADE	0.0175***	0.0000
Developed Countries		
LRGDPPC	2.3734***	0.0000
LCO2PC	-12.3310***	0.0000
TRADE	0.0304***	0.0000

Notes: *,**,and *** represent the 10%, 5% and 1% significance, respectively

By applying panel data cointegration using PMG ARDL technique, table 5 shows that, for long term coefficient, the results of all variables are significant (all P-value <0.01). The result also reveals that all long term elasticity estimations have the similar sign for each variable for both emerging countries and developed countries. However, this finding demonstrates a qualitatively different result from the previous study conducted by Nguyen and Kakinaka (2019) find that there is a different estimation result in terms of variable elasticity sign between low-income group and high-income group.

Table 5 also shows differences in the magnitude of cointegration values between emerging countries and developed countries in all variables. First, RREC has a positive long-term relationship with real GDP per capita of both emerging countries and developed countries. This result is in line with the findings of previous studies which find a positive correlation between GDP per capita and renewable energy consumption in the three different income level countries Omri, Daly and Nguyen (2015). However, in the current study, the magnitude of cointegration was greater than in the previous study. The current study indicates that a 1% increase in real GDP per capita will raise renewable energy consumption in developed countries by 2.373%. While in emerging countries, it has a lower coefficient, which is a 1% increase in real GDP per capita, there will be an increase renewable energy by only 0.568%.

One possible explanation for this difference is that developed countries might have more funds to invest in clean energy technologies compared to emerging countries. Investment in renewable energy technologies is relatively expensive. Thus, a large amount of capital is needed with a long return on investment. Even though emerging countries have a lower percentage than that of developed countries, they still have a positive relationship between GDP and the consumption of renewable energy. This positive direction indicates that emerging countries applied renewable energy gradually. Besides having limited availability of infrastructure for the development of renewable energy, emerging countries still need cheap energy sources to drive their economies during the transition period.

The results of the current analysis are in line with the Environmental Kuznets Curve (EKC), which describes the relationship between economic growth (as measured by per capita income) and the level of environmental degradation. According to Environmental Kuznets Curve (EKC), environmental degradation initially rises along with an increase in per capita income. However, after reaching a certain point (the turning point), environmental degradation decreases even though incomes rise. The result is an inverted U curve. The decline in environmental degradation will be achieved when the income of the population is high enough that some of that income is used to improve the environment.

Second, the current analysis shows that the CO_2 coefficient per capita has a negative relationship with the consumption of renewable energy in both country levels. The coefficient for CO_2 in emerging countries is 2.259, which means that an increase of 1% in CO_2 indicate a reduction in the consumption of renewable energy of about 2.259%. The coefficient for CO_2 in developed countries is 12.331, exceedingly higher than that for emerging countries. This means that an increase in CO_2 of 1% in developed countries indicate a reduction in the consumption of renewable energy by 12.331%.

These results suggest that increases in CO_2 emissions come from a rise in the use of conventional energy for domestic country activities. If a country gets energy from conventional energy sources, it automatically releases additional CO_2 into the atmosphere. This might explain why the magnitude of the consumption of renewable energy in emerging countries is smaller than that of the developed countries. The increase in CO_2 use in emerging countries is caused by a greater consumption of non-renewable energy, not from a significant reduction in the consumption of renewable energy. Moreover, there may be different conditions in developed countries, if CO_2 increases, it is definitely due to significant reduction in renewable energy consumption, because the majority of developed countries have a high percentage of the usage of renewable energy. However, this finding is inconsistent with earlier studies, which said that the consumption of renewable energy has a positive relationship with CO_2 emissions (Salim and Rafiq, 2012; Omri and Nguyen, 2014). Their justification was that a rise in CO_2 emissions would lead to increased efforts to have a clean environment by using energy from renewable energy technologies. Thus, the interpretation of these different findings can be a debatable issue.

Third, the international trade coefficient has a positive relationship with the consumption of renewable energy in both country levels. This differs from the initial expectation that, for emerging countries, there would be a negative relationship between the consumption of renewable energy and international trade. Assuming that emerging countries continued to use non-renewable energy as their main source of energy, an increase in international trade would lead to a significant increase in the consumption of non-renewable energy rather than renewable energy. Positive relationships between renewable energy and international trade are consistent with the results of Omri and Nguyen (2014), which used dynamic system-Generalized Method of Moments (GMM) in their econometric method. Even though their estimation result for high-income countries is not statistically significant, they assume that as long as the tradeable goods and services are consumed and produced using energy effectively, trade openness may have a significant impact on the total demand for energy, including renewable energy.

In the current study, the difference in magnitude of the consumption of renewable energy and international trade coefficients of emerging countries and developed countries slightly higher. In emerging countries, for every 1% increase in trade would raise RREC by 0.017 %. Meanwhile, in developed countries, a coefficient of 0.030 means that for every 1% increase in trade may rise RREC by 0.030%. The current study suggest that one way to maximize the usage of renewable energy is to increase international trade in both emerging countries and developed countries. Such trade is expected to facilitate the transfer of environmentally friendly technologies from developed countries, which are concerned with the environment, to emerging countries, which required support in financing, infrastructure and technology and diffuse the adoption of production technologies using renewable energy. This argument is also in line with the study of 15 Asian countries (Nasreen and Anwar, 2014), which found that trade openness enables developing countries to import and adopt advanced technology from developed countries to reduce energy intensity but still produce more output.

Overall, the empirical analysis in the present study concludes that international trade leads to greater rates of consumption of renewable energy as a long-run relationship. It means that, in the future, economic development along with international trade and advances in environmental technology are expected to further facilitate and promote the consumption of renewable energy in every country. However, government should issue a policies to support significant growth and development of renewable energy along with the economic growth of the country in a manner consistent with the country's level of development.

CONCLUSION

This paper investigate whether, in the long run, the consumption of renewable energy could be affected by GDP per capita, CO_2 emissions and international trade in a group of emerging countries and a group of developed countries. This paper also considers the magnitude of the impact of each variable affecting the consumption of renewable energy. By comparing two panels of countries, this study conducts a panel cointegration analysis with Pooled Mean Group-Autoregressive Distributed Lag (PMG-ARDL) during the period 1990-2014. The main findings are that: (i) all long term elasticity estimations in each variable are statistically significant for both emerging countries and developed countries, (ii) the consumption of renewable energy is positively related with real GDP per capita in the development levels of both groups of countries, (iii) CO_2 per capita has a large magnitude and negative correlation with the consumption of renewable energy in both panels, especially in developed countries, (iv) international trade has a positive influence on the consumption of renewable energy in the long term for both emerging countries and developed countries.

Based on these findings, the level of income of a country, level of CO_2 emissions and the amount of trade openness play an important role in the consumption of renewable energy in the long run. In the future, it appears that GDP per capita and international trade will expand through further economic growth and globalization of the world. If this is the case, the consumption of renewable energy is further expected to grow in both emerging countries and developed countries. However, whether the promotion of the consumption of renewable energy solves environmental problems depends a great deal on the future trajectory of CO_2 emissions along with economic development. In this context, the government of each country should develop policies that encourage the use of renewable energy and control CO_2 emissions as the nation's economy grows. State revenue should be used to provide incentives for developing alternative energy and diversifying energy resources. In addition governments should minimize tariff and non-tariff trade barriers to help facilitate the transfer of clean energy technologies from developed countries to emerging countries.

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APPENDIX

Table 4. Unit Root Test

	Null : Unit Root									
	Levin,Lin,and Chu (LLC)		Breitung t-stat		Im,Persaran and Shin (IPS) W-stat		ADF-Fisher Chi-square		PP-Fisher Chi-Square	
Emerging Countries										
RREC	0.576	[0.7171]	1.190	[0.883]	0.629	[0.735]	54.495	[0.133]	94.513***	[0.000]
Δ RREC	-19.323***	[0.000]	-9.460***	[0.000]	-17.046***	[0.000]	298.018***	[0.000]	990.725***	[0.000]
LRGDPPC	0.014	[0.505]	2.111	[0.982]	2.497	[0.993]	24.615	[0.992]	24.003	[0.993]
Δ LRGDPPC	-4.007***	[0.000]	-5.343***	[0.000]	-2.617***	[0.004]	72.148***	[0.004]	119.592***	[0.000]
LCO2PC	-1.128	[0.129]	-0.426	[0.334]	-0.695	[0.243]	61.188***	[0.044]	66.093***	[0.017]
Δ LCO2PC	-11.387***	[0.000]	-4.558***	[0.000]	-10.385***	[0.000]	202.867***	[0.000]	723.156***	[0.000]
TRADE	-2.023***	[0.021]	-0.225	[0.411]	-0.313	[0.377]	48.027	[0.313]	66.978***	[0.01]
Δ TRADE	-18.062***	[0.000]	-11.778***	[0.000]	-14.278***	[0.000]	250.522***	[0.000]	534.120***	[0.000]
Developed Countries										
RREC	8.831	[1.000]	9.912	[1.000]	9.058	[1.000]	26.776	[0.998]	50.138	[0.547]
Δ RREC	-15.630***	[0.000]	1.548	[0.939]	-14.747***	[0.000]	318.929***	[0.000]	763.713***	[0.000]
LRGDPPC	1.696	[0.955]	0.863	[0.806]	2.856	[0.997]	29.408	[0.995]	33.949	[0.975]
Δ LRGDPPC	-8.745***	[0.000]	-7.024***	[0.000]	-7.308***	[0.000]	146.434***	[0.000]	300.772***	[0.000]
LCO2PC	4.464	[1.000]	8.237	[1.000]	7.003	[1.000]	21.379	[0.999]	40.347	[0.879]
Δ LCO2PC	-13.048***	[0.000]	6.025***	[0.000]	-14.293	[0.000]	275.232	[0.000]	616.121	[0.000]
TRADE	-0.813	[0.792]	-1.354*	[0.08]	-1.230	[0.109]	63.525	[0.131]	70.441***	[0.045]
Δ TRADE	-13.141***	[0.000]	-10.845***	[0.000]	-14.263***	[0.000]	271.546***	[0.000]	299.862***	[0.000]

Notes: (1) The associated p-values are given in parentheses. ; (2) Optimal lag lenghts are determined by Modified Akaike Infor Criterion (MAIC).; Individual Intercept and individual linear trend are included.; (4) *,**,*** represent the 10%, 5%,1% significance level, respectively

Table 5. Pedroni Test

	Within dimension (panel statistics)			Between dimension (individual statistics)		
	Test	Statistics	Probability	Test	Statistics	Probability
Emerging Countries						
Pedroni	Panel v-Statistic	0.647	0.258	Group rho-Statistic	1.873	0.969
	Panel rho-Statistic	0.999	0.841	Group PP-Statistic	-5.734***	0.000
	Panel PP-Statistic	-3.944***	0.000	Group ADF-Statistic	-6.510***	0.000
	Panel ADF-Statistic	-4.214***	0.000			
Pedroni (2004)						
Weighted statistic	Panel v-Statistic	-1.015	0.845			
	Panel rho-Statistic	0.282	0.611			
	Panel PP-Statistic	-3.944***	0.000			
	Panel ADF-Statistic	-4.214***	0.000			
Developed Countries						
Pedroni	Panel v-Statistic	-0.119	0.547	Group rho-Statistic	1.558	0.940
	Panel rho-Statistic	-0.542	0.293	Group PP-Statistic	-8.572***	0.000
	Panel PP-Statistic	-7.604***	0.000	Group ADF-Statistic	-7.051***	0.000
	Panel ADF-Statistic	-8.402***	0.000			
Pedroni (2004)						
Weighted statistic	Panel v-Statistic	-1.529	0.937			
	Panel rho-Statistic	0.619	0.268			
	Panel PP-Statistic	-9.322***	0.000			
	Panel ADF-Statistic	-9.101***	0.000			

Notes: (1) Lag Lenghts are determined by Schwarz Info Criterion (SIC).; (2) Individual intercept and individual linear trend are included in this test.; (3) *,**,*** represent the 10%, 5%,1% significance level, respectively

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