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The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: A global study with the application of heterogeneous panel estimations

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A B S T R A C T

This present study explores the relationship of renewable and non-renewable energy consumption with carbon emission by using panel data of 74 nations from 1990 to 2015. In doing as so, we apply the second-generation econometrics of panel data to examines the cross-section independence and control the heterogeneity between cross-sections. The CIPS unit root test, Westerlund (2007) bootstrap cointegration, Pedroni co-integration, FMOLS and heterogeneous panel causality techniques have been applied. The outcomes affirm that all variables are integrated over the long-run. The results also show that the nonrenewable energy consumption has a positive effect on environmental degradation whereas; renewable energy has a negative impact on environmental degradation and help to reduce environmental hazards. Similarly, financial development also has a negative and significant impact on environmental degradation. Furthermore, the Kuznets hypothesis are also tested and found its existence. This study provides valuable policy implications for the government and the policy makers.

1. Introduction

The present era of energy dependent economies has given supreme attention to the contentious topic of green energy in both developing and developed countries [1–6]. Green energy is also known as renewable energy. It is explained as the energy that is gathered by renewable sources of rain, sunlight, geothermal heat, wind, waves, etc. and exercises minimal damage to the environment [7]. Usually, renewable energy provides energy in four diverse sectors including transportation, electricity generation, water & air cooling/heating and rural energy services. In accordance to the statistics of Renewable Energy Policy Network for 21st Century [REN21] [8]; renewable energy contributed almost 22% to electricity generation and 19% of their humans' global energy consumption in 2013 and 2012, correspondingly. Among the renewable energy consumption, the share of electricity from solar, biomass, the wind, geothermal is 2%. Similarly, 3.8% of the electricity is obtained from hydroelectricity, 4.2% from heat energy (non-biomass) and 9% is attained from traditional source of biomass. Global investment in renewable technologies is totaled more than 214 billion US$ in the year of 2013, with nations like the United States and China comprehensively capitalizing in bio-fuels, hydro, solar and wind [8].

Renewable energy resources occur on large ecological regions as compared to other energy sources, which are focused on a minimum number of countries. The quick positioning of renewable energy is causing in significant economic benefits, climate change mitigation and energy security. According to the report of United Nation Environmental Programme [UNEP] [9]; there is huge funding for encouraging green sources of energy including solar & wind power by an international public view inspection. At the state level, there are at least more than 30 states everywhere in the world have renewable energy subsidizing more than 20% of energy supply. With the help of this, States renewable energy markets are predictable to linger to develop in the forthcoming decade [44]. In all over the world, countries are trying to switch their total energy

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towards renewable energy as much as possible, whereas, the global renewable energy capacity is aimed to rise by 43% in between 2017 and 2022 (International Energy Agency [10]. This includes the policies made by Peru to produce 60% of its power from renewable sources by 2024, Germany and Sweden also claimed to be carbon-free by 2050, whereas, Norway and Iceland are already producing full electricity by using renewable energy [11,12]. This list goes on, containing 144 nations with energy conservation commitments, including fifty countries supporting an entire phase-out of carbon emissions by 2050 and almost hundred nations claiming zero emissions by 2100 [11].

The review of past studies suggested that green energy production and usage contribute substantially to the economic and environmental activities of countries. This is due to the fact that the importance of renewable energy consumption lies in its environmentally benevolent nature and is recognized as a natural endowment that is considered as more sustainable source to offers stable industrial, human and environmental development [43]. Keeping in mind the high inclination of countries to achieve environmental conservation, the investigations regarding the causal connection between green energy and economic development is necessary for environmental policies. In earlier studies, there are various investigations determining the long run association between renewable energy consumption and economic growth. These studies emphasized on various variables, time periods, countries and multiple econometric techniques. The results of these studies show all the direction regarding these two variables. Some studies show the unidirectional causal association among renewable energy and economic development, some show bidirectional causal relationship, whereas, some show no causal dependence among the variables. [13–16,41]. Furthermore, the studies of the past also more commonly focus on green energy and economic growth and ignores the association between green energy and environmental condition in the form of carbon emission. Therefore, there is a need to examine the causal linkage between renewable energy and environmental degradation in those countries who invest a huge amount of money on generating renewable energy for the betterment of economic as well as environmental condition.

Also, a strand of the literature considers that renewable energy does not decrease carbon emissions [17,18]. In this context, Apergis et al. [19] contend that the adoption of renewable energy consumption is frequently connected with an extraordinary trouble of setting and installing renewables. In the greater part of the occasions, the trouble of installing renewable systems is supplemented with a concurrent use of traditional non-renewable sources of coal and petroleum gas and is more apparent in laying out the systems of solar and wind energies. In those situations, the advantages of renewable intermittency are frequently beaten by the expense of idle capacities along with the wasted aim of having low carbon economy. In this way, the economy fails to reduce the structure of a brown economy because of the slow deployment process which ends up in resulting the unfavorable outcomes in the economy. Thus, the presence of ambiguity in the association between renewable consumption, carbon emission and economic growth also calls for the need to re-examine the relationship with refined methodology.

The current study makes numerous substantial contributions to the renewable energy, non-energy-growth relationship in the globalized economy. The earlier studies in this regard, focus more on the panels of different countries in describing the vigorous relationship among renewable and non-renewable energy consumption and environmental degradation. As per our knowledge the main denunciation in the past studies is the selection of panels. The panel of countries selected for a past studies have an issue of heterogeneity and also might be an issue of cross-sectional dependent throughout the panel. Present study overcomes this issue by applying recent heterogeneous panel analysis techniques along with cross-sectional dependence test. This is essential, as renewable and non-renewable energy policies make and set by the global level can also affect single countries all together, along with the additional exogenous shocks. Current study is the pioneering attempt to focus on renewable and non-renewable energy consumption and environmental degradation by opting heterogeneous panel analysis for polluting the environment most.

Secondly, past studies usually used either use total energy consumption or renewable energy consumption in, we deploy both the type of energy consumption such as non-renewable energy consumption and renewable energy consumption including trade and financial development so that we can explain the comparative effect of these in the economic growth route.

Finally, present study examines the long run elasticity related to the both type of renewable and non-renewable energy consumption for panel and separate countries. These elasticities reflect both the cross-sectional and time dimension nature of the panel and give more substantial result as compared to the time series techniques. These techniques are valuable and beneficial for the policy makers for making the policies bases on the result of long-run demand for renewable and non-renewable energy consumption in the carbon emission process for considered countries.

Lastly, the remaining of the study is organized as follows: Section 2 explains the current literature on the association among renewable, non-renewable, carbon emission and economic growth nexus. Section 3 clarifies the methodological grounds of the statistical investigations. Section 4 presents the findings of the data. And finally, Section 5 accomplishes the study by providing implications and future recommendations.

2. Literature review

The number of the researches that examined the association among renewable and non-renewable energy with environmental degradation, in the form of carbon emission, are quite minimal to explain such an extensive phenomenon. In this regard, the review of the limited literature constitute quite contrasting results, that has contributed in extending the ambiguity regarding the specific relationship between the variables, thus demanding fresh studies to elucidate and validate the indecisive results of the existing literature [20]. Among them, Apergis et al. [19] examine a causal connection between carbon emission and green energy consumption by taking annual data of 19 developing and developed countries from 1984 to 2007. The outcomes of panel VECM show that green energy is noteworthy to influence carbon emission in long-run whereas, in short-run renewable energy does not influence carbon dioxide emission. Along with this, there is a unidirectional causal association among green energy and CO2 emission in Malaysia [21,22].

On the other hand, Ajmi et al. [23] analyzed the relationship between energy utilization and carbon dioxide emission in G7 countries. The findings of time-varying Granger causality suggested that the path of causality between the variables, for the case of United States, runs in both directions simultaneously. However, for France, the direction of causality is running from energy utilization to CO2 emission. Moreover, Tang and Tan [48] also identify the causal connection between consumption of energy and CO2 emission in Vietnam utilizing yearly sample from 1976 to 2009. The outcome of Granger causality confirms the presence of unidirectional causality suggesting that the direction of causal association runs from energy to emission.

Moreover, another remarkable study, Menyah and Rufael [14] examine the causal linkage between renewable energy utilization, nuclear energy and CO2 emission in the United States. They use a time series sample of US from 1960 to 2007. The technique was uses in that study is modified Granger causality investigation. The results of Granger causality confirm that there is no causal connection among green energy utilization and carbon dioxide emission in any direction in US. Thus, it can be concluded that renewable energy utilization has not touched a benchmark where it could create an essential reduction in the emission of CO2. On the other hand, there is another study on United States by Soytas et al. [24]. They examine the causal relationship among energy utilization and CO2 emission. They utilized yearly time series sample from the period of 1960–2004 of United States. The outcomes of Granger causality confirm that there is a unidirectional causal relationship exists between energy consumption and CO2 emission in US which runs from energy consumption to CO2 emission.

Based on the above literature review, it can be concluded that there are various studies have been done on the topic of energy utilization and CO2 emission in developing and developed countries. Nonetheless, there are very limited researches have been examined on the causal linkage of non-renewable energy consumption/renewable energy and carbon dioxide emission. The results indicate that renewable energy has no causal relationship with carbon emission in United States [14]. Along with this, renewable energy utilization also has no causal connection with carbon dioxide emission in panel studies of 19 countries by Apergis et al. [19]. Therefore, still there is a need to check the causal connection of renewable energy utilization and CO2 emission by some time-frequency causal analysis. Through this statistical technique, we can easily observe the causal relationship of renewable energy utilization and carbon emission in different time period.

Concentrating on the time series investigation, Troster et al. [50] examined the association between renewable energy utilization, economic development and oil prices of United States between the years 1989–2016. By applying the framework of Granger causality-in-quantiles, they discover a bidirectional causal connection among sustainable energy consumption and economic development for the U.S. Correspondingly, Shahbaz et al. [47] explored the connection between renewable energy and financial development of Pakistan. Their investigation uses quarterly information from 1972 to 2011 and connected the ARDL framework to inspect the long-term association among the factors. The discoveries of the examination affirm the noteworthy long-run connection among renewable energy utilization and the financial development, while the consequences of the VECM Granger causality recommend that there likewise existence of bidirectional causal connection among renewable energy and economic development of Pakistan.

In Germany, Rafindadi and Ozturk [43] explore the effect of renewable energy in influencing economic enhancement, utilizing quarterly sample for the period 1971–2013. The discoveries of the examination uncovered that a 1% expansion in energy consumption upgrades real GDP of the country by 0.22%. Comparable outcomes are found in the investigation of Tiwari [49] which investigated the relationship among CO2 emission, renewable energy and economic development in India for the period 1960–2009. The consequences of the investigation recommend that an expansion in renewable energy is probably going to increase financial development and decreases the level of carbon emission of the country. With respect to China, Fang [39] inspected the possibilities of renewable energy consumption in advancing financial prosperity for the 1978–2008 period. Utilizing various measures of economic development, the investigation applies a multivariate OLS and finds a noteworthy positive connection of renewable energy consumption with GDP and per capita income of country. Like Tiwari [49], the investigation likewise underpins the existence of a conversion influence of the renewable energy on economic development.

On the other side, Sadorsky [45] examines the impact of per capita income in impacting renewable energy for top 18 emerging nations. Not at all like Fang [39], the discoveries of the examination supports the existence of the growth impact among the factors. The outcomes from the cointegration explain a positive impact, proposing that a 1% increase in per capita income improves per capita renewable consumption by 3.5%. Comparative outcomes are found in Sadorsky [46], suggesting that an expansion in GDP for every capita is evident to increase renewable energy utilization in the G-7 nations. Moreover, when Menegaki [40] examines the causal effect of renewable energy utilization on economic development in 27 European nations, the outcomes affirm the presence of a neutrality effect. Similarly, the results of panel causality utilizing annual sample for the period 1997–2007 propose that renewable energy utilization and financial development fail to established any causal connection between renewable energy consumption and financial development over the European nations. Additionally, Alper and Oguz [38] analyze the commitment of renewable energy in new EU part nations for the period 1990–2009. Utilizing the ARDL approach, their outcomes affirm the presence of a positive effect of renewable energy consumption on financial development. Like Menegaki [40], the causal impacts for five out of the six inspected nations in east and south Europe (i.e., Estonia, Poland Hungary, Cyprus and Slovenia) support the neutrality effect. As for the Czech Republic, the examination supports the presence of the conservative impact between the factors.

3. Methodology

Current study taken the variable of Y as a per capita of real GDP, CE as per capita of CO2 emission, E is part of non-renewable energy consumption from total energy, R is the renewable energy consumption from total energy, F is the financial development and T is the trade. The data of real GDP (dollars), carbon dioxide emission (metric tons) and non-renewable energy consumption (millions tons), renewable energy consumption (millions tons) and financial development (% of GDP) have been collected from World Bank (world development indicators). Past studies mostly use energy as a whole or only the part of non-renewable energy with carbon emission model. In this study, we use both the types of energy i.e. renewable and non-renewable energy for the determinants of carbon emission model. Present study covers the time period from 1990 to 2015 for top 74carbon emission countries according to KOF globalization index. The carbon dioxide emission function for our model is as follows:

$$CE_{it} = f\left(Y_{it},\ Y_{it}^2, E_{it},\ R_{it},\ F_{it}\right)$$

where, CE_{it} is form of carbon dioxide emission per capita, Y_{it} (Y_{it}^2) is a real GDP per capita and (square of real GDP per capita), E_{it} is a non-renewable energy from total energy consumption, R_{it} is a renewable energy from total energy consumption andF_{it} is a financial development which is calculated by (% of GDP).

3.1. Estimation techniques

In the present study, we examine the long-run relationship between the variables by using a panel cointegration technique. Likewise, current study investigates the long-run effect of renewable and non-renewable energy consumption of environmental degradation by using fully modified ordinary least square (FMOLS) approach. Lastly, we use a heterogeneous panel non-causality test to investigate the short-run causal relationship between renewable, non-renewable energy consumption and environmental degradation.

3.2. CD and CIPS test

Initially, we find that whether the data we have taken has the characteristic of cross-sectional independence or dependence. Pesaran's [25] cross-sectional dependence test is use to fulfill this purpose. This is the major issue which needs to be solved before approaching to panel unit root test. The old unit root test has low power and is not effective when they are used on the panel series which already has a cross-sectional dependence issue [26,27]. Consequently, in present study, we employ Pesaran [28] CIPS unit root test which is based on the hypothesis of cross-sectional dependence. This panel unit root test is the essential for the panel cointegration models. This test is used to examine the order of incorporation of the variables. If entire variables are integrated of the equal level i.e. $I\,(1)$, then this is an indication that entire of the data set has a unit root problem at level and are stationary at first difference. So, it can be concluded all the variables in the data set may have a relationship in long-run equilibrium.

3.3. Panel cointegration technique

In the current study, we apply bootstrap panel cointegration proposed by Westerlund [29] to examine the long-run relationship between the variables throughout the complete sample of 74 economies. This analysis is more beneficial if the time series component of every cross-section is smaller. Owing to these features research scholars have newly adopting the bootstrapping panel cointegration technique to investigate the long run relationship between the variables [30]. The old traditional techniques have accepted the null hypothesis of no cointegration even in case where cointegration is strongly proposed by theories. Irrespective of traditional techniques, Westerlund [29] has newly established a recent panel cointegration test focused on structural instead of residual dynamics. The outcomes disclose that these tests have restricting normal distributions and they are more reliable in term of consistency. Westerlund [29] explains that the outcome of the new test give decent size accuracy and are extra powerful than the residual based tests by Pedroni [31–33]. Based on this evidence, current study will analyze the effect of renewable and non-renewable energy consumption on environmental degradation.

This study employs the panel co-integration test. This test was proposed by Westerlund [29] and Persyn and Westerlund [34]. The hypothesis of cointegration is evaluated by using the two different tests (i) group mean test and (ii) panel test. Based on the Error Correction Model, Westerlund [29] develop four test statistics, Ga, Gt, Pa, and Pt and all these four statistics are normally distributed. The Gt, Pt are calculated in the standard way, by using the standard error parameters of the Error Correction model. Whereas, Ga and Pa are based on the standard errors given by Newey and West [35]; which are adjusted from autocorrelations and heteroskedasticity.

In order to run this test, all the variables are assumed to be stationary at first difference I (1). This test evaluates the absence of co-integration by determining whether error correction is present for the whole group and also in individual panel members. On the basis of the existence of cointegration, the long-run parameters are estimated. In a cross-sectional analysis, the error variance varies across the groups which affect the consistency of the estimators. To overcome this issue the generalized least squares method (GLS) can be used. But the variance variability still exists, such as the correlation of the squared residuals with the regressors in each group. Within the group, there are two sources which cause the heteroskedasticity problem, it could either by differences in the variance of the residual terms conditioned on the regressors or by differences in the unconditional variance of the residual terms. So, in order to control both the sources causing the heteroskedasticity, the fully modified ordinary least square (FMOLS) is used.

3.4. Long-run elasticities

Based on panel data set, the use of ordinary least square (OLS) is considered to bias and its distribution focus upon an annoyance constraint. Pedroni [31,32] reasons that in the case of regression result, annoyance constraints could result for the existence of endogeneity and serial correlation issue between the regressors. So, to solve these problems, we apply the FMOLS model. This technique focuses on the nonparametric method in order to resolve the issue of serial correlation and endogeneity. Therefore, we use FMOLS technique to examine the long-run equilibrium relationship.

3.5. Heterogeneous panel causality test

We investigate the short-run bivariate causal relationship between the variables by selecting a framework that supports the heterogeneity of the models throughout the cross sections. This panel causality technique has been introduced by Dumitrescu and Hurlin [36]. This technique is suitable for stationary data by using the fixed coefficients in the vector autoregressive (VAR) model. The implication of this approach is that it taking different log structure and similarly heterogeneous measurement throughout the cross-section under both assumptions. Firstly, the null hypothesis of no causal relationship is testing and then alternative hypothesis for testing the causal relationship at least for few cross sections. Finally, the Wald statistics are computed to each of the cross sections individually for testing Granger noncausality. Dumitrescu and Hurlin [36] reason that this panel causality test meets to a normal distribution in homogeneous noncausality hypothesis when T indicates to infinity fist and then N represents to infinity.

4. Data analysis and findings

4.1. The cross-sectional dependence and unit root tests

Table 1 explains the outcomes for the CD test and CIPS unit root test. The CD test outcomes for the most carbon emission countries show that the rejection of the null hypothesis of cross section independence at the 1% level of significance for all variables, signifying indication of cross-sectional dependence. We used newly established CIPS unit root test instead of conventional methods of unit root test. This test discusses for cross-sectional dependence in the data series. The outcomes of the CIPS unit root test show that the rejection of the null hypothesis for all variables at first order differentials. Thus, the results of CIPS unit root propose that all the variables are showing non-stationary behavior at the level and

Table 1
Results of cross-sectional dependence and CIPS unit root test.

Variable	CD test	p-value	CIPS test	
			Level	1st difference
COE	43.293	0.0000	−2.049	−5.178***
GDP	237.807	0.0000	−1.472	−3.310***
ENC	35.038	0.0000	−2.046	−4.794***
REN	14.161	0.0000	−2.158	−5.121***
FID	75.168	0.0000	−2.212	−4.364***

Note: ***, **, * indicates statistical significance at 1%, 5% & 10%.
Source: Authors' estimation.

showing stationary behavior at the first-order difference. In simple words, entire variables are integrated of order I (1). So, there must be an evidence of cointegration relationship between the variables in long run.

4.2. Findings of panel cointegration tests

Table 2 explains the results of Pedroni panel cointegration test results. These tests reject the null hypothesis of no cointegration at the 1% level of significance because two test of the within measurement (Panel PP statistics and Panel ADF statistics) and two tests of the between dimension (group PP statistics and group ADF statistics) support this rejection. Therefore, four tests out of seven tests reveal that the variables move together in the long run equilibrium in carbon emission model.

The cointegration among the variables is also analyzed by using the second-generation co-integration test. The results related to the bootstrap panel cointegration are mentioned in Table 3. Both with dimensions and within dimensions results are reported. The result confirms the acceptance of alternative hypothesis and the rejection of the null hypothesis. Thus, the second-generation test also confirms that the under-examined variables are co-integrated in the long run in carbon emission model.

4.3. Findings from fully modified ordinary least square (FMOLS)

The long run association among the variables is examined by using the FMOLS technique. The FMOLS technique was given by Phillips and Hansen [37] and then further modified by the Pedroni [31]. We choose this technique because they account for endogeneity and autocorrelation problems and give robust results.

We investigate the long run estimates by taking the FMOLS and Dynamic Ordinary Least Square (DOLS) coefficients. The results of FMOLS have been reported separately for each model in Table 4. The long run beta value calculated using two different approaches which are very much similar and significant at the 10% level. Table 4 explains that, for the model with carbon dioxide emission for the FMOLS method, the results of panel estimate conclude that the long run impact of CO2 emission by GDP is nearly equivalent to 0.737; a 1% rise in non-renewable energy consumption will increase the CO2 emission by 1.123%; a 1% rise in renewable energy consumption will decrease the CO2 emission by 0.924%; a 1% rise in financial development will decrease the CO2 emission by 0.174.

In this model, it is explained that non-renewable energy consumption increases the CO2 emission in the long run while renewable energy decreases the CO2 emission in the long run. Therefore, there is a need to introduce environmentally friendly technologies when the collaboration between two countries is taken place or with in a country too. We also examined the presence of Environmental Kuznet curve (EKC) hypothesis between the economic growth and CO2 emission in most of the carbon emission countries. In order to examine this, we construct a new variable square rate of economic growth represented by (y^2) and added in the model. It can be seen from the results report in Table 4 that the economic growth has a positive value whereas the square rate of economic growth shows the negative value. This confirms the existence of the Kuznets curve hypothesis i.e., the inverted U-shape association between the economic growth and CO2 emission. This implies that at the initial stage, the economic growth increases the CO2 emission but after reaching a certain level it starts minimizing the CO2 emission. This finding is sensible in a manner that now the countries that are going for economic development via renewable energy consumption is more inclined to join hands with those countries which are opting for environmentally friendly technologies. Thus, the more development in the examined countries will help the government to decrease the CO2 emission. Finally, financial development also has a negative and significant impact on environmental degradation.

4.4. Heterogeneous panel causality test

The causal relationship between the non-renewable and renewable energy consumption withCO2 emission is analyzed by the Heterogeneous Panel Causality Test. The result is reported in Table 5. The result shows that a bidirectional causal relationship

Table 2
Results of Pedroni ((Engle-Granger based) Panel Cointegration.

Estimates	Stats.	Prob.
Panel v-statistic	−1.508	0.934
Panel rho-statistic	4.584	1.000
Panel PP statistic	−11.671	0.000
Panel ADF statistic	−11.988	0.000
Alternative Hypothesis: Individual AR Coefficient		
Group rho-statistic	5.145	1.000
Group PP statistic	−24.643	0.000
Group ADF statistic	−14.758	0.000

The null hypothesis of Pedroni's [42] panel cointegration procedure is no cointegration.
Source: Authors' estimation.

Table 3
Results of Westerlund [29] bootstrap panel cointegration.

Statistic	Value	Z value	*p* value	*Robust p* value
Gt	−2.476	−1.289	0.099	0.010
Ga	−25.749	−17.913	0.000	0.000
Pt	−24.821	−7.741	0.000	0.070
Pa	−31.093	−31.884	0.000	0.000

Note: The null hypothesis of Westerlund [29] panel cointegration procedure is no cointegration.
Using the boot strap approach of Westerlund [29] to account for cross-sectional dependence, the number of replications is 400.
The p-values are for a one sided test based on normal distribution.
The robust p-value are for a one sided test based on 400 bootstrap replications.
Source: Authors' estimation.

Table 4
Results of long run analysis through FMOLS & DOLS.

	FMOLS			DOLS		
Variable	Coeff.	T-stats.	Prob.	Coeff.	T-stats.	Prob.
Y	0.737	10.023	0.000	0.357	14.834	0.000
Y^2	−0.009	−2.157	0.031	−0.008	−2.643	0.009
E	1.123	20.818	0.000	0.636	16.377	0.000
R	−0.924	−16.974	0.000	−0.233	−15.809	0.000
F	−0.174	−32.782	0.000	−0.058	−4.620	0.000

Source: Authors' Estimations

Table 5
Results of heterogeneous panel causality test.

Null Hypothesis	Stats.	Prob.
Y does not homogenously cause C	11.331	0.000
C does not homogenously cause Y	1.308	0.258
E does not homogenously cause C	8.978	0.000
C does not homogenously cause E	7.336	0.000
R does not homogenously cause C	8.178	0.000
C does not homogenously cause R	5.787	0.000
F does not homogenously cause C	1.612	0.107
C does not homogenously cause F	1.239	0.215

Note: *** indicates statistical significance at 1%.
Source: Authors' estimation.

exists between the non-renewable energy consumption and renewable energy consumption withCO2 emission and the causality is running from non-renewable energy consumption and renewable energy consumption to CO2 emission. This implies that the both the types of energy cause the CO2 emission in carbon emission model.

5. Conclusion and policy implications

Current study investigates the role of renewable and non-renewable energy consumption in environmental degradation by using a multivariate structure and panel data sets for 74 most carbon emission economies from 1990 to 2015. The outcomes of the current study are the pioneering attempt to investigate the relationship between economic growth, carbon emission, renewable and non-renewable energy consumption with huge panel of countries. The results of this study support the fundamental observation in the literature that non-renewable energy consumption has a positive and significant impact on the overall environmental degradation whereas, renewable energy consumption has a negative and significant impact on the environment of the globe. In short, non-renewable energy is probably increasing the environmental degradation of the world while renewable energy helps to reduce and control the environmental degradation of the world and present study also supports this. Similarly, financial development also has a negative and significant impact on environmental degradation.

Based on the current results, it can be recommended that government of high carbon emission countries need to expand international and national strategies to not simply deal environmental degradation but to also decrease non-renewable energy consumption as well. Along with this, they also need to encourage renewable energy consumption in all sectors. Furthermore, government also injects more investment in high technologies for an effective and efficient energy generation system which will help to reduce the level of CO2 emission. Additionally, there must be some appropriate and suitable alternate choice for these countries to increase the focus towards non-renewable energies that are comparatively free from environmental degradation. Likewise, government must take an effective action for instance decreasing the utilization of non-renewable energy and enhancing the share of renewable energy use. Moreover, government might also commence micro-finance proposal for hydro energy and bio-energy production. Due to this government will get the benefit and also sustainable development can be achieved. Therefore, energy policies in these countries ought to develop taking into concentration environmental growth, economic growth and renewable energy consumption.

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