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Article

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Research paper

The heterogeneity of renewable energy consumption, carbon emission and financial development in the globe: A panel quantile regression approach



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ABSTRACT

The present study examines the heterogeneity of renewable energy consumption, Carbon dioxide emission and financial development in the global panel of 192 countries. Panel quantile regression has been used for tickling distributional and unobserved individual heterogeneity. The findings indicate that our variables in the model on each others are heterogeneous across quantiles. More specifically, the effect of renewable energy consumption on carbon emission is negative while financial development has increasing influence on carbon emission. Carbon emission decreases the use of renewable energy while financial development positively affects renewable energy consumption. The increasing effect of carbon emission and renewable energy consumption on financial development has also been found. Finally, the current study findings give important recommendations to policy makers.

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1. Introduction

Energy has been considered as an important factor for achieving sustainable development. The role of renewable energy consumption has been investigated as it plays a prominent role in carbon emission and carbon emission also influence renewable energy consumption. The demand for renewable energy usage has been increased in the past few decades and still increasing day by day. Increasing demand for energy can be the reason of increased in population, life style and improvements in competitiveness are some of the reasons of increasing energy demand. The statistics indicates that the total energy consumption in the world have been increased which is based on fossil fuel resources. Increase in fossil fuels consumption increase carbon emission in atmosphere which affects environment such as the cause of global warming. Where it's been agreed that environmental degradation is mainly the reason of carbon emission. Different research organizations and policy makers such as European Union commission works to support several research programs to reduce pollution, reduce the consumption of fossil fuel and achieve efficacy in energy consumption by new innovations in technologies, specifically for renewable energy (ECD, 2015). [Menyah and Wolde-Rufael \(2010\)](#) argues that renewable energy consumption reduce pollution however the

utilization of clean energy has not yet reached the desired level to reduce carbon emission. The production of green energy can prevent the future environmental degradation, however it can be transferred from fossil fuel to renewable energy and its a challenge. One of the transforming difficulties of fossil fuel to renewable energy can be the cost of production. Several financial obstacles come in the process of renewable energy production which may include startup cost, operating costs and infrastructures. Different researchers statues that financial development is important in renewable energy production and environmental degradation such as [Zhang \(2011\)](#), [Xu et al. \(2018\)](#), [Katircioğlu and Taspinar \(2017\)](#), [Destek and Sarkodie \(2019\)](#) and [Sarkodie and Strezov \(2019\)](#). In this context, the need of well-developed financial system has been identified to provide efficient funding's, risk management and liquidity services. Financial market may also help in this process by enhancing capital allocation. Better financial system can make investments in growing industries however an under developed financial system reduce the number of industries ([Wurgler, 2000](#)). [Zhang \(2011\)](#) statues that financial institutions play important role in reducing environmental emissions. Financial institutions enhance the quality of environments and promote environment friendly projects through research and facilitate clean technologies investment such as investment in renewable energy projects which increase environmental projects and reduce emissions. Moreover, it is also helping improve the efficiency of economic activities by minimizing financial costs and capital risk. It enhance research and development activities

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and invests in clean technologies by promoting the inflow of foreign direct investment, banks and stock markets activities. It also facilitate the credit facilities to promote the power of purchasing machinery, devices, houses and automobiles which can help enhance environmental degradation. Moreover, financial development help businesses to set up new plants and machinery which can help in environmental degradation and clean the environment (Baloch and Suad, 2018). The role of financial market is vital in the countries where renewable energy related investments are encouraged highly. FDI inflow of a country may also affect other sectors such as financial development and it can also influence environmental degradation and carbon emission. In the preceding literature, there is arguing debate on the effect of FDI on carbon emission, renewable energy consumption and its impact on other factors. Stretesky and Lynch (2009) states that if there is FDI in the form of technological products which can help reduce air pollution of a country. Similarly, different researchers argues that FDI reduce air pollution and increase economic growth by increasing productivity of a country and thus its leads to the high amount of energy consumption. Moreover, carbon emission is the result of high energy consumption which bring pollution and polluting firms invest in developing countries to minimize production cost because these countries have not sufficient regulations regarding environment which can increase the use of energy in that country (Acharyya, 2009; Lau et al., 2014). Therefore, these insufficient regulations regarding environment increase carbon emission which attract FDI inflow. Therefore, the importance of FDI in the study has been also examined.

There have been conducted several studies on the association of these variables but have not fully organized with complete measure. Numerous studies have focused on different topics related to renewable energy consumption, growth and some other factors, however the interrelationship of financial development with renewable energy consumption and carbon emission has not been investigated as its very important. Most of the studies we found in the preceding literature in which they have examined the impact of these variables on carbon emission while we could not find even a single study who have investigated the impact of carbon emission or financial development on renewable energy consumption or the impact of carbon emission and renewable energy consumption on financial development. Therefore the current study contributes to the empirical literature of renewable energy consumption, carbon emission, economic growth, financial development and related to better explain this dilemma. To the best our knowledge, ever the first time this study is going to be conducting which is a comprehensive study on the impact of renewable energy consumption, financial development and carbon emission on each other's based on heterogeneity Panel quantile regression. Panel quantile regression is more efficient estimator as it more robust and a more intuitive appeal in the panel regression because it stratifies the independent variables distributional effects on dependent variables into different quantile ranges. The rest of the paper is organized as follows: Section 2 is composed of step by step previous literature, Section 3 illustrates the methods used in the analysis, and Section 4 is composed of the study results while the last section is the conclusion.

2. Literature review

Predicated on the past studies, the current study present literature review in the following sub sections. Section 1 illustrate a brief description of the prevailing literature on Renewable energy consumption and carbon emission, Section 2 is composed of Financial development, energy consumption and carbon emission while the last section is composed of Foreign direct investment, carbon emission and energy consumption.

2.1. Renewable energy consumption and carbon emission

The role of renewable energy consumption has been investigated as it plays a prominent role in carbon emission and carbon emission also influence renewable energy consumption. Shafei and Salim (2014) presents that increase in the consumption of renewable energy reduce carbon emission in OECD countries. Similarly, Sadorsky (2009) states that carbon emission and GDP drives renewable energy consumption. Işık et al. (2019) studied renewable energy consumption, population, fossil energy usage, carbon emission and economic growth where their findings validate the EKC hypothesis. Their study further indicates the negative impact of fossil energy consumption on carbon emission in Texas while positive effect of energy consumption on carbon emission in Florida where the same impact is lower for other US states. Ben (Aïssa et al., 2014) finds that economic growth have been affected positively by international trade and renewable energy consumption. Similarly, Hanif (2018) has studied fossil fuels, renewable energy consumption, solid fuels and urban expansion association with carbon emission in sub Saharan Africa. He has used generalized method of moments where his results indicates that fossil and solid fuels usage effect carbon emission positively while renewable energy significantly decrease carbon emission in the sample countries. Zoundi (2017) found that the exploitation of renewable energy consumption was restricted by different conditions and the economic growth level in low income economies. On the other hand (Ben Jebli et al., 2014) argue that international trade and renewable energy consumption have bidirectional causal relationship and renewable energy consumption increase economic growth. Apergis and Payne (2014) have found the presence of long run relationship between carbon emission and renewable energy consumption. Sinha et al. (2018) argue that the renewable energy initial stage cost results demotivate in developing economies to funds renewable energy sources. Its seems that investing and promoting low income countries renewable energy sources may lead to restrain the short run economic growth of these countries.

2.2. Financial development, energy consumption and carbon emission

Several previous studies have used the proxy of financial development in different countries and its association with carbon emission. Al-Mulali and Sab (2012) have examined carbon emission and energy consumption impacts on financial development where they have found that energy consumption enhance financial development which is the reason of high emission of carbon dioxide. Similarly, Jalil and Feridun (2011) and Goldsmith (1969) have studied the association of financial development and energy consumption where they have found that financial development is the cause of high growth. Zhang (2011) statues that financial institutions play important role in reducing environmental emissions. Financial institutions enhance the quality of environments and promote environment friendly projects through research and facilitate clean technologies investment such as investment in renewable energy projects which increase environmental projects and reduce emissions. Likewise, Tamazian and Rao (2010) and states that financial development effect carbon emission negatively while Zhang (2011) argues that financial development increase carbon emission in china. On the other hand, Acaravci and Ozturk (2012) states that there is no effect of finance of carbon emission in Turkey. Moreover, Sarkodie and Strezov (2019) statues that a well operating financial system promote FDI inflow which in turn contribute to environmental degradation. Majeed and Mazhar (2019) have studied the effect of environment on financial development in 131 countries where they statues that

financial development enhance the quality of environment and lowers ecological footprint and energy consumption, FDI and per capita GDP degrade environmental quality by increasing the ecological footprint.

2.3. Foreign direct investment, carbon emission and energy consumption

The impact of foreign direct investment on carbon emission have also been studied by several researchers. [To et al. \(2019\)](#) have examined that foreign direct investment caused pollution degradation in the Asian region where their findings indicate that FDI strongly affects environment. [Wang et al. \(2016\)](#) have studied the major drivers of carbon emission in China and found that FDI positively influences environment in China. Similarly, [Zakarya et al. \(2015\)](#) states that there is cointegration between foreign direct investment, carbon emission, energy consumption and economic growth. [Öztürk and Öz \(2016\)](#) have also studied FDI inflow, energy consumption and carbon emission in Turkey. They have found a long-run association of these variables. Similarly, the relationship of foreign direct investment and carbon emission has also been studied by different researchers for different countries. [Kaya et al. \(2017\)](#) and [Kacar and Kayalica \(2014\)](#) have studied the association of carbon emission, foreign direct investment, international trade and economic growth where they have found that FDI and trade affect carbon dioxide emission positively. Moreover, [Li et al. \(2019\)](#) have studied the relationship of foreign direct investment and environment where they found a negative relationship between the variables. They found a negative relation between foreign direct investment and environmental performance by using an oriented quintile regression model. Moreover, [Hanpattanakit et al. \(2018\)](#) have found that greenhouse gas emission is the cause of transportation which is associated with climate change. [To et al. \(2019\)](#) have found that foreign direct investment causes environmental degradation in Asia. Moreover, they have found that environment is affected by foreign direct investment. [Wang et al. \(2019\)](#) have investigated that foreign direct investment affects economic growth in China but FDI has a controversial impact on environment.

3. Methodology

3.1. Data, variables and descriptive statistics

The present study examines the impact of Renewable energy, Carbon dioxide emission and financial development on each other's in the global panel of 192 countries. Data for the variables have been collected from the world development indicator for the period of 1980 to 2018. The variables included in the study are Renewable energy consumption (% of total final energy), Carbon dioxide emission measured in terms of metric tons per capita which is considered the primary greenhouse gas emission responsible for global warming in previous studies and financial development which is proxied by domestic credit to private sector. The study's main variables are carbon emission, financial development and renewable energy consumption while trade openness which is measured by the share of trade openness in GDP, Foreign direct investment (net inflows as a percent of GDP), urban population, labor force and merchandise trade (% of GDP) are control variables included in the model. The variables' definition is given in [Table 1](#) while the descriptive statistics of all these variables are given in [Table 2](#).

Summary statistics of all variables are given in [Table 2](#) where most of the variables' distributions are skewed and the Kurtosis values are also given which shows the concentration.

Table 1
Variable definitions.

Variables	Definition
CO2	Carbon dioxide Carbon emission (metric tons per capita)
RE	Renewable energy consumption (% of total final energy)
FDPVT	Financial development proxied by domestic credit to private sector
FDI	Foreign direct investment (net inflows as a percent of GDP)
POP	urban population
TO	Trade Openness (% of GDP)
FBF	Labor force
MT	merchandise trade (% of GDP)

Table 2
Summary statistics.

Variables	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
CO2	8.987	2.637	1.992	16.146	-0.040	2.39
RE	2.779	1.703	-6.339	4.588	-1.524	6.09
FDPVT	3.324	1.002	-1.682	5.733	-0.450	3.13
FDI	0.618	1.726	-12.509	7.156	-1.962	13.18
POP	14.631	2.266	7.942	20.529	-0.490	3.02
TO	4.251	0.620	-3.863	6.080	-2.677	28.73
FBF	14.940	1.814	10.373	20.484	-0.104	3.13
MT	3.976	0.538	1.411	5.839	-0.213	3.74

3.2. Econometric techniques

In this paper, we use panel quantile regression model to investigate the impact of financial development, renewable energy consumption and carbon emission on each other's in the global panel. We use panel quantile regression to explore the conditional distribution in countries regarding the study variables' association. The use of traditional regression methodology may lead to over or under estimating of relevant coefficient or may not be successful to detect an important relationship because these techniques focus on mean effects ([Binder and Coad, 2011](#)). Panel quantile regression was introduced by [Koenker and Bassett \(1978\)](#) in their seminal works. The generalization form of median regression analysis to other quantiles can be the following;

$$Q_{yi}(\tau | x_i) = x_i^T \beta_\tau \quad (1)$$

Quantile regression in heavy distributions is more robust however it cannot deal with unobserved heterogeneity of a country. Thus the current paper used panel quantile fixed effects which can examine the conditional heterogeneity and unobserved individual heterogeneity. [Lamarche \(2010\)](#) and [Galvao \(2011\)](#) and also [Koenker \(2004\)](#) have applied quantile regression to panel data considering econometric theory. The fixed effect panel quantile regression can be illustrated as follows;

$$Q_{yi}(\tau_k | \alpha_i x_{it}) = \alpha_i + x'_{it}(\tau_k) \quad (2)$$

Panel quantile regression with fixed effect has a major problem with the presence of a considerable amount of fixed effects is due to the incidental parameters problem ([Lancaster, 2000](#); [Neyman and Scott, 1948](#)). There will be inconsistency when individuals go to infinity however there is fixed observations for each cross sections. The use of fixed effect is to eliminate fixed effects unobserved effects. The facts of these methods are that expectations are linear which is not the reason for the conditional quantiles ([Canay, 2011](#)). For the elimination of such problems [Koenker \(2004\)](#) have proposed an appropriate methodology where the authors deal with unobservable fixed effect where he has fixed it as a parameter to be estimated jointly with the covariate effects for different quantiles. In this method the computational problems have been minimized by using penalty term of estimating

Table 3
Panel unit root tests.

Levels	LLC	IPS	Breitung	Fisher ADF	Fisher PP
CO2	15.51***	16.37	0.61	5.78	5.80
RE	-2.14	1.82	8.90	-0.32	1.18
FDPVT	1.516	0.535	4.318	1.186	4.565
FDI	-21.22***	-29.61***	-8.699***	-18.99***	-23.45***
POP	10.563	17.47	-9.165***	16.208	157.04
TO	-3.518***	-5.659***	-4.889***	-8.501***	-8.076***
FBF	2.255	5.556	11.932	6.0359	14.477
MT	-9.500***	-10.223***	-7.646***	-10.144***	-9.822***
First difference					
CO2	-84.4***	-83.2***	-29.78***	-62.681***	-66.07***
RE	-48.20***	-44.9***	-16.01***	-33.7***	-45.36***
FDPVT	-47.1529***	-43.1916***	-31.857***	-40.282***	-44.504***
FDI	-81.832***	-85.0019***	-1.211***	-61.405***	-66.405***
POP	-48.966***	-61.186***	-0.5014***	-52.179***	-48.635***
TO	-78.292***	-74.164***	-49.1023***	-54.581***	-65.1400***
FBF	-8.8155***	-16.8040***	-22.042***	-13.7056***	-16.9053***
MT	-81.7178***	-77.4694***	-36.4168***	-58.488***	-65.535***

Note:
***Significance at 1% level.

parameters where the parameter estimation can be calculated as follows;

$$\min_{(\alpha, \beta)} \sum_{k=1}^K \sum_{t=1}^T \sum_{i=1}^N w_k P_{\tau k} (y_{it} - \alpha_i - x_{it}^T \beta (\tau_k)) + \lambda \sum_I |\alpha_I|, \quad (3)$$

In the above equation, the countries (N) index represented by I , the number of observation is presented by T for countries, K is the quantiles index, the explanatory variables matrix is given by x , where $P_{\tau k}$ is the loss function of quantile, W_k is the weight to the k th quantile using for the contribution of k th quantile controls on the fixed effect estimation. The current study focus on the equally weighted quantiles which is given by $W_k = 1/K$ of Alexander et al. (2011), Moreover, λ represent the tuning parameter which is used to improve the estimate of β and reduce individual effects to zero. The penalty term will disappears when the λ goes to zero and then the usual fixed effect estimator can be obtained. However we will get model estimate without individual effects if λ term goes to infinity. The current paper λ has been set is equal to 1 (Damette and Delacote, 2012). The specification of quantile function for τ for the current study variables can be the following;

$$Q_{yi}(\tau | \alpha_i, \xi_t, x_{it}) = \alpha_i + \xi_t + \beta_{1\tau} RE_{it} + \beta_{2\tau} Fdpvt_{it} + \beta_{3\tau} TO_{it} + \beta_{4\tau} FDI_{it} + \beta_{5\tau} UP_{it} + \beta_{6\tau} LBF_{it} + \beta_{7\tau} MT_{it}. \quad (4)$$

$$Q_{yi}(\tau | \alpha_i, \xi_t, x_{it}) = \alpha_i + \xi_t + \beta_{1\tau} CO_{it} + \beta_{2\tau} Fdpvt_{it} + \beta_{3\tau} TO_{it} + \beta_{4\tau} FDI_{it} + \beta_{5\tau} UP_{it} + \beta_{6\tau} LBF_{it} + \beta_{7\tau} MT_{it}. \quad (5)$$

$$Q_{yi}(\tau | \alpha_i, \xi_t, x_{it}) = \alpha_i + \xi_t + \beta_{1\tau} RE_{it} + \beta_{2\tau} CO_{it} + \beta_{3\tau} TO_{it} + \beta_{4\tau} FDI_{it} + \beta_{5\tau} UP_{it} + \beta_{6\tau} LBF_{it} + \beta_{7\tau} MT_{it}. \quad (6)$$

where i represent countries, time by time t , y_{it} is the indicator for emission, renewable energy and financial development respectively in Eqs. (1)–(3). RE is Renewable energy, CO is Carbon dioxide Carbon emission, Fdpvt is financial development, TO is trade openness FDI is Foreign direct investment UP is urban population, LBF is labor force while MT is merchandize in the model (see Fig. 1).

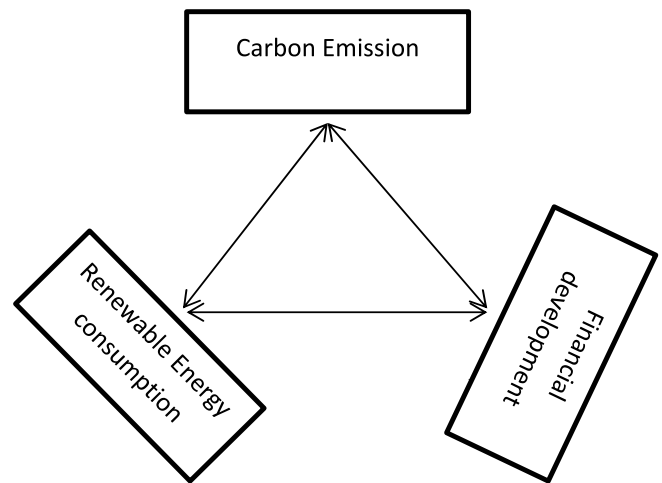


Fig. 1. Three way association among carbon emission, renewable energy consumption and financial development.

4. Results and discussion

4.1. Results of panel unit root test and panel cointegration

This section reports the results of panel unit root tests. We employ these tests to check the stationary of the variables before estimating co integration and panel quantile regression models to know whether the study variables are stationary not. For this purpose, the current study employed five tests of panel unit root both in levels and in first difference for the study variables. These tests are including LLC (Levin et al., 2002), IPS test (Im and Pesaran, 2003), Breitung (2002), Fisher PP test and Fisher-ADF test (Maddala and Wu, 1999). All the unit root tests reject the null hypothesis of unit root which statutes that all the variables are stationary. The results of these five unit root tests indicates that null hypothesis of unit root test cannot be rejected at level for all variables but can be rejected at the first differences. Therefore the first differences have also been checked. The results of these tests are given in Table 3.

All of the findings in the table given above are statistically significant at the level of 1% which allows us for the panel cointegration test among the study variables. For co integration

Table 4
Johansen Fisher panel cointegration test.

Hypothesized No. of CE(s)	Fisher Stat.* (from trace test)	Prob.	Fisher Stat.* (from max-eigen test)	Prob.
None	1299.	0.0000	807.1	0.0000
At most 1	4940.	0.0000	3343.	0.0000
At most 2	4780.	0.0000	2477.	0.0000
At most 3	3306.	0.0000	1869.	0.0000
At most 4	2302.	0.0000	1364.	0.0000
At most 5	1539.	0.0000	960.5	0.0000
At most 6	893.2	0.0000	741.1	0.0000
	438.8	0.0000	438.8	0.0000

*Probabilities are computed using asymptotic Chi-square distribution.

test, we use Fisher panel cointegration test which is proposed by Maddala and Wu (1999) where the results in this test depend specially on the VAR lag order system. The results accept alternative hypothesis and reject the null hypothesis at 1 percent level of no cointegration. Table 4 shows the results of panel co-integration test for the global panel for the period of 1985 to 2019. It is observed that all the data series are co-integrated which use one lag and indicate that seven cointegrating vectors exist. Further the results confirm that there is long run association of the study variables.

4.2. Panel quantile regression results

Table 5 presents the results of the panel quantile regression estimation on the effect of Renewable Energy Consumption and Financial Development on Carbon Dioxide emission in the Global panel of 192 Countries. The results are presented for quantile (5th, 10th, 20th to 90th and 95th) percentiles distribution of each dependent variable. The results of all models indicate that various factors for all three dependent variables are heterogeneous.

The estimated coefficient of renewable energy consumption is highly significant at 1 percent level in all quantiles and the sign is negative which indicates that renewable energy consumption reduce carbon dioxide emissions. Zhou and Li (2019) have also found the similar results to our findings by using panel quantile regression model for 33 countries which further support our findings that renewable energy consumption significantly reduces carbon emission in the current study sample countries. Apergis and Payne (2014) also support our findings where they statutes that renewable energy consumption significantly reduce carbon emission.

Similarly, the coefficient of financial development is also highly statistically significant and positive in all quantile at 1 percent level which indicates that financial development increase carbon emission. Our findings are in line with the study results of Zhang and Cheng (2009) who have also found that financial development significantly increases carbon emission in China while (Boutabba, 2014) found this result for India. Raza and Shah (2018), Diallo and Masih (2017), Omri et al. (2015), Jian et al. (2019) and Jiang and Ma (2019) have also found that financial development significantly increase carbon dioxide emission which enforce our study findings.

The results of FDI in our results is clearly heterogeneous where the estimated coefficient of FDI is negative and insignificant which is insufficient to support the pollution haven hypothesis in the low-emissions countries. However, the coefficient in positive significant at the highest quantile (95th quantile), implying that the influence of FDI on carbon emissions is positive. The insignificant results at low quantile indicates that most of foreign countries invest in the non polluting sectors in the countries with low emissions where may have given attention

to environmental issues in high emission countries where FDI may enhance the level of specialized technological skills and innovations for production. Multinational companies may also use advance technologies which may tend to disseminate cleaner technology which is less harmful for environment. These discussions indicates that FDI improves environmental quality in high emission countries. The current study results are similar to Atici (2012) who states that no effect of FDI on environment. The negative effect can be reason that there are numerous projects of foreign direct investment done by using effect amount of renewable energy or in the production projects of renewable energy. Jebli and Youssef (2015), Apergis and Payne (2010) and Zhu et al. (2016) have found similar results while our results are opposite to the findings of Owusu-Brown (0000), Zhou et al. (2018), Balibey (2015) and Peng et al. (2016) states that FDI have positive impact on CO₂ emissions. Mert and Bölük (2016) also founds that FDI reduce carbon emission in Kyoto countries. Likewise, Zhu et al. (2016) have also found the same results in medium carbon emission countries and high carbon emissions countries which support the hypothesis of “pollution haloes”. Additionally, Atici (2012) have found that FDI reduce pollution in Asian countries. However, the current findings are contradicted with that of Salahuddin et al. (2018), Owusu-Brown (0000), Balibey (2015) and Peng et al. (2016) which indicate that FDI increase carbon emission.

Similarly, the coefficient of population which is a control variable is clearly significant and positive at 1 percent level and in all quantiles indicate that urban population affects carbon emission positively implying that a larger population size leads to higher carbon emissions in low-emissions countries and high-emissions countries.

The coefficient of trade is negative and significant at the lower and higher percentiles, indicating that a higher level of trade openness can relieve carbon emissions in low- or high-emissions countries. The results suggests that trade openness contribution to carbon emission in the global panel is low. Therefore the countries should try to promote the contribution of trade openness to carbon emission. The results regarding trade openness of the current study findings are reinforced by the study of Jayanthakumar et al. (2012) and Dogan et al. (2017) who also have found that trade openness reduce carbon emission significantly. The current study result regarding the negative significance impact of trade openness on carbon emission can be that there may not be more openness to trade for import or export and may not need more fossil energy for transport, production or consumption may reduce carbon emission. Likewise, the coefficient of labor force is statistically significant in all quantiles form lowers to higher which indicates that labor force negatively significantly affect carbon emission. Merchandize trade is also significant highly in all quantiles at 1 percent significance level which indicates that its effect carbon emission positive significantly.

4.3. The effects of carbon dioxide emission and financial development on renewable energy consumption

In Table 6, the coefficient of Carbon emission is highly statistically significant and its impact on renewable energy consumption is negative in all quantiles which indicates that increase in carbon dioxide emission reduce renewable energy consumption in the global panel. The current study findings are similar to the findings of Bilan et al. (2019) who have found that carbon emission have negative impact on renewable energy consumption while contradictory with those of Saidi and Hammami (2015) and Hwang and Yoo (2014) who states that increase in carbon emission increase the use of energy.

The coefficient of financial development which is proxied by private sector credit is also highly significant and positive most

Table 5
The effects of renewable energy consumption and financial development on carbon emission.

Variables	Quantiles										
	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
RE	−0.374*** (0.018)	−0.280*** (0.016)	−0.339*** (0.020)	−0.346*** (0.013)	−0.351*** (0.015)	−0.374*** (0.018)	−0.380*** (0.020)	−0.394*** (0.019)	−0.388*** (0.021)	−0.389*** (0.016)	−0.393*** (0.018)
FDPVT	0.543*** (0.025)	0.717*** (0.023)	0.662*** (0.028)	0.622*** (0.019)	0.586*** (0.022)	0.543*** (0.025)	0.477*** (0.029)	0.461*** (0.027)	0.423*** (0.030)	0.439*** (0.022)	0.383*** (0.026)
FDI	−0.021 (0.017)	−0.022 (0.015)	−0.017 (0.019)	−0.018 (0.013)	−0.022 (0.015)	−0.021 (0.017)	−0.007 (0.019)	0.020 (0.018)	−0.007 (0.020)	0.022 (0.015)	0.031* (0.017)
Urban Pop	1.268*** (0.051)	1.392*** (0.046)	1.261*** (0.056)	1.265*** (0.039)	1.277*** (0.044)	1.268*** (0.051)	1.246*** (0.057)	1.295*** (0.055)	1.409*** (0.060)	1.224*** (0.045)	1.089*** (0.051)
TO	−0.170* (0.088)	−0.320*** (0.080)	−0.277*** (0.098)	−0.150** (0.068)	−0.126 (0.077)	−0.170* (0.088)	−0.189* (0.099)	−0.245** (0.095)	−0.077 (0.104)	−0.189** (0.078)	−0.212** (0.089)
Labor force	−0.236*** (0.054)	−0.315*** (0.049)	−0.234*** (0.060)	−0.249*** (0.041)	−0.251*** (0.047)	−0.236*** (0.054)	−0.192*** (0.061)	−0.252*** (0.058)	−0.382*** (0.063)	−0.261*** (0.048)	−0.102* (0.054)
MT	0.560*** (0.080)	0.413*** (0.072)	0.405*** (0.089)	0.328*** (0.062)	0.416*** (0.070)	0.560*** (0.080)	0.611*** (0.090)	0.604*** (0.087)	0.386*** (0.094)	0.313*** (0.071)	0.361*** (0.081)
Constant	−8.906*** (0.401)	−10.03*** (0.363)	−8.780*** (0.446)	−8.513*** (0.309)	−8.762*** (0.351)	−8.906*** (0.401)	−9.033*** (0.453)	−8.275*** (0.434)	−7.620*** (0.471)	−5.709*** (0.356)	−5.840*** (0.406)

Note:

*Shows the level of significance at 10% level.

**Shows the level of significance 5% level.

***Shows the level of significance at 1% level.

Table 6
The effects of carbon dioxide emission and financial development on renewable energy consumption.

Variables	Quantiles										
	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
CO2	−0.669*** (0.0278)	−0.974*** (0.0804)	−0.950*** (0.040)	−0.808*** (0.0463)	−0.675*** (0.0312)	−0.669*** (0.0278)	−0.641*** (0.0267)	−0.556*** (0.0280)	−0.430*** (0.0226)	−0.376*** (0.0213)	−0.285*** (0.0349)
FDPVT	0.185*** (0.0309)	0.221** (0.0893)	0.239*** (0.0452)	0.242*** (0.0515)	0.196*** (0.0346)	0.185*** (0.0309)	0.181*** (0.0296)	0.161*** (0.0311)	0.0799*** (0.0251)	0.0891*** (0.0237)	0.0506 (0.0388)
FDI	−0.0309* (0.0175)	0.115** (0.0506)	0.00699 (0.0256)	0.0116 (0.0292)	0.0177 (0.0196)	−0.0309* (0.0175)	−0.0470*** (0.0168)	−0.0224 (0.0176)	−0.0184 (0.0142)	−0.0253* (0.0134)	−0.00976 (0.0220)
Urban POP	0.205*** (0.0676)	0.490** (0.195)	0.728*** (0.0988)	0.469*** (0.113)	0.191** (0.0757)	0.205*** (0.0676)	0.207*** (0.0648)	0.201*** (0.0680)	0.110** (0.0549)	0.105** (0.0518)	0.0741 (0.0849)
TO	−0.313*** (0.0901)	−0.516*** (0.260)	−0.627*** (0.132)	−0.599*** (0.150)	−0.333*** (0.101)	−0.313*** (0.0901)	−0.318*** (0.0863)	−0.297*** (0.0906)	−0.337*** (0.0732)	−0.229*** (0.0689)	−0.106 (0.113)
L. force	0.454*** (0.0555)	0.618*** (0.160)	0.337*** (0.0811)	0.362*** (0.0924)	0.492*** (0.0621)	0.454*** (0.0555)	0.391*** (0.0532)	0.313*** (0.0558)	0.271*** (0.0451)	0.172*** (0.0425)	0.118* (0.0697)
MT	0.328*** (0.0834)	0.170 (0.241)	0.432*** (0.122)	0.367*** (0.139)	0.223** (0.0934)	0.328*** (0.0834)	0.338*** (0.0799)	0.170** (0.0839)	0.180*** (0.0678)	0.0400 (0.0638)	−0.0797 (0.105)
Constant	−0.916* (0.494)	−5.215*** (1.426)	−5.022*** (0.722)	−1.976** (0.822)	−0.893 (0.553)	−0.916* (0.494)	−0.133 (0.473)	1.143** (0.497)	2.450*** (0.401)	3.768*** (0.378)	4.388*** (0.620)

Note.

*Shows the level of significance at 10% level.

**Shows the level of significance at 5% level.

***Shows the level of significance at 1% level.

of in all quantiles while insignificant in the highest quantile (95th quantile). These results are in line with [Kim and Park \(2016\)](#) and [Burakov and Freidin \(2017\)](#) who have also found positive impact of financial development on renewable energy. [Brunnschweiler \(2010\)](#), [Hassine and Harrathi \(2017\)](#) and [Eren et al. \(2019\)](#) have also supported that financial development positively and significantly affect the use of renewable energy. The findings further suggest that financial development is very important in renewable energy consumption. A well-developed financial system can offer better incentives to clean energy production projects and R&D activities to support the use of renewable energy which is helpful in clean environment establishment. The scarce financial resources are obstacles for the consumption of renewable energy where increase in financial services help increase the firms access to financial resources to adopt clean energy. The coefficient of foreign direct investment is negatively significant at 10 percent level in 5th quantile and then its became positive significant at 10th quantile and then insignificant in 20th, 30th and 40th quantile. Again its negative significant at higher quantiles the 40th, 50th and 90th quantile while insignificant in others quantiles. The negative significant results at low quantiles indicate that foreign

direct investment reduces the use of renewable energy in lower countries and vice versa.

Urban population is significant and positive in all quantiles except the 95th quantile which indicates that urban population increase the consumption of renewable energy in the global panel in the lower quantiles. The coefficient of trade openness is also highly statistically significant and negative in all quantiles except the 95th quantile which indicates that trade openness negatively influence renewable energy consumption in the global panel. Labor force and merchandise trade is highly significant and positive in all quantiles while merchandise trade is insignificant only in the 90th and 95th quantiles which shows that labor force and merchandise trade increase renewable energy consumption while it is not true for the highest quantiles.

4.4. The effect of carbon dioxide emission and renewable energy consumption on financial development

Moreover, the coefficient of carbon dioxide emission is highly statistically significant at 1 percent level in all quantiles which

Table 7

The effect of carbon dioxide emission, renewable energy consumption, on financial development.

D. Var FD Variables	Quantiles										
	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
CO2	0.570*** (0.0241)	0.655*** (0.0503)	0.570*** (0.0366)	0.569*** (0.0291)	0.575*** (0.0255)	0.570*** (0.0241)	0.563*** (0.0261)	0.558*** (0.0214)	0.566*** (0.0215)	0.580*** (0.0237)	0.604*** (0.0183)
RE	0.131*** (0.0188)	0.361*** (0.0391)	0.208*** (0.0284)	0.166*** (0.0226)	0.152*** (0.0198)	0.131*** (0.0188)	0.0786*** (0.0203)	0.0448*** (0.0166)	0.0476*** (0.0167)	0.0292 (0.0184)	0.0400*** (0.0143)
FDI	0.0185 (0.0151)	−0.0123 (0.0314)	−0.00256 (0.0229)	0.0272 (0.0182)	0.0170 (0.0160)	0.0185 (0.0151)	0.00974 (0.0163)	0.00723 (0.0134)	0.0130 (0.0135)	−0.0150 (0.0148)	−0.00789 (0.0115)
Urban Pop	−0.486*** (0.0568)	−0.601*** (0.118)	−0.583*** (0.0861)	−0.507*** (0.0685)	−0.489*** (0.0601)	−0.486*** (0.0568)	−0.507*** (0.0614)	−0.571*** (0.0504)	−0.589*** (0.0507)	−0.487*** (0.0559)	−0.561*** (0.0432)
TO	0.555*** (0.0780)	0.00325 (0.162)	−0.0516 (0.118)	0.351*** (0.0939)	0.477*** (0.0825)	0.555*** (0.0780)	0.588*** (0.0843)	0.612*** (0.0691)	0.553*** (0.0695)	0.282*** (0.0766)	0.272*** (0.0592)
L force	−0.0217 (0.0487)	0.0487 (0.101)	0.0841 (0.0737)	−0.00485 (0.0586)	−0.0306 (0.0515)	−0.0217 (0.0487)	0.0175 (0.0526)	0.0922** (0.0431)	0.0945** (0.0434)	−0.0347 (0.0478)	−0.00842 (0.0370)
MT	−0.503*** (0.0719)	0.121 (0.150)	0.186* (0.109)	−0.326*** (0.0866)	−0.478*** (0.0761)	−0.503*** (0.0719)	−0.486*** (0.0777)	−0.506*** (0.0638)	−0.469*** (0.0641)	−0.299*** (0.0707)	−0.317*** (0.0546)
Constant	4.379*** (0.409)	2.426*** (0.852)	3.172*** (0.619)	4.112*** (0.493)	4.461*** (0.433)	4.379*** (0.409)	4.345*** (0.442)	4.480*** (0.363)	5.010*** (0.365)	6.164*** (0.402)	6.958*** (0.311)

Note:

*Shows the level of significance at 10% level.

**Shows the level of significance at 5% level.

***Shows the level of significance at 1% level.

illustrates that carbon emission affect financial development positively. When there is increase in carbon emission increase financial development. Zhang and Cheng (2009) also states that carbon dioxide emission and financial developments are associated and CO₂ increases the level of financial development in china. Al-Mulali and Sab (2012) also found that CO₂ have positive long run relationship with financial development however, the current findings are contradictory with the findings of Salahuddin et al. (2015) and Shahbaz et al. (2016) have found negative association.

Likewise, the coefficient of renewable energy is also highly statistically significant and positive in all quantiles except the 90th quantile which shows that renewable energy consumption also effect financial development positively in lower countries quantiles. Al-Mulali and Sab (2012) have also found that energy consumption positively affect financial development. The coefficient of foreign direct investment is insignificant in all quantiles which indicates that foreign direct investment have no effect on financial development in the globe (see Table 7).

Urban population and merchandize trade are also highly significant mostly in all quantiles while the sign is negative which indicates that its effect financial development negative significantly. Its further indicates that increase in urban population and merchandize trade decrease financial development. Trade openness is significant and positive in all quantiles except 10th and 20th quantiles, labor force is insignificant expect for the 70th and 80th quantiles which indicates that labor force positively effect financial development at the higher quantiles.

5. Conclusion and policy implication

The present study examines heterogeneity of renewable energy consumption, Carbon dioxide emission and financial development significance for each other's in the global panel. Data for the variables have been collected from the world development indicator for the period of 1980 to 2018. We have used panel unit root tests, cointegration and Panel quantile regression. The unit root shows the stationarity of the variables where the cointegration results shows the long run associations between the study variables. The panel quantile regression results indicate that renewable energy consumption negatively and significantly affect carbon emission while financial development have an increasing effect on carbon emission. Similarly, Carbon emission have been found to be negatively significantly related with renewable energy consumption while the financial development

have been found that it positively affects renewable energy consumption. Likewise, both the renewable energy consumption and carbon emission effect financial development positively and significantly. The current study findings have considerable policy implication for the countries to encourage clean technologies by increasing the use of renewable energy which can be a major driver to enhance the quality of environment. Energy is very important factor for poverty reduction and development of a country. Therefore the current study suggest to the sample countries to establish energy development programs, reduce the use of fossil fuels and shift to clean and renewable energy consumption as renewable energy consumption can significantly enhance environmental quality. The findings further suggest that financial development is very important in renewable energy consumption. Countries should focus to well-develop their financial system which can offer better incentives to clean energy production projects and R&D activities to support the use of renewable energy which is helpful in clean environment establishment. Financial institutions should be promoted because its can help provide support to environment friendly projects which contributes to the countries environments. The scare financial resources are obstacles for the consumption of renewable energy where increase in financial services help increase the firms access to financial resources to adopt clean energy. Regarding FDI, the host countries should know about the impacts of foreign direct investment on environment before they introduce foreign investors to the countries while its suggested that countries with high emission should improve the level of foreign direct investment. Likewise, the suggestions for those countries with high emission could increase population size and economic growth which may help reduce carbon emission. Trade openness is also suggested to be improved in the sample countries. Our study is limited to the study variables. Further study should consider developed or developing regions and may include other variables to better explain this relationship.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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