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Research Article

The Dynamic Interrelationship of Environmental Factors and Foreign Direct Investment: Dynamic Panel Data Analysis and New Evidence from the Globe

Hayat Khan,[1] **Itbar Khan**,[2] **Le Thi Kim Oanh**,[1] **and Zhang Lin**[1]

[1]*Business School of Guangxi University, Nanning, China*
[2]*Business School of Xiangtan University, Hunan, China*

Correspondence should be addressed to Zhang Lin; zhanglin1898@gxu.edu.cn

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Studies on the role of renewable energy consumption and other environmental factors in carbon emission have got considerable attention recently, and they are predicted to get exaggerated in the coming decades. Energy usage increases economic growth and development of a country and backs to global warming and carbon emission which affect the local environment. For the prosperity of a country, it is felt crucial to measure the unavoidable impacts which effect environmental quality. Consequently, the current study investigates the interrelationship of renewable energy consumption, carbon dioxide emission, foreign direct investment, and economic growth in 190 countries of the world for the period of 1980 to 2018. By employing both static and dynamic models, the findings indicate that carbon emission, renewable energy consumption, foreign direct investment, and economic growth affect each other significantly whereas renewable energy consumption has been found beneficial for environmental quality; however, it decreases the inflow of FDI. RE has a decreasing impact, while FDI and carbon emission promote economic growth. The study suggests the promotion of renewable energy resources and policies related to FDI to promote the quality of the environment and achieve economic growth as well.

1. Introduction

Environmental factors and their association with other variables have been studied by several researchers, and it has been argued that some factors increase carbon emission and vice versa. The role of renewable energy has been considered beneficial for environmental quality in most of the preceding studies where it also effects economic growth of a country. On the other hand, economic growth also has an influence on renewable energy consumption. Al-Mulali and Sheau-Ting [1] and Ocal and Aslan [2] examine that the use of renewable energy instead of energy from fossil' fuels increases economic growth, while on the other hand, Menyah and Wolde-Rufael [3] debated that the use of renewable energy is beneficial for environmental quality while the utilization of renewable energy in most of the countries has not yet reached the desired level to help reduce emission. Shafiei and Salim [4] conducted a study on OECD countries and have found that the use of renewable energy significantly contributes to the environment and reduces carbon emission. Sadorsky [5] has found that carbon emission and GDP are the drivers of renewable energy usage, while Ben Jebli et al. [6] show that renewable energy consumption has a bidirectional causal relationship with trade openness where renewable energy consumption increases the growth rate. There is an arguing debate on the relationship among these variables in the prevailing literature. Several researchers have also considered the impact of FDI on carbon emission. A study conducted by Huynh and Hoang [7] studied the influence of FDI on pollution in 19 developing countries of Asia for the period of 2002 to 2015. They have found that the inflow of FDI in the initial stage increases pollution whereas the improvement in institutional quality lowers this effect till the achievement of a threshold of institutions quality;

however, beyond the threshold, FDI has been found to lower the air pollution in the Asian developing countries. Likewise, Zhu et al. [8] have found that foreign direct investment increases carbon emission in the sample cities of China. They further state that FDI reduces carbon emission during the lagging period of one phase. A study conducted by Li et al. [9] examines the relationship of foreign direct investment with carbon emission by using an oriented quantile regression model where they indicate that there exists a negative relationship between the study variables. Similarly, the study of Zhu et al. [10] shows the negative impact of FDI on carbon emission while they have found the increasing impact of energy consumption on carbon emission. The current study is a comprehensive study which examines the interrelationship of renewable energy consumption, carbon emission, economic growth, and foreign direct investment in the global panel by using dynamic panel models while such kind of studies in a new way have never been conducted before. The study is organized in the given sequence: Section 2 illustrates empirical literature review regarding the association between different variables regarding the current study, Section 3 is composed of the methodology, Section 4 presents the findings of the study, while Section 5 concludes the study.

2. Literature Review

Several studies have been conducted on the association of renewable energy consumption, carbon emission, economic growth, and foreign direct investment but with little accord. The linkage of renewable energy consumption with other variables such as GDP, carbon emission, international trade, and nonrenewable energy has been studied by different researchers such as Shafiei and Salim [4]; Jebli and Youssef [11]; and Dogan and Seker [12]. A study conducted by Jebli and Youssef [13] and Apergis and Payne [14] states that there is unidirectional casualties from renewable energy to trade openness and carbon emission, from tourism to FDI and trade openness and from growth to tourism and renewable energy consumption, while there is bidirectional causality between the variables in the long run. Hanif [15] examined the relationship between economic growth, fossil fuels, solid fuels, renewable energy consumption, and carbon dioxide emission in sub-Saharan Africa for the period from 1995 to 2015. They have used the GMM model where the findings show that the impact of fossil fuels and solid fuels on carbon emission is positive while renewable energy has a decreasing influence on carbon dioxide emission. A study conducted by Ali et al. [16] examines the association between carbon emission and energy consumption, and they have found no impact of the industry value added on carbon emission; however, they state that technological advancement can lead to environmental quality protection. They further found the bidirectional long run association of carbon emission to energy consumption, technological innovation, and structural change. Khan et al. [17] studied the association between energy consumption, carbon emission, and economic growth in Pakistan for the period from 1965 to 2015. By using the ARDL model, the results show that economic growth and energy consumption have an increasing impact on carbon emission both in long and short run. They suggest that renewable energy sources are beneficial for the environment and decrease carbon emission. Isik et al. [18] examined the impact of renewable energy consumption, energy from fossil fuels, and GDP on carbon emission for ten US states. The findings of their study validate the EKC hypothesis and found the negative impact of fossil fuels on carbon emission in Texas while energy consumption has been found to have an increasing influence on carbon emission in Florida. Sarkodie et al. [19] have studied renewable energy and foreign direct investment in climate mitigation in the presence of governance for 47 sub-Saharan African countries. They have found that renewable energy decreases the greenhouse gas emission while FDI, income level, and governance worsen climate change. Alola et al. [20] have studied the dynamic impact of economic growth, trade policy, fertility rate, and renewable and nonrenewable energy consumption on ecological footprint in 16 European countries. They have found that nonrenewable energy consumption depletes environmental quality while renewable energy consumption improves environmental sustainability. Bhat [21] studied renewable and nonrenewable energy consumption, economic growth, and carbon emission in five emerging economies for the period from 1992 to 2016. By using a pooled mean group and panel generalized method of moments, they have found that labor, capital, and nonrenewable energy consumption are positively associated in the long run while the impact of renewable energy consumption is positive and insignificant. On the other side, they found a positive impact of nonrenewable energy on carbon emission and a negative impact of renewable energy consumption of carbon emission. Ito [22] studied carbon emission, renewable and nonrenewable consumption of energy, and economic growth and found a negative impact of nonrenewable energy consumption on economic growth and a positive impact of renewable energy consumption on economic growth in developing countries. Likewise, Khan et al. [17] have studied the interrelationship of renewable energy consumption, financial development, and carbon emission in the globe by employing the panel quantile regression model. Their findings confirm that their study variables are heterogeneous on each other across quantiles. Furthermore, Frankel and Romer [23] state that financial liberalization and development attract foreign direct investment and increase the degree of investment rated to R&D which can enhance the performance of the environment. Similarly, Zhu et al. [8] have examined the influence of foreign direct investment, economic growth, population, and other factors on carbon emission in China. They have employed dynamic panel data and models where their findings indicate that foreign direct investment increases carbon emission in the sample cities of China. They further state that FDI reduces urban emission during the lagging period of one phase. A study conducted by Li et al. [9] examines the foreign direct investment relationship with the environment by using an oriented quantile regression model where they indicate that there exists a negative relationship between the study variables.

3. Methodology

3.1. Data. This study examines impact of renewable energy consumption, carbon emission, economic growth, and FDI on each other whereas data for these variables and other control variables for the study have been collected from the world development indicator for the period of 1980 to 2018. The study has used OLS, fixed effect, two-step GMM, and two-step system GMM models for analysis. The study variables include renewable energy consumption used as a % of total final energy, carbon dioxide emission calculated as metric tons per capita, and foreign direct investment calculated as net inflows as a percent of GDP and GDP per capita (annual growth percent). Other variables used are urban population, trade openness, and total government expenditure. The beginning period was based on the availability of data.

3.2. Econometric Techniques. The current study uses the OLS, fixed effect, two-step GMM, and two-step system GMM models to investigate the interrelationship of renewable energy consumption, carbon dioxide emission, foreign direct investment, and economic growth in the global panel of 190 countries. We have used different econometric models to effectively investigate the interrelationship among the study variables. The static models are used to compare the current findings with the preceding studies results, while the main focus of this study is the system GMM as the OLS or fixed effect models might lead to different econometric problems and give inefficient results. Similarly, we also employ difference GMM where the difference GMM uses the first differences of regressor and the dependent variables to transform the regression for abstracting the country-specific effects and make regressor time invariant. The autocorrelation problems can be eliminated as the first difference lagged a dependent variable instrumented with precedent levels in difference GMM. Arellano and Bover [24] state that these modeling might also give inefficient conclusions if there are sedulous nature-independent variables. Therefore, the present study utilizes system GMM, specifically the two-step GMM model as its considered better than the one-step system GMM estimator by different researchers such as Law and Azman-Saini [25]. Focusing on the two-step system GMM estimators, the impact of carbon emission, FDI, and economic growth on renewable energy has been investigated, and the equation can be illustrated as follows:

$$\mathrm{RE}_{\mathrm{it}} = a_1 \mathrm{RE}_{i,t-1} + a_2 \mathrm{CDO}_{\mathrm{it}} + a_3 \mathrm{FDI}_{\mathrm{it}} + a_4 \mathrm{GDPPC}_{\mathrm{it}} + a_5 X_{\mathrm{it}} + \varepsilon_{\mathrm{it}}. \tag{1}$$

Secondly, we have then taken CO_2 as the dependent variable and have found the impact of renewable energy consumption, foreign direct investment, and economic growth on carbon emission where the equation can be stated as;

$$\mathrm{CDO}_{\mathrm{it}} = a_1 \mathrm{CDO}_{i,t-1} + a_2 \mathrm{RE}_{\mathrm{it}} + a_3 \mathrm{FDI}_{\mathrm{it}} + a_4 \mathrm{GDPPC}_{\mathrm{it}} + a_5 X_{it} + \varepsilon_{it}. \tag{2}$$

Thirdly, we have taken FDI as the dependent variable, and renewable energy consumption, carbon emission, and GDPPC are explanatory variables to find its impact on FDI where, empirically, the equation can be stated as follows:

$$\mathrm{FDI}_{\mathrm{it}} = a_1 \mathrm{FDI}_{i,t-1} + a_2 \mathrm{RE}_{it} + a_3 \mathrm{CDO}_{\mathrm{it}} + a_4 \mathrm{GDPPC}_{i,t} + a_5 X_{it} + \varepsilon_{it}. \tag{3}$$

Lastly, we have taken GDP per capita as dependent variables and carbon emission, renewable energy consumption, and foreign direct investment as explanatory variables to find its impact on economic growth. The equation can be expressed as follows;

$$\mathrm{GDPPC}_{\mathrm{it}} = a_1 \mathrm{GDPPC}_{i,t-1} + a_2 \mathrm{RE}_{\mathrm{it}} + a_3 \mathrm{CDO}_{\mathrm{it}} + a_4 \mathrm{FDI}_{\mathrm{it}} + a_5 X_{it} + \varepsilon_{it}. \tag{4}$$

All of the above mentioned four models on the interrelationship of renewable energy consumption, carbon emission, foreign direct investment, and economic growth are illustrated in Figure 1.

In the above mentioned equations; RE is renewable energy consumption (% of total final energy) where an increase in the use of renewable energy sources might act as an inhibitor of carbon emission. CDO is carbon dioxide emission (metric tons per capita) used to represent environmental degradation and FDI is foreign direct investment calculated as net inflows as a percent of GDP, while GDPPC is gross domestic product per capita used for economic growth. $\mathrm{RE}_{\mathrm{it\text{-}1}}$, $\mathrm{CDO}_{\mathrm{it\text{-}1}}$, $\mathrm{FDI}_{\mathrm{it\text{-}1}}$, and $\mathrm{GDPPC}_{i,t-1}$ are the first lag of left-hand variables used as explanatory variables in equations (1)–(4), respectively, to quantify the proceeding years' effect on the present year, and X_{it} represents the vector of control variables that hypothetically affects our left-hand side variable. The control variables include urban population, where the available literature shows that a population increase acts as a driver of carbon emissions, trade openness, and total government expenditure as a % of GDP, whereas subscripts i ($i = 1 \ldots \mathrm{N}$) and t ($t = 1980 \ldots 2018$) are index, country and time, respectively.

4. Results and Discussion

The estimated results on the interrelationship of renewable energy consumption, carbon dioxide emission, foreign direct investment, and economic growth are given in this section for the panel data of 190 countries of the globe. Static and dynamic models have been utilized which include the OLS, FE, Arellano-Bond [26] two-step difference GMM, and the Arellano and Bover [24] two-step system GMM. As mentioned in the previous section, as the two-step system GMM is a more robust and efficient estimator, the current study focuses on the two-step system GMM and considers its results. To know the validity of the instruments and model fitness, the Sargan test and Arellano and Bond tests results are given in all tables where these results indicate that the Sargan test and serial correlation tests p values are insignificant and the null hypothesis cannot be rejected in all tables. Therefore, these results support the current study estimation results and imply that there is no correlation.

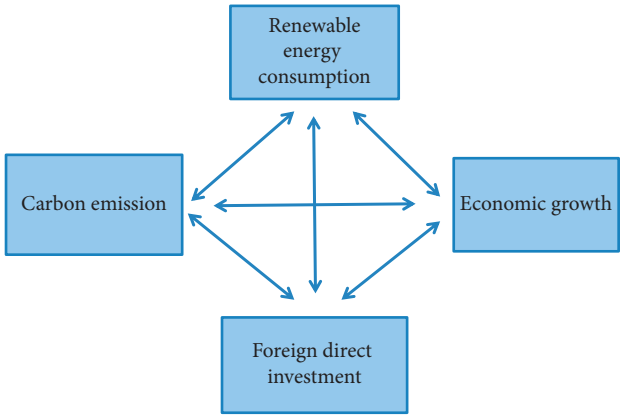

Figure 1: The interlinkage of carbon emission, renewable energy consumption, foreign direct investment, and economic growth.

Therefore, the included instruments in the model are valid and the GMM panel-estimated model aligns with econometric theory.

Tables 1–3 give the results on the interrelationship of carbon dioxide emission, renewable energy consumption, foreign direct investment, and economic growth for the global panel of 190 countries.

4.1. The Impact of Renewable Energy Consumption, Economic Growth, and FDI on Carbon Emission. Results on the impact of renewable energy consumption, economic growth, and FDI on carbon dioxide emission are given in Table 1, where column 1 shows the list of variables, column 2 presents the results of the OLS model, and columns 3, 4, and 5 show the results of fixed effect, two-step GMM difference, and two-step system GMM, respectively. The results indicate that the lagged value of carbon dioxide emission is highly significant which shows that both system and difference GMM models are suitable estimators. The results of the Sargan test and AR2 test of serial correlation also support the validity of instruments used in the model of the current study. For instance, the AR2 p value is 0.546 and the Sargan test p value in the system GMM is 0.013 which is above the significance level and confirms the validly of the study models and instruments.

The estimated coefficient of renewable energy consumption given in the table is highly significant at 1 percent level in all four econometric models while the sign is negative which illustrates that renewable energy consumption reduces carbon dioxide emission and it is beneficial for the quality of environment. More specifically, system GMM model results show that a percent increase in the consumption of renewable energy lowers carbon emission by 0.013 percent in the globe. The negative impact can be the reason due to substitutability of fossil fuels on renewable energy sources and reduction in former energy use. The results confirm that the use of renewable energy consumption instead of using energy from fossil fuels is beneficial for the quality of environment.

The results further validate the findings on the impact of renewable energy sources. Our findings are in favor of ecological modernization theory where it emphasizes on technological innovation for enhancing environmental quality and it also supports environment transition theory, clean development mechanism, and social choice theory. Bilgili et al. [27] also state that renewable energy enhances environment quality because its replaces conventional technologies which depend on nonrenewable energy from fossil fuels. The use of renewable energy does not burden the environment and sustainability as compared to conventional energy usage and it also ensures energy security. Alola et al. [20] have found that renewable energy consumption improves environmental quality. Likewise, our findings are in line with those of Sharif et al. [28] and Koengkan [29]; Jebli and Youssef [11]; Jebli et al. [30]; Jebli et al. [31]; Li and Su [32]; and Abolhosseini et al. [33] who have also found that renewable energy consumption reduces carbon emission significantly. Mert and Bölük [34] also found that renewable energy consumption reduces carbon emission in Kyoto countries, while our findings are opposing to those of Nicholas Apergis and Payne [14], Farhani and Shahbaz [35], Leitão [36], and Apergis and Payne [14] conducted in developing and developed countries and to the study of Jebli and Youssef [11] conducted on Tunisia which claims the increasing effect of renewable energy on carbon dioxide emission.

Likewise, foreign direct investment is significant high in models 1 and 2 and model 4 at 1 percent significant level while the relationship with carbon dioxide emission is negative which illustrates that the increase in foreign direct investment reduces carbon emission. For instance, the result of the system GMM indicates that if there is a percent increase in foreign direct investment, it will reduce carbon emission by 0.007 percent in the global panel. This may be due to the large number of FDI projects in the region by using the renewable energy sources in production. The countries might have facilitated those foreign investors who bring clean technologies to the countries which help protect the environment and also might have good polices for foreign direct investment projects which are beneficial for the quality of environment. However, Sarkodie et al. [19] have found that FDI increases greenhouse gas emission which may be due to the sample size of sub-Saharan African countries and might also have yet well-facilitated foreign investors to bring clean technologies for production. The studies of Jebli and Youssef [11] and Zhu et al. [10] have reinforced our findings while they are contradictory with the study of Zhou et al. [37]; Sarkodie and Strezov [38]; Sarkodie et al. [19]; and Peng et al. [39] who state the positive impact of FDI on CO_2 emissions. Additionally, Atici [40] states that FDI is good for pollution reduction in Asia. The coefficients of log GDP per capita are also statistically significant at 1 percent level and positive in all models, which indicates that increase in per capita GDP increases carbon emission. This result can be the reason that more necessities of economic growth can be the use of more energy from fossil for the goods production which leads to increase carbon emission. The results suggest that there are including developing countries in the panel which are facing challenges of environmental degradation as these countries are using

Table 1: The effects of renewable energy consumption, economic growth, and FDI on carbon dioxide emission.

Dependent variable Carbon emission	(OLS) Model 1	(FE) Model 2	(GMM) Model 3	(SGMM) Model 4
Renewable energy	−0.344***	−0.103***	−0.065***	−0.013***
	(0.015)	(0.012)	(0.008)	(0.002)
Foreign direct invest	−0.042***	0.017***	0.001	−0.007***
	(0.016)	(0.005)	(0.001)	(0.001)
L. GDP per capita	0.082***	0.011**	0.003***	0.010***
	(0.020)	(0.005)	(0.000)	(0.000)
Urban population	0.899***	0.980***	0.779***	0.031***
	(0.015)	(0.052)	(0.026)	(0.005)
Trade openness	−0.240***	−0.257***	−0.148***	−0.019**
	(0.072)	(0.057)	(0.022)	(0.009)
Govt. expenditure	0.236***	0.045	0.019***	−0.026***
	(0.054)	(0.027)	(0.006)	(0.005)
CDO_{it-1}			0.336***	0.960***
			(0.010)	(0.005)
Constant	−9.712***	−6.347***		−0.124*
	(0.334)	(0.721)		(0.072)
Observations	1,141	1,141	758	1,141
R-squared	0.926	0.575		
Number of id		147	133	147
AR(1)			−3.33 (0.014)	−0.167 (0.096)
AR(2)			826.07 (0.023)	−4.87 (0.015)
Sargan test			−0.60 (0.546)	883.65 (0.013)

Note. OLS is ordinary least square, FE, GMM, and SGMM are the fixed effect, generalized method of moments, and system generalized method of moments, respectively. The standard error is shown in parenthesis, and the significance level is shown by *, **, and *** at 1, 5, and 10%, respectively. AR1 and AR2 are the Arellano and Bond tests.

nonrenewable energy from fossil fuels to enhance economic activities which cause environmental degradation. The results regarding per capita GDP are in line with the findings of Katircioglu [41]; Acheampong [42]; Jebli et al. [30]; Menyah and Wolde-Rufael [3]; Lee and Brahmasrene [43]; De Vita et al. [44]; and Hourcade and Robinson [45] who have also found that the increase in per capita GDP drives carbon emission.

Similarly, the estimated coefficient of urban population is also highly statistically significant at 1 percent level and positive in all employed models which indicate that urban population affects carbon emission positively. The available literature also shows that an increase in population acts as a driver of carbon emissions. The results confirm that an increase in urban population increases emission because as the population increases, it needs to use more energy of fossil fuels to meet the requirements and can effect environmental quality. Increasing population is the problem these days in some countries which are included in the panel of our sample countries.

The coefficient of trade openness in all models is highly significant at 1 percent level, and the relationship with carbon emission in negative which indicates that if there is 1 percent increase in trade openness, it will reduce carbon emission by 0.019 percent in the global panel. The results suggest that more openness to trade in countries is beneficial to reduce carbon emission. The current results are in line with the findings of Jayanthakumaran et al. [13] and Dogan et al. [46]. The reason of the negative impact of openness to trade on carbon emission maybe the reason that there may not be high volume of trade for import export which may not use energy from fossil fuels for the purpose of production, transport, and other activities which may reduce emission. Similarly, the coefficients of government expenditure are also highly significant and positive which indicates that they affect carbon emission positively in the sample countries.

4.2. The Effects of Carbon Dioxide Emission, Economic Growth, and FDI on Renewable Energy Consumption. Results on the effect of carbon dioxide emission and foreign direct investment on renewable energy consumption are given in Table 1, where column 1 shows the list of variables, column 2 presents the results of OLS model, and columns 3, 4, and 5 show the results of the fixed effect, two-step difference GMM, and two-step system GMM, respectively. In the table, the lagged value of renewable energy consumption is highly statistically significant which shows that both the system and difference GMM models are suitable estimators. As mentioned in Section 4 that the Sargan test and AR2 insignificant p values give the validity of the models and instruments, the results of the Sargan test and AR2 are given in Table 2 which support the validity of the current study model instruments. For instance, the AR2 p value is 0.945 and the Sargan test p value is 1.000 which are above the significance level and confirm the validly of the study models.

The estimated coefficient of carbon dioxide emission is significant high, and its association with renewable energy consumption is negative in model, 1 model 2, and model 3 which indicates that carbon emission reduces the consumption of renewable energy. Khan et al. [17] have found the same result and state that carbon emission has a negative

Table 2: The effects of carbon dioxide emission and FDI on renewable energy consumption.

Dependent variable Renewable energy	(OLS) Model 1	(FE) Model 2	(GMM) Model 3	(SGMM) Model 4
Carbon emission	−0.829*** (0.037)	−0.623*** (0.044)	−0.346*** (0.000)	0.000*** (0.000)
Foreign direct investment	−0.078*** (0.024)	−0.029*** (0.007)	0.005*** (7.400)	0.006*** (1.710)
L. GDP(per capita)	−0.034 (0.030)	−0.025*** (0.007)	−0.013*** (4.211)	−0.010*** (2.751)
Urban population	0.689*** (0.043)	0.384*** (0.090)	0.306*** (0.005)	0.009*** (0.000)
Trade openness	−0.765*** (0.107)	0.340*** (0.086)	0.086*** (0.001)	0.003*** (0.000)
Govt. expenditure	0.111 (0.082)	0.089** (0.040)	0.0394*** (0.000)	0.021*** (0.000)
RE_{it-1}			0.550*** (0.001)	0.988*** (0.000)
Constant	−0.0505 (0.691)	0.759 (1.124)		−0.257*** (0.0027)
Observations	1,126	1,126	750	1,126
R-squared	0.502	0.251		
Number of id		143	131	143
AR(1)			−1.14 (0.255)	−1.15 (0.000)
AR(2)			−0.36 (0.722)	0.07 (0.945)
Sargan test			635.46 (0.738)	618.96 (1.000)

Note. OLS is ordinary least square, FE, GMM, and SGMM are the fixed effect, generalized method of moments, and system generalized method of moments, respectively. The standard error is shown in parenthesis, and the significance level is shown by *, **, and *** at 1, 5, and 10%, respectively. AR1 and AR2 are the Arellano and Bond tests.

impact on renewable energy while the results of model 4 indicate that carbon emission increases renewable energy consumption. Saidi and Hammami [47] and Hwang and Yoo [48] have found the same results to these findings while Tiwari [49] has found a long-run association between the two variables. On the other hand, Hossain [50] have found a unidirectional association between the variable, while Wu et al. [51] found a bidirectional relationship. Our findings are contradictory with the results of Bilan et al. [52] which he state that the negative impact maybe the less effective mechanisms and instruments in developing the implementation of renewable energy sources.

Likewise, the coefficient of foreign direct investment is highly statistically significant while the relationship is negative with renewable energy consumption in model 1 and model 2 and the result is highly significant and positive in model 3 and model 4. For instance the system GMM result in model 4 indicates that a percent increase in foreign direct investment inflow in the global panel will increase renewable energy consumption by 0.006 percent. The results further suggest that the inflow of FDI in the global panel is still lower than the desired level; however, high amount of foreign direct investment and projects will increase renewable energy consumption. Khan, khan, and Binah [17] have found the same results by showing that the inflow of FDI has a negative influence on renewable energy consumption.

Similarly, the coefficient of GDP per capita is highly significant at 1 percent level and negative in all models except model 1 which indicates that per capita GDP influences renewable energy consumption negatively in the global panel. The result of the system GMM indicates that a percent increase in GDP per capita will reduce renewable energy consumption by 0.010 percent in the global panel. Bilan et al. [52] also state that an increase in economic growth reduces renewable energy consumption which is in line with the current study's findings. Urban population, which is the control variable, is also highly significant at 1 percent level in all models, and the relationship with renewable energy is positive indicating that a percent increase in urban population will increase the consumption of renewable energy by 0.009 percent in the global panel. The coefficient of trade openness is also highly statistically significant and positive in the FE, GMM, and system GMM and negatively significant in the OLS model. The coefficient value in the system GMM indicates that a percent increase in trade openness will increase the consumption of renewable energy by 0.003 percent. The coefficient of government expenditure is highly statistically significant at 1 percent level and positive in all models except in model 1 which indicates that government expenditure affects renewable energy consumption positively. For instance, the system GMM results indicate that a percent increase in government expenditure will rise the consumption of renewable energy by 0.021 percent in the global panel.

4.3. The Effect of Carbon Dioxide Emission, Renewable Energy Consumption, and Economic Growth on Foreign Direct Investment. Results on the impact of carbon dioxide emission, renewable energy consumption, and economic growth on foreign direct investment is given in Table 3. Column 1 shows the list of variables, column 2 presents the

Table 3: The effect of carbon dioxide emission and renewable energy consumption on foreign direct investment.

Dependent variable Foreign direct investment	(OLS) Model 1	(FE) Model 2	(GMM) Model 3	(SGMM) Model 4
Carbon emission	−0.155*** (0.053)	0.669*** (0.187)	0.530*** (0.040)	−0.088*** (0.008)
Renewable energy	−0.115*** (0.033)	−0.167** (0.075)	−0.121*** (0.033)	−0.104*** (0.010)
L. GDP per capita	0.200*** (0.036)	0.156*** (0.031)	0.074*** (0.005)	0.084*** (0.003)
Urban population	−0.027 (0.054)	1.035*** (0.365)	0.005 (0.148)	0.011 (0.010)
Trade openness	0.389*** (0.131)	0.848** (0.349)	0.371*** (0.077)	−0.036 (0.040)
Govt. expenditure	−0.186* (0.097)	−0.251 (0.166)	−0.296*** (0.043)	−0.191*** (0.016)
FDI_{it-1}			0.139*** (0.006)	0.536*** (0.004)
Constant	−3.022*** (0.787)	−24.42*** (4.425)		−0.418** (0.172)
Observations R-squared	1,141 0.244	1,141 0.153	739	1,107
Number of id		147	131	147
AR(1)			−3.28 (0.001)	−3.58 (0.000)
AR(2)			0.65 (0.516)	1.09 (0.276)
Sargan test			778.47 (0.202)	818.86 (0.475)

Note. OLS is ordinary least square, FE, GMM, and SGMM are the fixed effect, generalized method of moments, and system generalized method of moments, respectively. The standard error is shown in parenthesis, and the significance level is shown by *, **, and *** at 1, 5, and 10%, respectively. AR1 and AR2 are the Arellano and Bond tests.

results of the OLS model, and columns 3, 4, and 5 show the results of the fixed effect, two-step GMM difference, and two-step system GMM, respectively. In the table, the lagged dependent variable is highly statistically significant which shows that both the system and difference GMM models are suitable estimators. The results of the Sargan test and AR2 test of serial correlation are given in the Table 3 supporting the validity of the current study model instruments.

The estimated coefficient of carbon emission is highly statistically significant and negative in the OLS and system GMM which indicates that an increase in carbon emission increases the flow of foreign direct investment, while for instance, the system GMM results indicate that a percent increase in carbon emission will reduce FDI inflow by 0.08 percent; however, the FE and GMM models results show the positive association of carbon emission with FDI inflow which indicates that an increase in carbon emission increases FDI. The current results are similar to the findings of Kılıçarslan and Dumrul [53] and Cao et al. [54] who also state that CO_2 emission and FDI have a positive relationship.

Similarly, the estimated coefficient of renewable energy is highly statistically significant at 1 percent level in all models, and the relationship with FDI is negative in the OLS and system GMM while positive in the FE and GMM. The system GMM result indicates that renewable energy consumption affects FDI significantly but negatively. More specifically, the result of the system GMM indicates that a percent increase in renewable energy consumption will reduce FDI by 0.088 percent in the global countries. Our findings are further reinforced by the studies of Marton and Hagert [55] who have also revealed the negative association between the variables.

Moreover, the coefficients of log GDP per capita are also highly statistically significant at 1 percent level and positive in all employed models which indicates that per capita GDP affects carbon emission positively. For instance, the system GMM result shows that a 1 percent increase in per capita GDP will increase FDI by 0.084 percent. The coefficient of trade openness is also highly significant in the OLS, FE, and DGMM which indicates that trade openness affects FDI significantly but positively. For instance, the difference GMM result indicates that a unit increase in trade openness will increase FDI by 0.371 percent in the globe. Government expenditure is significant and negative in the OLS, DGMM, and SGMM models which indicates that government expenditure effects FDI negative significantly. More specifically, the system GMM result indicates that a 1 percent increase in government expenditure will decrease FDI by 0.0.191 percent in the global panel.

4.4. The Effect of Carbon Dioxide Emission and Renewable Energy Consumption and Foreign Direct Investment on Economic Growth. Results on the impact of carbon dioxide emission, renewable energy consumption, and foreign direct investment on economic growth are given in Table 4. The results of the OLS, fixed effect, two-step GMM difference, and two-step system GMM are given in columns 2, 3,4, and 5, respectively. In Table 4, the lagged dependent variable is highly statistically significant which shows that both the system and difference GMM models are suitable estimators. The results of the Sargan test and AR2 test of serial correlation are given in the Table 4 which support the validity of

the current study's model instruments. The impact of carbon emission on economic growth results in all models is highly significant at 1 percent level and positive which indicates that carbon emission significantly increases economic growth. For instance, the results of the system GMM indicate that a percent increase in carbon emission will increase economic growth by 0.026 percent. The results of our study regarding the positive significant impact of carbon emission on economic growth are similar to the findings of Rahman et al. [56] who also show the positive impact of carbon emission in economic growth. The estimated coefficient of renewable energy consumption is also highly significant at 1 percent, while its impact on economic growth is negative which indicates that RE significantly decreases economic growth in the panel. Rahman et al. [56] have also found that renewable energy consumption has an negative impact on economic growth in Pakistan. Most of countries are trying to increase their economic activities by using nonrenewable energy from fossil fuels but nonrenewable energy degrades environmental quality while some countries have not yet reached to the desired level to use the renewable energy sources for production and so it is still needed to improve renewable energy consumption and enhance economic growth as well. The coefficient of FDI is also highly significant at 1 percent and positive which indicates that FDI positively affects growth and an increase in the inflow of FDI will enhance economic growth. For instance, the system GMM results show that a percent increase in FDI inflow will push upward economic growth by 0.063 percent. It is commonly agreed that FDI inflow helps increase the level of economic growth of any country. It is believed that the inflow of foreign direct investment is beneficial for economic growth while Gokmenoglu et al. [57] and Abdalla Sirag Khartoum, Sudan, and Hamisu Sadi Ali [58] have also found that FDI positively affects economic growth. In Table 4, the estimated coefficient of urban population is highly significant while the relationship with economic growth is negative which indicates that an increase in urban population reduces economic growth in the panel.

More specifically, the results of the system GMM indicate that a percent rise in urban population will decrease economic growth by 0.003 percent. Similarly, the estimated coefficient of trade openness is also highly significant in all models and positive indicates that trade openness significantly increases economic growth. On the other side, the estimated coefficient of government expenditure is highly significant in all models but negative which indicates that an increase in government expenditure significantly reduces economic growth in the global panel countries.

4.5. System GMM Results on the Relationship of Renewable Energy, Carbon Emission, and Foreign Direct Investment on Each Other. The system GMM results for all the independent variables FDI, carbon emission, economic growth, and renewable energy consumption impacts on each other are shown in Table 5, where column 1 represents the list of variables and column 2 to 4 show the dependent variables, where RE_{it-1}, CDO_{it-1}, $FDI_{it-1,}$ and EC_{it-1}, are the lag of dependent variables which are highly statistically significant at 1 percent significance level which shows that all these dependent variables in the anterior year is associated significantly and positively to the present year.

In Table 5, carbon emission has a positive and significant effect on renewable energy consumption and a negative significant impact on foreign direct investment. The findings indicate that an increase in carbon emission increases renewable energy consumption while it reduces FDI inflow. Likewise, the estimated coefficient given in the table of renewable energy consumption is significant at 1 percent and its impact of CO2 emission and FDI is negative which shows that renewable energy consumption reduces emission and the inflow of FDI significantly. Abolhosseini et al. [33] have also found the same results and state that renewable energy significantly reduces the rate of carbon emission where Marton and Hagert [55] also argue that FDI has a correlation with renewable energy negatively. Foreign direct investment is also significant and positive on renewable energy consumption while negative significant for carbon emission which means that a rise in FDI increases renewable energy and decreases carbon dioxide emission in the global panel. Marton and Hagert [55] have found the negative association between FDI and renewable energy while POLAT [59] states that FDI and renewable energy are associated.

Lastly, the coefficient of merchandise trade is statistically significant and positive for all dependent variables and negative significant for foreign direct investment which indicates that an increase in merchandise trade increases carbon dioxide emission and renewable energy consumption and reduces foreign direct investment inflow. Moreover, other control variables such as per capita GDP are also highly significant at 1 percent level for all dependent variables; however, the sign is negative for renewable energy which means that an increase in GDP per capita decreases the consumption of renewable energy and increases carbon emission and foreign direct investment. The estimated coefficient of urban population is also highly statistically significant at 1 percent level for all dependent variables where the sign is positive for renewable energy, carbon emission, and foreign direct investment which means that an increase in urban population increases the consumption of renewable energy, carbon emission, and foreign direct investment. Likewise, the coefficient of trade openness is significant high at 1 percent level, and the relationship is positive with renewable energy which indicates that an increase in trade openness increases renewable energy consumption; however, the relationship of trade openness is negative with other dependent variables which indicates that an increase in trade openness lowers carbon emission in the global panel. On the other hand, the coefficient of trade openness is insignificant with foreign direct investment which indicates that trade openness does not matter for FDI inflow. Similarly, government expenditure is significant at 1 percent level, and the relationship with renewable energy is positive which indicates that an increase in government expenditure increases the consumption of

Table 4: The effect of carbon dioxide emission, renewable energy consumption, and foreign direct investment on economic growth.

Dependent variable Economic growth	(OLS) Model 1	(FE) Model 2	(GMM) Model 3	(SGMM) Model 4
Carbon emission	0.071**	0.283**	0.254***	0.026***
	(0.027)	(0.129)	(0.065)	(0.000)
Renewable energy	−0.010	−0.158***	−0.133***	−0.029***
	(0.021)	(0.060)	(0.019)	(8.190)
Foreign direct investment	0.131***	0.123***	0.0721***	0.063***
	(0.018)	(0.022)	(0.005)	(1.280)
Urban population	−0.096***	−0.461**	−1.376***	−0.003***
	(0.034)	(0.218)	(0.143)	(0.000)
Trade openness	0.000**	0.000	0.003***	0.000***
	(0.000)	(0.001)	(0.000)	(3.340)
Govt. expenditure	−0.401***	−0.259**	−0.193***	−0.364***
	(0.061)	(0.115)	(0.062)	(7.25−)
$GDPPC_{it-1}$			−0.03***	0.215***
			(0.005)	(1.810)
Constant	2.226***	6.011**		1.123***
	(0.342)	(2.601)		(0.002)
Observations	1,586	1,586	879	1,342
R-squared	0.078	0.039		
Number of id		156	134	156
Sargan test			1054.31 (0.10)	1053.1 (0.1001)
AR1			−3.99 (0.00)	−4.29 (0.00)
AR2			−0.28 (0.78)	0.07 (0.28)

Note. OLS is ordinary least square, FE, GMM, and SGMM are the fixed effect, generalized method of moments, and system generalized method of moments, respectively. The standard error shown in parenthesis, and the significance level is shown by *, **, and *** at 1, 5, and 10%, respectively. AR1 and AR2 are the Arellano and Bond tests.

Table 5: System GMM results of all regressions (RE, CO2, FDI, and economic growth).

Variables	Renewable energy	Carbon emission	Foreign direct investment	Economic growth
Carbon emission	0.000***		−0.088***	−0.029***
	(0.000)		(0.008)	(8.190)
Renewable energy		−0.0134***	−0.104***	0.026***
		(0.00215)	(0.010)	(0.000)
Foreign direct invest	0.006***	−0.00722***		0.063***
	(1.710)	(0.00103)		(1.280)
L. GDP per capita	−0.010***	0.0102***	0.084***	
	(2.751)	(0.000855)	(0.003)	
Urban population	0.009***	−0.0197**	0.011	−0.003***
	(0.000)	(0.00953)	(0.010)	(0.000)
Trade openness	0.003***	−0.0264***	−0.036	0.000***
	(0.000)	(0.00553)	(0.040)	(3.340)
Govt. expenditure	0.021***		−0.191***	−0.364***
	(0.000)		(0.016)	(7.25−)
RE_{it-1}	0.988***			1.123***
	(0.0001)			(0.002)
CDO_{it-1}		0.960***		1,342
		(0.00531)		156
FDI_{it-1}			0.536***	
			(0.004)	
$GDPPC_{it-1}$				0.215***
				(1.810)

The standard error is shown in parenthesis, and the significance level is shown by *, **, and *** at 1, 5, and 10%, respectively.

renewable energy. For carbon emission, the government expenditure coefficient is negative and highly significant which indicates that government expenditure lowers the level of carbon emission and tourism. The last column of Table 5 shows that carbon emission and foreign direct investment highly significantly and positively affect economic growth which indicates that an increase in carbon emission and FDI enhances economic growth while

renewable energy consumption negatively affects economic growth. Other control variables urban population and government expenditure negatively influence economic growth, while trade openness increases economic growth in the global panel.

5. Conclusions and Policy Implication

The current study is composed of the dynamic impact of carbon emission, renewable energy consumption, and FDI on each other for the sample data on 190 countries. The variables' data have been gathered from WDI (world development indicator) for the time period from 1980 to 2018. Both static and dynamic models have been employed for the examination of this association. The findings basically focus on the two-step system GMM which indicates that carbon emission influences renewable energy positively and negatively affects FDI inflow which indicates that carbon emission brings increase in renewable energy and reduces the inflow of FDI. The results on the impact of RE on carbon emission are negative which evidence that renewable energy consumption reduces carbon emission and it is beneficial for environmental quality. The impact of RE on FDI is also negative which shows that it effects FDI negatively in the global panel. The impact of merchandise trade also effects all dependent variables significantly and positively and negatively significantly influences FDI which shows that an increase in merchandise trade increases carbon emission and renewable energy consumption; however; it reduces the inflow of FDI in the global panel. Likewise, per capita GDP, which is a control variable, is also significantly high at 1 percent level of all the study dependent variables and the sign is negative for renewable energy consumption which illustrates that per capita GDP reduces the consumption of energy and increases the level of FDI and carbon emission. Urban population is also significantly high at 1 percent level of all the target-dependent variables and the sign for renewable energy; FDI; and carbon emission is positive which evidence that urban population brings an increase in carbon emission, FDI, and renewable energy consumption. Likewise, the coefficient of trade openness is also significantly high which indicates that an increase in openness to trade increases the use of renewable energy consumption, while on the other hand, it decreases the rate of carbon emission in the panel while for FDI inflow, we have no evidence of any impact. The impact of government expenditure on renewable energy consumption is positive and significant which shows that it helps in increasing the usage of renewable energy consumption, while it has been found that it decreases carbon emission in the panel. Lastly, the impact of FDI and carbon emission on economic growth has been found to be positive, while the impact of renewable energy consumption has been found to be negative which indicates that RE decreases economic growth.

The findings of this study are very important and have significant policy implication for the countries to encourage the use of renewable energy instead of using fossil fuels energy which can be a major driver to enhance the environment quality as renewable energy in the study shows that it reduces emission. Similarly, policies-related FDI has been suggested by our findings, and improvement of infrastructure is also suggested which significantly contributes to quality of environment. The study is limited to variables used, and further researchers should consider other regions and use different methods and variables to efficiently investigate the interrelationship of such variables [38].

Data Availability

The data used in this paper are available on the World Bank Database, world development indicator.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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