Green Energy and Economic Growth Influence on Reducing Environmental Degradation: Empirical Evidences from China

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ABSTRACT

Recently, environmental degradation has gained global attention due to the high carbon (CO_2) emission and needs the researchers and regulators to focus control this global issue. Thus, the current article investigates the impact of green energy and economic growth on environmental degradation in China. The data was extracted from a secondary source like world development indicators (WDI) from 1981 to 2018. The present article has also used the "Augmented Dickey-Fuller" (ADF) test to examine the stationarity and the "Autoregressive Distributed Lag" (ARDL) model to explore the linkage among variables. The results indicated that green energy negatively correlates with environmental degradation and economic growth, and inflation is positively linked with China's environmental degradation. This study guides the relevant authorities to control ecological degradation using green energy.

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1.   Introduction

China has produced high CO_2 emissions and is a significant country among the top CO_2 emission-producing nations around the globe (Chien, Kamran, et al., 2021; Jiang, Wang, & Li, 2018). In addition, China is at the top in producing CO_2 emissions and contributes 28 percent to the total CO_2 emission produced by all the nations around the globe. China is producing about 10.06GT CO_2 emission while the United States (US) at the second number and producing 5.41GT CO_2 emission that is almost half than China having CO_2 emission. CO_2 emission is the primary cause of environmental degradation that enhances global warming. In addition, global warming creates significant issues in the deterioration of the environment nowadays (Bakhtyar, 2017; Chien, Kamran, et al., 2021; Zhou, Zhang, Zhou, & Zhou, 2017).

There are many causes to enhance the CO_2 emission in the country, but energy consumption is considered the largest source of CO_2 emission nowadays. China has also worked to reduce CO_2 emissions by developing significant policies to lower CO_2 emissions. They focus on the energy-related CO_2 emission caused by the high economic growth and economic activities (Shittu, Hassan, & Nawaz, 2018; Xie, Yu, Wang, & Liu, 2017). Due to the high economic activities in the country, the energy consumption is at the peak that produces elevated CO_2 emission and is considered the most significant source of CO_2 emission in China (Chien, Pantamee, et al., 2021; Yao, Zhou, Zhang, & Li, 2015; Zhuang et al., 2021). Figure 1 below shows the high CO_2 emission-producing countries, and China is at the top of the list.
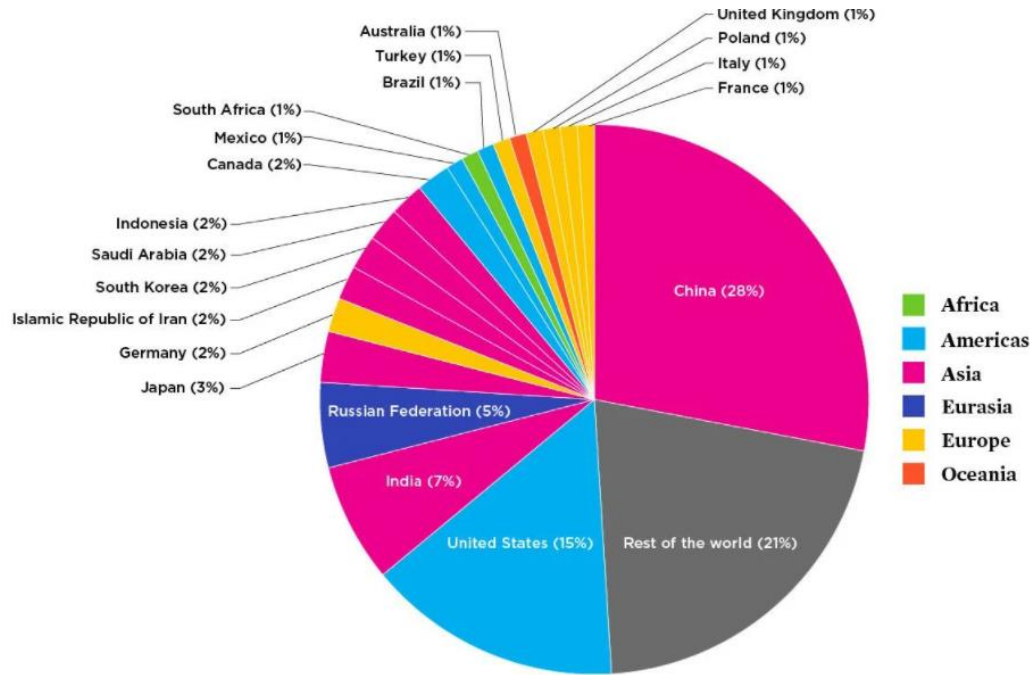
Figure 1: High CO2 Emission Producing Countries

Thus, it is necessary to examine the significant source of CO2 emission to reduce the environmental degradation in the country. So, the present study investigates the impact of green energy and economic growth on environmental degradation concerning CO2 emission in China. The second part of the article provides the literature related to the understudy constructs, while the third section of the present paper provides the methods adopted to conduct the analysis. In addition, the fourth part of the study shows the research findings using statistical tools. The last part of the study provides the discussions in which current study findings match with the past study's outcomes and show the study implications and limitations.

2.   Literature Review

This section provides the literature regarding the association among understudy variables. The current study has used green energy and economic growth to measure CO2 emission. In addition, inflation is also used as the control variable to predict CO2 emission. Thus, the section provides the literature related to green energy and CO2 emission, economic growth and CO2 emission, and inflation and CO2 emission.

Green energy is considered the significant factor that reduces energy-related CO2 emissions and reduces environmental degradation (Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021; Nawaz et al., 2021; Shair, Shaorong, Kamran, Hussain, Nawaz, et al., 2021). Most of the studies provide the negative association among the green energy and CO2 emission such as a study of T. Jiang et al. (2018), who conducted the study of top Asian economies using data from 1990 to 2017 and exposed that the usage of green energy can reduce the CO2 emission and also reduce the environmental degradation. In addition, a study by Wu, Peng, and Lin (2017) investigated the renewable energy (RE) impact on environmental degradation using data from China and exposed that the RE reduces CO2 emission, especially energy-related CO2 emission, and improves the environment. Moreover, Wang, Ge, Liu, and Ding (2016) also researched the RE role in reducing CO2 emission using the data from China and investigated that RE consumption improves the economy's growth and reduces the CO2 emission, and mitigates environmental degradation.

Economic growth requires high economic activities that use high energy, produce high CO2 emissions, and affect the environment (Shair, Shaorong, Kamran, Hussain, &

Nawaz, 2021; Sun et al., 2020). Most past studies explore the positive linkage between economic growth and CO2 emission, as Esso and Keho (2016) examined the nexus between economic growth and CO2 emission using data from African countries. It revealed that high economic growth leads to increased economic activities that use high energy, produce high CO2 emissions, and affect the environment. In addition, the study conducted by Zhao, Zhang, Li, Shao, and Geng (2017) on the nexus of economic growth and CO2 emission using China country and exposed that the economic activities always use high energy that becomes a significant cause of high CO2 emission in the country and environmental deterioration. Moreover, Lu (2018) also investigated the economic activities' influence on the CO2 emission using 12 Asian counties and revealed that high economic activities always generate high CO emission due to extensive use of energy and leads the countries towards environmental degradation. Inflation also enhances economic activities to gain extra margins that use high power, produce high CO2 emissions, and affect the environment.

Most of the past studies explore the positive linkage between inflation and CO2 emission such as McHenry (2012) examined the nexus between inflation and CO2 emission and revealed that inflation leads to high economic activities that use high energy and produce high CO2 emission and affect the environment. In addition, a study by González (2015) also examined the nexus of inflation and CO2 emission and exposed that inflation creates economic activities that always use high energy that become a significant cause of high CO2 emission in the country and environmental deterioration.

3. Research Methods

The article investigates the impact of green energy and economic growth on environmental degradation in China. The data was extracted from a secondary source like WDI from 1981 to 2018. The study equation is given below:

$$CO2_t = \alpha_0 + \beta_1 REP_t + \beta_2 REC_t + \beta_3 EG_t + \beta_4 INF_t + e_t \tag{1}$$

Where;
CO2 = Carbon Emission
t = Time Period
REP = Renewable Energy Production
REC = Renewable Energy Consumption
EG = Economic Growth
INF = Inflation

The current study has taken environmental degradation as the predictive variable and measured it as the "carbon dioxide damage (% of GNI)." In addition, green energy and economic growth have been used to predict the study. Green energy is measured as the REP and REC, while economic growth is measured as the "GDP growth (annual percentage)". Finally, the current study has also taken inflation as the control variable in the study. The results section shows the stationarity of the constructs examined using the ADF test. The stationarity of the variable is necessary to select the appropriate model. The ADF equation is given as under:

$$d(Y_t) = \alpha_0 + \beta t + YY_{t-1} + d(Y_t(-1)) + \varepsilon_t \tag{2}$$

In addition, if the ADF results show all the variables are stationary at a level, then pooled OLS is the appropriate model. Still, if some constructs are stationarity at the level and some variables are stationary at the first difference, then the ARDL model is suitable. Thus, stationarity has been examined individually, and the equations are mentioned below:

CO2 Emission

$$d(CO2_t) = \alpha_0 + \beta t + YCO2_{t-1} + d(CO2_t(-1)) + \varepsilon_t \tag{3}$$

Renewable Energy Production

$$d(REP_t) = \alpha_0 + \beta t + YREP_{t-1} + d(REP_t(-1)) + \varepsilon_t \tag{4}$$

Renewable Energy Consumption

$$d(REC_t) = \alpha_0 + \beta t + YREC_{t-1} + d(REC_t(-1)) + \varepsilon_t \tag{5}$$

Economic Growth

$$d(EG_t) = \alpha_0 + \beta t + YEG_{t-1} + d(EG_t(-1)) + \varepsilon_t \tag{6}$$

Inflation

$$d(INF_t) = \alpha_0 + \beta t + YINF_{t-1} + d(INF_t(-1)) + \varepsilon_t \tag{7}$$

The ARDL model is suitable because the ADF test exposed some constructs as stationary at 1(0), and some variables are stationary at 1(1). In addition, ARDL is also considered a suitable model when the authors used small samples, as in the present article, authors have used 38 observations. Finally, the ARDL model provides the short and long-run linkage among variables. The ARDL model equation has been given as under:

$$\Delta CO2_t = \alpha_0 + \sum\delta_1\Delta CO2_{t-1} + \sum\delta_2\Delta REP_{t-1} + \sum\delta_3\Delta REC_{t-1} + \sum\delta_4\Delta EG_{t-1} + \sum\delta_5\Delta INF_{t-1} + \varphi_1 CO2_{t-1} + \varphi_2 REP_{t-1} + \varphi_3 REC_{t-1} + \varphi_4 EG_{t-1} + \varphi_5 INF_{t-1} + \varepsilon_1 \tag{8}$$

4. Results and Discussions

Firstly, the current study findings have been run the correlation matrix that shows the directional association but ignored the significance of the association. The statistics have exposed that REP and REC have a negative association while economic growth and inflation are positively associated with CO2 emission. Table 1 shows the correlation matrix results of the article.

Table 1
Matrix of correlations

Variables	CO2	REP	REC	EG	INF
CO2	1.000				
REP	-0.533	1.000			
REC	-0.432	0.382	1.000		
EG	0.449	0.463	0.453	1.000	
INF	0.398	0.292	0.653	0.622	1.000

The article results also show the ADF test for the stationarity, and the results exposed that CO2 emission and EG are stationary at a level. At the same time, REP, RC, and inflation are stationary at first differences. Table 2 shows the ADF results of the article.

Table 2
Unit Root Test

Augmented Dickey-Fuller Test (ADF)	Level	t-statistics	p-values
CO2	I(0)	-3.928	0.012
REP	I(1)	-4.645	0.000
REC	I(1)	-5.983	0.000
EG	I(0)	-6.653	0.000
INF	I(1)	-3.873	0.015

Table 3
ARDL Bound Test

Model	F-statistics	Lag	Level of Significance	Bound test critical values	
				I(0)	I(1)
CO2/(REP,REC,EG,INF)	6.34	4	1%	6.73	6.99
			5%	5.17	5.77
			10%	4.76	4.87

In addition, the results section also shows the ARDL bound test to examine the co-integration that is necessary for the application of the ARDL model. The statistics exposed that the calculated f-statistics (6.34) are larger than the critical values at a ten and five percent significance level. Thus, the statistics revealed that co-integration exists, and the ARDL model can be executed. Table 3 shows these findings.

The results of the ARDL model indicated that green energy has a negative linkage with environmental degradation, and economic growth and inflation have a positive linkage with environmental degradation in China in the short run. Table 4 shows the short-run association among the nexus using the ARDL model.

Table 4
Short Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(REP)	-0.653493	0.156453	-4.176929	0.0010
D(REC)	-0.873625	0.145635	-5.998729	0.0000
D(EG)	1.198272	0.165442	7.242852	0.0000
D(INF)	1.456320	0.276352	5.269801	0.0000
CointEq(-1)*	-1.297353	0.153421	-8.456163	0.0000
R-squared	0.543281	Mean dependent var		-0.039832
Adjusted R-squared	0.539827	SD dependent var		2.234532

The results of the ARDL model also indicated that green energy has a negative linkage with environmental degradation and economic growth, and inflation has a positive linkage with environmental degradation in China in the long run. Table 5 shows the long-run association among the nexus using the ARDL model.

Table 5
Long Term Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REP	-1.277353	0.329282	-3.879069	0.0012
REC	-3.986532	1.058373	-3.766661	0.0015
EG	3.524272	0.757523	4.652363	0.0002
INF	2.872422	0.934627	3.073335	0.0215
C	0.972362	0.187463	5.186954	0.0000

The findings revealed that REP has a negative linkage with the CO_2 emission or environmental degradation that shows REP reduces the country's carbon emission. This outcome is matched with Long, Naminse, Du, and Zhuang (2015), who also investigated that the high REP is the significant element to reduce the CO_2 emission in the country. In addition, the outcomes of the present article exposed that REC also has a negative linkage with CO_2 emission and proved as the significant element to reduce environmental degradation due to CO_2 emission. This output is also similar to the results of Dogan and Seker (2016), who also examined that the high REC is the significant element to reduce the CO_2 emission in the country. However, the current article outcomes also investigated that economic growth has a positive linkage with the high CO_2 emission in the country that increases environmental degradation.

This finding is in line with the outcomes of Khan et al. (2018), who also investigated that high economic growth requires high consumption of energy and fuel that create CO_2 emission and affect the environment. Finally, the results of this article also examined that inflation also has a positive linkage with environmental degradation. This output is also supported by the outcomes of McHenry (2012), who also exposed that inflation motives the producers to generate large-scale production to reduce their cost that increases the CO_2 emission, and enhances environmental degradation.

The current article has theoretical implications in that it contributes to the literature on green energy and environmental degradation concerning CO_2 emission. In addition, the present study has also contributed to the literature on economic growth and environmental degradation. Moreover, it is also one of the first attempts that green energy, economic development, and inflation have been sued to predict environmental degradation to CO_2 emission and significant contribution ion the existing literature. In addition, the current

study also has practical implications, such as the present study guides the relevant authorities to control the environmental degradation using green energy. Moreover, the present article also provides help to the new researchers to examine this area in the future and guide the policymakers while establishing policies regarding green energy to control environmental degradation.

5.   Limitations and Future Directions

The current article has limitations that direct the upcoming researchers while investigating this area. The present study has taken only two predictors, such as green energy and economic growth, ignored the other factors, and suggested that the upcoming studies focus on other factors that affect the environment. In addition, the current research has taken only China under consideration and ignored other economies that also produce high CO_2 emissions and recommended that future studies include those countries in their analysis. Finally, the current article has used the ARDL model to test the association between the constructs and suggested that future researchers execute other statistical techniques to examine the association among variables.

References

Bakhtyar, B. (2017). A review on carbon emissions in Malaysian cement industry. *International Journal of Energy Economics, 7*(3), 282-286.

Chien, F., Kamran, H. W., Nawaz, M. A., Thach, N. N., Long, P. D., & Baloch, Z. A. (2021). Assessing the prioritization of barriers toward green innovation: small and medium enterprises Nexus. *Environment, Development and Sustainability*, 1-31. doi:https://doi.org/10.1007/s10668-021-01513-x

Chien, F., Pantamee, A. A., Hussain, M. S., Chupradit, S., Nawaz, M. A., & Mohsin, M. (2021). Nexus between financial innovation and bankruptcy: evidence from information, communication and technology (ict) sector. *The Singapore Economic Review*, 1-22. doi:https://doi.org/10.1142/S0217590821500181

Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews, 60*, 1074-1085.

Esso, L. J., & Keho, Y. (2016). Energy consumption, economic growth and carbon emissions: Cointegration and causality evidence from selected African countries. *Energy, 114*, 492-497.

González, M. B. (2015). *Implementing a carbon tax in Spain: how to overcome the fear of inflation.* Paper presented at the Third Annual Conference Fiscal Policies and the Green Economy Transition: Generating Knowledge Creating Impact.

Jiang, T., Deng, H., Bai, L., Zhang, R., Li, X., & Chen, H. (2018). Optimal energy flow and nodal energy pricing in carbon emission-embedded integrated energy systems. *CSEE Journal of Power and Energy Systems, 4*(2), 179-187.

Jiang, X.-t., Wang, Q., & Li, R. (2018). Investigating factors affecting carbon emission in China and the USA: A perspective of stratified heterogeneity. *Journal of Cleaner Production, 199*, 85-92.

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Qianli, D. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*, 588-599.

Long, X., Naminse, E. Y., Du, J., & Zhuang, J. (2015). Nonrenewable energy, renewable energy, carbon dioxide emissions and economic growth in China from 1952 to 2012. *Renewable and Sustainable Energy Reviews, 52*, 680-688.

Lu, W.-C. (2018). The impacts of information and communication technology, energy consumption, financial development, and economic growth on carbon dioxide emissions in 12 Asian countries. *Mitigation and Adaptation Strategies for Global Change, 23*(8), 1351-1365.

McHenry, M. P. (2012). Are small-scale grid-connected photovoltaic systems a cost-effective policy for lowering electricity bills and reducing carbon emissions? A technical, economic, and carbon emission analysis. *Energy Policy, 45*, 64-72.

Mohsin, M., Kamran, H. W., Nawaz, M. A., Hussain, M. S., & Dahri, A. S. (2021). Assessing the impact of transition from nonrenewable to renewable energy consumption on economic growth-environmental nexus from developing Asian economies. *Journal of*

        Environmental   Management,   284.
doi:https://doi.org/10.1016/j.jenvman.2021.111999

Nawaz, M. A., Seshadri, U., Kumar, P., Aqdas, R., Patwary, A. K., & Riaz, M. (2021). Nexus between green finance and climate change mitigation in N-11 and BRICS countries: empirical estimation through difference in differences (DID) approach. *Environmental Science and Pollution Research, 28*(6), 6504-6519. doi:https://doi.org/10.1007/s11356-020-10920-y

Shair, F., Shaorong, S., Kamran, H. W., Hussain, M. S., & Nawaz, M. A. (2021). Assessing the efficiency and total factor productivity growth of the banking industry: do environmental concerns matters? *Environmental Science and Pollution Research, 28*(16), 20822-20838.

Shair, F., Shaorong, S., Kamran, H. W., Hussain, M. S., Nawaz, M. A., & Nguyen, V. C. (2021). Assessing the efficiency and total factor productivity growth of the banking industry: do environmental concerns matters? *Environmental Science and Pollution Research, 28*(16), 20822-20838. doi:https://doi.org/10.1007/s11356-020-11938-y

Shittu, W. O., Hassan, S., & Nawaz, M. A. (2018). The nexus between external debt, corruption and economic growth: evidence from five SSA countries. *African Journal of Economic and Management Studies, 9*(3), 319-334.

Sun, H., Awan, R. U., Nawaz, M. A., Mohsin, M., Rasheed, A. K., & Iqbal, N. (2020). Assessing the socio-economic viability of solar commercialization and electrification in south Asian countries. *Environment, Development and Sustainability*, 1-23. doi:https://doi.org/10.1007/s10668-020-01038-9

Wang, Y., Ge, X.-l., Liu, J.-l., & Ding, Z. (2016). Study and analysis of energy consumption and energy-related carbon emission of industrial in Tianjin, China. *Energy Strategy Reviews, 10*, 18-28.

Wu, X., Peng, B., & Lin, B. (2017). A dynamic life cycle carbon emission assessment on green and non-green buildings in China. *Energy and Buildings, 149*, 272-281.

Xie, H., Yu, Y., Wang, W., & Liu, Y. (2017). The substitutability of non-fossil energy, potential carbon emission reduction and energy shadow prices in China. *Energy Policy, 107*, 63-71.

Yao, X., Zhou, H., Zhang, A., & Li, A. (2015). Regional energy efficiency, carbon emission performance and technology gaps in China: A meta-frontier non-radial directional distance function analysis. *Energy Policy, 84*, 142-154.

Zhao, X., Zhang, X., Li, N., Shao, S., & Geng, Y. (2017). Decoupling economic growth from carbon dioxide emissions in China: a sectoral factor decomposition analysis. *Journal of Cleaner Production, 142*, 3500-3516.

Zhou, X., Zhang, M., Zhou, M., & Zhou, M. (2017). A comparative study on decoupling relationship and influence factors between China's regional economic development and industrial energy–related carbon emissions. *Journal of Cleaner Production, 142*, 783-800.

Zhuang, Y., Yang, S., Chupradit, S., Nawaz, M. A., Xiong, R., & Koksal, C. (2021). A nexus between macroeconomic dynamics and trade openness: moderating role of institutional quality. *Business Process Management Journal, 27*(6), 1703-1719. doi:https://doi.org/10.1108/BPMJ-12-2020-0594