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Is China's financing for climate change prevention ensure green environment? Evaluating the role of higher education

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ABSTRACT

Over the last few years, China has maintained rapid economic growth globally. China has initiated various investments and improved higher education to tackle climate change issues and ensure a green environment. This study examines the influence of economic growth, higher education graduates, household consumption expenditures, industrial pollution prevention investment, and energy industry investment. Covering the period from 2000 to 2017, this study investigated a panel of 30 Chinese provinces. The data under study follows an irregular pattern, and all the variables are cointegrated; therefore, this study employed the novel method of moment quantile regression. Empirical findings suggest that economic growth and investment in the energy industry are the significant contributors to carbon emission in all the quantiles $Q_{0.25}$, $Q_{0.50}$, and $Q_{0.75}$. However, higher education graduates, household consumption expenditures, and investment in industrial pollution prevention negatively and significantly affect carbon emissions and promote environmental sustainability. The Granger causality test reveals a bidirectional causal association between carbon emissions and the explanatory variables. Based on the empirical findings, this study suggests investment in environmental recovery plans, adopting renewable energy sources, improving the level of higher education by more investments for higher education graduates, environmental education, and increased investment in pollution prevention industries.

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1. Introduction

Fossil fuels largely cause carbon dioxide (CO2) emissions. The energy sector's development of green and low-carbon trends is essential to meet CO_2 emission mitigation obligations, given the global low-carbon development trend and rising energy resources demand (Doğan et al., 2021; Umar et al., 2021). As per the International Energy Agency (IEA), global energy utilisation climbed by 2.3 percent in 2018, nearly double

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the average growth rate since 2010, whereas energy-related CO_2 emissions increased by 1.7 percent to 3.31 billion tons of CO_2, the highest level since 2010. This is accounted for the fastest rate of increase since 2013, and it was 70 percent faster than the 2010 average rate (IEA, 2019). The total CO_2 emissions in China were high, and they have increased at a rapid speed since 1990. As a result, China overtook the United States as the world's greatest CO_2 emitter in 2007, putting more pressure on international emissions reduction efforts in China (Li & Li, 2020). As a civilised developing economy, China willingly accepts responsibility for decreasing greenhouse gas (GHG) emissions and effectively contributes to the world's CO_2 emission management and regulation. The Chinese government has committed to reduce carbon output by 40–45 percent from 2005 levels by 2020, as well as to incorporate conservation of energy and reduction in emissions into the country's medium to longer developmental plans, demonstrating China's confidence and resilience in fighting global warming as a responsible great power (Liu et al., 2019; McCarthy, 2014).

The power (energy) industry is a major source of GHG emissions, and energy investment is critical to low-carbon development in China's energy industry (Paramati et al., 2022; Shahzad et al., 2022). By directing, managing, and accumulating social capital further into domains of cleaner or greener production and low carbon technologies, energy investment may successfully break through the energy industry's high carbon "lock-in" position (Lin & Yang, 2014; Zhang et al., 2017). Energy investment stimulates economic development while lowering the energy industry's carbon intensity and stabilising total GHG emissions (Bashir et al., 2020). Developing a comprehensive energy system with a core of structure optimisation requires a massive investment in fixed assets and a precise investment to deploy limited funds to diverse energy sectors (Li & Li, 2020). Appropriate energy investment is important to the energy optimisation structure, energy efficiency enhancement, and maximising its contribution to reducing CO_2 emissions (Magazzino et al., 2022).

Nonetheless, the association of various economic and environmental indicators is well structured in the existing literature. For instance, the impact of variables like economic growth, fossil fuel energy consumption, financial development, renewable energy, investments, trade, and environmental quality: still, the literature lacks empirical evidence of higher education on environmental quality (Zhu et al., 2021). Higher education, in particular, remains at the forefront of the educational system and is critical for scientific and technological advancement and innovations (Ai et al., 2016) and economic and sustainable development from a variety of viewpoints. Nevertheless, several higher education institutions have included climate change knowledge and environmental education into their institutional frameworks to promote sustainable development (Ramos et al., 2015). Consequently, higher education may have a significant impact on environmental quality through various mechanisms. From one aspect, higher education serves as a critical catalyst for scientific and technological advancement, which subsequently impacts carbon emissions efficiency, energy efficiency, and environmental quality in a country (Zhou et al., 2019). From another aspect, expanding higher education contributes to economic development via spending and investments, as seen in China over the last two decades, and so poses a danger to environmental protection.

The prime objective of this study is to examine whether investment or financing for the prevention of climate change is favourable for a green or sustainable environment in China (Ielasi et al., 2018). Specifically, this study aims to analyze the association between investment completed in industrial pollution prevention and CO_2 emissions (Hao et al., 2021). Also, another objective of this study is to analyze whether an investment in the energy industry affects the environmental quality captured by CO_2 emissions. Nonetheless, many studies attempt to examine the nexus of renewable energy investments and their consumption on CO_2 emissions (Awodumi & Adewuyi, 2020; Inglesi-Lotz & Dogan, 2018; Kök et al., 2018; Zhang et al., 2019). However, investment completed in industrial pollution prevention and investment in the energy industry remained out of focus in the literature (Jennings et al., 2021). Since China is an emerging economy with rapid economic growth over the last few decades, this study also aims to analyze the influence of economic growth on its environmental quality ((Sarwar et al., 2019;Umar et al., 2020). In addition, this study aims to analyze whether higher education graduates have any role in the environmental quality of China (Khan, Ali, et al., 2020). Although earlier studies have extensively investigated human capital in relation to CO2 emissions, it is a comprehensive measure of an individual's skills, knowledge, and experience (Bano et al., 2018; Sarkodie et al., 2020; Yang et al., 2017). There is a missing link between higher education graduates and environmental quality. Lastly, this study analyzes the missing link between household consumption expenditure and environmental quality. Since the expenditure pattern of a household determines the usage of energy resources of a household, which could influence the emission level, it is important to analyze the relationship between the said variables.

This study is novel and contributes to the existing literature in three ways: firstly, it is a novel contribution to the existing literature since it provides empirical evidence regarding the nexus of industrial pollution prevention and investment in the energy industry with the environmental quality of 30 Chinese provinces (Umar et al., 2020). Secondly, the role of higher education graduates is observed as a gap in the literature since most of the studies favour human capital (Singh & Yadava, 2021). Therefore, this study contributes to the literature by pioneering the association between higher education graduates and CO_2 emissions in Chinese provinces. Lastly, the association of household consumption expenditure with CO_2 emissions is hardly explored. Therefore, this study provides extensive evidence regarding this relationship (Y. Shen et al., 2021). Moreover, this study provides innovative policy measures that could help resolve the issue and attract policymakers' attention.

This study further consists of five sections: Section 2 presents the literature review; Section 3 provides data, model, and the methodological framework used for empirical assessment; Section 4 represents the empirical findings and discussion; Section 5 provides conclusion and policy implications.

2. Literature review

A recent study by (Khan, Khan, et al., 2020) studied the relationship between economic growth and energy consumption with CO_2 emissions from 1965 to 2015. The study used the autoregressive distributed lags (ARDL) model and concluded that economic growth and energy consumption significantly increase CO2 emissions in the short and long runs. In the case of 30 Chinese provinces, (Li & Li, 2020) revealed that investment in energy and economic growth is the region's leading factors of CO2 emissions. Also, the study demonstrates that regional economic growth plays a significant part in impeding the CO_2 emissions in the neighbouring regions via indirect effects. Energy consumption such as oil and natural gas enhances not only CO_2 emissions but also promotes economic growth in the top oil producing economies (Awodumi & Adewuyi, 2020). In addition, (Schröder & Storm, 2020) analyzed 58 OECD economies from 2007 to 2015 and employed fixed effect modelling. The empirical findings reveal that the per capita income significantly enhances environmental degradation via increased CO_2 emissions as economic growth increases energy demand (Taghizadeh-Hesary et al., 2021). Besides the linear impact of economic growth on carbon emissions, a number of studies provide empirical evidence regarding the non-linear, symmetric, asymmetric impact of economic growth on CO_2 emissions. In this regard, (Malik et al., 2020) analyzed Pakistan over the period 1971 to 2014 using ARDL and concluded that economic growth promotes CO_2 emissions in the short run but reduces CO_2 emissions in the long-run – validating the environmental Kuznets curve (EKC) in the region. (Ridzuan et al., 2020) the study revealed that urbanisation and economic growth are the key reasons for increased CO_2 emissions in Malaysia (Mirza et al., 2020). However, after achieving the threshold level of income, it will eventually reduce environmental degradation, particularly in the long-run, indicating the existence of EKC in the country.

Apart from the territory-based emissions, the recent study of (Safi et al., 2021) and (Wahab et al., 2021) examined the E-7 and G-7 economies, respectively. The empirical results of these studies demonstrate that economic growth and imports are the leading factors of consumption-based emissions, where such emissions are hazardous to human health (Wei et al., 2022). However, the recent strand of literature provides empirical evidence regarding minimising carbon emissions. For instance, most of the studies claimed that technological innovation (Wahab, 2021), renewable energy generation (Shahzad, Radulescu, et al., 2021), green development (Cai et al., 2022), investment in new energy industry and industrial pollution prevention (Luan et al., 2022), financial development and human capital (Qin et al., 2021), financial inclusion and renewable electricity output (Qin et al., 2021) are the key factors that enhance environmental sustainability via reducing CO_2 emissions.

On the other hand, numerous studies have provided evidence regarding the decoupling of economic growth from CO_2 emissions. in this regard, (Q. Wang & Wang, 2019) argued that industries are the primary factors of increased CO_2 emissions in the US. However, research and development (R & R&D) contributed to decoupling. (Wu et al., 2019) argued that China is moving rapidly to decouple economic growth from CO_2 emissions, where improvement in energy efficiency has a significant contribution between 2001 and 2015(Naseer et al., 2020). Concerning the role of industrialisation and urbanisation in decoupling, illustrated that urbanisation is the driving force for increasing decoupling elasticity. It significantly increases CO2 emissions, while industrialisation exhibits a preventive influence on decoupling elasticity due to the scale effect in the earlier stage. This further indicates that industrialization is the leading factor of economic growth rather than environmental pollution. From a metallic industry's perspective in China, (M. Wang & Feng, 2019) examine the role of technology and efficiency in decoupling over the period 2000–2016. Empirical findings reveal that expansion of investment scale is the basic obstacle in decoupling progress. However, change in potential energy intensity, and technological progress in production reduces emissions and facilitate decoupling (Singh & Yadava, 2021). Besides, (Salman et al., 2019) examined Indonesia, South Korea, and Thailand over the period 1990–2016 by using dynamic ordinary least square (DOLS) and fully modified ordinary least square (FMOLS) approaches. The empirical findings reveal that impartial and efficient institutional quality substantially contributes to economic growth and reduces CO_2 emissions in the region. Moreover, the study claimed bidirectional causal nexus between economic growth and CO_2 emissions.

Besides the nexus of economic growth and environmental degradation, the education level of the country – a component of human capital, also plays an influential role in the environmental quality or reducing CO_2 emissions (Williamson, 2017). In this regard, (Hao et al., 2021) investigated G-7 economies over the period 1991–2017 by using a cross-sectionally augmented ARDL approach. The estimated results revealed that economic growth causes environmental degradation in both the long and short runs. However, human capital, renewable energy, and environmental tax help promote environmental quality (Ghazouani et al., 2020; Shahzad, 2020; Shahzad, Schneider, et al., 2021). As one of the most essential factors in the manufacturing process, human capital may be employed to minimise CO_2 emissions by improving energy efficiency (Yang et al., 2017). Human capital via higher education level is used in industry to embrace new pollution-free processes and technology, cost-effective and environmentally friendly (Lan et al., 2012). A firm that has developed human capital may save plenty of environmental expenditures (Manderson & Kneller, 2012). Furthermore, a number of studies, including Lan et al. (2012), discover that Chinese provinces with high human capital have a negative relationship between foreign direct investment and CO_2 emissions. Moreover, (Bano et al., 2018) revealed that human capital could significantly reduce CO2 emissions in Pakistan without disturbing economic growth(Umar et al., 2021). Also, a Bidirectional causal association is found in the long-run over the period 1971–2014. On the other hand, (Sarkodie & Strezov, 2019) provide contradictory results that human capital is favourable for accelerating CO_2 emissions and leads to environmental degradation.

The consumption expenditures also play a substantial part in the environmental quality either by promoting environmental sustainability or degradation. In this regard, (Dai et al., 2012) analyzed the influence of households' consumption expenditures on CO_2 emissions and energy demand in the case of China (Sun et al., 2021). This study adopted the hybrid recursive dynamic computable general equilibrium model for 2050s prediction. The estimated results unveil that enhancement in household income level shifts their energy demand, which significantly increases CO_2 emissions in the region throughout the years to come. For the country, (L.-C. Liu et al., 2011) investigated the period from 1992–2007 via the input-output method. The empirical findings asserted that the household consumption responsible for direct and indirect CO_2 emissions accounted for more than 40 percent of the total CO_2 emissions. Besides, the study also found that urbanisation and increased population significantly promote CO_2 emissions in the region. In addition, (Heinonen & Junnila, 2011) and (Wang & Yang, 2014) also demonstrate the positive association of household income with the CO_2 emissions in various regions. In contrast, the recent study by (Salo et al., 2021) reveals that expenditures could be used as absolute decoupling sources for CO_2 emissions. Moreover, (Rocco et al., 2020) study reveals that production-based carbon emissions are one of the leading factors of carbon leakage. The consumption-based paradigm is observed as the efficient method to minimise global CO_2 emissions that tackle the phenomenon of carbon leakage due to production-based policies (Wang et al., 2020).

To achieve and maintain higher economic growth, most economies across the globe rely on various energy sources, particularly non-renewable energy sources, due to affordability and availability. Nonetheless, energy plays a substantial role in economic growth, yet it also holds an essential role in environmental sustainability or degradation. Specifically, several studies, including (Inglesi-Lotz & Dogan, 2018), demonstrate that non-renewable energy, such as petroleum, natural gas, and coal, are the leading factors of CO_2 emissions in the region. Besides, investment in non-renewable energy resources significantly leads to environmental degradation. On the other hand, these studies argued that investment in renewable energy sources could promote environmental sustainability. Similarly, economies have focussed on investment in industrial pollution prevention to achieve carbon neutrality targets. Many studies, such as those (Chen et al., 2021; Kök et al., 2018; Wang et al., 2020; Zhang et al., 2021), study various periods and regions are utilising different econometric approaches. These studies empirically demonstrate that investments in renewable energy and green energy substantially promote the culture of pollution prevention and enhance environmental quality by reducing CO_2 emissions in the atmosphere.

Since CO2 emissions are a widely known environmental concern, the environmental scientist and governors tend to control the issue and attain a low carbon economy. Therefore, several scholars have attracted policy-level attention regarding financial development and towards green finance in particular. For instance, (Ji et al., 2021) and (Ji et al., 2021) suggest that green finance and renewable energy funds play a leading role in curbing the climate change and CO_2 emissions issues. In addition, (Umar et al., 2021) revealed that exposure to carbon-neutral lending reduces the default risk of the financial sector and enhances its benefits. However, during the periods of the oil price boom, the default risk of the banking sector increases, which validates the resource curse in relation to financial development (Umar et al., 2021; 2021). Nonetheless, the crisis is not only natural, yet the political instability and economic uncertainty also enhance financial risk, which encourages the bitcoin price and other crypto-currencies and allows them to be a safe haven in the period of uncertainty (Karim et al., 2022; Umar et al., 2021). Since the recent Covid-19 pandemic, the global economy collapsed, increased costs, and asset quality deteriorated, and consequently, green and renewable energy funds are also declined (Naqvi et al., 2021; Rizvi et al., 2020; Yarovaya et al., 2020). Specifically, the investment strategy shifted from higher risk to lower risk-oriented financial strategies (Rizvi et al., 2020). However, the recent study by (Hasnaoui

Table 1. Variables' specification and data source.

Variable	Specifications	Data source
CO_2	The release of carbon into atmosphere via burning fossil fuel – is measured in metric tons.	EPS China (2020)
GDP	The total monetary or market worth of all completed products and services produced inside a country's boundaries in a certain time period and is measured in Million yuan.	EPS China (2020)
HEG	Graduates from Institutions of Higher Education (10,000 persons).	EPS China (2020)
HCE	Household Consumption Expenditure and is measured in yuan.	EPS China (2020)
FIN	The investment was Completed in Industrial Pollution Prevention and measured in 100 million yuan.	EPS China (2020)
IEI	Investment in Energy Industry is measured in 100 million yuan	EPS China (2020)

Source: Authors own estimation.

et al., 2021; Mirza et al., 2020; Yarovaya et al., 2021) argued that the equity funds that are ranked higher in the human capital efficiency perform better than their counterparts and the Islamic equity funds are the safe haven during the Covid-19 pandemic period (Mirza et al., 2020; Yarovaya et al., 2020).

3. Methodology

3.1. Data and model specification

Based on the objectives and literature, this study adopted six variables where CO2 emissions capture the critical variable indicating the environmental quality. Since there are various measures for environmental quality, including SO_2, and NO_2, among others. Still, the CO_2 emissions represent about 70 percent of pollution emissions, which is a prominent indicator of environmental quality (Khan, Khan, et al., 2020; Schröder & Storm, 2020). However, the explanatory variables considered are economic growth – captured by gross domestic product (GDP), while higher education is captured via graduates from institutions of higher education (HEG). Further, the household consumption expenditure (HCE) could also influence environmental quality as increased product utilisation encourages energy use, which fuels CO2 emissions and contributes to environmental degradation (Awodumi & Adewuyi, 2020). In addition, this study is motivated by the empirical study of (Luan et al., 2022) that considers investment completed in industrial pollution prevention (FIN) and investment in the energy industry (IEI). The reason behind adopting these variables is that China has taken various environmental recovery measures. Therefore, this study tends to discover whether such measures contribute to achieving a low carbon economy. Data for these variables are extracted from one source covering the period from 2000 to 2017 for 30 Chinese provinces. The variables' specifications and data source(s) are provided in Table 1.

From the above-mentioned variables, the generally constructed model is presented as:

Model

$$CO_{2,\ it} = (GDP_{it}, HEG_{it}, HCE_{it}, FIN_{it}, IEI_{it})$$

The model indicates that the variables such as *GDP*, *HEG*, *HCE*, *FIN*, and *IEI* are the function of CO_2 emissions. While this model could be transformed into a regression model as follows:

$$CO_{2,\ it} = \alpha_1 + \beta_1 GDP_{it} + \beta_2 HEG_{it} + \beta_3 HCE_{it} + \beta_4 FIN_{it} + \beta_5 IEI_{it} + \varepsilon_{it} \tag{1}$$

Here, α and β'*s* are the estimated coefficients, *i* and *t* in the subscript denote cross-sections and time, respectively. At the same time, ε denotes the random error of the regression model.

3.2. Empirical strategy

Since this study deals with panel data, this study initially started the empirical examination with normality testing and descriptive statistics. Afterward, this study moves towards the diagnostic tests, including the panel's slope coefficient heterogeneity and cross-section dependence. Heterogenous slope coefficients and dependence of cross-sections allow the current study to employ the second-generation unit root test. The stationarity of the variables allows this study to identify the long-run equilibrium relationship between the variables. Since the normality distribution holds substantial importance in empirical estimations, the test results could not be ignored. All the variables follow non-parametric properties, which indicates the adoption of a non-parametric approach such as the method of moment quantile regression, which is one of the most reliable estimators in dealing with non-linear data. The specific properties of each empirical estimator are provided in their respective sub-section.

3.2.1. Descriptive statistics and data normality

In the first priority, the current study evaluates the descriptive statistics of data under consideration for each variable. To empirically analyze the data, it is essential to represent the data in a summarised form. In particular, the data summary is presented via evaluating the mean, median, range values, and the standard deviation, where the latter indicates the deviation of observations from the mean value. In addition, the skewness and Kurtosis – traditional measures for normality of data, are also calculated for each study variable. The tabulated statistical values for each of these measures are 0 and 3, respectively. Besides, this study utilised the (Jarque & Bera, 1987) proposed normality test – The Jarque-Bera normality test that combinedly evaluates the skewness and excess Kurtosis to demonstrate the normality of the variable. The combined skewness and excess Kurtosis can be obtained using the following equation:

$$JB = \frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right) \tag{2}$$

From Eq. (2), *N* is the number of observations, *S* represents skewness, while *K* indicates *K–3* indicates excess kurtosis. The under-discussion test assumes the skewness and excess Kurtosis being zero – termed as a null hypothesis for data's normality. Yet, this hypothesis of data's normality can be rejected once the statistical estimates are obtained significant at any 1%, 5%, or 10% levels.

3.2.2. Slope heterogeneity and panel cross-section dependence

Once the normality features are discovered, the current study follows the panel data estimation techniques since we are dealing with the panel data (30 Chinese provinces). Regarding this study analyzed the slope coefficient heterogeneity and panel cross-section dependency. Since the industrial revolution in the late 18th century, globalisation and international trade have developed rapidly. This rapid transformation of the industrial sector altered the financial, economic, and environmental prospects of economies domestically and internationally. Since international trade has an interesting effect on product specialisation, it increases the dependency of one region over other regions due to various reasons, including financial, social, economic, energy, technological, and environmental motives. However, this interdependence of one region over other regions leads that state or region to have similar features in some respects while differences in other aspects. Yet, in a panel data approximation, homogenous characteristics may instigate biased, misleading, and inefficient estimates (Breitung, 2005; Le & Bao, 2020). Therefore, it is imperative to analyze the panel's slope homogeneity or heterogeneity features. In this sense, this study uses the slope coefficient homogeneity test proposed by (Pesaran & Yamagata, 2008) for the panel of 30 Chinese provinces. This test is appropriate since it identifies both the SCH and adjusted SCH (ASCH), which are provided in the equation forms below:

$$\hat{\Delta}_{SCH} = \sqrt{N(2k)^{-1}}\left(N^{-1}\acute{\mathrm{S}} - \mathrm{K}\right), \tag{3}$$

$$\hat{\Delta}_{ASCH} = \sqrt{N}\sqrt{\frac{T+1}{2K(T-K-1)}}\left(N^{-1}\acute{\mathrm{S}} - 2\mathrm{K}\right), \tag{4}$$

From the above equations, the $\hat{\Delta}_{SCH}$ evaluates slopes coefficient homogeneity and $\hat{\Delta}_{ASCH}$ evaluates the adjusted slope homogeneity for 30 Chinese provinces. The under-discussion test holds the null hypothesis of homogenous slopes coefficients for both $\hat{\Delta}_{SCH}$ and $\hat{\Delta}_{ASCH}$. On the other hand, the interdependence of provinces or countries over other regions must be examined since ignoring it may lead to inefficient estimates (Campello et al., 2019). Therefore, the (Pesaran, 2006) cross-section dependence (CD) test is employed to evaluate the cross-section dependency of the selected panel. The said test could be evaluated via the following equation:

$$\mathrm{CD}_{Test} = \frac{\sqrt{2T}}{[N(N-1)]^{1/2}}\sum_{i=1}^{N-1}\sum_{k=1+i}^{N} T_{ik}, \tag{5}$$

The null hypothesis for the said test assumes that the cross-sections of the panel are independent. However, if the null hypothesis is rejected via significant statistical values, an appropriate empirical estimators would be required to entertain the slope heterogeneity and cross-section dependence issues.

3.2.3. Unit root test

The estimated results for 30 Chinese provinces revealed that the slopes coefficients are heterogenous, and the cross-section dependency is present in the panel. Therefore, this study utilises an appropriate estimator dealing with slope heterogeneity and cross-section dependency. Otherwise, the empirical estimates may be biased and inefficient. Hence, we used the (Pesaran, 2007) cross-sectionally augmented IPS (CIPS) unit root test. Firstly, (Pesaran, 2006) proposed a factor modelling approach to allow for cross-section dependency. This factor modelling approach merged the cross-sections' averages as common unobserved components into the model. Based on this approach, (Pesaran, 2007) extended a unit root testing method by considering the mean as the first difference of cross-sections' lags by further extending the Augmented Dickey-Fuller (ADF) regression model. Further, the under-discussion technique is appropriate since it tackles cross-section dependency in the presence of an unbalanced panel, that is $N \neq T$. The regression equation of the cross-section ADF is given as:

$$\Delta y_{i,t} = \theta_i + \beta_i^* y_{i,t-1} + d_0 \bar{y}_{t-1} + d_1 \Delta \bar{y}_t + u_{it}, \tag{6}$$

Where $\bar{y}_t$ denotes the average value of N observations. In addition, this equation could be transformed into the extended form by adding the lags of the first difference of y_{it} and $\bar{y}_t$ to tackle the issue of serial correlation, given as:

$$\Delta y_{i,t} = \theta_i + \beta_i^* y_{i,t-1} + d_0 \bar{y}_{t-1} + \sum_{j=0}^{n} d_{j+1} \Delta \bar{y}_{t-j} + \sum_{k=1}^{n} c_k \Delta y_{i,t-k} + u_{it}, \tag{7}$$

Hence, the (Pesaran, 2007) developed the CIPS in the selected panel of Chinese provinces by utilising the t-statistical average values for each cross-sectional unit ($CADF_i$), given as:

$$CIPS = N^{-1} \sum_{i=1}^{N} CADF_i \tag{8}$$

The null hypothesis of the said test assumes that the time series is non-stationary (presence of unit root). While statistically significant empirics could lead to the null hypothesis's rejection and conclude that the time series is stationary.

3.2.4. Cointegration testing

The stationarity test reveals that all the variables are stationary at level [I(0)] as well as the first difference [I(1)]. Therefore, we tested for the presence of the long-run association between the variables under consideration. In this sense, the current study employed the (Westerlund, 2007) error correction model (ECM) for identifying the cointegration between CO_2, GDP, HEG, HCE, FIN, and IEI. The primary efficiency of this test is that it provides efficient estimates while allowing for the panel data issues such as slope heterogeneity and cross-sectional dependency. Besides, this test provides mean empirics for both the group and panel. That is, the group mean empirics could be obtained via $G_t = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE\hat{\alpha}_i}$, and $G_t = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)}$, while the panel mean empirics could be evaluated by using $P_t = \frac{\hat{\alpha}}{SE(\hat{\alpha})}$ and $P_t = T\hat{\alpha}$.

3.2.5. Method of moment quantile regression

(Koenker & Bassett, 1978) proposed a panel quantile forecasting model to study the influencing elements, wherein the dependent variance and conditional averages are assessed throughout the model. Besides, if the data distribution is irregular/non-linear or non-normal, quantile regression is an efficient way to predict accurate estimates by tackling the issue. (Machado & Silva, 2019) introduce a new strategy in this area, namely the method of moments quantile regression, which is applied in the present study. This analytical method analyzes a quantiles' set's distributional and heterogeneous effects (Sarkodie & Strezov, 2019). For conditional quantile evaluation $Q_y(\tau|X)$ the location-scale modification is expressed as follows:

$$Y_{it} = \theta_i + \vartheta X_{it} + \left(\delta_i + \rho \acute{Z}_{it}\right).\mu_{it}, \tag{9}$$

In the above Eq. (9), the value of probability, $P\left(\delta_i + \rho\acute{Z}_{it} > 0\right) = 1,\ \theta,\ \vartheta,\ \delta,$ and ρ indicate the parameters to be assessed. Further, θ_i specified fixed effect indicated by i in the subscript, whereas $\delta_i,\ I = 1,\ 2,\ \ldots,\ n$. Besides, Z demonstrates the k-vector of the recognised X elements, where the renovations are distinct along with the component $\mathbb{I}$, provided as follows:

$$Z_{\mathbb{I}} = Z_{\mathbb{I}}(X),\ \mathbb{I} = 1,\ 2,\ \ldots,\ k, \tag{10}$$

It is interesting to note that, according to Eq. (9), the distribution of X_{it} is identical and independent for every individual time *(t)* and cross-section *(i)*. Consequently, the vector μ_{it} is orthogonal to X_{it} and is dispersed throughout the fixed i and t (Machado & Silva, 2019), that aids in the stabilisation of the remaining components and combats exogenous behaviour. Therefore, the above-mentioned Eq. (1) can be rewritten as follows:

$$Q_y(\tau X_{it}) = (\theta_i + \delta_i\ q(\tau)) + \vartheta X_{it} + \rho\acute{Z}_{it}q(\tau). \tag{11}$$

Where X_{it} represents a vector of the explanatory variables, including *GDP*, *HEG*, *HCE*, *FIN*, and *IEI*, while a natural log has been taken for variables under-discussion. In addition, $Q_y(\tau X_{it})$ indicated the distribution of quantiles for the dependent variable (i.e. CO_2) and could be analyzed conditional on the location of explanatory variables (X_{it}). Further, the given $-\theta_i\ (\tau) \equiv \theta_i +\ \delta_i\ q(\tau)$ Captures the scalar coefficient, which is a fixed effect for quantile τ of specific i. Unlike the traditional least square fixed effect model, the individual effect does not possess an intercept shift. The heterogeneous effect is responsive to changes and conditional distributions across quantiles due to the time-invariant properties of parameters. Moreover, $q(\tau)$ in the under-discussion model denotes the τ-th sample quantile, which this study limits to only three quantiles, that is, 25^{th}, 50^{th}, and 75^{th}, and reported as $Q_{0.25}$, $Q_{0.50}$, and

Table 2. Descriptive statistics.

	CO2	HEG	HCE	GDP	FIN	IEI
Mean	26383.53	14.74871	10955.28	31040.06	16.83341	578.7100
Median	20683.68	11.65456	8339.979	25359.50	10.97145	430.5000
Maximum	107289.7	48.30430	53617.00	128994.1	141.6000	3383.000
Minimum	812.5048	0.210000	1607.521	2661.557	0.100600	9.350200
Std. Dev.	20861.35	12.09625	8714.248	24436.22	17.72407	550.0681
Skewness	1.365149	1.031630	1.761815	1.341779	2.631896	1.791490
Kurtosis	4.595412	3.340243	7.014231	4.793074	13.14917	6.787518
Jarque-Bera	224.9971	98.38821	641.9254	234.3734	2941.044	611.6183
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Source: Authors own estimation.

$Q_{0.75}$, respectively. To examine each individual quantile, the following equation may be used and expressed as follows:

$$min_q \sum_i \sum_t \gamma_\tau \left(R_{it} - \left(\delta_i + \rho \acute{Z}_{it} \right).q \right), \tag{12}$$

Where$\gamma_\tau(A) = (\tau - 1).AI\{A \leq 0\} + TAI\{A > 0\}$ D emonstrates the check function.

3.2.6. Panel causality test

After assessing the explanatory components' long-run projections using the moments panel quantile regression technique, this study used the (Dumitrescu & Hurlin, 2012) Granger panel causality heterogeneity approach to assess the causation between variables under inquiry. This test is efficient and suitable since it addresses the issue of an unbalanced panel ($T \neq N$), among other things. Furthermore, the panel data concerns of cross-section dependency and slope coefficient heterogeneity are addressed by the (Dumitrescu & Hurlin, 2012) causality test, as (Banday & Aneja, 2020) mentioned.

4. Results and discussion

This section provides the descriptive statistics before empirical results in Table 2. The mean and median values are found positive, with a modest difference in both the values for all the variables. However, the range values hold moderate differences. The minimum and the maximum values are found to be extremely different, which indicates that along with the CO_2 emissions, the economic growth and other variables are increasing over time. Specifically, the number of higher education graduates, household consumption, investment in the energy industry, and industrial pollution prevention is increasing over time. The standard deviation extensively demonstrates the difference between the range values, indicating that all the variables are unstable and follow irregular paths and variations from the mean values. Besides, the skewness and Kurtosis demonstrate that all the variables are not normally distributed. However, the (Jarque & Bera, 1987) test provides more extensive normality estimates. Since the statistical values for all the variables are significant, the null hypothesis of data being normal could be rejected. Hence, it is concluded that all the variables follow an irregular, non-normal distribution.

Table 3. Slope heterogeneity and cross-section dependence.

Slope Heterogeneity Test	Statistics
$\tilde{\Delta}$	13.209***
$\tilde{\Delta}_{\text{Adjusted}}$	16.897***
Cross-Section Dependence	
CO_2	78.050***
GDP	87.836***
HEG	85.733***
HCE	87.791***
FIN	52.436***
IEI	79.174***

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.
Source: Authors own estimation.

Table 4. Unit root testing (Pesaran, 2007).

	Intercept and Trend	
Variables	I(0)	I(1)
CO_2	−2.413	−3.719***
GDP	−1.845	−3.266***
HEG	−3.442***	–
HCE	−2.165	−3.842***
FIN	−2.943***	–
IEI	−2.342	−3.472***

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%. I(0) is for level, and I(1) is for the first difference.
Source: Authors own estimation.

Table 3 provides empirical results for the (Pesaran & Yamagata, 2008) slope heterogeneity test and the (Pesaran et al., 2004) CD test. The results reveal that both the SCH and ASCH statistics are statistically significant at a 1% level, which leads to the rejection of the null hypothesis and concludes that the slope coefficients are heterogeneous. Since each province of China is regulated under the influence of different institutional and political factors. Therefore, policies regarding economic growth, environment, investment, and education could be employed varyingly. Hence, the slope coefficients for these provinces are heterogeneous. In addition, these provinces are connected through various channels. Such interconnectedness includes various trade, financial, political, and social channels. Besides, the trade among these provinces leads to the specialisation of one province, due to which other provinces rely on that specialised province. Therefore, the empirical findings of the (Pesaran et al., 2004) CD test provide statistically significant results for all the variables. This indicates that CO_2, *GDP*, *HEG*, *HCE*, *FIN*, and *IEI* are cross-sectionally dependent.

The empirical results demonstrate that the slopes are heterogeneous and cross-section dependency exists for all the variables. Therefore, this study employed an appropriate second-generation CIPS unit root test proposed by (Pesaran, 2007), and the empirical findings are reported in Table 4. From the results, it is noted that only two variables, i.e. *HEG*, and *FIN* are stationary at I(0) at a 1% significance level. However, CO_2, *GDP*, *HCE*, and *IEI* are found non-stationary at I(0). Therefore, this study checked for the presence of a unit root in these variables at I(1). The estimated results for these variables are found stationary at the 1% level. Hence, all the variables are found stationary yet follow mixed order of integration. Therefore, this study tested for the existence of a long-run cointegration relationship between the variables.

Table 5. Cointegration results (Westerlund, 2007).

Statistics	Value	Z-value
G_t	−3.214***	−5.469
G_a	−12.794**	−6.370
P_t	−16.515***	−5.081
P_a	−14.301***	−3.569

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.
Source: Authors own estimation.

Table 6. Method of moment quantile regression.

Quantiles	$Q_{0.25}$		$Q_{0.50}$		$Q_{0.75}$	
Dep. Var : CO_2	*Coefficient*	*Std. Err.*	*Coefficient*	*Std. Err.*	*Coefficient*	*Std. Err.*
GDP	0.220**	0.104	0.295***	0.079	0.558***	0.117
HEG	−0.359***	0.028	−0.320***	0.026	−0.274***	0.031
HCE	−0.065	0.111	−0.170**	0.106	−0.300**	0.125
FIN	−0.275***	0.026	−0.286***	0.024	−0.299***	0.029
IEI	0.359***	0.027	0.352***	0.026	0.341***	0.030
Constant	3.842***	0.096	3.844***	0.091	3.848***	0.108

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.
Source: Authors own estimation.

To test the cointegration association between CO_2, *GDP*, *HEG*, *HCE*, *FIN*, and *IEI*, this study employed the (Westerlund, 2007) cointegration approach, and the empirical results are provided in Table 5. This test undertakes that the error correction on a conditional panel error correction model is equal to zero. The results show that both the group mean statistics (G_t and G_a) and the panel statistics (P_t and P_a) are statistically significant at 1% and 5% levels. Therefore, the error correction is found in both groups, which is evident that all the mentioned variables are cointegrated in the case of 30 Chinese provinces.

Since the (Jarque & Bera, 1987) test indicates that the under consideration variables follow an irregular path, (Westerlund, 2007) also demonstrates the existence of a long-run association between the variables. Therefore, this study employed the novel method of moments quantile regression, which determines the long-run elasticities at each specific location, scale, and quantile, while allowing for data irregularity (Machado & Silva, 2019). The estimated results of the said test at the study quantiles ($Q_{0.25}$, $Q_{0.50}$, and $Q_{0.75}$) are provided in Table 6. The empirical results reveal that GDP significantly enhances CO_2 emissions in Chinese provinces. A one percent increase in GDP enhances CO_2 emissions from 0.220 to 0.558%, statistically significant at 1% and 5% levels. Besides, it is noted that the magnitude of CO_2 emissions and the significance level are increasing from lower to upper quantile(s). These results are consistent with the study of (Malik et al., 2020; Ridzuan et al., 2020; Schröder & Storm, 2020), which provides empirical evidence regarding the positive association between economic growth and the CO_2 emissions. Similarly, IEI positively and significantly affects CO_2 emissions in Chinese provinces. An increase of 1% in the said variables significantly increases CO_2 emissions in the region from 0.359 to 0.341%. Such findings are consistent with the existing studies (Awodumi & Adewuyi, 2020; Danish et al., 2017; Inglesi-Lotz & Dogan, 2018; Ridzuan et al., 2020)that empirically reveals that investment in the traditional energy industry as well as utilisation of petroleum, coal, natural gas, among others, significantly enhances environmental degradation. Since these sources are the basic components of industrial production, which fulfil energy demand for production and expansion of the sector. While investment in these sources promotes dependence on these sources in China. Also, this association is positive for GDP, IEI, and China, as China is an emerging economy. It is motivated to expand the industrial structure for higher economic growth and invest more in the traditional energy sources. Yet, non-renewable energy sources are the key factor in running the industrial sector. Therefore, the provinces are more biased to economic growth by utilising the traditional energy sources and enhanced investment in the traditional energy industry, adversely affecting environmental quality by encouraging CO_2 emissions in the region.

On the other hand, three variables are found to associate CO2 emissions negatively. Specifically, a one percent increase in the HEG significantly reduces CO_2 emissions by 0.359($Q_{0.25}$), 0.320($Q_{0.50}$) and 0.274($Q_{0.75}$) percent at 1% level in all the quantiles. Although the magnitude decreases from lower to upper quantile, its impact is still favourable for environmental quality improvement. These findings are consistent with the studies of (Hao et al., 2021; Yang et al., 2017). Such studies provide empirical evidence that human capital, where education is the primary component, negatively affects CO_2 emissions in the region. Since the enhancement of education level or higher education graduates enhances the rationale beyond economic growth or personal income. Therefore, with a higher number of graduates, the use of energy resources efficient use and innovative technologies also improve without affecting economic growth (Bano et al., 2018). On the other hand, this study contradicts the empirical results of Sarkodie et al. (2020), which reveals that human capital development leads to the enhancement of CO2 emissions, which harms the environment.

In addition, both HCE and FIN are found to have in negative relation to CO_2 emissions in China. A one percent increase in each variable significantly reduces CO_2 emissions by $0.170 - 0.300$ and $0.275 - 0.299$ percent, respectively. These findings are statistically significant at the 1% level. The economic rationale behind the negative association between HCE and CO_2 emissions is that enhancing households' expenditure on renewables and environmentally friendly products and services could significantly reduce CO_2 emissions. Following the empirical evidence, the empirical findings align with the empirical study of (Salo et al., 2021), which argued that expenditures are good decoupling tools for CO2 emissions and enhancing environmental quality. Using environmentally friendly goods and services further motivates industrialists to invest more in industrial pollution prevention. In this regard, various initiatives have been made, such as promoting and expanding the renewable energy sector, investment in green finances, and environmental-related technological innovation to reduce CO_2 emissions in the environment (Y. Shen et al., 2021; Wang et al., 2020). Since China is an emerging economy, investment in industrial pollution prevention and household consumption expenditures needs improvement for renewables adoption to attain environmental sustainability.

After analyzing the elasticities of each explanatory variable on CO_2 emissions, this study identified the causal nexus of CO_2 emissions and explanatory variables by using the (Dumitrescu & Hurlin, 2012) Granger panel causality heterogeneity approach. Table 7 shows the empirical results of the said test. The estimated results reveal that

Table 7. Causality test.

Pairwise Dumitrescu Hurlin Panel Causality Tests

H_0	$Wald_{Stats}$	$\bar{Z}_{Stats}$	$p-value$
$GDP \nrightarrow CO_2$	4.84235***	10.7020	0.0000
$CO_2 \nrightarrow GDP$	8.84232***	22.3482	0.0000
$HEG \nrightarrow CO_2$	4.90727***	10.8910	0.0000
$CO_2 \nrightarrow HEG$	3.43739***	6.61138	4.E-11
$HCE \nrightarrow CO_2$	4.22198***	8.89575	0.0000
$CO_2 \nrightarrow HCE$	6.27637***	14.8773	0.0000
$FIN \nrightarrow CO_2$	2.39459***	3.57517	0.0003
$CO_2 \nrightarrow FIN$	3.74496***	7.50689	6.E-14
$IEI \nrightarrow CO_2$	2.32511***	3.37289	0.0007
$CO_2 \nrightarrow IEI$	4.31943***	9.17949	0.0000

Note: Significance level is denoted by ***, ** and * for 1%, 5% and 10%.
Source: Authors own estimation.

there exists a bidirectional causal association between all the variables. Any policy change in the GDP has a significant causal influence on CO2 and vice versa, which is consistent with the findings of (Salman et al., 2019). Also, a bidirectional causal nexus is also validated between higher education graduates and CO2 emissions, which further confirms the earlier estimates that enhancement in graduates' number is negatively associated with CO_2 emissions due to the adoption of environmentally efficient approaches. Such findings are consistent with Bano et al. (2018) study, which validates the bidirectional causal nexus between human capital (where education is a primary component) and CO_2 emissions. Moreover, the null hypothesis of no granger causal association is rejected for *HCE*, *FIN*, *IEI*, and the CO_2 emissions. As a result, there exists a bidirectional causal association, which is consistent with the studies of (Danish et al., 2017; Inglesi-Lotz & Dogan, 2018) in different time series and panel data analyses. Hence, from a policy perspective, the variables such as *HCE*, *FIN*, and *IEI* must be considered for climate change prevention and environmental sustainability.

5. Conclusion and policy implications

5.1. Conclusion

China has been considered a rapidly growing economy – having a consistently growing per capita income for the last two decades. However, this rapid economic growth is sustained via the development of the industrial sector. Nonetheless, expansion of the industrial sector primarily relies on traditional fossil fuel energy, an increase that encourages CO_2 emissions. Since China is the leading energy importer and consumer country, excessive energy use leads them to be the largest pollution emitting country. To deal with the issue of excessive pollution emissions, China focuses on various initiatives – climate prevention financing. The current study aims to analyze whether financing for climate change prevention promotes a green environment in China. The results obtained via a novel method of moments quantile regression reveal that enhancing economic growth and investment in the energy industry increases the pollution level in China. The major economic portion of the Chinese economy is the industrial sector based on fossil fuel use. Consequently, the higher the use of energy enhances economic and industrial activities that contribute to economic growth, while further investing in the energy industry promotes fossil fuel utilisation. As a result, the pollution level increases. On the other hand, the empirical results suggest that higher education graduates, investment in industrial pollution prevention, and household consumption expenditure significantly improve environmental quality by reducing emissions. Since higher economic growth contributes to the development of these three sectors, Chine should consider enhancing the investment in industrial pollution prevention and improving the education level as the highly educated general public is well aware of environmental degradation. Therefore, these three measures could be used as remedial measures for improving environmental sustainability.

5.2. Policy implications

Based on the empirical findings, this study recommends that energy investment be diverted from non-renewable energy resources to renewable energy resources. Although China's economic growth is in a takeoff state, policies must still consider renewable energy generation and adaptation, particularly in the industrial sector. As the literature suggests, this will help recover environmental quality and contribute to economic growth. In addition, more focus is required on the education level or the higher education graduates in China, which could help the country by promoting the culture of renewables and encouraging environmentally friendly technologies. Moreover, policies are required to enhance expenditures on industrial pollution prevention. In particular, the governors must ensure investment and expenditures in the industrial sector regarding structural transformation to renewable energy utilisation. This will help eradicate dependency on fossil fuel energy and ensure a green environment.

5.3. Limitations of the study and future research directions

Nonetheless, this study provides substantial empirical results and policy insights. Still, this study is limited and could be extended in future research. In other words, this study investigates only China, while there are other economies at the top of the pollution emitting list. Therefore, future researchers could extend the adopted study and variables for a balanced or even unbalanced panel economies. This study analyzes the data only for the last 18 years due to the data unavailability issue. However, future studies could extend the time period for a comprehensive examination. Lastly, other financial variables such as financial inclusion and other economic and non-economic can be tested in this relationship in time series as well as panel data analysis.

Disclosure statement

No potential conflict of interest was reported by the authors.

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