frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 03 October 2022
DOI 10.3389/fenvs.2022.991298

OPEN ACCESS

EDITED BY
Qaiser Abbas,
Ghazi University, Pakistan

REVIEWED BY
Mohamed Marie,
Xi'an University, China
Stephen Taiwo Onifade,
KTO Karatay University, Turkey
Ashar Awan,
Nişantaşı University, Turkey

*CORRESPONDENCE
Lianfeng Xia,
13010@hnzj.edu.cn

SPECIALTY SECTION
This article was submitted to Environmental Economics and Management,
a section of the journal
Frontiers in Environmental Science

RECEIVED 11 July 2022
ACCEPTED 26 August 2022
PUBLISHED 03 October 2022

CITATION
Xia L, Liu Y and Tian Y (2022), Green finance strategies for mitigating GHG emissions in China: Public spending as a new determinant of green economic development.
Front. Environ. Sci. 10:991298.
doi: 10.3389/fenvs.2022.991298

RETRACTED: Green finance strategies for mitigating GHG emissions in China: Public spending as a new determinant of green economic development

Lianfeng Xia*, Yujia Liu and Yunqing Tian

Henan Polytechnic, Zhengzhou, China

RETRACTED

In order to lessen China's carbon footprint, the government has turned to environmentally friendly financing. A reduction in CO_2 has been reported in some Chinese provinces where green finance has been developed. Numerous regions in China from 2010 to 2020 are selected for this study. Based on a Dynamic Seemingly Uncorrelated, fully modified ordinary least squares and dynamic ordinary least squares regressions model, empirical research is performed with per capita growth in the economy, public spending, and the relationship between economic growth, human resources, and industrial arrangement as core variables to test the influence of green financing on CO_2 emission in Chinese provinces. According to the findings, green financing speeds up the reduction of carbon emissions. Moreover, the outcomes present that industrial structure, economic growth per capita, and trade openness increase carbon emissions. Likewise, public expenditures and human capital are significantly contributing to emissions reduction. The findings show that sustainable green environment can only be achieved by boosting the performance of green finance and increasing the level of green finance supported by the Chinese economy. Last but not least, policymakers should promote public health and education spending to fully engage in the protection of the environmental efforts to encourage green consumption while minimizing the structural problems resulting from economic activity.

KEYWORDS
green finance, public expenditures, carbon emissions, industrial structure, China

Introduction

Without wide-ranging radical strategies, a just shift to a carbon-neutral economy will be impossible (Alola et al., 2021). Without these policies, China's rapid decarbonization is impossible. This includes fiscal interventions to help build a zero-carbon structure, green manufacturing strategies, green plans for a National Investment Bank, and ecological policies to limit concentrated carbon utilization (Taiwo Onifade et al., 2021). These are just a few examples. Additionally, there is a green industrial approach and a green strategy for a National Investment Bank, among other examples of these policies (Onifade et al., 2021a). With its policy on a National Investment Bank, Post Bank, and regional development banks, labour has already pledged to make significant green government investments over the next decade. These funds will be raised through government bonds (Onifade et al., 2022). Financial markets and institutions can help fund climate mitigation and adaptation efforts, so a change is needed. This change is needed because the current finance system harms the environment (Alola and Onifade, 2022). The financial system is also at risk if it does not adapt quickly to the constraints imposed by climate change. As a result, climate change's economic and social consequences would be exacerbated. Transforming China's financial system should be made possible by adopting a global perspective. At least two factors necessitate this action. First, a significant number of China's banks have significant international operations and are linked to the international monetary system through a wide range of financial interconnections and shadow banking instruments. China's financial system will not be able to decarbonize properly if only China-focused interventions are implemented.

China's history of large-scale carbon dioxide production and environmentally damaging consumption patterns has made it a major contributor to the global buildup of greenhouse gases. China must be held accountable for the global climate change that is disproportionately impacting countries in the Global South and South Asia than it is countries in the North. There should be an emphasis on ensuring that China's citizens in the Global South benefit from adopting and developing green technologies in China when greening its financial system. This can be done by ensuring that China's financial system is greened in a way that provides this happens (Chen Y. et al., 2021). The Chinese government should take additional measures to ensure that countries in the Global South can adapt and mitigate the effects of climate change without resorting to neocolonial strategies (Lei et al., 2021; Wu and Zhu, 2021). Climate-aligned finance can be achieved in various ways, despite a growing consensus that this is the right thing to do (Wu X. et al., 2021; Yin et al., 2021). This can be accomplished in a variety of ways. As stated earlier, this report aims to outline a strategy for China's financial system that will result in a fundamental shift in how private finance approaches the issue of global climate change (Li et al., 2021). Unlike the Chinese government's green finance strategy, our strategy goes far beyond traditional approaches.

The growth of a Green Economy has become a conventional value alignment in recent years to improve and protect ecological environments in both social and global economic contexts (Geddes et al., 2020). As of this year, Rio de Janeiro hosted the United Nations Conference on Sustainable Development for the first time in 20 years (He et al., 2019). The concept of a green economy has been promoted as a potential new strategy for improving human well-being and reducing environmental risks (Nabeeh et al., 2021). It is seen as a way to put Agenda 21 into practice while encouraging more sustainable development (Knuth, 2018). Since it was adopted as "the future we want" at the Rio+20 summit, the Sustainable Development Goals (SDGs) have been implemented in their indicators (Lee et al., 2021), primarily dealing with international agreements such as the conventions on desertification, climate change, and biodiversity. A green economy's two most important investment areas are increasing natural capital, which is comprised of fisheries, agricultural, and forest stocks and water bodies (Liu et al., 2022a), and resource and energy efficiency in manufacturing (Zheng et al., 2021), renewable energy, waste management, transportation, buildings, (Sarma and Roy, 2021), and tourism. Fisheries, agricultural and forest stocks, and water bodies, are examples of natural capital. Environmental technology is referred to as resource and energy efficiency. Due to the fact that investment decisions made by governments affect the future of our economies, it is appropriate to place a high priority on investments (Zhang et al., 2021a). Investments in one type of infrastructure and one type of manufacturing or technological innovation can limit future options (Saeed Meo and Karim, 2021). In light of the scope of the issues and the adjustments that need to be made, it is widely accepted that reviving the economy requires a decision on one of several possible paths. Given the breadth of the issues to be addressed, this is not going to be an easy undertaking. As with any economic strategy, the normative green economy vision will require private and public sector investments to move the economy toward more environmentally and socially just strategies (Taghizadeh-Hesary et al., 2022). Thus, it is widely accepted that investments of this type require targeted public spending, policy reforms, and regulatory changes to emphasize government involvement's importance.

The recent global recession impacted the total amount and the breakdown of spending by the public sector in developing countries. Historically, developing countries have had a tendency toward pro-cyclical spending, which involves reducing expenditures during economic downturns and increasing spending during economic upturns. Nevertheless, during the last decade, emerging markets that possessed institutions of a high standard shifted their fiscal policies toward countercyclical spending, which involves an increase in expenditure during periods of economic contraction in order to mitigate the negative effects of the business cycle (Liu H. et al., 2022). As a result of increased investments in social safety nets, the breakdown of government spending can also shift during economic downturns (Atasoy, 2020). An economy's fiscal policy directly influences the accumulation of resources and the distribution of those resources (Srivastava et al., 2021). According to Zerbib (2019), between 2010 and 2012, government expenditures made up approximately 25% of GDP in developing countries on average. As a result, these expenditures have the potential to play a significant role in fostering the expansion of the rural economy. Zhang et al. (2022) conducted a study spanning multiple countries. They discovered that the composition of government spending has a significant impact on the levels of poverty as well as economic growth. Both Tu et al. (2021) find similar results, wherein government spending in India and China on investments such as irrigation, agricultural R&D, and rural infrastructure not only contributed to a reduction in poverty levels in the rural areas but also contributed to a growth in agricultural productivity. Recent empirical research has shown that variations in the level and composition of government spending have a significant impact on the amount of pollution in the environment (Liu et al., 2022b). In addition, the expenditures made by the various levels of government can have significantly different effects. For example, Islam investigated the environmental impact that would result from a shift in the proportion of money spent by various levels of government, comparing the proportion of money spent by the federal government to the total amount spent by state and local governments. They demonstrate that a change in the composition of spending at the state and local levels led to a reduction in air pollution, whereas the change at the federal level did not have any significant effect.

Most of the pollutant examined was produced as a by-product during manufacturing. Examples of this include sulfur dioxide and lead. There is only one study that we are aware of that links the effect of government spending on carbon dioxide (CO_2) (Chen Q. et al., 2021), which is a major contributor to emissions of greenhouse gases. However, this study also focuses on carbon dioxide produced during manufacturing. Surprisingly, the connection between fiscal policy spending on greenhouse gas emissions through deforestation has not yet been systematically analyzed, given that land-use change is the primary contributor to greenhouse gas emissions in the developing world (Li et al., 2022).

Specifically, the behavior of carbon emissions in the present and future is a complex situation that the conventional single-factor net effect analysis cannot fully explain. This is true both now and in the future. First, we recognize the analytical criteria that are the foundation of green finance. Next, we offer a consistent program to design the procedure and curtail the negative influences of inattention on this critical step in developing China's economy. The current research endeavours to use environmentally friendly financing and will provide recommendations for policies to address the dearth of accurate and exhaustive information. According to the study's findings, a new pattern could be used as an instructing tool to select alternative strategies for various types of financial activities. In the second place, this investigation makes contributions to the up-to-date writing, in the first place, in contrast with the previous investigation, which for the maximum part, forces the job of fiscal turn of occurrences, rather than just the influence of green finance on carbon emissions; this study gives a pioneering valuation of CO_2 emissions and green finance. This is one of the most important studies looking at the 30 provinces in China that have significantly used environmentally friendly finance. The precise discoveries regarding the impact of green finance on comparing carbon emanations serve as standards for various nations. Finally, the results of our observational study provide fresh insights into the contradictory response of CO_2 discharges to environmentally friendly financing. In addition to this, our contribution consists of using sophisticated econometric models to analyze carbon emissions. In addition, the level of financial growth, the manufacturing structure, the amount of public expenditures, the degree to which trade is open, and the amount of human capital are all primary factors in determining environmental quality. In addition, this study uses the dynamic SUR, FMOLS, and DOLS estimators, as well as the D-CCE and System GMM estimators, to investigate the suggested drawbacks in the existing literature. Furthermore, the robust outcomes current study used all of these estimators.

The rest of the study is organized as follows: the second section explains the literature review and the structure of the model. *Data and methods*; presents the design of the research. *Empirical results*; conducts an empirical examination and provides an explanation of the results, and *Conclusion and policy recommendations*; summarizes the findings of the study.

RETRACTED

Literature review

Green finance and carbon emissions

Environmental or sustainable finance are other terms for green finance, which differs from conventional financing. It was recommended in light of the growing conflict between increasing economic growth and environmentally responsible energy consumption (Xiong and Sun, 2022). According to the People's Bank of China, green finance is described as financial services that help businesses preserve and improve the environment, modify to climate change, and reduce and minimize waste while making the most use of existing resources (Onifade et al., 2021b). In the financial industry, green finance is a major invention that plays a significant role in balancing economic development and environmental protection. The terms "green finance" and "sustainable finance" are interchangeable. The opportunity is now available for people to reexamine the development of current monetary systems from the perspectives of both financial services and the natural world.

The theory of environmentally responsible finance has evolved into three distinct schools of thought over the last several decades. The first point of view that can be taken is at the financial application's instrument level. As a novel financial tool, green finance is alleged to have been developed by the government and financial organizations to address environmental issues, such as reducing pollution, saving energy, and providing customized financial services for green growth. As a result, it is used to help fund environmental initiatives (Dmuchowski et al., 2021). This perspective was commonly held in the early stages of the development of green finance theory. Financial goods like green insurance, green investments, green financing, and others were the focus of the study. Green finance has also been developed into an indicator system based on the volume of transactions of such products (Muganyi et al., 2021). The second way to approach the problem is from a more strategic vantage point, and this method begins at the top and works its way down. In order to develop policies for sustainable development, improve financial services, and create environmentally friendly investment products and financial strategies, green finance should adhere to ESG standards (Zhou et al., 2022) and be integrated into financial institutions, governments, and businesses (Yu et al., 2021). In the words of (Khan et al., 2021), the construction of a green economy indicator system should stimulate the usage of organizational text data, financial information, and corporate financial data (Zhang et al., 2020). There is a third type of perspective known as the behavioral perspective, which examines things from the ground up. Capital begins to flow to environmentally friendly products and industries as a result of the public's pro-environment preferences. As economic development moves toward a "deep green" state, and as public consciousness of environmental security grows, so does the number of environmental regulations and laws. Encouraging the growth of environmentally-friendly business practices is an important part of a greener financial system (Wang M. et al., 2021). As a result, academics emphasize the financial system's role in fostering a more environmentally friendly economy (Clark, 2019). Using only green financial capital input measures how efficiently green financial development is progressing. Saha et al. (2022) argue that the green financial system will be overlooked. As a result, a wider variety of financial expansion data must be considered, as well as surprising results such as environmental pollution for the environment. It is necessary to meet both of these conditions. A key goal of this paper is to develop and improve an indicator system for green finance development in light of this perspective.

Environmentally friendly projects and carbon trading are two primary ways green finance works to reduce carbon dioxide (CO2) emission levels. Green bonds and green financial policies, on the one hand, provide funds for green environmental protection initiatives. Decreases the cost of financing and executing environmentally friendly initiatives, enhancing their effectiveness and spurring the development of green technology while simultaneously lowering carbon emissions (Khoshnava et al., 2019). Green bonds were proposed in an investor-pleasing way to show that a firm cares about the environment while also increasing excitement for its stock. The ultimate goal was to improve the industry's environmental advantages while reducing carbon emissions. Alternatively, using economic and policy mechanisms to lessen carbon emissions by businesses and individuals is possible in a carbon tradeoff marketplace founded on carbon emission quotas. Carbon emission quotas are allocated to companies with emission lessening agreements through lawful means by the carbon trading department, which is responsible for the activity (Melnyk et al., 2020). There are two reasons why carbon emission quotas are retailed in the carbon-trading market: The financial rewards motivate companies to continue reducing their carbon dioxide emissions through advancements in science and technology (Jiang et al., 2020). Finally, by selling the carbon emissions they save through their carbon-saving efforts to businesses participating in the carbon-trading market, individuals can raise citizen awareness about the need to reduce carbon emissions while lowering overall carbon emissions. According to Liu et al. (2021), the Chinese carbon trading market development has the potential to substantially lower countrywide emission levels. To reduce carbon emissions, the carbon emission trading system, as proposed by Lin and Zhu (2019), has the potential to be an important market-oriented environmental policy tool.

We are still missing information on the following three points: One of the reasons is there is not enough green finance for the power of green zero-carbon transition growth for businesses, and another reason is that the green finance system has not kept up with the "double-carbon" vision to meet the strong demand for the green finance system following up studies. Both of these reasons contribute to the fact that there is not sufficient green funding support. For this reason, sustainable financial support for subsequent research is necessary. Green finance and carbon emissions have been studied extensively in theory. However, there have only been limited research studies on how green finance affects carbon emissions. Mostly, this is due to a dearth of available statistics on carbon discharges. Third, there is no established, all-encompassing index to measure the current expansion of green finance. As a result, this study uses the most up-to-date and accurate model available for calculating carbon emissions, panel data from China's provinces and cities, and comprehensive green finance indicators to empirically test the influence on carbon emissions of the development of green finance in China. In order to do this, we use inclusive signs of green finance, the current mature carbon emission calculation model, and study employed from cities and provinces in China.

In the early stages of research, Academics concentrated their attention primarily on the concept of green finance, including its connotation, responsive significance, development pathways, and the important impact that green finance performs on the administration of bank's performance, the treatment of pollution, and green economic expansion in developing countries (Srivastava et al., 2021). Studies relevant to the topic have shown that green finance raises the loan threshold for activities that produce high levels of pollution and emissions. Additionally, it offers low-interest rates to businesses in the low-carbon sector to meet their requirements for financing, which is a factor that encourages the rapid expansion of low-carbon industries (Yu et al., 2022). Qu et al. (2020) constructed a non-linear threshold panel model, for instance. Dulal et al. (2015) discovered that green credit policies significantly contribute to reducing emissions and saving energy within the constraints of industrial growth. De Morais et al. (2021) found that green credit rules successfully limit spending in energy-intensive industries in their financial CGE model. It can assist reduce the financial constraints that businesses have when investing in environmental guard, new energy, and new materials because of an increase in the supply of low-carbon products or services that will promote the expansion of environmentally friendly firms, in a nutshell (Zhao et al., 2021). In addition to this, it will reduce the capital supply that is available to businesses that produce a lot of pollution and emissions, compelling these businesses to undergo technological transformation and upgrading or to scale back their production in order to lower their carbon emissions (Liu et al., 2021).

Public spending and carbon emissions

A large body of research and published material is available on CO_2 emissions and public expenditures. In this part of the article, we will conduct a literature review and then discuss public expenditures and CO_2 emissions. It was found that there is a positive and significant correlation between renewable energy sources and the cost of medical care. The idea that increased spending on investments leads to a healthier and less polluted environment, which improves the healthcare system's effectiveness and contributes to overall economic growth, was investigated further. Using a sample from Africa and its surrounding area for 25 years, from 1990 to 2015, Lee and Lee (2022) concluded that the more CO_2 emitted, the more pollution generated. This, in turn, will lead to an increase in the cost of providing medical care. The ARDL model and approach that was used because of the goal of analyzing and obtaining the results indicated that there is a substantial and direct relationship between economic growth and healthcare expenses, whereas there is a negative relationship between CO_2 emission and healthcare expenditures. In contrast, the correlation between CO2 emissions and pollution was diminishing. As air pollution levels rise, so does mortality, as shown by Dmuchowski et al. (2021) and Yu et al. (2022) studies. The term "spending on the healthcare sector" suggests the global average, which is the factor that contributes to increased economic development. Pulicherla et al. (2021) examined the economies of India and China and hypothesized that the rate of population growth, technological advancement, and GDP will be the most important factors in determining future energy consumption. According to Karani and Failler (2020), the major causes of the increase in global energy demand are shifts in the worldwide structure, demographics, temperature, and technological advances.

Consequently, the relationship between medical care spending and economic growth has given rise to two schools of thinking. Alternatively, one school of thought proposes that nations that invest more money in the healthcare zone have a greater chance of being capable of enjoying a strong lifestyle, which in turn boosts the welfare of society and improves life expectations (Mikhno et al., 2021). In a similar vein, increasing the amount of money spent on the healthcare industry enhances the health of workers, which in turn raises their level of efficiency. As a result, their level of productivity rises, which ultimately contributes to an increase in economic development. On the other side, the second school of thought came to the conclusion that there is a relationship between the amount of money spent on healthcare and the rate at which the economy grows in both directions (Zhu and Liu, 2021). Spending more money on healthcare contributes to increased economic growth; on the other hand, nations with the higher gross domestic product are better positioned to increase their healthcare spending and vice versa. In the modern era, those who make policy, those who specialize in healthcare and the environment, and those who conduct research need to pay attention to CO2 emissions and expenditures in the healthcare sector. Wu M. et al. (2021) demonstrated a significant positive, strong relationship between carbon emissions and the amount of money spent on medical care. Owen et al. (2018) conducted research in 30 of China's provinces to investigate the correlation between the levels of CO_2 emissions and the effects those levels have on the public's health. According to the findings, both variables have a negative and significantly significant correlation. The results also indicate that facilities, as well as the state of the health field, have a straight impact on public health and economic growth.

The FMOLS method was applied to ascertain the connection between the two, during which the positive relationship between the healthcare field and gross domestic product and the negative association between the healthcare sector and CO_2 emission were investigated. A few additional investigators looked into the link between CO_2 emissions and healthcare costs and concluded that there is a positive and causal connection between the two. The investigation is based on panel data (Dong et al., 2021). According to the findings of these studies, fossil fuels account for between 85 and 93% of the world's total energy production. The expansion of energy production for the period can be broken down into three categories based on population and economic growth. From 1950 to 1980, there was a significant acceleration in the growth of per capita income; in the period 1980–2000, the growth of per capita income remained stable; and after the year 2000, an upward trend in per capita economic growth was observed.

The study of pollution, climate change, the environment, and the assessment and addressing of externalities are all topics that fall under the purview of sustainable green economics, a subfield of economics. In recent years numerous researchers have tried to find sustainable green economies (Zhang et al., 2021a; Zhang et al., 2022). The sustainable green economy is linked to increased resource productivity and utilization, which contribute to developing equitable and inclusive societies. It emphasized green taxes to internalize the externalities from utilization within an economy (Mealy and Teytelboym, 2020). Therefore, public and self-contained financing in economic activity, infrastructure, and assets reduces CO_2 emissions and pollution, improves efficiency, and prevents biodiversity loss and the loss of ecosystem services that cause growth and earnings in a green economy. Greening urban development has garnered international attention as a modern economic instrument for reducing pollution, protecting energy consumption and the environment, and advancing ecological goals. Previous research has attempted to define what constitutes a green economy precisely. Some international organizations have provided definitions for the term "green economy." For example, Valensisi and Davis (2011) defined it as an economy that is resource-efficient, equitable and has low carbon footprints. On the other hand, according to (Shao et al., 2021), it is a subfield of economics that investigates and studies topics such as global warming, pollution, the environment, and methods for reducing the impact of externalities. Again (Tang et al., 2022), investigated the green economy in conjunction with a bibliometric analysis and how sustainability is connected to the green economy.

In addition, a growing body of research on the green economy covers many topics. According to Guild (2020) green economy has the potential to ensure low carbon pollution and protect green capital. According to the findings of a variety of studies, green expansion not only helps create jobs but also promotes economic growth by reducing negative environmental impacts. Verma and Kandpal (2021) use input-output energy estimation as their primary research tool. Kazancoglu et al. (2018) researched the course Canada's green economy will take. While Wang Y. et al. (2021) investigated the effectiveness of the green economy's expansion in Chinese cities, Li et al. (2020) examined the scope of green economy advancement in various resource-rich Chinese cities. During this interim period, a significant number of studies have concentrated on the underlying causes of organic expansion. For instance, according to various change agents, Xu et al. (2019) evaluated the differences in the growth of the green economy in Chinese cities. These change agents included the population, the educational stages, and the social and economic standing of the city's residents. In addition, Massé et al. (2021) developed an indicator for measuring the expansion of the green economy in the various regions of China. They established a statistical equation and studied the impact of insufficient technological know-how, standard practices, and output within China's regions.

Green advancement, in addition, a number of studies, one of which is (Hu et al., 2021), investigated the impact that abundant natural and renewable resources have on green building in China. The researchers concluded that cities with substantial resources are more likely to be affected by pollution. Moreover (Horlings and Marsden, 2011), and (Sandberg et al., 2019) conducted a longitudinal data study on 38 countries and uncovered that if government expenditure on public well-being rises to 10%, the pollution of $SO_{2,}$ as well as lead intensities, will decrease to 4% plus 7%, respectively. These findings were based on the fact that if government expenditure on public well-being increases by 10%, the pollution of sulph (Shuai and Fan, 2020). In addition (Montefrio and Dressler, 2016), analyzed how the United States economy benefits from RE financing. They argued that the United States required a policy recommendation for building a green economy in order to promote job growth and the general welfare of society. Zhang et al. (2021b) utilized a panel findings analytical strategy for their research on the 20-year effect of government spending on economic development in developed economies. They argued that there is a strong correlation between advanced progress and monetary expenditures by the government. In the meantime, there has not been much research done on how public spending on research and development affects the development of environmentally friendly economies. While this was going on (Ünüvar, 2019), held the opinion that spending on research and development affects green development. Liu et al. (2022a) researched how fiscal policies affect Asian countries while the terrain was green. According to what they said, Asian countries are obstinate about accepting budgetary allotments to support economies to switch to a zero-carbon future (Potluri and Phani, 2020; Ma et al., 2022). As a result, the proposed fiscal policies were specific to a country to figure out how to attain the goal of a green economy. In addition, a significant amount of research on the connection between public spending and the destruction of ecological systems can be scattered throughout the published works. However, the academic community would need to conduct additional research to determine whether or not public spending can promote green development within the countries participating in the Belt and Road Initiative. As a result, this study looked into the observational outcomes found within this component to make up for this deficiency.

Data and methods

The variable discussed in this article is carbon emissions (CE). This paper refers to the current advanced measurement methods, chooses three kinds of energy consumption from the statistical yearbook—natural gas, electricity, and liquefied petroleum gas—and carries out the conversion in grouping with the CO_2 emission coefficient. This is necessary because such data are not included in the most recent statistical yearbook. The specific algorithm is represented as follows: CO_2 stands for carbon emissions; CE, Cn, and Cp stand for the CO_2 emissions projected grounded on the consumption of natural gas, electricity, and liquefied petroleum gas, correspondingly; Ee, En, and Ep stand for the consumption of the three different types of energy; and stands for the GHG emission coefficient of the coal-powered fuel chain. The symbol denotes the ratio of coal power production to total power production "," which equals 1.3023 kg/m3 kg/kWh. Where and stand for the CO_2 emission coefficients of natural gas and liquid petroleum gas, respectively. It should be emphasized that even though the use of electric energy does not result in the production of CO_2, thermal power generation is still the primary source of carbon emissions in China, which are greatly dependent on coal. This is because China's endowment features include being "rich in coal, poor in oil, and little in gas," and the price of coal is relatively low (Chen et al., 2020).

$$CO2 = Ce + Cn + Cp = \phi(\eta \times Ee) + \kappa En + \gamma Ep \qquad (1)$$

The variable used to explain things in this paper is green finance (GF). Green bonds are now used as proxy variables. However, the total amount of green credit only accounts for a portion of GF, and it is also important to consider the overall development of GF. For this reason, green securities, green credit, and green investment are considered wide-ranging indicators of GF's growth.

The economy serves as the basis upon which the development of the financial activity is built, and the industrial structure discloses the degree to which the supply side of regional development has been optimized. It also can effectively direct the flow of local capital (Rowan and Galanakis, 2020). Consequently, this study considers the following factors as threshold variables: 1) economic development level (ED). The PGDP is the illustrative measure of economic growth in the system and serves as the primary index for determining a region's economic expansion level. 2) Industrial structure (IND). Carbon emissions are intimately connected to a nation's industrial structure, particularly its secondary industry. As a result, the ratio of the value added by an industry to GDP in the secondary sector has been chosen as the threshold variable to denote the evolution of the industrial structure. Trade openness (TO): When referring to academic standards, each province's nominal total amount of export and import trade is utilized. The entropy method is used for standardization processing to determine the level of trade openness. Human capital (HUMC): The stock of HUMC in each province is computed according to the level of education using an algorithm developed by (Chen et al., 2020) as a point of reference.

The authors Lopez and Islam (Liu and Dong, 2021) argued that government expenditure on public goods (fitness and societal transfers, grants to households via education, ecological protection, investigation and growth, information dispersion, and infrastructure) yields a positive influence on economic growth by stimulating a scale-up effect that heightens stresses on the ecosystem. This is a slightly different argument than the one made by Knuth (2018). They also hypothesized that government spending on private goods (such as grants for fossil fuel production and energy consumption, farm plans, input subsidies, credit grants, government grants to companies, and other industry or exclusive firm grants) might not be effective in boosting productivity and economic growth, and consequently might have little to no effect on the scale that matters for environmental quality. They also argued that the assignment of government expenditures in favor of activities that are intensive in human capital, rather than activities that are intensive in physical capital (which are activities that generate a lot of pollution), could potentially generate an output composition effect that would result in an improvement in environmental quality. They went on to argue that the allocation of government expenditure in favour of public goods that enhance human capital and that can serve as a substitute for pollution-generating inputs in production could encourage cleaner production, which would result in a lower pollution-output ratio. Research and development (R&D) expenditures by the federal government could lead to the invention, manufacture, and use of cleaner final and intermediate products (inputs). There is also the possibility of an income effect, which occurs when the government provides subsidies to households or transfers money to individuals in order to increase their purchasing power. This encourages people to buy environmentally friendly products and calls for a cleaner environment. Table 1 provides a description of the different variables. Moreover, the scatterplot diagrams are given in Figure 1.

Econometric methodology

We utilized a 6-step methodology in order to determine the values of the long-term coefficients of Eq. 1. In the first step of this process, we looked into whether or not the panel data contained any cross-sectional dependencies. The implementation of this test was motivated by the possibility that the results of the empirical analysis would be skewed in the event that the cross-sectional dependency problem was not investigated. In order to accomplish this, we used the LM test that had been developed by (Rehman et al., 2021) as well as the CD test that had been developed by (Liu et al., 2021). The following formula is used to compile the statistics of these tests:

$$LM_{BP} = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\rho 2ij \qquad (2)$$

The above test is not valid when n methods eternity; thus (Moutinho et al., 2015), suggested a scaled sort of LM test, which can be written as:

10.3389/fenvs.2022.991298

TABLE 1 Description of variables.

Variable		Measurement	Source
Green finance	Green credit	Liabilities totals of publicly-traded environmental enterprises	Wind
	Green securities	Environmental listed firms' total market value	Wind
	Green investment	The province's total investment in energy and environmental protection	China Statistical (CS) yearbook
	CO_2	Indicator (carbon emissions based on electricity, natural gas, and liquefied petroleum gas usage)	CS yearbook
	GDPC	Economic growth per capita	CS Yearbook
	IS	Industrial structure	CS yearbook
	PE	Health expenditure	CS yearbook
	TO	Trade Openness (in current $)	CS yearbook
	HC	Human capital (gross enrolment in tertiary education)	CS Yearbook

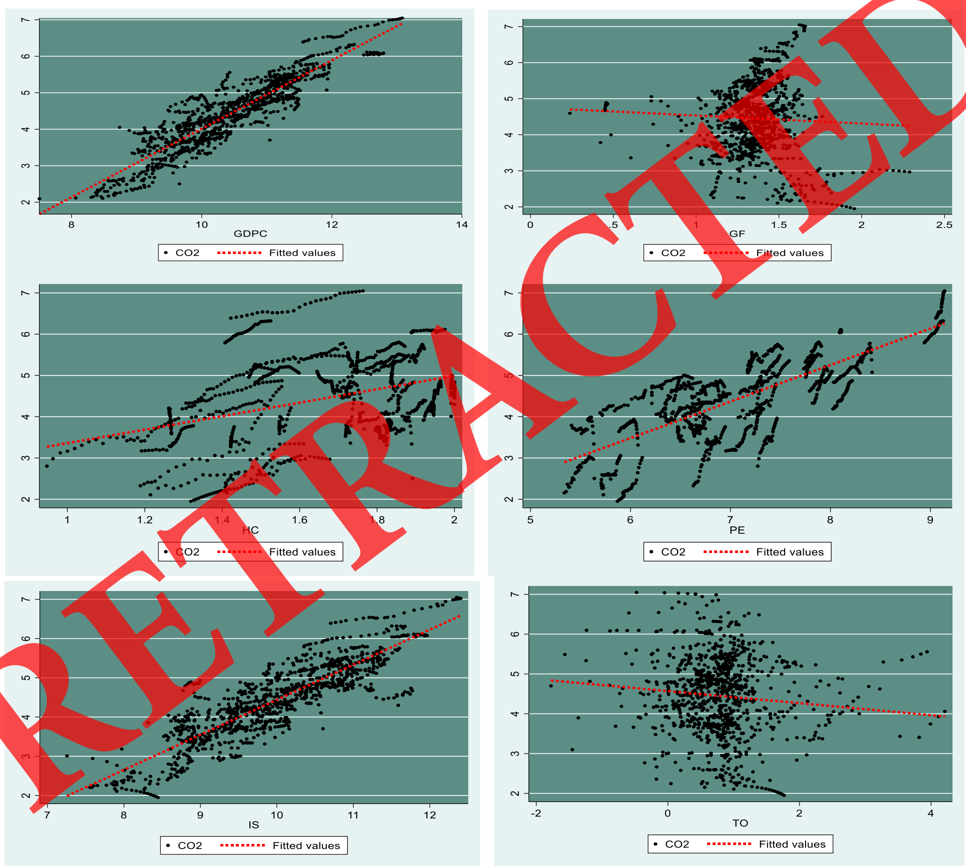

FIGURE 1
Scatterplot of variables.

$$BP_s = \sqrt{\frac{1}{N(N-1)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}[T\rho 2ij - 1]} \quad (3)$$

Normal approximation does not work well in this example because the BP is not centred at zero (mean) as n increases. This test has an asymptotically distributed asymptotically N (0, 1) when n is big, and t is finite. Thus, the BP-scaled LM test, now known as bias-corrected-scaled LM statistics, was rescaled and reentered (Streimikiene and Kaftan, 2021). The equation shown below can be used to present this data.

$$LM_{BC} = LM_p - \frac{n}{2(T-1)} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} [T\rho 2ij - 1] - \frac{1}{2(N-1)} \quad (4)$$

The CD test was also used in the study. The CD test use Eq. 6:

$$CD = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T\rho it \quad (5)$$

Where N denotes the sample size, T denotes the time period, and associations among errors of diverse cross-sections of country i and k are shown by $\hat{\rho}$.

Unit root results

The first thing that must be done in order to arrive at an accurate estimate of the results is to investigate the stationarity of the variables. Widely accepted methods are frequently utilized, such as the Levin-Lin-Chu test developed by Levin et al. (2002) and the Im, Pesaran, and Shin (IPS) test developed by Im et al. (2003). The disadvantage of these tests is that they cannot account for the CD and instead rely on the cross-sectional independence hypothesis. To circumvent the challenge posed by CD, the researchers in this investigation used second-generation unit root tests, such as the covariate-augmented Dickey-Fuller (CADF) and the augmented cross-sectional IPS (CIPS). The fact that these tests address both the problem of CD and the problem of heterogeneity is one of the most important features of these tests. Eq. 6 provides an expression for the CADF test statistics, which reads as follows:

$$\Delta X_{it} = \Phi_i + \delta_i X_{i,t-1} + \gamma_i \bar{X}_{t-1} + \Psi_i \Delta \bar{X}_t + \mu_{it} \quad (6)$$

Where X¯_(t-1) represents the mean across each cross-section. Further, the CIPS test can be presented as follows (Eq. 7):

$$CIPS = \frac{1}{N} \sum_{i=1}^{N} \delta_i (N, T) \quad (7)$$

Ordinary least squares (OLS) can be used to estimate long-run parameters if the findings of the unit root property analysis suggest that the variables in the research are stationary at the level (integrated of order 0). According to the unit root property test, a different set of data must be used if the study's variables are not steady at the level of integration (integrated of order 0). To estimate the coefficients, one must first determine whether or not there is a co-integration integration relationship between the variables in the model, which is impossible if the model contains non-stationary variables integrated to order 1. At this point, rather than using the co-integration integration tests developed by Baltagi and Kao (2000) and Gengenbach et al. (2006). We implemented the panel co-integration test developed by Persyn and Westerlund (2018).

After determining that the co-integration relationship between the variables did exist, we moved on to the next and most important step of the empirical work, which was to estimate the long-run coefficients of Eq. 1. The fully modified ordinary least squares (FMOLS) and the dynamic ordinary least squares (DOLS) estimators were both used in the first step of our analysis, which was the application of the co-integrating regressions developed by (Galvin, 2020). These estimators are built with the following components: FMOLS and DOLS are widely used in research because they help eliminate endogeneity issues among regressors and the autocorrelation problem. This is one of the reasons why these models are so popular (Samour et al., 2022). On the other hand, these methods do not consider the correlation between the various panel sections, which can result in less accurate estimate results. We overcame this limitation by employing a technique called dynamic seemingly unrelated regression (DSUR), which was first proposed by Manning and Mullahy (2003). This method not only takes into account issues of heterogeneity and cross-sectional dependence, but it is also appropriate for situations in which the sample size (N) is less than the time (T) (Wray, 2020). In accordance with the findings of (Falcone et al., 2018) and (Huang et al., 2022).

$$\beta FMOLS = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(Ait - bar\ Ai)^2\right)\right]^{-1} \times \sum_{t=1}^{T}(Ait - bar\ Ai)^2 barYit - Tbar\Delta e\mu$$
$$\beta DOLS = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\sum_{t-1}^{T}(Ait\ A'it)^2\right)\right]^{-1} \sum_{i=1}^{N}\left(\sum_{t-1}^{T}(Ait\ Yit)\right) \quad (8)$$

Moreover, this study has used the D-CCE and System GMM approaches to check the robustness.

Empirical results

Table 2 presents the findings of a statistical summary and pair-wise correlation analysis conducted between 2010 and 2020 on CO_2, green finance, GDPC, industrial structure, public expenditures, trade openness, and human capital. The period covered is from 2010 to 2020. The findings of the correlation analysis suggest a significant positive association between CO_2 emissions and the explanatory variables, with the exception of GF and human capital, which indicate a significant negative association.

All of the tests' findings to determine whether there is a cross-sectional dependence (CSD) in the panels indicate that the null hypothesis (H0) should not be accepted. The probability values of CO2 in rows 1, 2, and 3, as well as those of all other explanatory variables (i.e., green finance, carbon emissions, economic development, industrial structure, public expenditures on health, trade openness, and human capital) in all four rows, respectively, validate that all factors are cross-sectionally dependent on one another (see Table 3). This suggests that other countries on the panel were also affected by the unpredictability or disruption caused by one country.

TABLE 2 Descriptive statistics and pair-wise correlation tests.

	CO_2	GF	GDPC	IS	PE	TO	HC
Mean	6.5523	3.7456	10.8963	7.5563	5.1236	4.7456	3.2589
Median	6.4563	3.5623	10.8546	7.4512	5.1063	4.2385	3.1123
Max	8.5896	5.2358	13.7456	11.023	8.5693	7.3336	5.2365
Mini	0.2569	0.0021	2.3164	1.4521	0.0096	1.5698	0.0001
Pair-wise Correlation							
CO_2	1						
GF	-0.5622	1					
GDPC	0.5236	0.2344	1				
IS	0.7145	-0.1285	0.1252	1			
PE	0.5693	-0.2555	0.4579	-0.2369	1		
TO	0.1236	0.7023	0.4125	0.5696	-0.6321	1	
HC	-0.4566	0.6630	0.1245	0.4363	0.7412	0.1134	1

TABLE 3 Cross-section dependence test.

	CO_2	GF	GDPC	IS	PE	TO	HC
BP-LM	233.56 (0.000)	444.52 (0.000)	339.85 (0.000)	189.65 (0.000)	236.23 (0.000)	645.23 (0.000)	204.56 (0.000)
PS-LM	123.28 (0.0001)	189.32 (0.000)	256.33 (0.000)	179.23 (0.000)	211.56 (0.005)	552.45 (0.000)	190.23 (0.000)
BCS-LM	118.89 (0.000)	176.52 (0.000)	213.33 (0.000)	155.87 (0.000)	187.63 (0.000)	288.63 (0.000)	177.23 (0.000)
PCD	5.6323 (0.000)	10.789 (0.000)	12.589 (0.000)	7.456 (0.000)	6.2356 (0.000)	14.563 (0.000)	9.5236 (0.000)

Note: PB-LM: Breusch-Pagan LM, PS-LM: Pesaran scaled LM, BCS-LM: Bias-corrected scaled LM, PCD: Pesaran CD.

TABLE 4 CADF and CIPS unit root tests.

	CIPS		CADF	
Variable	Level	1st difference	Level	1st difference
CO_2	-3.5689**	-5.8945	-4.8932**	-5.9963
GF	1.5666	-3.0589*	2.0452	-4.9865*
GDPC	-2.0124	-5.9632*	-1.8965	-5.5666*
IS	-3.8745*	-7.5255*	-3.9678*	-6.8850
PE	-1.2356	-4.8523*	-1.8863	-5.4501*
TO	-3.1222*	-7.6312*	-3.9655*	-6.3699
HC	-1.5558	-3.9865*	-1.8966	-4.2874*

The results of both the CADF and the CIPS unit root approaches are presented in Table 4. According to the results of these experiments, the only constant factors are CO2 levels, IS levels, and trade openness levels. Therefore, to make the stationary variables, the study takes the first difference between them. CIPS and CADF, after taking the first difference, provide ample proof to reject the null hypothesis, which states that panels contain unit roots (H0 = panel contains unit root). Therefore, at order one [I (1)], all factors are integrated, demonstrating that every variable's presumption of the co-integration test is satisfied.

TABLE 5 Westerlund and Edgerton (2008) test.

Test		Mean shift	Regime shift
Dependent variable: Carbon emissions Index			
Z_{Φ} (N)	-6.563*	-4.569*	-4.452*
p-value	0.000	0.000	0.000
$Z_{\square}$ (N)	-5.782*	-4.569*	-3.855*
p-value	0.000	0.000	0.000

First, estimating the co-integration among the panel data is imperative before estimating the long-run and short-run coefficient values. Traditional co-integration tests, such as those conducted by (Dafermos et al., 2021; Zhang and Vigne, 2021), cannot produce reliable findings. Considering all this (Campiglio, 2016), delivers credible results by incorporating the CD into the data. According to Table 5, all variables are co-integrated at a level of significance equal to 1%.

RETRACTED

Long run outcomes of DSUR, FMOLS, and DOLS estimators

In terms of the primary effect, green finance has been shown to correlate significantly with the economy's decarbonization over time and across all relevant parameters (see Table 6). In addition, green finance's long-term negative and significant impact on CO_2 emissions is relatively consistent with what was expected. This finding is essential because it lends credence to the idea that overcoming the financial barrier constitutes one of the most significant obstacles to achieving a carbon-neutral economy by 2050. This study offers evidence from 30 provinces based on empirical results that support the ADB policy. It uses the Asian Development Bank's climate change finance approval-based measure. Our empirical findings spanning alternative measurements and robust estimators are valuable to policymakers and regulators that deal with environmental challenges and associated research. The results of our study lend credence to the presumption that environmentally responsible banking offers the expected benefits. This suggests that ecologically responsible investment and financing help preserve the environment's quality by lowering the amount of carbon dioxide emissions produced.

Although green finance is still in its infancy, our estimation work for this study demonstrates that GF successfully delivers what is anticipated. In particular, it results in a sizeable decrease in the amount of CO2 emissions produced by the sample economies located in the region. The Asian Development Bank (ADB) has initiated a number of one-of-a-kind projects that are friendly to the environment in economies participating in this initiative. Projects such as "Efficient Utilization of Agricultural Wastes, Integrated Ecosystem and Water Resources Management in the Baiyangdian Basin, and Ningxia Integrated Ecosystem and Agricultural Development Project" in China and "Climate Resilient Coastal Protection and Management" in India are a few examples of the work that the ADB is doing as part of these efforts. Other countries in Asia are presently undertaking similar initiatives, including Indonesia and Malaysia. Investing in ecologically beneficial projects, such as renewable energy and developing biodiversity and ecosystems, is another route to this successful effort. Individual governments also play an important role in this effort. This investment helps ensure that environmentally friendly projects are developed and implemented. This study contributes to the literature on environmental economics by quantifying green finance and demonstrating empirically how it affects environmental quality. Although it is primarily focused on Asia and has a small sample size and dataset, it does so by showing how these factors interact. In addition, it emphasizes the primary function of the ADB, which is to alleviate poverty throughout Asia and the Pacific. As a result, the current empirical research supports the contention that climate finance is environmentally conducive to the reduction of CO_2 in the sample group. As a result, Zeng et al. (2022) proposed that nations should be incentivized to accomplish the primary goals of the Paris agreement, which include the creation of new financial tools and the reallocation of capital to low-carbon projects.

Similarly, economic growth per capita (EG) is the second-factor determining carbon emissions, demonstrating a positive association with the explained variable. These findings prove that an asymmetric relationship exists between EG and carbon emissions in the countries that make up China. According to the findings, positive shocks in EG (such as falling oil prices and advances in technology, which both spur EG) lead to a decline in the quality of the environment in the Chinese economy. Notably, a 1% increase in volatility in the positive sum of EG results in a significant increase in carbon emissions. Sun et al. (2022) report that EG is responsible for an increase in the amount of environmental degradation in MINT countries. Positive shocks from EG have a short-term impact on the level of carbon emissions produced by the Chinese economy. As a consequence of this, the effect of EG on carbon emissions has a propensity to be asymmetric. In the chosen economy, there is a strong correlation between EG and CO2 emissions. As a result, EG will continue to rise even if environmental measures are taken. To be more specific, industrialization necessitates consuming a significant amount of energy, which is the primary driver of environmental pollution. In recent decades, the economy of China has exerted considerable effort toward improving its industrialization process and EG. As a result, it is anticipated that EG will contribute to a decline in the quality of the environment throughout the economic expansion. A significant quantity of energy high in carbon intensity is required to carry out economic activities across various sectors. This is one of the reasons that there is a correlation between economic growth and increased carbon emissions. The increase in economic activity in various sectors, such as the manufacturing sector (factories that produce iron, sugar, steel, and cement), the services sector (e.g., retail and across-the-board trade, transport storeroom, possession of lodging, finance, and insurance, public management defense, public and individual services), and the development sector [e.g., real estate, national infrastructure, and the One Belt One Road project (OBOR)], raises the demand for energy needed for those sectors' respective operations. In China, non-renewable energy resources were responsible for satisfying the majority of the country's energy demand. As a result, our findings can be used to justify the assertion that an expansion of economic activities will lead to an increase in energy consumption, the majority of which will be derived from carbon-intensive energy sources, which will ultimately result in increased carbon emissions in China.

Another factor that can potentially influence the total emissions is the industrial structure used. According to the econometric methods that have been specified, the influence coefficient of industrial structure on carbon emissions is statistically significantly positive at the level of 1%. In addition, there is the possibility of unfavorable spatial spillover effects; for example, if the IS rises by one unit in the neighboring province, this will increase carbon emission in the local region. To achieve a shift in industrial structure in some locations, it is not difficult to establish that international and domestic industrial transfers are a significant means (Sun et al., 2022), and the immigration of some energy-intensive businesses leads to the rise in CO_2 emissions in delivery areas. It is because of these factors that the negative spatial spillover effect occurs. China's industrial structure is being upgraded, and it is not difficult to find that some regions rely on foreign and domestic industrial transfer to achieve this goal. In other words, some regions have seen an increase in their green total factor productivity as a result of the transfer of high input and high energy-consuming industries to neighboring regions. On the other hand, neighboring regions have seen a significant increase in their carbon emissions as a result of the industrial transfer process. The relevant studies back up the aforementioned conclusion. Clayton et al. (2021) investigated the characteristics of regional industrial transfer and China's carbon emissions intensity. They found that the net transfer out of the region is decreasing in energy intensity, while the net transfer into the region is growing in carbon emission intensity (Goyal and Joshi, 2011). According to empirical research, there are clear issues with "carbon emission transfer" and "carbon leakage" in China's regional industrial transfer. As a result, during the process of industrial structure promotion, the industrial transfer will result in obvious ecological difficulties in the regions that are receiving new industries, but it will have a significant impact on reducing the intensity of carbon emissions in regions that are producing new industries. This is in line with the hypothesis that the IS has a detrimental effect on the spatial spillover of carbon emissions. Some regions have increased their industrial structure through industrial transfer, which has increased green total factor productivity and reduced carbon emissions. At the same time, the problem of carbon emissions in neighboring regions has worsened.

After we have completed our research on the influence that the composition of industries has on emissions, we will look into the potential role that governmental spending on health can play in mitigating the effects of CO_2 emissions. A one % increase in public expenditures results in a reduction in CO_2 emissions of approximately 0.655% (DSUR), 0.362% (FMOLS), and 0.604%, according to the coefficients of the public expenditures, which are negative and significant (DOLS). The findings prove that the existing health policies in China's economy are headed in the right direction to protect the environment from emissions. According to the results of a number of investigations, including those conducted by Matchaya (2020) and Silva et al. (2019), the allocation of public funds to environmental protection has a sizeable bearing on CO_2 emissions. In the fight against environmental concerns, PE has been recognized as a driving factor because it is impossible to uncover and address environmental challenges without funds. While PE offers assistance to various entities in their efforts to address the issues, China's economy can potentially reduce the amount of money that the government spends on environmental concerns.

Importantly, the estimated results provide compelling evidence that trade openness exerts a heterogeneous effect on carbon emissions when considering the roles played by green finance, economic development, industrial structure, and public expenditures. This is illuminating because it suggests that openness in trade has a constructive effect on reducing carbon emissions. This indicates that the impact of economic openness on carbon emissions will change in tandem with the level of income being generated. This lends credence to a view reported previously by Hilber and Mayer (2009), namely that trade openness contributes to carbon emissions across the board despite having varying degrees of influence on various panels. The contradictory effects of openness to trade on carbon emissions lead one to believe that while it helps the environment in countries with high levels of wealth, it makes the pollution problem worse in countries with low levels of wealth. This falls in line with the widely acknowledged phenomenon of carbon transfer that occurs during international trade. The environmental management system in China is inadequate, which contributes to the country's generally lower environmental standards compared to those of other countries with higher income levels. As a result, developed countries have either transferred or outsourced industries with high carbon emissions to China as a result of the formation of global supply chains. This lends credence to the opinions of (Onofrei et al., 2021), who pointed out that polluting industries are most prevalent in developing countries and tend to produce a disproportionately high amount of waste. It was determined that the "Pollution Refuge Hypothesis" is correct (Micah et al., 2021), and trade-implied carbon emissions were also assumed to be an important means of transferring pollution. As a consequence, open trade's effect on the environment shifts from positive to negative as levels of income decline.

The most important takeaway from this research, which should assist them in accomplishing their objectives, is that the effect of human capital on carbon emissions is detrimental. If China's human capital, measured by the number of students enrolled in tertiary education and years spent in school, increases, then the country's carbon emissions will decrease. This indicates the potential for a reduction in carbon emissions through the long-term improvement of human capital. If more students enroll in higher education programs, this will create potential labor that is better educated, innovative, productive, and understanding. It will also contribute to the improvement of energy security and the reduction of carbon emissions. Education is a factor that is considered to be of the utmost importance for developed nations; however, China is currently in a position where it is up-growing. Education is the only category in which the Chinese government has allocated a significant portion of

TABLE 6 Outcomes of DSUR, FMOLS and DOLS.

Variable	DSUR		FMOLS		DOLS	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
GF	-0.6389*	0.1356	-1.0896*	0.2385	-0.9952*	0.1274
GDPC	0.7026**	0.1522	0.6600*	0.1127	0.6341*	0.1822
IS	0.0236*	0.0110	0.4696*	0.1023	0.4063*	0.1201
PE	-0.6551*	0.1321	-0.3622*	0.1233	-0.6041*	0.1523
TO	0.8755*	0.2222	0.6520*	0.1332	0.8923*	0.1114
HC	-0.3352**	0.0962	-0.6945*	0.1125	-0.5296*	0.1344

TABLE 7 Outcomes of D-CCE and system GMM estimators.

Variable	D-CCE estimator		Sys. GMM	
	Coefficient	Std. Error	Coefficient	Std. Error
$CO_{2\ t-1}$	-0.7985*	0.2563	-0.6956*	0.1351
GF	-0.7145*	0.1122	-0.5012*	0.2270
GDPC	0.5411**	0.1033	0.7541*	0.3385
IS	0.1162*	0.0992	0.4122	0.1098
PE	-0.6321*	0.1301	-0.7842*	0.2512
TO	0.7863*	0.1971	0.6138*	0.1233
HC	-0.4503*	0.1512	-0.0986*	0.0023
			AR_1	3.1245 (0.045)
			AR_2	1.9632 (0.069)
			Sargan test	18.639 (0.088)
			Wald Test	112362 (0.000)

RETRACTED

GDP in recent years' budgets. Unless the government invests more money in expanding access to education, the rate at which emissions are reduced will quicken as the number of students enrolled in educational institutions increases. On the other hand, a lack of education results in the production of unskilled workers and an increase in the consumption levels of households. Education in China is currently accessible thanks to the numerous public institutes and excellent educational facilities. In China, there is an abundant supply of technical institutes that offer courses in technical education. There are many positive aspects to the education system, such as the substandard evaluation system, the high quality of teachers, the low unemployment and poverty rates, the consistent population growth, the absence of political interference, and the massive budget allocation for the education sector. Therefore, based on our findings, we may conclude that an increase in human capital through education can help limit the growth of carbon emissions over the long term. In turn, countries that place a greater emphasis on education tend to have more skilled workers, which increases energy efficiency and makes it simpler to adopt new environmentally friendly technologies that reduce carbon emissions.

Robustness check

There were a number of different robustness tests carried out. The empirical model was re-estimated using the other two estimators, D-CCE and System GMM. This was done to guarantee that the empirical estimations were accurate. As can be seen in Table 7, all of the estimated coefficients of the variables that explain the data point in the same direction.

Conclusion and policy recommendations

This study quantifies green finance as "climate mitigation finance," and it examines the impact on the carbon emissions in 30 provinces of China subject to data constraints. Considering the expanding role of green finance, this study quantifies green finance as "climate mitigation finance." The second-generation panel unit-root test developed by Pesaran is utilized when conducting unit-root testing. The Fully Modified Ordinary and Dynamic Ordinary Least Square models are used as a baseline. Then Dynamic, Seemingly Un-correlated regressions with the robust function are used as a model. Finally, the Fully Modified Ordinary model is used. Our findings show that mitigation finance has a significantly negative impact on carbon emissions. The diagnostic problems associated with the selected estimators' settings are significant; therefore, to correct them, we use the Dynamic common correlated effect mean group and the System GMM as alternative specifications for robustness, which both produce comparable results. In addition, the researchers discovered a positive connection between industrial structure, economic per capita, and trade openness in relation to carbon emissions. Similarly, public expenditure and human capital demonstrate their negative impact on carbon emissions.

Policy recommendations

The results of this study have a number of applications in practice. According to our research findings, the following policy recommendations are proposed for effectively reducing carbon emissions.

First and foremost, industrial structure transformation performance must be improved (industrial structure rationalization and optimization). This is owing to a lack of progress in meeting the carbon emission implications of industrial structural transformation. In addition to promoting advanced technology, tightening environmental legislation, and fostering green production motivation, these consequences include the following: In addition to improving the efficiency of industrial structure transformation, these advantages help to reduce greenhouse gas emissions and combat global warming.

According to (Yumei et al., 2021), cooperation centered on the distribution of technology improves environmental quality by fostering increased levels of efficiency and modernization. Therefore, the incorporation of environmental provisions into a trade agreement has been recognized by numerous countries as the most effective method for safeguarding the global economy. Therefore, trade agreements ought to strengthen the capacity of governments to address issues associated with the environment. In a similar vein, removing trade restrictions on products that are friendly to the environment may result in an increase in environmentally conscious innovations at a reduced price. For instance, the Trans-Pacific Partnership (TPP) treaty committed to assisting developing countries in their transition into clean industries. Additionally, it adopts low-carbon mechanisms by encouraging the production of environmentally friendly commodities and investments.

Accelerating efforts to reduce the use of coal requires delaying the construction of new coal plants, actively promoting electrification in industry and clean heating in buildings, effectively pricing carbon, and providing countries that are dependent on coal with targeted support for the transition to renewable energy and an economy based on sustainable practices. Our findings demonstrate that increasing trade volume does not automatically increase emissions; the opposite is also true, as countries are gradually adopting environmentally friendly production technologies. Long term, the quality of the environment will improve as a result of this transformation, which will reduce the heavy reliance on conventional energy for production. Reducing environmental pollution without having a negative impact on trade volumes or real income, in general, requires power-dependent nations to assist in the development of generation capacity and investment in renewable energy, as well as restructure energy-saving efforts to cut down on excessive energy loss. In addition, the current economic obstacles that stand in the way of promoting renewable energy must be removed. This can be accomplished by improving coordination between authorities, providing adequate subsidies for developers, mitigating the risks associated with green investments, and gradually implementing renewable energy markets. As a result, reviewing the policies concerning trade openness is necessary.

Based on the findings of this study, it appears that China's goals of reducing carbon emissions and increasing economic growth can be accomplished through the accumulation of human capital.

The advancement of human capital through improvements in education access, the maximum number of students enrolled in secondary education, and the average number of years spent in school will assist in producing labor that is more highly skilled and efficient in the future by embracing innovative production techniques and cutting-edge technologies, which also contribute to the reduction of carbon emissions, labor that is educated and skilled plays a constructive role in the efficient use of energy. This study has the potential to assist the Chinese government in formulating a comprehensive and efficient plan about expenditures on education for skilled labor in order to increase productivity, which in turn leads to economic growth and restricts the growth of carbon emissions. The nation's decision-makers should prioritize human capital by investing in education and expanding the number of educational facilities available in China. The government of China ought to encourage public institutes by providing financial aid for low-income students, educational scholarships, qualified faculty members, and an absence of political influence while simultaneously exerting control over private institutes to prevent them from charging exorbitant tuition fees. A nation should take the appropriate steps to ensure that all students in the country have access to free education, at least through the secondary level, and that education is provided without charge. As a result, the government should also invest in public education, enforcing environmental standards by employing advanced machinery, environmentally-friendly industrial processes, training workers, and spreading awareness about the negative effects of carbon dioxide emissions. This will help to boost the production of goods and services, which in turn will facilitate economic growth and reduce carbon emissions. China can lower its carbon emissions without damaging its economic expansion.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://data.worldbank.org/.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

10.3389/fenvs.2022.991298

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Alola, A. A., Adebayo, T. S., and Onifade, S. T. (2021). Examining the dynamics of ecological footprint in China with spectral Granger causality and quantile-on-quantile approaches. *Int. J. Sustain. Dev. World Ecol.* 29, 263–276. doi:10.1080/13504509.2021.1990158

Alola, A. A., and Onifade, S. T. (2022). Energy innovations and pathway to carbon neutrality in Finland. *Sustain. Energy Technol. Assessments* 52, 102272. doi:10.1016/J.SETA.2022.102272

Atasoy, A. T. (2020). Behavioral responses of green builders to discontinuous certification schemes. *Resour. Energy Econ.* 60, 101141. doi:10.1016/j.reseneeco.2019.101141

Baltagi, B. H., and Kao, C. (2000). "Nonstationary panels, cointegration in panels and dynamic panels: A survey," in *Advances in econometrics* (Emerald Group Publishing Limited), 7–51. doi:10.1016/S0731-9053(00)15002-9

Campiglio, E. (2016). Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy. *Ecol. Econ.* 121, 220–230. doi:10.1016/j.ecolecon.2015.03.020

Chen, T. L., Kim, H., Pan, S. Y., Tseng, P. C., Lin, Y. P., and Chiang, P. C. (2020). Implementation of green chemistry principles in circular economy system towards sustainable development goals: Challenges and perspectives. *Sci. Total Environ.* 716, 136998. doi:10.1016/J.SCITOTENV.2020.136998

Chen, Q., Ning, B., Pan, Y., and Xiao, J. (2021a). Green finance and outward foreign direct investment: Evidence from a quasi-natural experiment of green insurance in China. *Asia Pac. J. Manag.* 39, 899–924. doi:10.1007/s10490-020-09750-w

Chen, Y., kumara, E. K., and Sivakumar, V. (2021b). Investigation of finance industry on risk awareness model and digital economic growth. *Ann. Oper. Res.* doi:10.1007/s10479-021-04287-7

Clark, W. W. (2019). "Chapter 9 - smart green healthy communities: Cases of science parks and microcities," in *Climate preservation in urban communities case studies*, 357–414.

Clayton, J., Devine, A., and Holtermans, R. (2021). Beyond building certification: The impact of environmental interventions on commercial real estate operations. *Energy Econ.* 93, 105039. doi:10.1016/j.eneco.2020.105039

Dafermos, Y., Gabor, D., and Michell, J. (2021). The wall street consensus in pandemic times: What does it mean for climate-aligned development? *Can. J. Dev. Stud./Revue Can. d'etudes. du Dev.* 42, 238–251. doi:10.1080/02255189.2020.1865137

de Morais, L. H. L., Pinto, D. C., and Cruz-Jesus, F. (2021). Circular economy engagement: Altruism, status, and cultural orientation as drivers for sustainable consumption. *Sustain. Prod. Consum.* 27, 523–533. doi:10.1016/j.spc.2021.01.019

Dmuchowski, P., Dmuchowski, W., Baczewska-Dąbrowska, A. H., and Gworek, B. (2021). Green economy – growth and maintenance of the conditions of green growth at the level of polish local authorities. *J. Clean. Prod.* 301, 126975. doi:10.1016/j.jclepro.2021.126975

Dong, S., Xu, L., and McIver, R. (2021). China's financial sector sustainability and "green finance" disclosures. *Sustain. Account. Manag. Policy J.* 12, 353–384. doi:10.1108/SAMPJ-10-2018-0273

Dulal, H. B., Dulal, R., and Yadav, P. K. (2015). Delivering green economy in Asia: The role of fiscal instruments. *Futures* 73, 61–77. doi:10.1016/j.futures.2015.08.002

Falcone, P. M., Morone, P., and Sica, E. (2018). Greening of the financial system and fuelling a sustainability transition: A discursive approach to assess landscape pressures on the Italian financial system. *Technol. Forecast. Soc. Change* 127, 23–37. doi:10.1016/j.techfore.2017.05.020

Galvin, R. (2020). Yes, there is enough money to decarbonize the economies of high-income countries justly and sustainably. *Energy Res. Soc. Sci.* 70, 101739. doi:10.1016/j.erss.2020.101739

Geddes, A., Schmid, N., Schmidt, T. S., and Steffen, B., 2020. The politics of climate finance: Consensus and partisanship in designing green state investment banks in the United Kingdom and Australia. *Energy Res. Soc. Sci.* 69, 101583. doi:10.1016/j.erss.2020.101583

Gengenbach, C., Palm, F. C., and Urbain, J. P. (2006). Cointegration testing in panels with common factors. *Oxf. Bull. Econ. Stat.* 68, 683–719. doi:10.1111/j.1468-0084.2006.00452.x

Goyal, K. A., and Joshi, V. (2011). A study of social and ethical issues in banking industry. *Int. J. Econ. Res.* 2, 49–57.

Guild, J. (2020). The political and institutional constraints on green finance in Indonesia. *J. Sustain. Finance Invest.* 10, 157–170. doi:10.1080/20430795.2019.1706312

He, L., Liu, R., Zhong, Z., Wang, D., and Xia, Y. (2019). Can green financial development promote renewable energy investment efficiency? A consideration of bank credit. *Renew. Energy* 143, 974–984. doi:10.1016/j.renene.2019.05.059

Hilber, C. A. L., and Mayer, C. (2009). Why do households without children support local public schools? Linking house price capitalization to school spending. *J. Urban Econ.* 65, 74–90. doi:10.1016/j.jue.2008.09.001

Horlings, L. G., and Marsden, T. K. (2011). Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could "feed the world. *Glob. Environ. Change* 21, 441–452. doi:10.1016/j.gloenvcha.2011.01.004

Hu, G., Wang, X., and Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Econ.* 98, 105134. doi:10.1016/j.eneco.2021.105134

Huang, H., Chau, K. Y., Iqbal, W., and Fatima, A. (2022). Assessing the role of financing in sustainable business environment. *Environ. Sci. Pollut. Res.* 29, 7889–7906. doi:10.1007/s11356-021-16118-0

Im, K. S., Pesaran, M. H., and Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *J. Econom.* 115, 53–74. doi:10.1016/S0304-4076(03)00092-7

Jiang, Z., Lyu, P., Ye, L., and Zhou, Y. W. (2020). Green innovation transformation, economic sustainability and energy consumption during China's new normal stage. *J. Clean. Prod.* 273, 123044. doi:10.1016/j.jclepro.2020.123044

Karani, P., and Failler, P. (2020). Comparative coastal and marine tourism, climate change, and the blue economy in African Large Marine Ecosystems. *Environ. Dev.* 36, 100572. doi:10.1016/j.envdev.2020.100572

Kazancoglu, Y., Kazancoglu, I., and Sagnak, M. (2018). A new holistic conceptual framework for green supply chain management performance assessment based on circular economy. *J. Clean. Prod.* 195, 1282–1299. doi:10.1016/J.JCLEPRO.2018.06.015

Khan, M. A., Riaz, H., Ahmed, M., and Saeed, A. (2021). Does green finance really deliver what is expected? An empirical perspective. *Borsa Istanb. Rev.* 22, 586–593. doi:10.1016/j.bir.2021.07.006

Khoshnava, S. M., Rostami, R., Zin, R. M., Štreimikiene, D., Yousefpour, A., Strielkowski, W., et al. (2019). Aligning the criteria of green economy (GE) and sustainable development goals (SDGs) to implement sustainable development. *Sustainability* 11, 4615. doi:10.3390/su11174615

Knuth, S. (2018). Breakthroughs" for a green economy? Financialization and clean energy transition. *Energy Res. Soc. Sci.* 41, 220–229. doi:10.1016/j.erss.2018.04.024

Lee, C. C., and Lee, C. C. (2022). How does green finance affect green total factor productivity? Evidence from China. *Energy Econ.* 107, 105863. doi:10.1016/J.ENECO.2022.105863

Lee, C. C., Lee, C. C., and Li, Y. Y. (2021). Oil price shocks, geopolitical risks, and green bond market dynamics. *North Am. J. Econ. Finance* 55, 101309. doi:10.1016/j.najef.2020.101309

Lei, X., Xu, Q. Y., and Jin, C. Z. (2021). Nature of property right and the motives for holding cash: Empirical evidence from Chinese listed companies. *MDE. Manage. Decis. Econ.* 43, 1482–1500. doi:10.1002/MDE.3469

Levin, A., Lin, C. F., and Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *J. Econom.* 108, 1–24. doi:10.1016/S0304-4076(01)00098-7

Li, Z., Ju, S., Duan, M., and Cai, S. (2020). Quantitative selection of leading industries of green economy in coastal cities based on industrial relevance. *J. Coast. Res.* 103, 566–569. doi:10.2112/SI103-115.1

Li, J., Zhao, Y., Zhang, A., Song, B., and Hill, R. L. (2021). Effect of grazing exclusion on nitrous oxide emissions during freeze-thaw cycles in a typical steppe of Inner Mongolia. *Agric. Ecosyst. Environ.* 307, 107217. doi:10.1016/j.agee.2020.107217

Li, Z., Kuo, T. H., Siao-Yun, W., and The Vinh, L. (2022). Role of green finance, volatility and risk in promoting the investments in Renewable Energy Resources in the post-Covid-19. *Resour. Policy* 76, 102563. doi:10.1016/J.RESOURPOL.2022.102563

Lin, B., and Zhu, J. (2019). Fiscal spending and green economic growth: Evidence from China. *Energy Econ.* 83, 264–271. doi:10.1016/j.eneco.2019.07.010

Liu, Y., and Dong, F. (2021). How technological innovation impacts urban green economy efficiency in emerging economies: A case study of 278 Chinese cities. *Resour. Conserv. Recycl.* 169, 105534. doi:10.1016/j.resconrec.2021.105534

Liu, W., Du, M., and Bai, Y. (2021). Mechanisms of environmental regulation's impact on green technological progress—Evidence from China's manufacturing sector. *Sustainability* 13, 1600–1623. doi:10.3390/su13041600

Liu, H., Tang, Y. M., Iqbal, W., and Raza, H. (2022a). Assessing the role of energy finance, green policies, and investment towards green economic recovery. *Environ. Sci. Pollut. Res.* 29, 21275–21288. doi:10.1007/s11356-021-17160-8

Liu, Z., Vu, T. L., Phan, T. T. H., Ngo, T. Q., Anh, N. H. V., and Putra, A. R. S. (2022b). Financial inclusion and green economic performance for energy efficiency finance. *Econ. Change Restruct.*, 1–31. doi:10.1007/s10644-022-09393-5

Ma, Q., Tariq, M., Mahmood, H., and Khan, Z. (2022). The nexus between digital economy and carbon dioxide emissions in China: The moderating role of investments in research and development. *Technol. Soc.* 68, 101910. doi:10.1016/J.TECHSOC.2022.101910

Manning, W. G., and Mullahy, J. (2003). *Technical working paper series*.

Massé, F., Givá, N., and Lunstrum, E. (2021). A feminist political ecology of wildlife crime: The gendered dimensions of a poaching economy and its impacts in Southern Africa. *Geoforum* 126, 205–214. doi:10.1016/j.geoforum.2021.07.031

Matchaya, G. C. (2020). Public spending on agriculture in Southern Africa: Sectoral and intra-sectoral impact and policy implications. *J. Policy Model.* 42, 1228–1247. doi:10.1016/j.jpolmod.2020.05.002

Mealy, P., and Teytelboym, A. (2020). Economic complexity and the green economy. *Res. Policy*, 103948. doi:10.1016/j.respol.2020.103948

Melnyk, T., Reznikova, N., and Ivashchenko, O. (2020). Problems of statistical study of "green economics" and green growth potentials in the sustainable development context. *Balt. J. Econ. Stud.* 6, 87–98. doi:10.30525/2256-0742/2020-6-3-87-98

Micah, A. E., Cogswell, I. E., Cunningham, B., Ezoe, S., Harle, A. C., Maddison, E. R., et al. (2021). Tracking development assistance for health and for COVID-19: A review of development assistance, government, out-of-pocket, and other private spending on health for 204 countries and territories, 1990–2050. *Lancet* 398, 1317–1343. doi:10.1016/s0140-6736(21)01258-7

Mikhno, I., Koval, V., Shvets, G., Garmatiuk, O., and Tamošiūnienė, R. (2021). Green economy in sustainable development and improvement of resource efficiency. *Cent. Eur. Bus. Rev.* 10, 99–113. doi:10.18267/j.cebr.252

Montefrio, M. J. F., and Dressler, W. H. (2016). The green economy and constructions of the "idle" and "unproductive" uplands in the Philippines. *World Dev.* 79, 114–126. doi:10.1016/j.worlddev.2015.11.009

Moutinho, V., Costa, C., and Bento, J. P. C. (2015). The impact of energy efficiency and economic productivity on CO 2 emission intensity in Portuguese tourism industries. *Tour. Manag. Perspect.* 16, 217–227. doi:10.1016/j.tmp.2015.07.009

Muganyi, T., Yan, L., and Sun, H. P. (2021). Green finance, fintech and environmental protection: Evidence from China. *Environ. Sci. Ecotechnology* 7, 100107. doi:10.1016/j.ese.2021.100107

Nabeeh, N. A., Abdel-Basset, M., and Soliman, G. (2021). A model for evaluating green credit rating and its impact on sustainability performance. *J. Clean. Prod.* 280, 124299. doi:10.1016/j.jclepro.2020.124299

Onifade, S. T., Alola, A. A., Erdoğan, S., and Acet, H. (2021a). Environmental aspect of energy transition and urbanization in the OPEC member states. *Environ. Sci. Pollut. Res.* 28, 17158–17169. doi:10.1007/s11356-020-12181-1

Onifade, S. T., Erdoğan, S., Alagöz, M., and Bekun, F. V. (2021b). Renewables as a pathway to environmental sustainability targets in the era of trade liberalization: Empirical evidence from Turkey and the caspian countries. *Environ. Sci. Pollut. Res.* 28, 41663–41674. doi:10.1007/s11356-021-13684-1

Onifade, S. T., Andrew, |, Alola, A., and Alola, A. A. (2022). Energy transition and environmental quality prospects in leading emerging economies: The role of environmental-related technological innovation. *Sustain. Dev.* doi:10.1002/SD.2346

Onofrei, M., Cigu, E., Gavriluta, A. F., Bostan, I., and Oprea, F. (2021). Effects of the Covid-19 pandemic on the budgetary mechanism established to cover public health expenditure. A case study of Romania. *Int. J. Environ. Res. Public Health* 18, 1134. doi:10.3390/ijerph18031134

Owen, R., Brennan, G., and Lyon, F. (2018). Enabling investment for the transition to a low carbon economy: Government policy to finance early stage green innovation. *Curr. Opin. Environ. Sustain.* 31, 137–145. doi:10.1016/j.cosust.2018.03.004

Persyn, D., and Westerlund, J. (2018). Error-correction–based cointegration tests for panel data. *Stata J.* 8, 232–241. doi:10.1177/1536867X0800800205

Potluri, S., and Phani, B. V. (2020). Incentivizing green entrepreneurship: A proposed policy prescription (a study of entrepreneurial insights from an emerging economy perspective). *J. Clean. Prod.* 259, 120843. doi:10.1016/j.jclepro.2020.120843

Pulicherla, K. K., Adapa, V., Ghosh, M., and Ingle, P. (2021). Current efforts on sustainable green growth in the manufacturing sector to complement "make in India" for making "self-reliant India. *Environ. Res.* 206, 112263. doi:10.1016/j.envres.2021.112263

Qu, C., Shao, J., and Cheng, Z. (2020). Can embedding in global value chain drive green growth in China's manufacturing industry? *J. Clean. Prod.* 268, 121962. doi:10.1016/j.jclepro.2020.121962

Rehman, E., Ikram, M., Rehman, S., and Feng, M. T. (2021). Growing green? Sectoral-based prediction of GHG emission in Pakistan: A novel NDGM and doubling time model approach. *Environ. Dev. Sustain.*, 12169–12191. doi:10.1007/s10668-020-01163-5

Rowan, N. J., and Galanakis, C. M. (2020). Unlocking challenges and opportunities presented by COVID-19 pandemic for cross-cutting disruption in agri-food and green deal innovations: Quo Vadis? *Sci. Total Environ.* 748, 141362. doi:10.1016/j.scitotenv.2020.141362

Saeed Meo, M., and Karim, M. Z. A. (2021). The role of green finance in reducing CO2 emissions: An empirical analysis. *Borsa Istanb. Rev.* 22, 169–178. doi:10.1016/j.bir.2021.03.002

Saha, T., Sinha, A., and Abbas, S. (2022). Green financing of eco-innovations: Is the gender inclusivity taken care of? *Econ. Research-Ekonomska Istraz.*, 1–22. doi:10.1080/1331677X.2022.2029715

Samour, A., Baskaya, M. M., and Tursoy, T. (2022). The impact of financial development and fdi on renewable energy in the uae: A path towards sustainable development. *Sustainability* 14, 1208. doi:10.3390/su14031208

Sandberg, M., Klockars, K., and Wilén, K. (2019). Green growth or degrowth? Assessing the normative justifications for environmental sustainability and economic growth through critical social theory. *J. Clean. Prod.* 206, 133–141. doi:10.1016/j.jclepro.2018.09.175

Sarma, P., and Roy, A. (2021). A scientometric analysis of literature on green banking (1995-march 2019). *J. Sustain. Finance Invest.* 11, 143–162. doi:10.1080/20430795.2020.1711500

Shao, X., Zhong, Y., Liu, W., and Li, R. Y. M. (2021). Modeling the effect of green technology innovation and renewable energy on carbon neutrality in N-11 countries? Evidence from advance panel estimations. *J. Environ. Manage.* 296, 113189. doi:10.1016/j.jenvman.2021.113189

Shuai, S., and Fan, Z. (2020). Modeling the role of environmental regulations in regional green economy efficiency of China: Empirical evidence from super efficiency DEA-Tobit model. *J. Environ. Manage.* 261, 110227. doi:10.1016/j.jenvman.2020.110227

Silva, J. M. C., Castro Dias, T. C. A., Cunha, A. C., and Cunha, H. F. A. (2019). Public spending in federal protected areas in Brazil. *Land use policy* 86, 158–164. doi:10.1016/j.landusepol.2019.04.035

Srivastava, A. K., Dharwal, M., and Sharma, A. (2021). Green financial initiatives for sustainable economic growth: A literature review. *Mater. Today Proc.* 49, 3615–3618. doi:10.1016/j.matpr.2021.08.158

Streimikiene, D., and Kaftan, V. (2021). Green finance and the economic threats during COVID-19 pandemic. *Terra Econ.* 19, 105–113. doi:10.18522/2073-6606-2021-19-2-105-113

Sun, Y., Sun, H., Ma, Z., Li, M., and Wang, D. (2022). An empirical test of low-carbon and sustainable Financing's spatial spillover effect. *Energies* 15, 952. doi:10.3390/EN15030952

Taghizadeh-Hesary, F., Zakari, A., Alvarado, R., and Tawiah, V. (2022). The green bond market and its use for energy efficiency finance in Africa. *China Financ. Rev. Int. ahead-of-p* 12, 241–260. doi:10.1108/CFRI-12-2021-0225

Taiwo Onifade, S., Gyamfi, B. A., Haouas, I., and Bekun, F. V. (2021). Re-Examining the roles of economic globalization and natural resources consequences on environmental degradation in E7 economies: Are human capital and urbanization essential components? Resour. *Resour. Policy* 74, 102435. doi:10.1016/J.RESOURPOL.2021.102435

Tang, Y. M., Chau, K. Y., Fatima, A., and Waqas, M. (2022). Industry 4.0 technology and circular economy practices: Business management strategies for environmental sustainability. *Environ. Sci. Pollut. Res.* 29, 49752–49769. doi:10.1007/s11356-022-19081-6

Tu, Q., Mo, J., Liu, Z., Gong, C., and Fan, Y. (2021). Using green finance to counteract the adverse effects of COVID-19 pandemic on renewable energy investment-The case of offshore wind power in China. *Energy Policy* 158, 112542. doi:10.1016/j.enpol.2021.112542

Ünüvar, B. (2019). “Financing the green economy,” in *Handbook of green economics*. Editors S. Acar and E. Yeldan (Academic Press), 163–181. doi:10.1016/b978-0-12-816635-2.00010-9

Valensisi, G., and Davis, J. (2011). *Least developed countries and the green transition: Towards a renewed political economy agenda*.

Verma, S., and Kandpal, D. (2021). “Chapter 16 - green economy and sustainable development: A macroeconomic perspective,” in *Environmental sustainability and economy*. Editors P. Singh, P. Verma, D. Perrotti, and K. K. Srivastava (Elsevier), 325–343. doi:10.1016/B978-0-12-822188-4.00016-6

Wang, M., Li, X., and Wang, S. (2021a). Discovering research trends and opportunities of green finance and energy policy: A data-driven scientometric analysis. *Energy Policy* 154, 112295. doi:10.1016/j.enpol.2021.112295

Wang, Y., Lei, X., Zhao, D., Long, R., and Wu, M. (2021b). The dual impacts of green credit on economy and environment: Evidence from China. *Sustainability* 13, 4574. doi:10.3390/su13084574

Wray, R. (2020). “Money and the public purpose,” in *A great leap forward*. Editor R. Wray (Academic Press), 137–186. doi:10.1016/b978-0-12-819380-8.00004-x

Wu, M., Wu, J., and Zang, C. (2021a). A comprehensive evaluation of the eco-carrying capacity and green economy in the Guangdong-Hong Kong-Macao Greater Bay Area, China. *J. Clean. Prod.* 281, 124945. doi:10.1016/j.jclepro.2020.124945

Wu, X., Liu, Z., Yin, L., Zheng, W., Song, L., Tian, J., et al. (2021b). A haze prediction model in chengdu based on lstm. *Atmos. (Basel)* 12, 1479. doi:10.3390/atmos12111479

Wu, Y., and Zhu, W. (2021). The role of CSR engagement in customer-company identification and behavioral intention during the COVID-19 pandemic. *Front. Psychol.* 12, 721410. doi:10.3389/fpsyg.2021.721410

Xiong, Q., and Sun, D. (2022). Influence analysis of green finance development impact on carbon emissions: An exploratory study based on fsQCA. *Environ. Sci. Pollut. Res. Int.*, 1–12. doi:10.1007/s11356-021-18351-z

Xu, L., Shah, S. A. A., Zameer, H., and Solangi, Y. A. (2019). Evaluating renewable energy sources for implementing the hydrogen economy in Pakistan: A two-stage fuzzy MCDM approach. *Environ. Sci. Pollut. Res.* 26, 33202–33215. doi:10.1007/s11356-019-06431-0

Yin, L., Wang, L., Huang, W., Liu, S., Yang, B., and Zheng, W. (2021). Spatiotemporal analysis of haze in beijing based on the multi-convolution model. *Atmos. (Basel)* 12, 1408. doi:10.3390/atmos12111408

Yu, C. H., Wu, X., Zhang, D., Chen, S., and Zhao, J. (2021). Demand for green finance: Resolving financing constraints on green innovation in China. *Energy Policy* 153, 112255. doi:10.1016/j.enpol.2021.112255

Yu, Z., Khan, S. A. R., Ponce, P., Lopes de Sousa Jabbour, A. B., and Chiappetta Jabbour, C. J. (2022). Factors affecting carbon emissions in emerging economies in the context of a green recovery: Implications for sustainable development goals. *Technol. Forecast. Soc. Change* 176, 121417. doi:10.1016/j.techfore.2021.121417

Yumei, H., Iqbal, W., Irfan, M., and Fatima, A. (2021). The dynamics of public spending on sustainable green economy: Role of technological innovation and industrial structure effects. *Environ. Sci. Pollut. Res.* 1, 22970–22988. doi:10.1007/s11356-021-17407-4

Zeng, Y., Wang, F., Wu, J., Zeng, Y., Wang, F., and Wu, J. (2022). The impact of green finance on urban haze pollution in China: A technological innovation perspective. *Energies* 15, 801. doi:10.3390/EN15030801

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *J. Bank. Finance* 98, 39–60. doi:10.1016/j.jbankfin.2018.10.012

Zhang, D., and Vigne, S. A., 2021. The causal effect on firm performance of China’s financing–pollution emission reduction policy: Firm-level evidence. *J. Environ. Manage.* 279, 111609. doi:10.1016/j.jenvman.2020.111609

Zhang, M., Lian, Y., Zhao, H., and Xia-Bauer, C. (2020). Unlocking green financing for building energy retrofit: A survey in the Western China. *Energy Strategy Rev.* 30, 100520. doi:10.1016/j.esr.2020.100520

Zhang, D., Awawdeh, A. E., Hussain, M. S., Ngo, Q. T., and Hieu, V. M. (2021a). Assessing the nexus mechanism between energy efficiency and green finance. *Energy Effic.* 14, 85–18. doi:10.1007/s12053-021-09987-4

Zhang, D., Mohsin, M., Rasheed, A. K., Chang, Y., and Taghizadeh-Hesary, F. (2021b). Public spending and green economic growth in BRI region: Mediating role of green finance. *Energy Policy* 153, 112256. doi:10.1016/J.ENPOL.2021.112256

Zhang, H., Geng, C., and Wei, J. (2022). Coordinated development between green finance and environmental performance in China: The spatial-temporal difference and driving factors. *J. Clean. Prod.*, 131150. doi:10.1016/J.JCLEPRO.2022.131150

Zhao, H., Kamp, L. M., and Lukszo, Z. (2021). Exploring supply chain design and expansion planning of China’s green ammonia production with an optimization-based simulation approach. *Int. J. Hydrogen Energy* 46, 32331–32349. doi:10.1016/j.ijhydene.2021.07.080

Zheng, G. W., Siddik, A. B., Masukujjaman, M., and Fatema, N. (2021). Factors affecting the sustainability performance of financial institutions in Bangladesh: The role of green finance. *Sustainability* 13, 10165. doi:10.3390/su131810165

Zhou, G., Zhu, J., and Luo, S. (2022). The impact of fintech innovation on green growth in China: Mediating effect of green finance. *Ecol. Econ.* 193, 107308. doi:10.1016/J.ECOLECON.2021.107308

Zhu, X., and Liu, K. (2021). A systematic review and future directions of the sharing economy: Business models, operational insights and environment-based utilities. *J. Clean. Prod.* 290, 125209. doi:10.1016/j.jclepro.2020.125209