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Green finance, environmental regulations, and green technologies in China: Implications for achieving green economic recovery

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Green finance, environmental regulations, and green technologies in China: Implications for achieving green economic recovery

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Abstract

The current research looks at how environmental rules and green technologies have impacted green economic recovery in China in the context of foreign direct investments and green finance from 2000 to 2020. We used panel cointegration techniques of the second generation. The cross-sectional dependency and cointegration test confirmed the correlation between the panels. The long-run cointegration results validate the connection between environmental rules, green technology investment, green finance, and green economic recovery. In this context, some of the most important measures include environmental regulation (E.R.), green finance (G.F.), and increasing investment in environmentally friendly technologies (GTI). The estimated results demonstrate a positive contribution towards the green economic recovery from green finance, the development of green technologies, and environmental regulations. Evidence suggests that green economic recovery is inversely associated with foreign direct investment. Policy implications for environmental planning in China are provided based on findings from an empirical study.

Keywords: Green finance; Environmental regulation; Green economic recovery; Green technology; foreign direct investment

JEL classification numbers: K32; Q55; Q56

1. Introduction

There has been a lot of talk about the influence of global warming on carbon emissions and the connection between those emissions and economic expansion and energy utilization (Chen *et al.,* 2021). The nature of the environment is the most important component in determining or achieving sustainable development, as stated by the United Nations (U.N.) Convention on Changing Environments since the Third Millennium, which was negotiated in December 1997. According to the United Nations Convention on Climate Change's Kyoto Protocol, this has been true since the turn of the millennium (Sadiq *et al.,* 2021). Summits are also scheduled to take place in Johannesburg and Rio de Janeiro. Nevertheless, the development of economic activity and the rise in energy consumption are the principal causes of environmental damage because these factors constitute key conduction routes(Wei and Lihua, 2022a). In order to slow down the rate at which the environment is deteriorating, growth strategies need to consider environmental concerns. Striking this delicate balance can be challenging for politicians. The recent economic development acceleration is mainly regarded as industrialization, urbanization, and transport infrastructure development. All three processes depend significantly on fossil fuels such as oil and coal. Oil and coal are essential to the functioning of industrial processes, electric power generation, and transportation systems (Khan *et al.*, 2021a). A high level of energy efficiency is often cited as a benefit when discussing rapid economic expansion, new industries' creation, and cities' growth.

The expansion of the financial sector is an additional source of carbon emissions (Tang *et al.*, 2019). The increased availability of financing that results from financial development is beneficial to both individuals and businesses. As a result of an increase in the demand for machines and automobiles, there will be growth in both the manufacturing and transportation industries(Zhou *et al.*, 2006). The advancement of finance has a complex impact on energy use on a global scale. It is also essential to give some thought to the use of environmentally friendly funding in order to reduce pollution. The importance of literature on environmentally responsible finance has been rapidly growing. The world is now aware that the best strategy for halting the rise in average temperatures across the globe is to put money into environmentally friendly financial projects. As a result of the decreased usage of energy, there has been an increase in the need for environmental friendly financing (Qiu *et al.*, 2021). If more people spend their money on environmentally friendly financial programs, there will be less pollution across the earth. The needs of a good and sustainable society can be met in the long run by a global economic system that can generate, regulate, and manage investment resources. Allotting funds for renewable growth, agricultural goods, and methods with the specific intention of bringing about a green financial shift in order to mitigate the increasing CO2 emissions in a humane and environmentally responsible manner is what is meant by the term "green financing"(Liu *et al.*, 2021a). The management of environmental issues and the reduction of anticipated levels of risk are two of the primary objectives of green finance. It is a vital step toward ensuring that investments that perpetuate unsustainable growth tendencies are placed lower on the list of priorities than green efforts. Green finance is aided by long-term investment and receptiveness to environmental concerns, which encompasses many of the scenarios for sustainable development described in the United Nations' Sustainable Development Goals (SDGs). This is due to the fact that many of the prerequisites for sustainable development are already present in green finance (Zhao *et al.*, 2022a).

Along with investments in green technology, coordinating the marketing of green products across the supply chain can significantly impact a company's long-term viability (Khan and Chaudhry, 2021; Wen and Zhang, 2022; Xie *et al.*, 2021). In order to translate consumer concern for the environment into action at the register, stores must engage in "green marketing" (Zhao *et* *al.*, 2022b). Many stores, however, are hesitant to invest in green marketing because they are typically not subject to emission controls (Yu and Wang, 2021a). As a result, there needs to be a coordinated effort to split the costs of green marketing. To work together, the manufacturer will put money into green technology, and the retailer will promote green products through green marketing. In addition, the retailer's willingness to engage in green marketing is increased if the manufacturer bears a portion of the marketing expenses (Khan *et al.*, 2021b). Improvements in energy efficiency and mitigation of pollution's negative effects on the environment are two areas where environmental regulation has consistently shown positive results (Ngo, 2022a). Investments in environmental protection, energy efficiency, and robust economic growth largely fell flat. For this reason, the ruling elite is looking for strategies to boost energy efficiency (Raza, 2020). Similarly, most economies have introduced a novel deployment model from an institutional standpoint, focusing on reworking the current environmental management system, carrying out the local government's environmental responsibility, safeguarding citizens' health, and promoting sustainable social development (Dai *et al.*, 2021).

Foreign Direct Investment (FDI) is critical to the progress of developing countries and should not be underestimated. The positive effects of foreign direct investment (FDI) on financial resource provision, technology spillovers, human capital formation, R&D, international trade integration, market expansion, and economies of scale have led many to label it a key driver of economic growth (Kinyondo and Huggins, 2021). The advantages of foreign direct investment are beneficial to the growth of the manufacturing sector (Bashir *et al.*, 2022; Zhang *et al.*, 2021).

This research analyses how various forms of green economic recovery (CO_2 emissions) are affected by environmental regulation (E.R.), green finance (G.F.), foreign direct investment (FDI), and investment in green technology (GTI). This study aimed to examine the impact of the E.R.

policy on green productivity growth in China between 2000 and 2020. These categories describe the originality of this research. Because few studies have examined the relationship between the preferred parameters in the context of China from 2000 to 2020. The research offers novel insights and implications for policy to boost rapid green economic recovery. The findings of this study stress the need for stringent environmental regulations. In addition, we use the G.F., FDI, and GTI functions to explore GER further. As a result, the environmental and economic sectors may provide additional insight into the factors contributing to green output. Third, in contrast to the previous investigation on traditional efficiency, which has mostly concentrated on a beneficial result, the authors used various econometric tools to investigate negative yield and address the potential limitation of energy and environmental restrictions. The results will help policymakers, and other interested parties determine which industries should and should not be involved in environmental protection.

2. Review of literature

2.1 Green technology investment and Green Economic Recovery

Since carbon emission is one of the time's most pressing environmental issues, many studies have focused on it from various angles (Hsu *et al.*, 2021a). The need for carbon emissions-based green certificates is investigated by Li *et al.* (2020). Towards this end, Cai *et al.* (2020) examine how renting green investment, energy use, financial growth, and natural resources can help bring about the desired reduction in carbon emissions. While they ignore G.T.'s practical application, we consider it in the context of GTI optimization. CO2 emissions strongly correlate with G.T. developments (Ouyang *et al.*, 2020). In their study, Mulatu (2017) examines the connection between new eco-friendly technologies and rising incomes. They conclude that green technology innovation and economic growth are subject to a moderating influence from environmental regulations. The most compelling aspect of research—the provision of an optimal GTI subsidy policy—is also ignored by these reports: carbon emission. As part of carbon emission trading schemes, G.T. implementation is crucial to reducing carbon dioxide emissions. That strategy has been used to lower emissions by a few researchers. For instance, Duan *et al.* (2021), for example, zeroed in on the growth of eco-friendly construction in a developing nation. Our study is unique because we focus on monopoly market choices for G.T. implementation. In their research, Cai *et al.* (2020) show how crucial G.T. is to achieving SDGs. There is some thought given to the decision to implement G.T., but no consideration is given to offering a subsidy to cut carbon emissions. To lower greenhouse gas emissions, we think about using G.T.s and how to best subsidize their price.

However, there is less information available about how to maximize profits in monopoly markets than in other types of markets. In their analysis of the impact of oil supply on capital assets, Hou *et al.* (2020) assume a market dominated by a single oil company. They look at the Valorem tax when oil extraction causes climate change. They don't think about how to implement G.T.s or how to subsidize them. Our research differs from others because we focus on G.T. deployment while assuming optimal GTI subsidy and GTI provision. Zhang *et al.* (2020) analyze a monopolized energy and ancillary services market in which electrical energy storage generates revenue. They link the cost of fuel and the initial investment in thermal power plants to the cost of electrical energy storage. The researchers didn't look into GTI or emission-cutting policies in their study. To clean up the environment, we evaluate a discrete simulation-based optimization to increase profitability with G.T. adoption and minimize carbon dioxide emissions, taking into account the best subsidy for GTI. Health and welfare in the monopoly market are presented by Ngo (2022b). In contrast, our research considers a subsidized G.T. price set by the government in the monopoly market. Our results will aid policymakers in maximizing profits in a monopoly market where G.T. investments are subsidized.

2.2 Environmental Regulations and carbon emissions

Current environmental regulations are widely regarded as crucial tools for addressing environmental issues. Previous studies in this field have shown that environmental regulations do help to lower carbon emissions. Emissions requirements, taxes, monitoring, environmental impact study systems, industrial technology requirements, and so on are all examples of control and command regulation tools that the government might use to begin cutting carbon dioxide emissions (Jingxiao Zhang *et al.*, 2020). The government has concluded that these administrative actions are necessary to accomplish emission reduction objectives by guiding enterprises to conduct low-carbon technology changes and encouraging select businesses to introduce advanced technological solutions. The government has also implemented stringent administrative measures to promote the relocation or closure of certain highly polluting enterprises (He *et al.*, 2020). Numerous prior studies have corroborated this viewpoint. Using dynamic spatial models, Yameogo *et al.* (2021) examined the results of a variety of environmental policies and regulations on carbon emissions. The findings supported the idea that command and control regulations aided in cutting down on emissions. Shuai and Fan (2020) looked at how environmental rules affect eco-efficiency. Their findings indicated that environmental regulations based on command and control helped boost eco-efficiency in both central and western China.

However, market-based restrictions, such as taxes on fossil fuels, sewage charges, clean growth mechanisms, carbon trading schemes, government subsidies, and so on, have also helped the government reach its goal of reducing emissions (Wellalage *et al.*, 2021). Research shows that by taking these steps, the government can increase businesses' manufacturing and environmental governance costs, ultimately lowering their reliance on fossil fuels. Some companies will take initiatives to develop clean technology and boost the levels of technological development in order to achieve the intended carbon reduction (Pan and Chen, 2021). Many empirical studies have confirmed this viewpoint as well. Example: Guo and Yuan (2020) built a model for cross-provincial emissions trading and found that such systems reduced carbon emissions at a low cost. Additionally, Jianming Zhang (2020) studied the effects of three environmental rules on carbon reduction in the Chinese power sector and concluded that government subsidies and market-based regulations would favor carbon discharge reductions. In another related study, Hsu *et al.* (2021b), another related study, found that environmental rules based on the market and voluntary compliance have contributed positively to eco-efficiency gains in eastern China.

Though, it was noted that other studies showed that environmental rules would potentially raise carbon emissions, which runs counter to the above-mentioned conclusions. It was (Xiang *et al.*, 2022) who first put up the idea of a "green paradox," the belief that climate change mitigation policies will hasten the use of fossil fuels and increase carbon emissions. In addition, Dong *et al.* (2021) investigated a "green paradox," highlighting how the impacted oil markets would anticipate a future decrease in demand and enhance the existing supply before the imposition of environmental regulations, which could increase the current carbon emissions standards. Li *et al.* (2019) observed the detrimental effects of announcing environmental policies too soon. Consequently, households tended to increase their fossil energy usage in the lead-up to the taxes being applied, which boosted carbon emissions. Energy use and carbon emissions could rise due to a number of factors, including those mentioned by Wang and Zhang (2022), such as gradual increases in carbon tax rates, delays in their implementation, and subsidies for alternative sources of energy.

2.3 Green Finance and Green Economic Recovery

Green finance is not just about funding to combat climate change. Environmental objectives include reducing industrial pollution, improving water quality, and protecting biological variety. Money can be found to implement mitigation and adaptation plans (Wu *et al.*, 2021). Any company or project that strives to decrease or avoid the emission of greenhouse gases results in a financial flow known as a "mitigation flow" (GHGs). Money being spent making products and people more resistant to the consequences of climate change is known as "adaptation financial flow." Economic growth and energy use were found to be related in N11 nations when the distributed lag metric causality approach was put to the test (Peng *et al.*, 2020). Energy environmental protection efforts were found to have been undertaken by Israel, Egypt, Italy, Guatemala, Nepal, Korea, Netherlands, and Argentina. It has been noted that countries in the Eurozone and around the world have become more aware of how international trade can spur infrastructure facilities (Wei and Lihua, 2022b), specifically by creating a clean environmental framework that encourages the implementation of RE. From a monetary point of view, the development of financial sources has been recommended to provide a number of energy and environmental improvements (Ren *et al.*, 2018).

There will be a growing reliance on the international financial industry to help mitigate climate change. This sector will be significantly aided by introducing new green assets, particularly renewable energy. Therefore, investors may help reduce the impact of climate change and pollution by allocating a portion of their portfolios to green investments. There are a number of approaches to factor climate risk into financial decisions (Song *et al.*, 2021). Alternative solution financing, venture capital for clean technologies, and project finance are all examples of how green traders put their money to work. These strategies include negative and positive testing, energetic possession, and growth (Ahmad *et al.*, 2021).

However, there remains some ambiguity around what constitutes "green" investments and how specific investment businesses should be categorized. Overhyped "green" financial derivatives ("greenwashing") are common, in which companies overestimate their positive effect on the environment. As a rule, asset management firms and issuers are left to their own devices when determining how much weight to give to environmental metrics when valuing a company (Ye and Wang, 2019). Conflicts of interest among buyers, creditors, and some target providers lead to inconsistent and incorrect data on the environmental impact of different government issuers. In order to direct new investors toward borrowers who can undertake the shift toward a low-carbon environment, shareholders and rating issuers need to be transparent and consistent in their recommendations (Zhu *et al.*, 2019).

3. Data and Methods

The relationship between green finance and green economic revival is explored using up-to-date research methods (CO2 emissions). We utilize the market capitalization of green bonds as a surrogate for green finance and as a metric for GER. From DataStream, we get information from the year 2000 until 2020. The International Energy Agency provides the fundamental factor of interest: the amount of money spent on renewable energy technology. Carbon emissions and their spatial spillovers are both affected by the same sources. However, carbon emission and FDI data come from the World development indicators.

The hypothesis of the study:

H1: Environment regulation significantly increases green economic recovery in China.

H2: Green finance has a positive role for GER in selected economies.

H3: Investment in green technologies significantly contributes to GER for the selected panel.

H4: Foreign direct investment has a significantly negative association with green economic recovery.

3.1. Model Creation

This study focuses on green economic recovery, and it uses investment in green technology (GTI), environment regulations (E.R.), foreign direct investment (FDI), and green finance (G.F.) as determinants. However, the general form of the selected variables is written as,

$$GER_{i,t} = \beta_0 + \beta_1 GTI_{i,t} + \beta_2 ER_{i,t} + \beta_3 FDI_{i,t} + \beta_4 GF_{i,t} + \mu_{i,t} \quad (1)$$

Where GER, GTI, E.R., FDI, and G.F. represent the green economic recovery, green technology investment, environmental regulations, foreign direct investment, and green finance; however, μ is a random error, and i refers to a number of cross-sections, and t is the time period.

Before proceeding further, it is necessary to check out the basic condition of the test via descriptive statistics and pairwise correlation.

Data is presented using both descriptive and inferential statistics. The number of observations, standard deviation, maximum, mean, minimum, and median for each study variable is presented in Table 1.

Table 1. Descriptive Statistics of the selected variables

	Mean	Median	Maximum	Minimum	SD
GEC	23584.2	6432.96	48976.7	1.2831	46460.6
ER	22493.6	6787.46	51307.7	1.29255	44229
GF	23438.6	6778.01	50152.7	1.27155	44229
FDI	22266.9	6808.48	46349.4	1.28205	25845.2
GTI	11179	4477.68	22727.1	2.5641	69947.7

Table 2 and Figure 1 shows the results of the pairwise correlation. The results found a negative correlation between G.F., GTI, and green economic recovery. Moreover, environmental regulations and foreign direct investment have a positive association with explained variable. From such outcomes, there exists no multicollinearity in the selected panel data. However, the VIF test outcomes are presented in Table 3.

Table 2. Pairwise Correlation test

	GEC	ER	GF	FDI	GTI
GEC	1.000				
ER	0.598*	1.000			
GF	-0.293*	0.668**	1.000		
FDI	0.751*	0.080*	0.617*	1.000	
GTI	-0.633**	0.395*	0.689*	0.386*	1.000

Table 3. VIF test

	VIF	Tolerance
GEC	4.965	0.2014
ER	3.266	0.3061
GF	1.245	0.8032
FDI	5.652	0.1769
GTI	1.999	0.5002
Mean VIF	3.425	

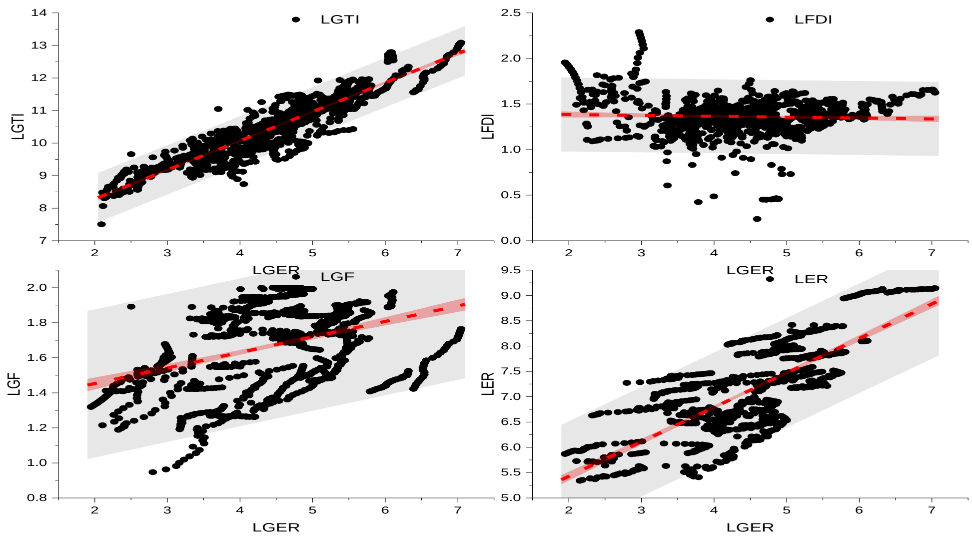

Figure 1. Correlation analysis

3.2. Estimation strategy

Dealing with CD across regions is an important topic in panel causality analysis. Therefore, the CD ratio has been calculated using the method described in (Zhang, 2021). Further U.R. tests that were deemed necessary were also used. When the period is larger than the number of observations (T > N), the test proposed by Zhou *et al.* (2021) becomes plausible. However, when T< N, the test becomes useful for both symmetric and asymmetric datasets. Using omitted common effects when common stocks are present can lead to the cross-correlation of error (Zhang and Song, 2021). This could be due to the influence of unseen parts. There is more of a tendency for CD to occur in panel data than not. Ignoring the CD can disrupt the standard panel's unbiased and consistency, which can then produce inaccurate statistical results. Therefore, verifying the CD of chosen datasets is crucial before moving on to a more complex analysis. We employed three tests in this study to verify CD's validity. Table 5 shows that H0 is rejected at a 1% significance level, and CD is found in the series because the probability values of the co-integrated equation are less than 0.001. In light of these results, the second-generation U.R. tests taking the CD into account are applied to the preferred environmental and E.D. factors (see Table 4).

Table 4. CSDs test

	Pearson test	Frees test	Freidman test
Value	7.999	2.845	77.256
P-value	0.000	0.000	0.000

Assessing whether or not the underlying variables are stationary is the first step toward producing reliable results of estimates. Commonly used procedures include the Levin-Lin-Chu test by Huang *et al.* (2021) and the (Koçak *et al.*, 2020), and Shin (IPS) test by Saidi and Mbarek (2017). however, their reliance on the cross-sectional independence hypothesis means they fail to account for the CD. In order to circumvent the issue of CD, the authors of this work apply second-generation unit root tests like Cros-augmented Dickey-Fuller (CADF) and augmented cross-sectional IPS (CIPS). Due to their ability to resolve CD and heterogeneity issues, these tests are more reliable than their simplistic counterparts. CADF's statistical significance is calculated using the formula:

$$\Delta X_{it} = \Phi_i + \delta_i X_{i,t-1} + \gamma_i \bar{X}_{t-1} + \Psi_i \Delta \bar{X}_t + \mu_{it} \quad (2)$$

Where X¯_(t-1) is the average value over all slices. The CIPS analysis can also be written as (Equation 3):

$$CIPS = \frac{1}{N} \sum_{i=1}^{N} \delta_i \,(N, T) \quad (3)$$

Table 5. CADF & CIPS unit root tests

Variable	CADF unit root test		CIPS unit root test	
	Level	1st difference	Level	1st difference
LGER	-3.541*	-5.411	-4.885*	-7.245
LGTI	-1.325	-3.852*	-1.963	-2.987*

LER	-2.777**	-3.583	-3.554*	-5.841
LGF	-1.620	-3.652*	-1.524	-3.999*
LFDI	-1.325	-4.880*	-1.522	-3.365*

The error correction-dependent cointegration method considers the CSD and is used to test for a long-term relationship between the chosen variables (Westerlund and Edgerton, 2008). Because the Westerlund test mitigates the annoyance caused by the endogeneity of the repressors, it was selected. This test builds four no-co-integration null hypotheses and uses two statistical tests to determine whether or not the panel is co-integrated (see Table 6). The following error correction equation forms the basis for both CSD and non-strictly exogenous regressor tests:

$$y_{it} = \alpha_{0i} + \alpha_{1i}t + Z_{it} \quad (4)$$

$$X_{it} = x_{i,\,t-1} + \mu_{it} \quad (5)$$

Where $i = 1, 2, 3, \ldots\ldots$, N and $t = 1, 2, \ldots\ldots\ldots$, T with the Z_{it} specified as

$$\delta_i(L)Z_{it} = \delta_i(Z_{it-1} + \gamma_{1,}x_{i,t-1}) + \beta_i(L)\mu_{it} + \varepsilon_{it} \quad (6)$$

$$\delta_i(L)\Delta y_{i,t} = \theta_{0i} + \theta_{1i}t + \delta_i(y_{i,\,t-1} - \gamma_1, x_{i,\,t-1}) + \beta_i(L)\mu_{it} + \varepsilon_{it} \quad (7)$$

Where the deterministic components are given by the $\theta_{0i} = \delta_i\ (1)\ \alpha_{1i} - \delta_i\ \alpha_{0i} + \delta_i\alpha_{1i}$ and similarly, $\theta_{1i} = -\ \delta_i\ \alpha_{1i}$. Further, panel and group statistics can be written in a general form.

$P\tau = \delta\text{-hat} / \gamma\text{-hat}_{\delta\text{-hat},}$ ……, $P_\alpha = T_{\delta\text{-hat}}$ and $G\tau = \frac{1}{N}\sum_{i=1}^{N} \delta - \text{hat} / \gamma - \text{hat}\delta - \text{hat}$, ……., G_α which is equal to $\frac{1}{N}\sum_{i=1}^{N} T\,\delta - \text{hat}/\ \delta_i(1)$, thus this cointegration test recommended using the bootstrap method to deal with CSD.

Table 6: Westerlund Co-integration test

Statistics	Value	Z-value	P-value	Robust P-value
G_t	-7.653	5.246	0.000	0.000
G_a	-1.349	4.995	1.000	1.000
P_t	-13.295	6.231	0.051	0.000

P_a	-5.856	3.652	1.000	0.002

3.2. Augmented Mean Group and Long-term relationship

Panel estimators can be misleading, inferior, and even inconsistent when models have a cross-sectional dependency, heteroscedasticity, and serial correlation, as stated by Luo *et al.* (2021). The purpose of this work is to remove these obstacles. CCE (common correlated effects) was first proposed by Pesaran,s and expanded upon by Ye *et al.* (2021) and others (Khan *et al.*, 2021c). Compared to traditional, first-generation econometric methods, there are a number of benefits to using this approach instead. This does not include factor loadings or estimates of undiscovered common factors. At this point, the Augmented Mean Group (AMG) estimator will have been used in the current investigation. Ju *et al.* (2020) created the AMG algorithm in this analysis. By incorporating a dynamic effect parameter into its two-stage operation, AMG can deal with cross-sectional dependence (CD) and evaluate the reported common dynamic effect (Brandi *et al.*, 2020). An additional benefit of the AMG technique is that it allows for the estimation of parameters that depend on non-stationary factors (M. Zhang *et al.*, 2020). An overview of the primary panel model is provided below:

$$lnGER_{it} = \beta_0 + \beta_1 \ln GTI_{it} + \beta_2 \ln ER_{it} + \beta_3 \ln GF_{it} + \beta_4 \ln FDI_{it} + \varepsilon_{it} \quad (8)$$

The above equation is calculated with the first differenced form and T-1 period dummy as follows,

$$\Delta\, lnGER_{it} = \beta_0 + \beta_1 \ln GTI_{it} + \beta_2 \ln ER_{it} + \beta_3 \ln GF_{it} + \beta_4 \ln FDI_{it} + \sum_{t=2}^{T} pt\ (ADt) + \mu_{it} \quad (9)$$

Where ADt denotes T-1period dummy first differences and pt denotes period dummy parameters. The following is an example of an exchange between the predicted values pt and the T parameters that are part of the dynamic process:

$$\Delta GER_{it} = \beta_0 + \beta_1 \ln GTI_{it} + \beta_2 \ln ER_{it} + \beta_3 \ln GF_{it} + \beta_4 \ln FDI_{it} + d_1(\delta_t) + \mu_{it} \quad (10)$$

$$\Delta GER_{it} - \delta_t = \beta_0 + \beta_1 \ln GTI_{it} + \beta_2 \ln ER_{it} + \beta_3 \ln GF_{it} + \beta_4 \ln FDI_{it} + \mu_{it} \quad (11)$$

Mean values of design variables for each group are then determined after the group-specific regression model has been fitted with t. However, FMOLS, DOLS, and CCE-MG estimation methods are used to ensure the reliability of the results in this study.

4. Results and discussion

Descriptive and inferential statistics are used to present the results. Table 7 shows the outcomes of the FMOLS, DOLS, AMG, and CCE-MG models.

Based on the data, it appears that carbon emissions are inversely proportional to the pollutant discharge fee, which can be considered a surrogate for environmental legislation. This shows the value of environmental restrictions in the case of some economies and how they aid in reducing carbon emissions. According to the numbers, raising the pollutant discharge price by one percentage point reduces carbon emissions by a respective -1.861%, -1.162%, -1.552%, and -1.826%. That environmental laws in China are helping to accomplish targeted nationally decided contributions and then reduce them further was confirmed by the negative and statistically significant link. The findings revealed here are consistent with those of (Yu and Wang, 2021b; Jingxiao Zhang *et al.*, 2020).

Additionally, there is a statistically significant negative correlation between green funding and carbon emissions. The empirical findings confirm that G.F. helps lower carbon emissions in some economies (Yuan and Xiang, 2018). Funding in environmentally friendly techniques and the reputation of an organization or a firm that how much that particular company is in line with environmental regulations and laws may be at the root of the aforementioned negative relationship between the two. Loans are given to only those businesses and industries that abide by environmental standards. The Green Credit policy and the Five-Year development plan assist some economies in cutting carbon emissions. Carbon emissions can be reduced by using green money in research and development activities. However, further investment in this field is required to introduce more eco-friendly technology.

The same holds for the environment; pollution levels rise due to FDI. An increase of 1% in this variable would lead to increases of 1.826%, 1.688%, 1.667%, and 1.862% in CO_2 emissions. Since FDI is so influential, it's safe to assume it is invested in polluting sectors in low-emissions countries. Although tougher environmental restrictions may be in place and more attention paid to environmental issues in countries with large emissions. Therefore, FDI may not benefit high-emitting countries, as it may not lead to the development of management, technical expertise, and production technology. In addition, these technologies will not be transferred indirectly to domestic enterprises through backward or forward interconnection. There is a risk that multinational corporations would export dirty technology that is even more detrimental to the environment than that used in nations with high emissions. Consequently, increased FDI in countries with high emissions reduces environmental quality in those areas. In a few countries, the findings support the heaven effect idea. The study results are consistent with those of Wang *et al.* (2022), who use fixed and random effects panel models to examine the connection between FDI and pollution in ASEAN nations. The author's findings are consistent with the halo effect hypothesis, and they show no sign of an adverse effect of FDI on the environment. However, this finding does not contribute to a fuller understanding of the processes that affect carbon emissions. Dong *et al.* (2021) provide similar support for the halo effect concept but use data from the Middle East and North Africa (MENA) rather than the China we examine in our research.

Similarly, spending on environmentally friendly technologies leads to less pollution. This means that a 1% increase in this component would result in a -1.111%, -1.131%, -1.118%, and -1.116% decrease in environmental pollution. In order to lower carbon emissions, subsidies are important (Shao *et al.*, 2021). As we focus on the GTI to decrease carbon dioxide emissions in the economies of China, our findings surpass the ignored portion of some research (Ramzan *et al.*, 2022). Our results are consistent with those of (Ngo, 2022c) because of the presence of vegetation. Compared to their studies, ours stands out because of our unique focus on the growth of environmentally friendly technology as a determinant of industrial power consumption. The study findings guide policymakers as they determine the best GTI and how much money to allocate to energy subsidies to solve the industrial sector's energy consumption issues.

Table 7. Impact of study variables on GER (CO2 emissions)

Variables	DOLS	FMOLS	AMG	CCE-MG
ER	-1.8616*	-1.1627**	-1.5526**	-1.8261***
	(1.162)	(1.8626)	(1.2866)	(1.8161)
G.F.	-1.7616*	-1.2627**	-1.6626**	-1.7161***
	(1.262)	(2.8626)	(6.2866)	(6.8161)
FDI	1.8267**	1.6886**	1.6671**	1.8621**
	(2.777)	(1.67)	(2.1866)	(2.1176)
IGT	-1.1116**	-1.1311*	-1.1188**	-1.1162**
	(6.1716)	(1.1627)	(2.6862)	(6.681)
Constant	7.6727**	8.7817**	6.1812*	1.6671**
	(11.6162)	(8.8767)	(1.8666)	(1.8666)
R2	1.6616	1.6668	N/A	N/A
Obs.	140	140	140	140

Notes: t statistics are in parenthesis; ***p < 0.001, **p < 0.05, *p < 0.1.

The authors then ran a Heterogeneity test to see how spending on alternative energy sources, green technology, environmental regulations, foreign direct investment, and green finance affected GER. It proved useful in proving to the writers that all forms of economic and social progress contribute to GER. The study sample was split into several groups based on their responses to each variable, as shown in Table 8. Although E.R., G.F., GTI, and GER all showed negative and statistically significant relationships, LFDI and GER showed no such results. The results show that E.R., GTI, and G.F. are all responsible for more environmentally friendly growth and revival. Meaningful regulation should be rigid and unyielding to ensure consistent application.

Table 8. Heterogeneity analysis

Variables	**LGER**	**LER**	**LGF**	**LFDI**	**LGTI**
LER	-0.4551	1.4525***	0.2277	2.0207***	1.0897***
	(0.522)	(2.5275)	(0.5725)	(2.5052)	(2.4123)
LGF	-0.7577	2.7525***	0.2277	5.0207***	3.6245***
	(2.7572)	(5.5275)	(0.5725)	(5.5052)	(2.8541)
LFDI	0.7505	0.7702**	0.7570	0.7725**	1.2587**
	(5.7577)	(2.7527)	(7.0577)	(2.0775)	(0.0111)
LGTI	-0.0077	0.0557*	0.0052	0.0227**	0.0999**
	(2.7055)	(0.5557)	(5.702)	(0.2705)	(0.1174)
Constant	5.5572*	5.0707**	5.7777*	5.2727*	5.8932*
	(2.2757)	(2.5507)	(5.777)	(2.725)	(2.557)
R2	0.7725	0.72	0.7722	0.7757	0.7701
Obs.	140	140	140	140	140

Note: This table shows the findings of heterogeneity results. t statistics are in parenthesis; ***p < 0.001, **p < 0.05, *p < 0.1. Source: Author's conception, based on Stata software.

4.1. Robustness test

As suggested by Gonzalez-Trevizo *et al.* (2021), the authors conducted a secondary analysis utilizing additional emissions factors, such as environmental legislation, to account for the impact of E.R. varies depending on the evaluations of green economic recovery. Similarly, this study shows that everything but FDI helps the green economic recovery greatly. Table 9 shows the first test with the E.R., GTI, green financing, and explained variable. Both studies showed that GER benefited greatly from research aspects.

Table 9. Robustness Test

Variables	**(1)**	**(2) [t-1]**
LER	-0.2944**	-4.2444**
	(4.4441)	(4.6644)
LGF	-0.1444**	-4.4444**
	(4.5541)	(4.231)
LFDI	0.3404	0.3404
	(4.1141)	(4.7714)
LGTI	-0.4124*	-0.1444*
	(1.4044)	(0.1774)
Constant	4.4441*	4.1404**
	(4.4764)	(1.2404)
R2	0.5644	0.434
Obs.	140	140

Note: This table shows the findings of the robustness test. t statistics are in parenthesis; ***p < 0.001, **p < 0.05, *p < 0.1. Source: Author's conception, based on Stata software.

4.2. Mechanism analysis

All of the variables, as mentioned earlier, with the exception of FDI, contribute to green economic recovery, as shown by the baseline regression and robustness analysis. However, the mechanism analysis needs to be examined by rerunning the regression with each variable. If higher-ups pay attention to any signs highlighted in this analysis, they can achieve rapid green economic growth.

Table 10's study reveals a negative correlation between carbon emissions and column 1's depiction of the results of green technology investment, suggesting that a sizable shift in the latter would result in a 5.77 percentage-point hastening of the green economic recovery. On the other hand, environmental rules and green finance contribute significantly to the rapid green economic recovery by 0.116% and 1.965%, respectively. On the other hand, foreign direct investment (FDI) substantially raises carbon emissions and is some countries' biggest obstacle to green economic recovery.

Table 10. Mechanism Analysis

D.V.	(1)	(2)	(3)	(4)
	LGER	LGER	LGER	LGER
LGTI	-5.778*			
	(0.042)			
LER		-0.116***		
		(0.034)		
LFDI			3.417*	
			(0.175)	
LGF				-1.9652*
				(0.174)
Control excludes	Yes	Yes	Yes	Yes
Cons.	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	140	140	140	140
Adj. $R2$	0.735	0.779	0.713	0.754

Notes: Standard errors of estimated parameters are shown in parentheses; *, **, and *** denote significant levels of 10%, 5%, and 1%, respectively.

4.3. Heterogeneity Analysis

This section's final paragraph presents some empirical proof of heterogeneity. The major explained variable and the lagged explanatory variable for each variable are the primary foci of this study's investigation into heterogeneity. Table 11 shows the estimated results. However, according to the given outcomes, the investment in green technology, environmental regulations, and green finance significantly improves the environmental quality, which refers to improving the green economic recovery at both stages (main and lagged explained variable). However, there is a significant increase in emissions, which is not suitable for green economic recovery at the main and lagged defined variable China.

Table 11. Heterogeneity analysis

	LGER	**$LGER_{t-1}$**	**LGER**	**$LGER_{t-1}$**	**LGER**	**$LGER_{t-1}$**	**LGER**	**$LGER_{t-1}$**
Panel Group	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LGTI	-3.758*	-1.897*						
	(0.549)	(0.164)						
LER			-0.961**	-0.909*				
			(0.226)	(0.301)				
LFDI					1.491*	0.716**		
					(0.234)	(0.207)		
LGF							-1.526*	-1.096**
							(0.332)	(0.785)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cons.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	140	140	140	140	140	140	140	140
Adj. R^2	0.766	0.734	0.914	0.890	0.832	0.793	0.871	0.859

Notes: Standard errors of estimated parameters are shown in parentheses; *, **, and *** denote significant levels of 10%, 5%, and 1%, respectively.

5. Conclusion

The primary objective of this research is to examine the effect of green financing, FDI, investment in green technologies, and environmental policies on the green economic recovery in China from 2000 to 2020 using a panel dataset. Sequential regression is used to examine the potential connections. The estimating method shows that green finance, GTI, and environmental restrictions all have a beneficial impact on GER. Further, foreign direct investment has been shown to have a negative impact on environmentally friendly economic revival. Research shows that spending money on environmentally friendly technologies significantly affects GER for the same group.

Some policy recommendations for a sustainable economic revival are presented there. The first major conclusion draws attention to the centrality of green financing in enabling green economic growth. Therefore, it is essential to keep pushing for financial institutions' green evolution and create appropriate rules and regulations to facilitate this change. At this time, green finance has established itself as a cornerstone of the eco-friendly economy. On the one hand, local governments should develop provincial green finance-development institutions in order to effectively realize a win-win situation of ongoing green evolution of finance and energy poverty elimination.

Taking into account the associated empirical data, we can say that environmental restrictions can effectively boost the green economic recovery and have a knock-on effect on pollution. In a nutshell, the primary reason environmental-related patents may have a beneficial influence on CO2 emissions is that they erect barriers against the adoption of technology that are harmful to the environment (Liu *et al.*, 2021b). Though helpful in reducing pollution, environmental policies geared toward economic growth in China is not efficient enough to counteract the negative impact of energy use on pollution.

Investment in green technologies can cut CO2 emissions while encouraging economic growth, so the world urgently needs to support emerging economies' green innovation capabilities to fight climate change. Investments in environmentally friendly technologies continue to be crucial in the fight against climate change (Peng, 2020), but they are effective primarily in advanced economies. As documented by Ai *et al.* (2021), support for basic research is a key factor in fostering technological advancement. So, governments in rich economies should invest more in research and development and push businesses to put money into environmentally friendly technologies. However, a new framework for the global dissemination and implementation of green technologies must be built. Since green technology is often out of reach for those living in low-income economies, new mechanisms involving intellectual property, green financing, and government backing are needed to speed up its spread and increase its use. Given the state of industrial technology, low-income nations should also encourage green management practices that boost resource use efficiency (Hsu *et al.*, 2021c).

Foreign direct investment (FDI) has been shown to boost economies in ways that go beyond the initial returns on investment. As a result, the rise in CO2 emissions may be attributable to the fact that FDI-accompanied technological advancement did not immediately lead to a massive improvement in the efficient utilization of energy resources. The Asian economies have not made substantial technological progress or innovation in energy utilization or the manufacturing of energy carriers, which has prevented the creation of environmentally friendly products and services. Foreign direct investment does not automatically result in a paradigm shift toward green innovation and growth that boosts energy efficiency and creates new forms of renewable power. Foreign direct investment (FDI) does not improve nations' capacity to address environmental issues, but it does result in the development of environmentally friendly goods and services that profit business, society, and government. As a result, the foreign direct investment policy has to be revised.

Future research should take into account the limitations of this study. However, it adds new insights to the existing studies in terms of the sample, methodology, research variables, and analytic timeframe. Additional research on the connection between GDP, green legislation, and CO2 emissions from different nations or demographics is possible. This estimating model aims to shed light on the measures that must be taken to stimulate green economic recovery. It may include other elements such as institutions, globalization, corruption, etc. In addition, future research may use different pollution indicators or econometric methods, leading to different conclusions.

Competing Interests

The author declares that there is no conflict of interest.

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