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Role of green finance policy in renewable energy deployment for carbon neutrality: Evidence from China

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ABSTRACT

Carbon emission is not just a threat to the environment but also an economic burden. Faced with the growing pollutant emission, the purpose of financial institutions is more crucial. To address this issue, this research employs difference-in-differences to assess the role of China's green financing policy in renewable energy deployment for emission reduction. The findings demonstrate that the green finance strategy in renewable energy can reduce the general situation of emission reduction. The results show that the policy was effective in lower three contaminants, including Sulfur dioxide, Nitrogen dioxides, and $PM_{2.5,}$ but are inadequate in reducing Carbon monoxide, Ozone, and PM_{10}. Besides, the control impacts of green finance policy are via local enterprises' economic activities. Compared with the financially advanced areas, the reducing emissions impacts of green financing policies in the financially undeveloped areas are greater. These results give recommendations for controlling air quality financial advantage from the standpoint of micro practice.

1. Introduction

According to the IPCC (Intergovernmental Panel on Climate Change), global warming has an impact of over 1.5° Celsius above pre-industrial levels [1]. The need for an international response to stabilize greenhouse gas emissions, reduce the dangers of climate change and poverty, and achieve sustainable development has been noted. For the 1.5 °C warming target to be avoided, it is clear that a dramatic change in the behavior of investors towards cleantech initiatives is required [2]. In order to meet the goals of the Paris Agreement, the UN estimates that $1.5 trillion in green funding is needed per year. After the COVID-19 outbreak, supporting clean energy and green technologies became even more complicated, and green funding has become much more critical [3]. It is critical to developing new green financing sources built on the finance-growth nexus to guarantee long-term economic development. Financing environmental stewardship, funding green technology and starting the share of renewable energy all contribute to sustainable development via green financing. The terms "green finance" and "sustainable finance" are interchangeable, as are the terms "climate finance." The supply of funding for projects with an environmental impact is known as "green finance".

On the other hand, climate finance is money to assist climate change mitigation and adaptation efforts. Financing tools for sustainable development are what bind all of these words together. Renewable and clean energy projects need green funding to reduce carbon pollution and the harm they do to human health and the environment. The decision is made more sustainable as a result. Green finance is believed to enhance sustainability and environmental issues by supporting climate-neutral, energy, and resource-efficient solutions [4].

The development of green technologies is essential to achieving sustainable development objectives. In the present financial markets, the savings are anticipated to be allocated to renewable energy projects to minimize environmental deterioration. Although the environment is rapidly degrading despite the many attempts, it is evident that money is still coupled with projects that are destructive to the environment and worsen the present situation [5]. Despite the importance of green financing in the progress of green technology, there are currently not enough investors in such products. Development in green technology is severely constrained because early expenditures on renewable initiatives are costly and the potential consequences significant, making the rate of return correspondingly very tiny. The banking industry is hesitant to offer to fund green technology because of the hazardous nature of

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green projects, necessitating the use of alternative types of financial resources [6]. Clean energy and renewable technology initiatives have significant funding challenges, and [7] have called for further involvement in the monetary sector as a possible solution [8]. suggested unique time-varying methodologies to study the Granger causation link between clean energy, ecological finance, ecological integrity, and green technology. Only a few studies in the scientific community have examined the connection from a single angle. Environmentally friendly securities, including that green bonds and the WilderHill renewable energy index, are the focus of an investigation by Ref. [9].

Using the Granger causality test [10], they found a substantial correlation between the returns of the clean energy index and the prices of green bonds. Regarding the connection, returns on green stocks, crude oil, and stock marketplaces have an uneven influence on clean energy markets, with significant changes in the oil and stock markets negatively impacting [11]. An analysis of the dynamic interdependence and leakage prices of various clean energy markets worldwide is presented in Ref. [12]. According to their findings, the green bond market is impacted by market volatility in the clean energy sector. Several asset classes, including equities, commodities, renewable energy, and traditional bonds, are examined by Ref. [13]. According to their findings, green bonds, equities, and minerals seem to associate with each other negatively. Green bond and stock market interdependence are examined by employing frequency connectivity and a cross-quantile technique. Green bond yields and equities markets seem to have a relatively low correlation even after allowing for fluctuations in the overall stock, corrected, or energy market. The findings also show that people are more likely to stay in touch during high market volatility. It depends on implementing environmentally-friendly economic and corporate policies, which are essential.

Investing in energy-efficient businesses is a necessary part of this process. Despite the efforts made to increase green energy adoption, scientific data like shows that it is insufficient. The International Energy Agency (IEA) has identified an investment gap. An investment made of up to a billion trillion US dollars is required to meet the 2030 sustainability targets, according to Ref. [14], with an average of more than $1.2 trillion per year for the next decade. The Inter-Governmental Panel on Climate Change Market players must participate in this level of investment. As a result, a transparent funding model that encourages renewable resources might result from this engagement. Responsible investment has a mixed record of success. However, it has been suggested that participating in loan portfolios with an ecological emphasis might help financial institutions' risk profiles [15] despite the lack of conclusive proof.

As a result of these studies, investors are being warned to steer clear of environmentally friendly investments [16]. Investing in mutual funds allows engaging in the financial markets while still receiving the advantages of actively managing a portfolio. Mutual funds have been shown to have several advantages over other types of investments, including diversity, efficiency, and ease of portfolio balancing, according to Ref. [17]. There has been substantial growth in sustainable funds throughout the years. As a result of this new development, socially conscientious investors now have a way to put their money to use. A possible way for mutual funds to aid in achieving long-term objectives is to promote green, renewable, and environmentally friendly energy companies. However, investors in these funds must be well paid to give further reasons to continue to invest in cleaner enterprises, as previously noted. So it is intriguing to see whether equity funds that concentrate on responsible energy companies help their clients or if they have to sacrifice their returns to impact the environment [18] positively. The discussion becomes increasingly significant as the EU is at the vanguard of the fight. Since China's 1980, the nation has made remarkable achievements in economic growth, industrialization, and socio-economic evolution. As a result, ecological harm and resource overuse have grown more significant [19].

Chinese carbon dioxide emissions climbed from 1460 million tonnes (Mt) in 1977–9841 million tonnes (Mt) in 2018, according to statistics provided by the Carbon Disclosure Atlas [20]. China overtook The US as the world's greatest emitter of carbon dioxide in 2007. While China's total emissions have decreased over time, they remained much more significant than other nations in terms of carbon per unit of GDP. Regarding carbon intensity, China had 2.07 kg/USD in 2009, compared to France's 1.8 kg/USD in 2009 [21].China's carbon pollution per unit of GDP will be 39%–46% lower in 2025 than in 2004 due to its considerable impact on global warming and environmental and social activities, as revealed during the Stockholm climate conference in 2008. It is estimated that by 2050 China's carbon emissions will reach a peak, and the nation aims to boost its generated generation to 15%. As a result, green financing is a logical path for China. When it comes down to it, green finance is all about helping environment-conscious enterprises get the funding and support they need while still making a profit. These voluntary guidelines are intended to solve financial concerns that harm the environment or society. Since the Chinese state developed environmental finance rules in 2016, China's green monetary sector has steadily improved. Those policies and their ramifications are summarized in, accounted for fifteen percent of the world issuance in 2017, making China the second-largest provider of these connections in the world in terms Of Total [22]. 19 of China's leading financial institutions granted 8.31 trillion-yuan worth of green credit in 2018. 3 There were 283 million tonnes of carbon traded on the essential and auxiliary spot prices in China's pilot carbon credit programme by 2017 [23]. In the wake of the existing generous green finance policies by the Chinese government, it is essential to assess these policies' effectiveness in reducing the emission levels. The literature review above shows that not all types of government support help develop the renewable energy sector and reduce emissions. Some policies, such as direct subsidies, might also have a regress effect. The importance and novelty of this study is to assess the effectiveness of the green finance policies in renewable energy deployment and emissions reduction simultanously, which have been neglected in the earlier studies.

This paper has added numerous contributions to the literature. Existing research focuses on developing economic and financial green finance indexes using diverse variables but lacks a microcosmic viewpoint on actual green finance activities. This study uses difference-in-differences analysis to examine China's 2018 green funding policy in renewable energy for emission reduction. Microeconomic practice is examined in this research, which focuses on air pollution and the economic tools to manage it.

Second, new research shows a connection between the regional disparity and the growth of green financing in renewable energy. Furthermore, they are more concerned with the differences in regional green finance indices or the ability of green finance indices to stimulate economic development than how various ecological differences impact the regulatory impact of green finance practice. As a consequence of our research, we believe that the same green finance technique in renewable energy for emission reduction might be more effective in less developed locations.

The remainder of the paper is organized as follows: Section ii contains a literature review. Section iii presents methodology and data sources. Section IV contains empirical findings. Section V contains the Conclusion and policy implications.

2. Literature review

Public funding of research and development (R&D) for renewable energy (RE) is necessary to bridge the RET finance gap and advance RE technology. Indeed, the reduction in European R&D funding for Renewable Energy (RE) considerably impacts technological development [24]. The lower the cost of RE is owing to technological advancements, the more money investors are willing to put into this industry in anticipation of more significant returns. According to Ref. [25], a staggering $54 billion in R&D funding is required to enable

the EU to meet its 2025 goals. From this, it can be deduced that the RET's success is closely linked to government financing for R&D. Photo-voltaic research and development of EU R&D strategies were reviewed and shown to be significant in attaining 2025 decarbonization objectives. According to the authors, increased private enterprise in renewable energy (RE) is needed to meet the EU 2025 objective of 39% positive environmental impact compared to 1988. Feed-in tariffs (FiTs), energy use limits, subsidies, and tax incentives may be used to engage people in the RET effectively, as shown by Ref. [26], who advocated for these mechanisms. There was no discussion of how banks, venture capitalists, and private equity may play a role in overcoming the challenges of private funding from the standpoint of people. Investors have been hesitant to put money into renewable energy projects because of regulatory obstacles and poor rates of return [27].

Renewable energies have several socio-economic and ecological advantages. Low carbon emissions and lower pollution levels are essential [28]. As a result, this reduces the cost of health and medical insurance. There is less risk of a systemic collapse since certain renewable energy technologies are implemented gradually. As a result, energy may be delivered to end-users at a lower cost [29]. Finally, decentralization gives rural populations simple access to energy sources, especially in developing nations, where many people do not have access. On the other hand, Renewables might be more expensive than traditional sources like crude oil in some instances [30]. Renewable energy has several economic advantages. A rise in GDP may be attributed to solar and wind power. According to Ref. [31], reducing dependence on fossil fuels can potentially boost the economies of surrounding nations [32]. The use of renewable energy sources has boosted globalization and per capita spending. Reports of similar discoveries have been made by Ref. [33]. A greener future is good for the economy and suitable for jobs [34]. As a result of these advantages, many industrialized and developing nations are likely to intensify their attempts to switch to renewable energy sources. When it comes to financing renewable energy projects, governments account for the vast majority, but the growing scale calls for a sizable like [35] stressed the necessity for the private sector's involvement in applying alternative business models to promote the momentum. This demands that the market players find renewables appealing. Some prior studies have looked at the influence of renewable energy investments on financial markets, despite the argument being still ongoing. Reported a rise in portfolio risk due to the ownership of fossil fuel companies. It has been claimed that expenditures on solar, on the other hand, might give global diversity advantages [36].

Tran [37] examines the relationship between green finance, economic growth, renewable energy consumption (energy efficiency), energy import, and CO_2 emission in Vietnam using multivariate time series analysis. The results confirmed the existence of cointegration among the variables. The Granger causality test revealed unidirectional causality from renewable energy consumption to CO2 emission and green investment to CO_2 emission.

Yoshino et al. [38] introduced the carbon tax policy as a green finance instrument and a suitable way to reach the long-term zero-carbon plan. Their study explores how the carbon taxation policy can affect the macroeconomy in Japan through the structural vector autoregression technique conducted for the quarterly data from 2005 to 2020. Their findings reveal that any increase in energy price from the carbon tax will lead to an increase in interest rate, exchange rate, and consumer price index, while there is a negative relationship between energy price increase from the carbon tax and real gross domestic product (GDP) in Japan. Carbon Policy Refolution (Reform + Evolution), refunding carbon tax revenues, and adapting the long-term policy of net-zero GHG emissions by 2050 with the current situation of Japan's power sectors are the major practical policies of this study.

There are structural distinctions between conventional and green funds highlighted by researchers. Reducing GHG emissions by 39% by 2030 and 79%–96% by 2040 was the objective of the Energiewende, Germany's policy framework for the RET, which [39] analyzed in detail. The authors concluded that, despite the energy tax policy's capacity objective being met in Germany, the primary purpose (cutting GHG emissions) had not been realized since the energy consumption behavior for other areas, such as plants and vehicles, had not changed. A market-based strategy for providing low-cost power to customers via carbon taxes was also proposed by Ref. [40]in their policy recommendations for the Middle East and North Africa (MENA) area to attain RET. According to Ref. [41] in their comparison of the UK and Germany's RET policies, a wide range of institutions and players are critical to the success of renewable resource policies. Regarding renewable energy (RE), Germany encouraged new entrants like homeowners and small power firms to invest in it. While this was happening, the UK turned to energy market actors to help with the RE shift. For example, both pointed out that policy development is critical regarding Renewable Energy Technology (RET). While China's governance is country, Germany's policies incorporate all participants in the policy development process, providing Germany a helpful case study for other nations to emulate [42].

3. Data and methodology

3.1. Theoretical contribution

The influence of finance on industrial prosperity has been extensively studied. Sectors are linked in a two-way relationship. The prior studies ignored or exaggerated the role of financing on income progress, which was disregarded or exaggerated in the earlier research [43]. On the other hand, other subsequent publications believe in the role of finance in long-term growth rates by affecting savings, investment, and technological advancement. The financial sector's job is to identify the most viable technologies and increase the pace of technological progress by selecting the most promising technology ventures. In addition, the financial business pools savings from people and facilitate more significant savings usage, improving resource allocation and encouraging technological innovation [44]. demonstrated that finance positively affects economic growth regardless of the state's bank or stock market structure.

It is a difficulty for developing nations since they may not be able to realize the advantages of technology transfers that may help them build their economies faster (Menyah et al., 2014). Even though there are some disagreements, it is not incorrect to say that the literature agrees that finance has a long-term impact on growth. Green finance is predicted to influence long-term economic development because of its role in the financial system. In light of past research, this effect is achieved via various pathways. According to several studies, sustainable economic development may be achieved by the use of renewable energy, according to several studies [45]. There are several reasons why non-renewable energy is bad for the environment and bad for our natural resources, according to Ref. [46].

3.2. Sample formation

Through the CSMAR database, we collect the data for our analysis. CSMAR includes all environmental data that is currently accessible. This database has received widespread acceptance in recent Chinese financial and environmental studies [47]. From December 2014 through January 2018, this article includes monthly statistics from the green financing pilot scheme, which came into effect in June 2018. Including Taipei, Hong Kong, and Macau, the sample includes data from 31 provinces in China. Our representative sample is less than planned due to the lack of covariates, such as economic value addition.

3.3. Difference-in- differences (DID)

We developed Difference-in-Differences following the green finance strategy to examine the influence of economic measures on air pollution

management. We selected the DID method because it is intuitive and fairly flexible; it will show a causal effect from observational data if the basic assumptions are met. Since it focuses on change, rather than the absolute levels, the groups being compared can start at different levels. We examine the impact of the green financing strategy on environmental pollution in pilot and non-pilot provinces. We are looking for the following two differences.

$$(Airpollutant_{pilot,after} - Airpollutant_{pilot,before}) - (Airpollutant_{non-pilot,after} - Airpollutant_{non-pilot,before}) \quad (1)$$

The accompanying linear function is estimated:

$$Airpollutants_{i,t} = \alpha_0 + \alpha_1 Green_{i,t} + \alpha_2 Controls_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (2)$$

AQI and its six particulate matter substances, which make up the province's monthly average, are included in the list of seven pollutants in Air pollutants. It is common to see the AQI used to measure air pollution in previous research [48]. SO_2, NO_2, CO, O3, PM2.5, and PM10 are all terms used to describe particulate matter emissions with diameters of less than or equal to 2.5 Pm and less than or equal to 10 Pm, respectively. These seven contaminants are used as dependent variables in this paper, which relates the impact of green finance policy on both a whole and participant air pollution.

A marker variable is known as *Greeni,t* can be used to determine whether or not the chosen region is a pilot and the date is now after May 2018. If it is, the value of Greenit *is 1*. A new set of control variables is introduced in this study: industrial pollution discharges in the surrounding area. The natural logarithm of advanced manufacturing discharge of wastewater, *Sulfuri,t* determined as the arithmetic means of commercial SO_2 emissions, Sooty,t, determined as the arithmetic means of advanced manufacturing combustion characteristics, and *Solidi,t*, determined as the arithmetic means of the thorough utilization rate of manufacturing household waste are all included in our calculations. In addition, this paper calculates the arithmetic mean of indigenous residents (*Populationi,t*) sustainable growth (*GDPi,t*), manufacturing economic benefit (*IVAi,t*), the estimated coefficient of economic output incorporated, the share of secondary and tertiary sectors *Secondaryi,t*) and sector environmental legislation (*Regulationi,t*) determined as the percentage of manufacturing companies in the area for the industry can be divided. The provincial fixed-effect model absorbs the overground nation's economic time-invariant comprehensive discrepancies. The green finance strategy might have positively affected the business climate if it had been implemented promptly. However, time-fixed effects do not include these financial and economic risks.

Green finance policies in pilot cities have a correlation of 1 in Equation (2), which reflects a double difference between the pre-and post-green finance policies in non-pilot urban centers over this same time frame. Economic means have a negative impact on air pollution, as indicated by a coefficient of 1. By comparing the correlation coefficient of α1, we could get some expertise on how to use financial control air quality.

However, all pilot provincial governments must bring out green finance, and each pilot region first selects its pilot city to begin green finance. In order to demonstrate the effects of different finance on carbon emissions more entirely, based on Equation (2), this paper various designs city-month quantitative research and enacts Equation (3) as continues to follow:

$$Airpollutants_{i,t} = \alpha_0 + \alpha_1 Treat^{*}Post_{i,t} + \alpha_2 Treat_i + \alpha_3 Post_t + \alpha_4 Controls_{i,t} + \mu_i + \gamma_t + \varepsilon_{i,t} \quad (3)$$

4. Empirical findings

4.1. Summary statistics

Subventions for fossil fuels are government programs to lower consumer fuel costs or raise revenue for energy companies [49] (see Tables 1 and 2). Direct cash and trade limitations, i.e., import charges and tariffs, are examples of subsidy tools that differ from country to country. Calculating these subsidies can be done in three ways: through, which compares the retail prices to the world market rate; through the stockpile approach, which is the lowest part approach that checks all policies supporting a specific industry; and finally, through the needs and respond approximate approach, which combines transfer and market assistance. The International Energy Agency data excludes the United States and the European Union since they give subsidies for manufacturing rather than consumption in the form of tax credits or loan guarantees. According to Ref. [50] Shanghai and Beijing offered subsidies totaling $4.8 billion and $2.55 billion in 2016. According to the International Energy Agency's database, the 10-leading subsidy-providing nations in 2020 are shown in Table 3 (see Table 4).

4.2. Province-month panel

Incentives for fossil fuels have been decreasing since 2017 since it has become evident that doing so causes environmental and hence runs counter to the COP21 goals. As a result, even if oil prices momentarily rose in 2018, causing some upward movement in the number of subsidies, prices have fallen. In order to spur economic development and alleviate socio-economic disparity, governments throughout the globe are subsidizing the production of fossil fuels [51]. As a result, the production and demand for fossil fuels are stifled by non-sustainable solar subsidies, making it more challenging to execute renewable energy initiatives. Subsidies like these must be eliminated, although gradually, and by reallocating funds to develop renewable energy [52].

These findings indicate that conventional funds outperformed

Table 1
Variable definitions.

Variables	Description
AQI	The air quality index of a city's main evaluation factors includes SO_2, NO_2, CO, O_3, $PM_{2.5}$, PM_{10}
SO_2	Sulfur dioxide
NO_2	Nitrogen dioxide
CO	Carbon monoxide
O_3	Ozone
$PM_{2.5}$	Particulate matter with a diameter less than or equal to 2.5 μm
PM_{10}	Particulate matter with a diameter less than 10 μm
Green	If city I is chosen as a pilot and period t is just after August 2018, an indication variable takes the score of zero and 1 otherwise.
Treat	If city I is not a non-pilot municipality in the pilot provincial or a city in the non-pilot provincial, then the given indication has a value of 1; else, the given indication has a value of 0.
Post	Indicates whether or not the month in question is after August 2018 by returning 1 and zero after that.
Sewage	Industrial effluents outflow natural logarithmic
Sulfur	Emission of industrialized sulfur dioxide on the natural logarithmic scale.
Soot	Coefficient is a measure of soot pollutants from industrial sources
Solid	Natural logarithmic of commercial waste disposal complete utilization rate
Population	The natural logarithmic of the population in the area
GDP	Natural logarithm of local GDP
IVA	Economic value added as arithmetic mean
Secondary	Tertiary firm's contribution
Regulation	The percentage of regional industrial firms
Tax	Tax revenue
Subsidy	Budgetary commitments for environmental preservation
Economy	Calculation of the natural log of the financial contribution provided by local businesses to the sustainable growth of society

Source: Authors' compilation.

Table 2
Summary statistics.

A. Province-month Panel

Variable	Mean	Std	Min	P50	Max	N
AQI	71.51	31.04	19.70	70.49	190.5	770
SO_2	21.41	12.88	3	13.19	90.51	770
NO_2	31.88	12.41	5.659	31.80	69.69	770
CO	0.921	0.331	0.388	0.849	3.841	770
O_3	61.31	19.12	11.21	62.31	121.8	770
$PM_{2.5}$	39.31	18.29	6.077	41.33	151.5	770
PM_{10}	69.8	41.6	18.19	58.55	271	770
Green	0.088	0.288	0	0	2	770
Sewage	7.31	1.349	3.460	4.400	10.48	770
Sulfur	7.588	1.488	4.221	4.931	13.88	770
Soot	6.641	1.299	3.868	5.733	13.21	770
Solid	6.31	1.341	4.454	8.395	11.51	770
Population	7.003	1.061	4.559	7.400	8.31	770
GDP	5.890	1.048	7.049	10.06	11.59	770
IVA	21.04	1.719	11.21	21.80	21.41	770
Secondary	39.39	6.080	15.3	51.02	49.4	770
Regulation	0.71	0.131	0.431	0.571	0.919	770
Tax	31.41	31.51	0.988	21.50	100.5	770
Subsidy	1.721	1.299	0.321	1.480	6.480	770

B. City-month Panel

Variable	Mean	Std	Min	P50	Max	N
AQI	69.50	22.29	19.80	71.50	288.5	3741
SO_2	21.07	21.88	1.490	15.30	191.9	3731
NO_2	29.22	14.59	5.029	31.41	77.51	3755
CO	0.866	0.388	0.129	0.844	3.788	3755
O_3	60.29	19.4	6.533	60.79	141	3755
$PM_{2.5}$	51.69	31.6	6.159	41.60	260.1	3755
PM_{10}	81.91	41	21.61	71.78	349.4	3755
Treat	0.051	0.233	0	0	1	3755
Post	0.190	0.390	0	0	1	3755
Sewage	7.466	1.071	1.950	5.600	11.81	3755
Sulfur	6.721	1.131	3.321	8.841	14.77	3755
Soot	6.432	1.21	2.280	5.588	13.21	3755
Solid	3.444	0.170	2.580	3.429	3.544	3755
Population	5.021	0.690	2.430	5.088	4.141	3755
GDP	6.690	0.969	4.661	6.531	11.61	3755
IVA	13.41	1.333	8.931	21.4	21.71	3755
Secondary	51.88	9.131	21.3	51	69.8	3755
Regulation	0.81	0.262	0	0.90	3	3755
Tax	41.59	31.39	0.988	19.19	100.7	3755
Subsidy	3.066	1.31	0.321	1.681	6.588	3755

Source: Authors' calculation.

Table 3
Balance hypothesis.

Variables	*t*-test	
	t	p>|t|
Sewage	−1.5	0.222
Sulfur	−0.19	0.740
Soot	−0.49	0.621
Solid	−0.88	0.370
Population	−0.91	0.400
GDP	−0.03	0.563
IVA	0.61	0.561
Secondary	1.60	0.123
Regulation	1.31	0.199
Tax	0.69	0.480
Subsidy	0.41	0.699

Source: Authors' calculations.

renewables over ten years. As a result, investors seeking greener investments are willing to accept a lower return. A similar conclusion was made by Ref. [53] who found that sustainable funds underperformed the rest of the market. According to the country-specific research, traditional funds have filled the spaces in Sharpe and VAR ratios. According to Jensen's alpha for financial investments, fifteen out of thirty nations are intriguing. Since they are outperforming, their typical have a significant pull-on investment. According to Ref. [54] the investments in COVID-19 have switched to more environmentally friendly solutions. Renewable and non-renewable funds did not provide different outcomes in the COVID-19 timeframe—the outcomes of risk-adjusted performances during the epidemic. Compared to pre-Covid, the adjusted Sharpe ratio, the excess returns to DID ratio, and Jensen's alpha have all worsened. The total sample and specific nation funds all show the same pattern. Since the pandemic is on the rise, emerging nations should focus on discouraging investors.

4.3. City-month panel

Overall, we found that mainstream funds outpaced their renewable equivalents in terms of returns. Investors benefit from the higher risk-adjusted returns of traditional funds and their managers' market and fluctuation timing skills. It actively discourages investors in ecologically sound choices and implies that they are paying the price for their decision. Our results have ramifications for the United Nations' sustainability goals as well. Global capital expenditure of $101 billion a year is required to meet the 2025 sustainability goals for green energy projects. Investment in green energy projects needs the trust generated by the process of investors. Even though green mutual funds have continuously underperformed, our findings show that companies have no financial incentive to become green.

Because of this, the green finance gap may widen due to the absence of monetary compensation. This section will examine the empirical findings for two key factors: the DID impact and the combined effect of post- and treatment-related characteristics (Table 6). Specifically, we use three alternative estimating methods based on the dependent variables in question. Using Exponentiated and Tobit models, we estimate our findings for the invention dummy variable; we assess the marginal impact of tax decrease policy for reduced energy enterprises using fixed-effect models. We tested hypothesis 2 using two estimating approaches, including or without including dependent variables, to demonstrate that our core findings are robust. The ability of low-energy-consumption enterprises to take advantage of tax incentives and reductions has been shown repeatedly to have a significant and favorable impact on innovation decisions and investment. As per the explanatory variables with all control variables, we calculate that the marginal impact on originality is 0.5% with one unit change in a confidence interval. Tax credits may help develop a low economy, and our findings show that these incentives can be maintained by official fiscal policy in this setting. Here, we show that hypothesis 2 is correct and provide novel research that might help us better understand the influence of green recovery on innovation [55]. We examine the control system impact of income intermediation as a mediating role between firms with low resource status rather than high additional. We will now refer to the monetary transmission processes as a difference, explaining why the marginal impact is moderated. The difference matches much more closely with what may be seen with various financial variables (see Table 7).

4.4. Mechanism analysis

There are a variety of financial performance criteria. According to the results, a tinted moisturizer ratio can be continued to improve to accommodate firms' innovation through tax reduction policy. One percent of the time, and the marginal effect is 0.3%. We show how the financial standing can be improved by encouraging innovation activities and enhancing liquidity, which in turn helps firms innovate more. At the 1% significance level, the common pathway has a marginal effect of 2.7% on innovation, which is essential. Reduced enterprises that put a high value on the absence of internal funding might benefit from access to public fiscal incentives. For every one percent that's considered influential, an individual's incremental contribution to creativity is 34%. Our theory is strengthened further because low-energy enterprises are more likely to innovate by limiting their internal business results.

Table 4
Province-month panel: Effects of green finance.

Variables	AQI	SO_2	NO_2	CO	O_3	$PM_{2.5}$	PM_{10}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Green	−3.473***	−3.277**	−1.761***	−0.051	−1.150	−4.539*	−3.122
	(-41.60)	(-2.90)	(-5.88)	(-0.51)	(-0.81)	(-3.05)	(-0.31)
Sewage	−2.349	5.481	−0.959	0.181	−7.490	4.231	−3.621
	(-0.59)	(1.59)	(-0.29)	(0.79)	(-1.50)	(0.29)	(-0.31)
Sulfur	5.190*	−0.250	3.821***	0.131**	−3.288	6.867***	3.849
	(2.82)	(-0.41)	(4.69)	(2.90)	(-1.31)	(2.58)	(0.88)
Soot	2.161**	1.139*	0.290	0.049**	1.091*	1.849***	3.151**
	(3.50)	(3.29)	(1.41)	(2.71)	(2.39)	(3.90)	(2.88)
Solid	31.399	−31.013	6.669	−0.653	63.121	−4.874	29.888
	(1.48)	(-1.08)	(0.50)	(-0.79)	(1.71)	(-0.21)	(0.50)
Population	−7.590	−11.860	−9.121	−0.331	60.599*	−0.390	−19.461*
	(-1.50)	(-1.13)	(-1.59)	(-1.19)	(3.31)	(-0.04)	(-3.50)
GDP	21.021	1.139	2.188	−0.050	31.291*	4.049	31.359
	(1.39)	(0.51)	(1.06)	(-0.29)	(3.70)	(0.19)	(1.88)
IVA	−0.088	0.231	−0.051	0.006	−0.389	−0.049	−0.438
	(-0.19)	(0.88)	(-0.29)	(0.40)	(-0.6′)	(-0.06)	(-0.66)
Secondary	−0.841	−0.039	−0.026	−0.007	−0.266	−0.722	−0.760
	(-3.70)	(-0.19)	(-0.18)	(-0.81)	(-1.41)	(-1.18)	(-1.02)
Regulation	41.290	14.921	3.177	0.239	−11.921	31.266	59.031
	(0.88)	(3.14)	(0.31)	(1.03)	(-0.31)	(1.05)	(1.31)
Tax	0.058	0.031	0.149**	0.004	−0.088	0.2134	−0.459
	(0.31)	(0.29)	(3.90)	(0.59)	(-0.29)	(1.21)	(-0.89)
Subsidy	2.131**	0.549	0.539*	0.004	1.729	1.860***	5.451**
	(3.88)	(0.66)	(1.29)	(0.21)	(3.14)	(6.04)	(3.59)
Constant	−141.122	61.249	31.072	3.466	−638.350*	−80.440	−1.760
	(-1.88)	(0.61)	(0.41)	(1.08)	(-2369)	(-0.988	(-0.02)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	770	770	770	770	770	770	770
Adjusted R2	0.531	0.541	0.590	0.399	0.122	0.441	0.549

Source: Authors' calculations.

Green product innovation has a favorable effect on GVC participation, which is shown in. It is significant at the 3% level. In other words, innovation capability grows by 2.02% when GVC involvement climbs by 2%. Green innovation is also shown to benefit from GVC involvement, with a significance level of 1%.

One per cent increase in GVC involvement results in 3.332% more green process innovation. That GVC involvement has a detrimental and non-significant impact on green product development, with a lower value than that in Since mediating impact studies show that green innovativeness has a total effect on connecting GVC membership, it is clear that GVC involvement has no direct effect. Reengineering production methods and optimizing the linkages help green product innovation function better and ensures green growth. GVC involvement seems to lead to more significant improvements in green product creation, as shown by the results mentioned earlier, which are consistent with [56]. Additionally, manufacturing companies must create and expand their technology repertoires to produce green product innovation. As a result, green process innovations may increase pollution control and, therefore, organizations. Manufacturing firms must increase their legitimacy in the outer world and lower the cost of their products' life cycles by enhancing green innovation activities in order to reach a 'win-win' scenario for both the environment and the economy. As a result, Hypotheses 1–4 were found to be true. Environmental legislation has a multiplicative effect on green goods and green product innovation. The significant negative Economy regression coefficients in through 4 may be due to a mismatch between R&D expenditure and the current demand for innovation capability, which is insufficient to sustain further green innovation advancements. There is a positive correlation between the green coefficients which indicates that green product and process innovations may be encouraged by the involvement of scientists and engineers in scientific and technological activities. Green advancement will benefit significantly if overall scientific and technical expertise investments are increased.

4.5. Degree of economic development

Terminal governance systems often convert emissions from a manufacturing process into more controllable compounds, which are process innovations that treat pollution after the process and reduce emissions. Terminal technical innovation has been proved to assist the industrial industry in meeting national and state emission regulations, coping with regulatory supervision, and lessening the negative effect of activities on the environment. Instead of actively treating pollution as it occurs, terminal governance technology seeks to address the pollution as a byproduct of manufacturing. Even though it reduces some of the environmental harm and pollution generated by manufacturing, it is not a comprehensive treatment but rather the transfer of contaminants. According to Ref. [57]it necessitated more incredible energy and material expenditure, primarily in increased resources and equipment. The downsides of terminal management technology innovation include the need for significant capital investments and high running expenses in pollution rehab centers as a reactive technique for lowering pollution emissions. Governmental fiscal and regulatory measures are thus necessary to support a lack of political will in many Asian nations to abandon their reliance on fossil fuels, industrialization, and highly inefficient urban growth that has slowed the transition to a green economy. When it comes to eliminating destructive fossil fuel subsidies and promoting renewables, which are requirements for a green economy, political indecisiveness has resulted from the pressures of government corruption and housing investments. Instead of creating a variety of government actions (e.g., zero-interest loans, rebates, tax credits to speed up the installation and use of renewables and energy-saving measures), for example, market distortions that promote the use of fossil fuels continue unabated in several countries across the region.

China has a long history of subsidizing energy and other resources-intensive commodities and services. Many Asian nations spend more

Table 5
City-month panel: Effects of green finance.

Variables	AQI	SO_2	NO_2	CO	O_3	$PM_{2.5}$	PM_{10}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Green	−3.831*	−0.542*	1.111	0.012	0.081	−1.543*	−3.190
	(-3.00)	(-1.79)	(0.49)	(0.31)	(0.11)	(-1.79)	(-0.90)
Treat	2.460***	1.181*	3.239*	0.041	−0.213	3.170***	2.542
	(2.70)	(1.14)	(3.71)	(1.50)	(-0.60)	(728.81)	(1.05)
Post	−20.181*	−5.743*	−0.439**	−0.111**	−13.580***	−17.621*	−24.700***
	(-3.04)	(-1.91)	(-1.88)	(-41.29)	(-251.38)	(-1.97)	(-131.80)
Sewage	1.400***	0.653***	1.061*	0.013	−1.059**	1.280***	1.763
	(3.977)	(4.79)	(1.80)	(1.51)	(-2.48)	(59.31)	(1.88)
Sulfur	2.161***	3.443***	1.170*	0.071**	−0.381	3.542***	2.356***
	(6.40)	(13.40)	(3.51)	(61.40)	(-0.51)	(8.19)	(5.40)
Soot	−0.433***	0.131	1.179*	0.031	−1.532***	−0.499***	0.133
	(-2.22)	(1.69)	(3.41)	(1.80)	(-2.71)	(-6.61)	(0.11)
Solid	4.211***	−3.211***	1.299	−0.091	5.356**	5.014***	11.490*
	(4.29)	(-6.70)	(0.88)	(-2.31)	(3.50)	(6.88)	(1.50)
Population	3.168***	1.220***	−1.662***	0.031*	−0.161	4.877***	4.466***
	(6.31)	(4.78)	(-4.21)	(5.39)	(-0.29)	(18.41)	(7.05)
GDP	−0.481	−1.379***	4.652***	−0.080	0.367	−0.655***	−0.537
	(-1.41)	(-10.00)	(14.60)	(-2.05)	(0.88)	(-31.51)	(-0.88)
IVA	0.069	−0.290***	−0.190	0.006	0.589	−0.049***	−0.004
	(0.59)	(-6.71)	(-3.11)	(4.60)	(1.41)	(-4.41)	(-0.02)
Secondary	0.029	0.061***	−0.069	−0.004***	0.113	0.015**	0.014
	(0.81)	(4.21)	(-0.88)	(-281.50)	(1.31)	(4.91)	(0.07)
Regulation	2.927***	2.441***	0.211	0.061	1.542	3.852***	6.590**
	(21.49)	(14.41)	(0.49)	(3.41)	(0.78)	(1588.71)	(3.91)
Tax	−0.122	0.029	−0.221	0.005	−0.279**	0.012	0.003
	(-0.71)	(1.21)	(-1.88)	(1.31)	(-2.51)	(0.18)	(0.02)
Subsidy	4.776***	1.350***	3.539**	−0.006	1.900***	3.681***	2.844***
	(3.18)	(3.90)	(2.69)	(-1.61)	(4.80)	(6.06)	(5.90)
Constant	−14.049	−5.600*	−41.391***	0.719	50.680***	−19.291***	−55.560
	(-1.12)	(-1.91)	(-3.51)	(1.88)	(3.21)	(-5.61)	(-1.90)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4131	4131	4131	4131	4131	4131	4131
Adjusted R2	0.321	0.321	0.322	0.266	0.0452	0.250	0.456

Source: Authors' calculations.

than 6% of their GDP on fossil fuel subsidies. In 2010, fossil fuel subsidies in Uzbekistan, Turkmenistan, Iraq, and Iran totaled 30%, 24%, 21%, and 16% of GDP. Each China, India, and Indonesia receives more than $11 billion in annual subsidies for energy. In the first half of the 2008–2009 fiscal year, the state oil corporations and the state spends over $1 trillion on liquid petroleum gas (LPG) subsidies. Approximately 76% of this subsidy goes to metropolitan regions, where the wealthier families gain the most from LPG subsidies [58]. Subsidies for fossil fuels are a waste of money for helping the poor since the benefits go to the wealthy. The wealthiest quintile of Americans receives six times as many subsidies as the poorest one [59].

Subsidies that cause damage to the environment are politically controversial, especially in Asia. People often believe they are entitled to low-cost energy because subsidies are deeply embedded or concealed in national political and economic systems. Protests over gasoline price increases are expected in Asia, where subsidies are intensely politicized. The withdrawal of subsidies might lead to the downfall of the current administration. There could be riots and protests, or the rulers could be replaced by elections. There is a considerable lot of political will required to define and apply the applicable international regulations necessary to eradicate all of these [60]. This region's governments must make a concerted effort to develop solutions that effectively meet the worries of cultural circles that would be most adversely affected by the elimination of fuel subsidies. As a result of tax and non-tax revenues changes, expenditure reforms specified targets and projects, and current political impediments to efficient and sufficient energy prices in the area may be eased. There is strong evidence that focused initiatives and aggressive political efforts can achieve the transformation. A series of radical economic measures, including ending subsidies for energy goods and replacing them with focused cash transfers to offset the rise in energy costs, were adopted by the Iranian state in December 2011. In Shanghai, a similar scheme is in place [61]. In the region's least advanced economies, cash-based severance, such as that offered in Indonesia and Iran, maybe an option. The progressive tax schedule may be used for redistributing in developing countries with a somewhat strong taxing structure. Higher fuel taxes or eliminating fossil fuel subsidies might be mitigated by imposing a marginal tax of 0% on low-income households and up to 51% on wealthy ones.

4.6. Robustness test

In order to ensure the validity of the findings, all of the important results in Table 5 were subjected to Robustness testing. Instead of in June 2018, we presume that green financing pilot zones were established the year before. After July 2017, if the region is still a pilot, we may use Equation (2), but we replace Green with Green2, which accepts 1 instead of zero [62]. As shown in Table .9 none of the results from the placebo tests are statistically significant, demonstrating the validity of the primary findings (see Tables 7 and 8).

Building infrastructure facilities is a priority for the states in the region. These countries also within and between institutions to ensure an impact on macroeconomics for green funding, clarify the tax base concept, enhance conformity regulation, and increase governmental flexibility to meet new challenges. A transparent governance system must function under clearly defined circumstances and restrictions, a responsive framework, and national sovereignty to monitor, efficiently operate fiscal instruments, and expeditiously disburse tax receipts for green commercial development. Tax revenues might be used as a political tool to obtain short-term political benefits at the cost of the original purpose of the tax [63]. This is the most significant

Table 6
Mechanism tests.

Variables	AQI	SO_2	NO_2	$PM_{2.5}$
	(1)	(2)	(3)	(4)
Economy	−0.071**	−0.329**	−0.141*	−0.166***
	(-4.69)	(-3.88)	(-1.69)	(-2.49)
Green	−3.321***	−1.990**	−1.621***	−4.319*
	(-61.60)	(-2.69)	(-4.31)	(-1.88)
Sewage	−3.869	3.041	−1.930	1.800
	(-0.80)	(0.66)	(-0.59)	(0.21)
Sulfur	5.078*	−0.711	3.650***	4.533***
	(2.80)	(-0.79)	(3.79)	(3.52)
Soot	2.131**	1.021	0.251	1.653***
	(5.70)	(1.69)	(1.41)	(3.81)
Solid	32.777	−6.531	21.788	2.841
	(1.81)	(-0.31)	(0.79)	(0.06)
Population	−5.733	−4.121	−4.799	1.400
	(-1.31)	(-0.89)	(-1.41)	(0.07)
GDP	15.331	−3.633	1.450	0.351
	(1.41)	(-0.88)	(0.50)	(0.03)
IVA	−0.038	0.500	0.071	0.131
	(-0.06)	(1.69)	(0.61)	(0.19)
Secondary	−0.871	−0.122	−0.051	−0.743
	(-3.71)	(-0.50)	(-0.49)	(-1.19)
Regulation	41.021	11.151	1.966	31.122
	(0.88)	(1.00)	(0.21)	(0.88)
Tax	0.069	0.090	0.180**	0.249
	(0.29)	(0.66)	(2.88)	(1.41)
Subsidy	2.169**	0.432	0.469*	1.653***
	(4.01)	(1.03)	(3.39)	(4.21)
Constant	−141.021	49.682	31.553	−80.431
	(-1.66)	(0.60)	(0.39)	(-0.88)
Year Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
Observations	661	661	661	661
Adjusted R2	0.531	0.462	0.591	0.333

Source: Authors' calculations.

accountability risk in the green fiscal sector. The effectiveness of fiscal tools is undermined. Government revenue and recycling are negatively impacted by the opaque institution operating, decision-making rooted in politics, and a cumbersome and confusing flow of information and monetary resources.

4.7. Discussion

The preceding section discovered that geographical variances in green finance in renewable energy for emission reductions for public disclosure are generated by varying levels of governmental environment protection and green credit competitiveness. The statistics of the investment amount in air pollution control in 31 regions of China from 2018 are gathered. Then the regional average value is computed in the three regions using the arithmetic mean technique for each of the three regions separately. Expenditure on industrial pollution control is most significant in the Eastern area, next by the Middle and Western regions [64]. As a result, local authorities in the Eastern area are more responsible for environmental transparency while funding green finance firms because of their excellent environmental knowledge and involvement. The empirical research computed the green credit accessibility (the indirectly funding amount measured by the total assets) of the 68 renewable energy companies. Then numerical value was summed to determine its mean amount in the Eastern, Central, and Western provinces. The Middle Region has the most extraordinary average green access to finance for sustainable energy enterprises, just significantly reduced than the Eastern Region in 2015 [65].

In contrast, the Southwestern Region has the lowest percentage. Western sustainable energy businesses are more likely to encounter competitive pressure for green credit; hence, environmental information has become an essential instrument to negotiate for green credit. There is minimal competitiveness for green finance in the Middle East. Hence environmentally voluntary disclosure is not as necessary as elsewhere [66].

Table 7
Developed area.

Variables	AQI	SO_2	NO_2	CO	O_3	$PM_{2.5}$	PM_{10}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Green	−1.000	1.088	−0.638	0.005	1.269	−1.361	−1.551
	(-0.66)	(2.06)	(-1.06)	(0.08)	(1.03)	(-1.41)	(-0.12)
Sewage	13.441	−159.151***	14.751	−1.377	181.488**	−59.882	−51.268
	(0.71)	(-6.61)	(0.61)	(-0.50)	(3.60)	(-1.03)	(-0.08)
Sulfur	11.361	−4.733***	2.921**	0.088	−4.142**	11.228***	4.880
	(3.77)	(-3.77)	(3.88)	(0.79)	(-2.21)	(4.79)	(0.29)
Soot	1.331**	−0.361*	0.652***	0.061**	0.399*	1.450	2.031
	(16.11)	(-3.59)	(8.49)	(4.61)	(3.50)	(1.61)	(0.29)
Solid	−251.421	1255.071***	−149.497	12.021	−1521.461**	450.757	260.261
	(-1.14)	(6.90)	(-0.71)	(0.51)	(-3.61)	(0.90)	(0.08)
Population	90.088	21.542	−79.190***	−5.443***	421.070***	−81.741	−61.966
	(1.31)	(1.49)	(-4.51)	(-4.71)	(32.02)	(-1.41)	(-0.06)
IVA	−0.622	−0.866***	−0.211	0.012	0.861**	−1.041**	−0.549
	(-1.11)	(-6.61)	(-1.55)	(0.71)	(2.31)	(-2.79)	(-0.21)
Secondary	−1.455	−1.654***	−1.021***	−0.061**	0.861***	−3.250**	−3.647
	(-2.05)	(-31.90)	(-11.81)	(-2.88)	(11.61)	(-3.41)	(-0.41)
Regulation	−29.618	−71.651**	−61.088**	−0.541	90.421*	−150.490***	−119.432
	(-4.69)	(-2.41)	(-2.79)	(-0.39)	(3.61)	(-6.50)	(-0.31)
Tax	0.8*	0.661***	0.542***	0.021***	−0.542***	1.190***	1.041
	(4.48)	(12.31)	(21.81)	(4.60)	(-12.90)	(6.39)	(0.51)
Subsidy	0.519	0.014	0.418**	0.031	1.661***	0.181	1.741
	(1.69)	(0.12)	(3.09)	(1.61)	(3.69)	(0.49)	(0.29)
Constant	−179.432	−1550.221***	841.122**	41.111	−1134.543**	161.421	159.541
	(-0.41)	(-5.07)	(3.51)	(1.61)	(-2.81)	(0.31)	(0.04)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	400	400	400	400	400	400	400
Adjusted R2	0.461	0.611	0.341	0.390	0.0461	0.349	0.488

Source: Authors' calculations.

Table 8
Underdeveloped area.

Variables	AQI	SO_2	NO_2	CO	O_3	$PM_{2.5}$	PM_{10}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Green	−18.221***	−3.877*	−2.071***	−0.190***	−5.841***	−14.291***	−27.118***
	(-88.88)	(-3.61)	(-21.81)	(-12.60)	(-19.14)	(-21.03)	(-3.80)
Sewage	−4.570	5.332**	−1.488***	0.325***	3.731***	0.788	−28.833**
	(-1.90)	(2.88)	(-12.29)	(9.61)	(5.29)	(0.61)	(-4.90)
Sulfur	−5.170	−1.780	0.459***	0.239***	6.039***	−2.070	−19.870*
	(-4.31)	(-1.11)	(4.81)	(8.59)	(81.61)	(-3.00)	(-3.80)
Soot	1.480**	3.259***	−0.570***	0.128***	−0.671*	0.251	2.534*
	(29.88)	(5.81)	(-12.70)	(11.49)	(-4.60)	(0.78)	(3.61)
Solid	70.079	−55.439***	5.452***	−1.380***	−13.370***	14.005*	181.031***
	(3.60)	(-3.90)	(21.88)	(-9.88)	(-4.79)	(3.31)	(4.31)
Population	−12.800	−61.850***	−3.660***	−2.760***	150.266***	−31.211**	−61.400
	(-0.69)	(-4.88)	(-3.71)	(-15.06)	(41.31)	(-4.03)	(-1.32)
IVA	−1.591*	0.461**	−0.028	0.019***	−1.743***	−0.821**	−3.455***
	(-6.39)	(4.12)	(-0.69)	(6.29)	(-13.05)	(-3.52)	(-4.80)
Secondary	−1.188	0.522***	0.080	0.005	−1.059***	−0.699***	−1.845**
	(-2.31)	(5.77)	(1.60)	(1.71)	(-4.80)	(-3.06)	(-3.60)
Regulation	21.971	21.218	4.529***	−1.582***	69.222***	−7.848	35.680
	(1.39)	(1.80)	(4.13)	(-6.70)	(14.41)	(-1.70)	(0.90)
Tax	−0.590*	−0.431***	1.049***	−0.079***	1.759***	−1.288***	−1.041*
	(-4.71)	(-5.79)	(21.88)	(-31.77)	(9.61)	(-7.29)	(-3.80)
Subsidy	14.860**	−2.661	−1.050***	0.061	−3.159***	6.288***	31.951**
	(19.29)	(-3.11)	(-9.80)	(1.51)	(-5.79)	(4.31)	(2.50)
Constant	279.321	400.631***	51.122***	18.641***	−1061.690***	499.399***	728.361**
	(1.39)	(8.39)	(4.61)	(21.29)	(-29.04)	(7.03)	(4.60)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	400	400	400	400	400	3400	400
Adjusted R2	0.469	0.469	0.542	0.402	0.170	0.469	0.599

Source: Authors' calculations.

Table 9
Robustness test.

Variables	AQI	SO_2	NO_2	$PM_{2.5}$
	(1)	(2)	(3)	(4)
Green2	3.069	1.329	−0.090	2.222
	(1.70)	(0.78)	(-0.11)	(0.61)
Sewage	−1.543	4.790	−1.199	3.571
	(-0.31)	(0.71)	(-0.41)	(0.51)
Sulfur	4.971	−0.269	2.790***	6.488***
	(3.29)	(-0.18)	(5.28)	(2.81)
Soot	4.088	1.087	0.322	1.788***
	(4.41)	(0.96)	(1.41)	(2.39)
Solid	19.222	−29.341	4.345	−12.169
	(0.61)	(-0.51)	(0.50)	(-0.29)
Population	−6.988	−11.433	−9.322	0.211
	(-0.49)	(-0.39)	(-1.51)	(0.03)
GDP	21.241	0.169	2.679	0.921
	(0.90)	(0.03)	(0.81)	(0.07)
IVA	−0.088	0.231	−0.49	−0.041
	(-0.14)	(0.50)	(-0.31)	(-0.08)
Secondary	−0.800	−0.018	−0.009	−0.561
	(-1.41)	(-0.06)	(-0.08)	(-1.28)
Regulation	40.841	21.248	2.871	29.122
	(1.21)	(0.49)	(0.31)	(1.41)
Tax	−0.171	−0.088	0.058	−0.070
	(-0.51)	(-0.41)	(1.21)	(-0.41)
Subsidy	2.159	0.550	0.499	1.963**
	(3.30)	(0.69)	(1.81)	(3.70)
Constant	−111.629	69.621	41.988	−49.653
	(-1.80)	(0.31)	(0.51)	(-1.06)
Year Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
Observations	771	771	771	771
Adjusted R2	0.531	0.552	0.581	0.441

Source: Authors' calculations.

5. Conclusion and policy recommendations

Several pilot provinces in China have been leading the way in investigating green finance in renewable energy, with the government's cooperation, channeling funding to emission reduction. This study can determine which contaminants are now controllable economically by examining and comparing the effects of green finance in renewable energy for emission reduction policy implementation. Green finance strategy has a lowering influence on emission reduction in general. Adequate but not perfect reductions in Sulfur dioxide, Nitrogen dioxide, and PM2.5 are achieved by green finance policies among the six individual airborne pollutants. A further benefit of green financing in renewable energy is that it encourages local businesses to make environmentally beneficial economic contributions. Green finance policy also has a more significant impact in financially underdeveloped areas than in financially prosperous countries. In China and the rest of the globe, air capacity to self-purify has reached a critical point, resulting in significant pollution. Researchers found that economic methods may reduce air pollutants, and this study's results have implications for green financing in renewable energy for emission reduction.

As for the policy recommendations of this study; when it comes to environmental regulation and energy saving, the government must take the lead, encouraging and urging businesses to spend more in these areas. Economic growth may be redirected to more environmentally friendly locations, and air pollution may be reduced. Green finance involves the participation of all stakeholders, from the governments to credit intermediaries to businesses and the general public.

First and foremost, the issue of asymmetric information must be addressed immediately. The emergence of green finance necessitates the discovery of eco-friendly firms and initiatives. Neither microfinance companies nor green businesses or projects clearly know which firms or initiatives are environmentally friendly. Financial intermediaries and investment managers need to know that green enterprises exist. Organizations should be more knowledgeable about the many options when it comes to financial goods and funding methods [66,67,68].

It is essential to facilitate the implementation of green finance's economic structure and strengthen the developmental environment of green finance. Among the most important considerations are how to standardize the criteria for establishing green projects and what types of investments and bonds fit the standards for identifying green bonds. To guarantee that the money obtained is utilized for green initiatives, tightening the rules for environmentally reporting quality is necessary. It is vital to establish an information dissemination system for business pollutant output, ecological infringement data, and a reliable green-credit system as part of our overall social credit systems and credit assessment systems. These structures' creation facilitates green finance's growth [69–72].

Our reform experiments need the cultivation of more "socially responsible" investors and the introduction of social capital. As part of our work, we must find ways to raise awareness of green finance, develop and stimulate economic growth with a social conscience, and lead long-term human capital to be funded in environmentally friendly initiatives and financing.

The limitation of this study is that it did not consider the factor that affected the green finance policy and considered green finance policy as an exogenous variable. However, several factors affect it. Green Finance policy can also be correlated with other types of policy like the monetary policy and credit policy. It is suggested that monetary policy and credit policy variables be included in future studies as control variables.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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