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Impact of Green Finance Reform and Innovation Pilot Zones on Regional Economic Growth

Guangning Wang*, Yuanhua Yang, Yinjun Xu

International Business School, Guangdong University of Finance and Economics, 510000 Guangzhou, China

* Correspondence: Guangning Wang (cjwgn666@student.gdufe.edu.cn)

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Abstract: As ecological civilization becomes a key national development strategy, green finance, which aims for sustainable development, plays a significant role in fostering regional economic growth. At the same time, local governments actively respond to central policies and, in the process of exploring financial reform and innovation, need to quantitatively assess the effectiveness of these policies. This paper takes the establishment of Green Finance Reform and Innovation Pilot Zones as a quasi-natural experiment to examine the impact of this policy on regional economic growth and its underlying mechanisms. The study finds that the establishment of Green Finance Reform and Innovation Pilot Zones effectively promotes regional economic growth, and the conclusion remains robust after conducting various sensitivity analyses. Further heterogeneity analysis explores the differing impacts of the policy in various regions, while considering green innovation as a positive mechanism mediating the relationship between the policy and economic growth. This study provides insights into the shift from "quantity" to "quality" in regional economic development.

Keywords: Green finance; Green finance reform and innovation pilot zones; Regional economic growth

1 Introduction

The green-oriented financial development model is becoming the mainstream trend in today's financial industry. Traditional finance has natural advantages in accelerating capital accumulation and optimizing resource allocation. However, with the slowdown in economic growth and the manifestation of environmental externalities, there is an increasing emphasis on environmental and sustainability issues. With the rapid development of sustainable concepts and modern financial tools, green finance, starting from the goal of environmental protection and resource conservation, plays a constructive role in promoting high-quality economic growth and achieving sustainable development. Further exploration of China's promotion of ecological civilization reform shows that green finance is playing an increasingly important role. The establishment of a green financial system helps to initiate new growth points, enhance economic growth potential, increase the technological content of the economy, alleviate the pressure of environmental issues on public finances, and maintain China's image as a responsible global power [1].

From the perspective of China's exploration and practice in green finance, it has gone through stages of increasing total amount, more diverse tools, and from no policy to a full-fledged policy. China's green finance progress has been relatively late compared to developed countries, but it has developed rapidly, thanks to the steady advancement of China's top-level design in green finance policies. The Guiding Opinions on Building a Green Financial System, released in 2016, is of milestone significance in China's green finance development process. It marks China as the first country globally to include the establishment of a green financial system in the highest policy documents to promote green finance development, which helps form a unified standardized financial market environment in China. In 2017, the State Council set up green finance reform and innovation pilot zones in eight cities (new districts) in five provinces (Zhejiang, Jiangxi, Guangdong, Guizhou, and Xinjiang) for a five-year period. This pilot policy guided local areas to develop models tailored to their characteristics, accelerating the further development of green finance in China. Currently, the first batch of five-year green finance reform and innovation pilot zones has concluded. As pioneer regions, they have accumulated valuable experience, and the quantitative analysis of their effectiveness has drawn considerable attention from scholars [2]. In addition, after the first batch of pilot zones were established,

China has successively launched green finance reforms in Lanzhou, Gansu, and Chongqing, and cities like Shanghai and Weihai in Shandong are also actively applying to establish national-level green finance reform and innovation pilot zones. How to combine local characteristics to build diverse regional green economies is also a focus of current academic research. From the existing research, studies on the macro and micro impacts of green finance are already common, and research on green finance policies is also emerging. On one hand, research on the relationship between modern finance and economic development is abundant. McKinnon was the first to deeply explore the relationship between financial regulation and output growth in developing countries from the perspective of financial repression, and since then, financial development as an endogenous variable promoting economic growth has been widely studied [3]. Green finance is an important part of the modern financial system. Early research focused more on improving environmental quality and serving the development of the real economy, with the Environmental Kuznets Curve proposed by Grossman and Krueger being the most typical [4]. With the rise of environmental protection concepts, society gradually became aware of the hindering effect of environmental pollution on economic development, which led to conscious choices by consumers in their consumption, conscious avoidance by enterprises in their production, and conscious decision-making by governments and financial institutions in investment and financing. This promoted the transition of green finance from a concept to specific practice [5]. Furthermore, green finance promotes economic development through measures such as encouraging green consumption, expanding investment scale [6], and improving corporate performance [7]. Wang Yao provided a comprehensive theoretical summary of the contribution of green finance to economic growth in China, as well as how and in what ways it should develop, which has been widely recognized [8]. Subsequent empirical studies by scholars have mainly focused on different research perspectives and mechanisms.

Most scholars treat green credit as a representative variable of green finance and conduct research based on this, using the issuance of green bonds to test companies' potential commitment to the environment [9]. Later studies explored the importance of investor attention in guiding capital flows to sustainable investments in green industries [10]. A smaller number of scholars have considered the interactions resulting from the diversity of green finance products, such as the diversification of returns generated by the combination of green bonds and other financial markets [11] and the impact of different financial products on local pollution emissions [12], exploring the product heterogeneity of green finance and providing some basis for the development of more targeted green finance products. Regarding regional differences, some scholars have studied the impact of green finance and digital financial inclusion on the stability of the banking system in economies with varying levels of financial development [13]. From this, it can be observed that developed economies, represented by the EU and G20 countries, are better able to utilize green finance to achieve green growth due to advantages such as per capita income, technological innovation, and capital scale [14]. When considering financial products, the value of green bonds helps with energy conservation and emission reduction, but combining green financing methods with tax exemptions is more effective for energy saving and emission reduction, thus achieving green growth. This provides some insight into the mechanism of diversified policy effects [15, 16]. In developing countries, there is an inverted U-shaped relationship between green finance and environmental sustainability, especially in low-income countries or in countries facing sudden crises, where the sustainability effects of green finance are harder to manifest [17]. However, by examining key policies in Asian developing economies, some scholars have pointed out that these policies can improve green literacy by influencing markets, currencies, and other factors [18]. Focusing on India, a representative developing economy, it was found that the integration of financial technology growth and green finance can effectively improve the effectiveness of green finance, and policies can effectively encourage the private sector's participation in green finance [19].

On the other hand, research on green finance-related policies has mainly focused on the "Green Credit Guidelines" issued in 2012, exploring its impacts on investment and financing issues [20], green technological innovation [21], and the dual impacts on the environment and economy [7]. Regarding the "top-down" design of the pilot zones and the "local adaptation" development characteristics, previous policies were insufficient to cover the characteristics of all green finance products. Whether new policies further enhance the role of resource allocation in financial markets and whether they further promote economic growth needs further investigation. Currently, research on green finance reform and innovation pilot zones mainly focuses on the micro-level, including promoting corporate green innovation, production efficiency, and pollution reduction [2, 22]. These studies typically define different types of polluting enterprises and label companies within the pilot zones to match their policy effects, providing valuable conclusions on different mechanisms. However, by focusing solely on enterprises within the pilot zones and not considering macro factors, it is difficult to measure the overall economic effect of the pilot zones [22, 23], which does not align with the pilot zones' intent to be promoted nationwide. At the macro level, current research focuses on industrial structure adjustment effects and signal transmission effects [24, 25]. A few studies have examined urban high-quality growth, typically focusing on urban green efficiency and energy efficiency [26, 27]. These studies emphasize the long-term effects of the pilot zones on high-quality economic growth, but fail to adequately reflect the direct effects of green finance on regional economic growth, such as short-term product innovation and the ability to generate economic effects that promote long-term policy development.

In this regard, this study aims to supplement the current research on green finance in the following aspects: first, based on a comparison of domestic and international green finance research, focus on summarizing foreign research on different green finance products and incorporate this into the domestic policy-making process; second, address the current lack of research on pilot zones in China by further exploring the macro effects of pilot zone policies, conducting empirical quantification from the perspective of regional economic growth to evaluate their policy effects, and drawing evidence from the experience of the first batch of pilot zones to optimize the current support for economic development; third, explore the heterogeneity of green finance policies and their mechanisms, and verify in what situations and through which paths green finance development can be effectively promoted, in order to better tailor policies to local characteristics.

2 Theoretical Analysis and Research Hypotheses

Economic growth is the foundation of high-quality development. Only by continuously expanding the scale of the economy can we achieve industrial structure transformation and upgrading, efficiency improvements, and the co-construction and sharing of development achievements [28]. From the perspective of economic growth theory: classical economic growth theory highly emphasizes the role of capital accumulation in the process, recognizing the role of capital and social division of labor in improving labor productivity; neoclassical economic growth theory argues that the continuous growth of per capita output relies on technological progress, which is the main cause of the wealth gap between countries; endogenous economic growth theory stresses the need to invest in education and research and development to maximize the supply of high-quality human resources, meaning that government policies should focus on the generation of new technologies to drive economic growth. Based on the above economic growth theories, optimizing the allocation of financial resources can help enterprises achieve capital accumulation and promote regional educational and technological advancement, thus fostering regional economic development. At the same time, the profit-seeking nature of financial capital often leads to disorderly expansion of enterprises, which in turn causes negative externalities in regional economies. According to the Environmental Kuznets Curve, as per capita income increases, environmental pollution rises from low to high, and the degree of environmental degradation intensifies with economic growth, which will hinder regional economic growth. Green finance, as an emerging financial tool to support the development of environmentally friendly industries, is a financial innovation in the field of finance aimed at sustainable economic development. It has basic functions such as capital accumulation, investment guidance, information transmission, and resource integration [29]. The pilot policy of green finance reform and innovation pilot zones can, on one hand, complement traditional economic policies and promote green economic development [30]; on the other hand, it can optimize the economic structure and improve supply-side quality, adjusting the industrial structure at the macro level to improve overall social productivity, while encouraging enterprises to innovate and improve individual economic efficiency at the micro level. Therefore, we propose Hypothesis 1.

Hypothesis 1: The green finance reform and innovation pilot zone policy can effectively promote regional economic growth.

Existing research shows that pilot programs for energy and green policies generally contribute to driving regional economic growth. However, the implementation effects of location-oriented policies exhibit strong heterogeneity and persist at different points after establishment [31]. As a new pilot policy, green finance policies complement other policies, forming a "dual effect" that drives financial capital towards the development of sponge cities and smart city construction, while simultaneously improving the quality of economic growth [26]. Capital and sub-provincial cities, as well as municipalities directly under the central government, are often pilot areas for major national development strategies. Therefore, compared with cities of lower administrative levels, these areas can obtain more financial resources and support, which results in differences in the complementarity of green finance policies with other policies. In addition, the spatial and regional differences have, to some extent, led to imbalances in regional economic development. Given the current imbalance of regional economies in China, it is essential to explore an effective path for promoting economic growth tailored to local conditions to fully leverage the supportive role of green finance. Although China's green finance development level is continuously improving, there is a regional imbalance in its development. If certain provinces maintain regional imbalances for a long time, serious discrepancies will emerge, affecting the overall development of green finance and hindering the integrated construction of green finance in China [32]. The eastern regions of China, compared to the central and western regions, make greater use of clean energy, while most cities in the western regions have abundant resources but face the "resource curse" problem. Under these conditions, the support provided by green finance for regional transformation and upgrading varies [33]. Therefore, the selection of green finance reform and innovation pilot zones is mainly based on factors such as the industrial structure, geographical location, and the positioning of future green finance development in different cities. This shows that the green finance reform and innovation pilot policy is a beneficial exploration by the country to encourage local areas to carry out reform pilot work according to their own conditions. Furthermore, from the perspective of the various participants, it can be seen that: the central government has designed the top-level

green finance policy and examined the effectiveness of pilot zones in cities with different industrial structures; local governments have made adjustments according to local industrial conditions, focusing on serving the most characteristic industries in their areas, leading to significant economic growth in some regions; financial institutions in various regions have diversified green finance products, offering enterprises more options for financing; enterprises have received more support through utilizing different financial instruments for financing and obtaining policy subsidies, thus having enough funds to sustain innovation. Therefore, we propose Hypothesis 2.

Hypothesis 2: The promotion effect of green finance reform and innovation pilot zones on regional economic growth exhibits heterogeneity.

3 Research Design

3.1 Model Construction and Variable Selection

This study considers the 10 cities included in the five provinces and eight regions determined by the State Council's executive meeting in 2017 as the experimental group. Due to severe data missing for Changji Prefecture and Hami City in the Xinjiang Uygur Autonomous Region, the final experimental group consists of the cities of Quzhou, Huzhou, Guangzhou, Guiyang, Anshun, Nanchang, Jiujiang, and Karamay. The remaining 287 prefecture-level cities are taken as the control group. If a city is a green finance reform and innovation pilot city, a virtual variable between groups is assigned the value 1, otherwise it is assigned the value 0. Following the approach of most studies, the proposal of the green finance system in 2016 is regarded as the starting point for the establishment of the green finance reform and innovation pilot zones. Thus, 2016 is taken as the starting year for the pilot, with the year and subsequent years assigned a value of 1, otherwise assigned a value of 0. This paper uses the interaction term of the group dummy variable and the time dummy variable as the policy variable for the green finance reform and innovation pilot zone, constructing the core explanatory variable, did. A two-way fixed effects model is used for difference-in-differences (did) estimation to examine the net effect of establishing green finance reform and innovation pilot zones on regional economic growth. The specific model is set as Eq. (1).

Table 1. Variable selection and data sources

Variable Type	Variable Name	Variable Meaning	Measurement Method
Dependent Variables	lnagdp	Economic development level	Logarithm of per capita GDP
	lngdp	Economic development level 2	Logarithm of GDP, used as an instrumental variable for robustness checks
Explanatory Variables	did	Policy implementation	First batch of pilot areas, value of 1 from 2016 onwards, otherwise 0
	did2	Policy implementation 2	Second and third batches of pilot areas, value of 1 from 2016 onwards, otherwise 0 , used as an instrumental variable for robustness checks
Control Variables	PI	Pollution index	Weighted using entropy method, constructed from three dimensions: Waste gas, waste water, and waste
	FAL	Financial agglomeration level	Measured using location entropy, calculated as the ratio of the number of financial industry workers to total employment in the city, relative to the national proportion
	FDL	Financial development level	Year-end balance of loans and deposits of financial institutions / regional GDP
	FDI	Foreign direct investment level	Total actual foreign investment / regional GDP
	FIL	Fiscal investment level	Fixed asset investment / general government fiscal expenditure
	STR	Overall industrial structure upgrade	First industry value-added proportion * 1 + *second industry value-added proportion* * 2 + third industry value-added proportion *3
Mechanism Variable	lnGI	Green innovation	Logarithm of the sum of green invention patents and green utility model patents, plus 1

$$\ln agdp_{it} = \beta_0 + \beta_1 \,\mathrm{did} + \beta_2 \sum C_{\mathrm{i}} + \mu_{\mathrm{i}} + v_{\mathrm{t}} + \varepsilon_{\mathrm{t}} \tag{1}$$

In the above model, the dependent variable lnagdp represents the economic development level of city i in year t; C represents a series of variables that may affect the regional economic development level; did represents the treatment period dummy variable. If city i is identified as a green finance reform and innovation pilot zone in year t, it is assigned a value of 1, otherwise 0; μ and v represent city-level and time-level fixed effects, respectively; ε is the random disturbance term.

3.2 Variable Selection and Data Sources

To clearly define and measure all the variables, this section summarizes and categorizes them in tabular form, as shown in Table 1.

Based on the reference to most studies and considering the availability and completeness of the data, as well as the economic disruption caused by the COVID-19 pandemic in 2020, this study selects 280 prefecture-level cities in China from 2006 to 2019 as the research subjects to explore the impact of green finance policies on regional economic growth. The data mainly comes from the annual China Statistical Yearbook and databases such as EPS, CNRDS, with samples containing missing values being excluded.

4 Empirical Results

4.1 Empirical Model Selection

First, descriptive statistics of the processed variable data were conducted, followed by correlation and multi-collinearity diagnostics, as shown in Table 2. The test results show that the VIF (Variance Inflation Factor) values are all less than 3, indicating that multicollinearity is not a significant issue. In addition, to select the appropriate model for panel data regression analysis, a Hausman test was conducted to determine whether the fixed-effects model or the random-effects model should be used for the baseline regression. The test results show a p-value of 0.00<0.01, strongly rejecting the null hypothesis that "the random explanatory variables are not correlated with the explanatory variables". Therefore, the fixed-effects model should be chosen for the baseline regression.

4.2 Baseline Regression

The baseline regression model was estimated while controlling for both year fixed effects and region fixed effects, with the following seven regression results derived by progressively adding control variables. Table 3 presents all regression results. Column (1) displays the regression results without any control variables, while Columns(2-7) show the results as control variables are gradually included. Environmental pollution significantly suppressed regional economic growth by increasing production costs and limiting the sustainable use of resources. On the other hand, foreign direct investment (FDI) had a significant positive effect on economic development through the spillover effects of capital, technology, and management experience. Fiscal expenditure was identified as an important driver of growth, likely enhancing regional economic development capacity by improving infrastructure and public services. Higher levels of financial agglomeration and financial development, under certain conditions, might have a suppressive effect on regional economic growth. This phenomenon may reflect the following mechanisms: first, excessive financial agglomeration might lead to an imbalanced distribution of financial resources across regions, inhibiting the development potential of underdeveloped areas; second, regions with high levels of financial development may fail to effectively convert financial advantages into economic growth due to inefficient use of funds or resource misallocation.

Table 2. Descriptive statistics

VarName	Obs	Mean	SD	Min	Median	Max
lnagdp	3850	10.4226	0.722	4.60	10.43	13.06
did	3850	0.0083	0.091	0.00	0.00	1.00
PI	3743	0.7061	0.319	0.03	0.95	1.00
FDI	3850	0.0186	0.019	0.00	0.01	0.20
FIL	3850	4.6718	1.910	0.01	4.45	13.77
FAL	3850	1.0175	0.408	0.10	0.97	3.52
FDL	3850	2.2464	1.198	0.56	1.91	21.30
STR	3850	2.2645	0.145	1.89	2.25	2.83
lngdp	3826	6.2125	1.229	2.80	6.08	10.55
lnGI	3850	4.2140	1.854	0.00	4.13	10.11

Table 3. Baseline regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ml	m2	m3	m4	m5	m6	m7
VARIABLES	lnagdp	lnagdp	lnagdp	lnagdp	lnagdp	lnagdp	lnagdp
did	0.088**	0.151***	0.146***	0.153 * **	0.142 * **	0.144***	0.144***
	(0.042)	(0.036)	(0.034)	(0.032)	(0.032)	(0.032)	(0.032)
PI		-0.056*	-0.061**	-0.051*	-0.056**	-0.059**	-0.060**
		(0.029)	(0.028)	(0.026)	(0.026)	(0.024)	(0.024)
FDI			1.729****	1.263***	1.218***	1.122***	1.124***
			(0.286)	(0.259)	(0.257)	(0.249)	(0.250)
FIL				0.033***	0.033***	0.026***	0.026***
				(0.003)	(0.003)	(0.003)	(0.003)
FAL					-0.044***	-0.035**	-0.035**
					(0.014)	(0.014)	(0.014)
FDL						-0.080****	-0.080***
						(0.019)	(0.019)
STR							-0.029
							(0.086)
Constant	10.422 * **	10.463***	10.434***	10.281***	10.330***	10.536***	10.602***
	(0.003)	(0.020)	(0.021)	(0.025)	(0.030)	(0.057)	(0.194)
Observations	3,850	3,743	3,743	3,743	3,743	3,743	3,743
R-squared	0.950	0.950	0.950	0.952	0.953	0.956	0.956
yearfix	YES	YES	YES	YES	YES	YES	YES
idfix	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

It is noteworthy that the industrial structure upgrade variable did not show a significant effect, which may reflect its limited short-term contribution or the model's inability to fully capture its impact. The baseline regression results indicate that, without considering control variables, the policy implementation effectively promoted regional economic growth. When considering the effects of other control variables, the conclusion becomes even more significant. In addition, while environmental pollution has a negative impact on economic development, this effect was not statistically significant, likely due to the nonlinear relationship between environmental pollution and economic growth. Green finance policies help balance this relationship [7]. Foreign investment and fiscal expenditure were found to effectively promote economic development, and the results were statistically significant. Financial agglomeration levels did not significantly promote economic development, suggesting that more financial professionals are needed to fully utilize financial resources for economic growth. Financial development, on the other hand, had a significant negative impact on economic growth, suggesting that a high savings ratio is detrimental to the efficient allocation of financial resources to stimulate economic growth. The industrial structure had a negative effect on economic growth but did not pass the significance test, indicating that the overall level of industrial upgrading is currently low, and industrial upgrading, as a support for financial-driven real economic development, is insufficient in its overall contribution.

4.3 Robustness Check

4.3.1 Parallel trend test

A key assumption when using the difference-in-differences (DID) model for policy evaluation is the parallel trends assumption, which states that, prior to the policy implementation, the treated cities (pilot cities) and control cities (non-pilot cities) should exhibit similar development trends or should not have systematic differences. In this study, the parallel trend test was conducted following the approach of Cui et al. [22]. The test results show that before the implementation of the green finance reform and innovation pilot policy, there were no systematic significant differences in the economic development levels between the pilot and non-pilot cities. Figure 1 illustrates this, as the economic development trends of both pilot and non-pilot cities follow a similar trajectory prior to the policy implementation, confirming the parallel trends assumption. After the policy implementation, the economic development levels in the pilot cities grew more significantly compared to the non-pilot cities. This indicates that the parallel trends assumption holds, making the use of the difference-in-differences method appropriate for evaluating the impact of the policy on regional economic growth.

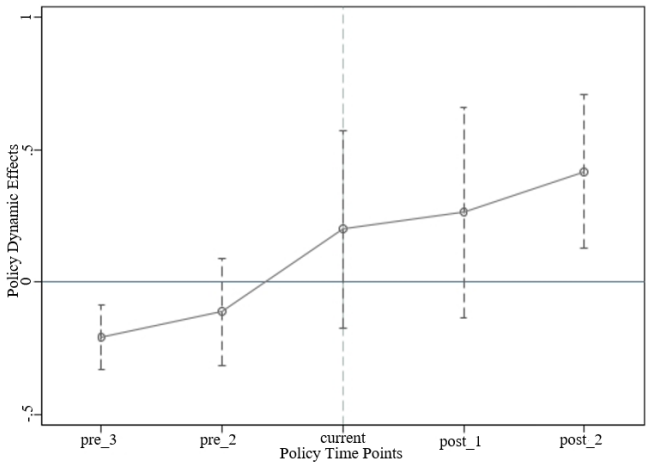

Figure 1. Parallel trends chart

Table 4. Robustness test

VARIABLES	(1) Replace Core Dependent Variable lngdp	(2) Adjust Sample by Replacing Explanatory Variables lnagdp	(3) Adjust Sample to Target Provinces lnagdp
did	0.160***		0.131***
	(0.037)		(0.034)
did2		0.157***	
		(0.026)	
PI	-0.016	-0.059**	-0.092**
	(0.034)	(0.024)	(0.043)
FDI	-0.607**	1.121****	2.925****
	(0.296)	(0.249)	(0.671)
FIL	0.023 * **	0.026***	0.031***
	(0.004)	(0.003)	(0.006)
FAL	-0.036**	-0.034**	-0.010
	(0.015)	(0.014)	(0.034)
FDL	-0.074***	-0.080***	-0.070***
	(0.017)	(0.019)	(0.022)
STR	0.170	-0.030	0.474**
	(0.147)	(0.086)	(0.233)
Constant	5.953***	10.603***	9.516***
	(0.325)	(0.194)	(0.519)
Observations	3,720	3,743	652
R-squared	0.977	0.956	0.970
yearfix	YES	YES	YES
idfix	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.3.2 Substitution of core dependent variable

To further test the robustness of the results, we followed previous research and used the logarithm of regional GDP as an instrumental variable. The empirical results are shown in Column (1) of Table 4, which demonstrates consistent findings.

4.3.3 Adjustment of research sample

In reference to the actual policy implementation, we included cities from the second and third batches of pilot cities into the experimental group for regression analysis. The empirical results are shown in Column (2) of Table 4. Additionally, following the approach of Liu and He [34], we addressed potential estimation biases caused by the large number of cities in the control group by narrowing the sample to include only cities within the same provinces

as the pilot cities for policy evaluation. The empirical results are shown in Column (3) of Table 4.

The robustness results are generally consistent with the baseline regression results, confirming the robustness of the conclusions. Specifically, the policy has a significant positive impact on overall economic growth. However, considering factors such as population and pollution, further efforts are needed to balance economic development and environmental protection. After incorporating the second and third batches of pilot regions, the coefficient of the core explanatory variable increased, indicating that the first batch of pilot areas has played a demonstrative role in the implementation of subsequent pilot areas. When the sample is narrowed to the provinces of the pilot areas, the coefficient of the core explanatory variable decreased, suggesting that the pilot policy is more effective when promoted nationwide rather than within individual provinces. This may be because some cities within the province have taken on parts of the industrial transfer, and the role of green finance in the overall industrial upgrading process has been more pronounced at the provincial level.

4.4 Further Testing

4.4.1 Heterogeneity analysis

Overall, the green financial reform and innovation pilot areas can effectively improve regional economic growth levels. However, due to factors such as geographical location and urban rank, the effects of the policy implementation vary across cities. From different perspectives, exploring the pilot policy of green financial reform and innovation can provide valuable reference for further promoting the national green financial system. Therefore, this study, referencing the research of Si and Yao [24], will examine the heterogeneous impacts of establishing green financial reform and innovation pilot areas on regional economic development from two aspects: urban administrative rank and geographical location. The geographical division is based on the National Bureau of Statistics' classification of the eastern region into 10 provinces (municipalities), with the remaining cities belonging to the central and western regions. The urban administrative rank is based on the classification of urban administrative levels by the Chinese Government website, where high administrative rank cities mainly include municipalities directly under the central government, provincial capitals, autonomous region capitals, and sub-provincial cities, while the remaining cities are considered general-level cities.

Table 5. Regression results

	(1)	(2)	(3)	(4)
	Eastern Region	**Central and Western Region**	**High-Level Cities**	**Other General Cities**
VARIABLES	**lnagdp**	**lnagdp**	**lnagdp**	**lnagdp**
did	-0.002	0.227***	-0.211***	0.200***
	(0.040)	(0.034)	(0.044)	(0.028)
PI	-0.040	-0.066**	-0.015	-0.059**
	(0.036)	(0.030)	(0.060)	(0.025)
FDI	-0.292	1.124***	2.404***	0.772***
	(0.411)	(0.334)	(0.386)	(0.258)
FIL	0.003	0.031***	-0.012	0.027***
	(0.006)	(0.004)	(0.008)	(0.004)
FAL	-0.013	-0.054****	-0.062*	-0.030**
	(0.023)	(0.017)	(0.035)	(0.015)
FDL	-0.092***	-0.078***	-0.163***	-0.077***
	(0.028)	(0.021)	(0.025)	(0.019)
STR	0.433***	−0.073	-0.496	-0.005
	(0.164)	(0.105)	(0.364)	(0.087)
Constant	9.995***	10.549***	13.089***	10.471***
	(0.368)	(0.240)	(0.881)	(0.196)
Observations	1,175	2,568	262	3,481
R-squared	0.966	0.948	0.958	0.953
yearfix	YES	YES	YES	YES
idfix	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

According to the empirical results in Table 5, columns (1) and (2) show that, in the eastern region, the did coefficient (green financial policy) is not significant, which may indicate that the marginal effect of the green financial policy is weaker in this region. This could be due to the stronger economic foundation in the eastern region, limiting the incremental effect of green finance, or the concentration of green finance resources in more efficient sectors, resulting in no significant impact on the overall economy. The FDI (foreign direct investment) coefficient is significantly negative, reflecting the over-concentration of foreign investment in specific industries, which fails to

drive broader economic growth. The Fai (financial agglomeration and development level) coefficient is significantly negative, indicating that the over-concentration or inefficient use of financial resources suppresses economic growth. In contrast, in the central and western regions, the did coefficient is significantly positive, suggesting that the green financial policy has promoted economic growth in these regions. This could be because the central and western regions have strong resource endowments, and their economic development still focuses on quantity over quality. The policy has effectively addressed capital and green technology gaps, thereby boosting economic growth. The Pollution coefficient is significantly negative, indicating that economic growth in the central and western regions is still constrained by environmental pollution to some extent.

Columns (3) and (4) show that, for high-level cities, the policy's effect on economic growth is significantly negative, while FDI has a strong positive contribution to economic growth. This could be because high-level cities often serve as testing grounds for major development strategies in their early stages. These cities tend to have advantages in technological innovation, human capital, and especially attracting foreign investment. As a result, foreign investment plays a more significant role in driving economic growth [20]. Green financial policies, unlike traditional major development strategies, focus on regions with significant differences in resource endowment and geographical location. These policies aim to promote the integration of the green financial system, but their effect on economic growth is weaker in high-level cities, possibly due to resource misallocation or insufficient policy implementation. For general-level cities, the policy's effect on economic growth is significantly positive, which is consistent with the baseline regression results. This suggests that most cities are still in a phase of rapid economic growth. These cities indirectly benefit from the green financial policy through technological diffusion or capital input. However, further efforts to establish a green financial system are needed to guide the economy towards high-quality growth.

4.4.2 Mechanism analysis

The empirical analysis in the previous section has demonstrated that the establishment of green financial reform pilot zones can significantly promote regional economic growth, although the pilot policy also exhibits heterogeneity. This section further explores the mechanisms through which the green financial reform pilot zones affect regional economic development. Based on the majority of studies on the mechanisms of green finance, this section examines the mediating role of regional green innovation levels. Specifically, it investigates how the pilot policy influences green innovation and how green innovation, in turn, affects regional economic development.

Table 6. Mechanism test

VARIABLES	(1) lnGI	(2) lnagdp
lnGI		0.065***
		(0.008)
did	0.215***	
	(0.049)	
PI	-0.034	-0.057**
	(0.064)	(0.024)
FDI	-1.880***	1.264***
	(0.667)	(0.250)
FIL	0.010	0.025***
	(0.008)	(0.003)
FAL	-0.057*	-0.034**
	(0.030)	(0.014)
FDL	-0.027**	-0.078***
	(0.013)	(0.019)
STR	0.165	−0.055
	(0.270)	(0.082)
Constant	3.987***	10.379***
	(0.618)	(0.190)
Observations	3,743	3,743
R -squared	0.944	0.957
yearfix	YES	YES
idfix	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 6, the results show that the green financial reform pilot policy significantly promotes regional green innovation, indicating that the policy has played an incentivizing role in encouraging green innovation among enterprises. On the other hand, regional green innovation has a positive effect on regional economic development, and the result is significant, suggesting that the economic benefits of green innovation have begun to emerge. In the future, there is a need to strengthen the policy support for green innovation to guide the improvement of economic development quality. Combining with the regional differences discussed earlier, it can be observed that in the eastern regions, where economic development is advanced and the industrial structure is optimized, enterprises' dependence on green financial policies is relatively low, and green innovation is already relatively mature. Therefore, the marginal effect of the policy on economic growth is weaker in the east, and there may be a "crowding-out effect" where market-driven green innovation is weakened by policy intervention. In the central and western regions, where green innovation capability is relatively weak, the policy plays a significant role in stimulating the enthusiasm of enterprises for green technology research and development and attracts more green investments. Meanwhile, the green financial policy acts as a lever in resource allocation, optimizing regional resource distribution and addressing market failures. For high-level cities, the solidification of industrial innovation paths and the over-concentration of financial resources might lead to a situation where policy resources could cause non-green innovation activities to be overlooked. This could even form a "lock-in effect" for traditional industries, weakening the overall economic benefits. In contrast, in lower-level cities, policy support accelerates the absorption of green innovation technologies, improving the quality of economic growth. The policy helps fill gaps in technology and financial resources, forming a significant positive incentive effect.

5 Conclusion

The green financial reform pilot policy launched in 2017 is not only a key step in building China's green financial system but also an important strategic support for the transition of the economy to high-quality development. This paper empirically analyzes the policy's effects using the difference-in-differences model, and the results show that the pilot policy has significantly promoted both the quantity and quality of regional economic growth.

Firstly, the green financial reform pilot policy has significantly boosted regional economic growth, and the policy's effectiveness has been confirmed through a series of robustness tests, demonstrating its contribution to economic scale expansion. In addition, the heterogeneity analysis of different batches of pilot zones and regions shows that the green financial policy has a stronger supportive effect in the central and western regions and general administrative-level cities. This suggests that the policy has a more prominent role in driving economic growth in regions with less concentrated resources and less developed financial systems. Particularly in the central and western regions, by improving resource allocation efficiency, the policy has facilitated the integration of green finance with local industries, contributing to sustainable local economic growth.

Secondly, the pilot policy has significantly promoted green innovation, providing strong support for regional economic development. As a key mechanism of the policy, green innovation not only promotes the quantity of regional economic growth but also drives the improvement of economic quality, offering a sustainable growth path for regional development. Therefore, green innovation is not only an effective mechanism for driving economic transformation and upgrading but also an important tool for guiding the economy toward green and sustainable development. Combining the heterogeneity analysis, green innovation as a mechanism can explain the differences in the extent and paths of policy support in different regions. The core of green innovation lies in promoting the integration and flow of regional resource elements, enabling central and western regions as well as lower-level cities to break through technological barriers and achieve the "compensatory effect" of green innovation. In the eastern and high-level cities, policy design needs to be further optimized to reduce negative effects, emphasizing the synergy between market mechanisms and policy interventions.

Based on the findings, this paper offers the following policy recommendations:

(1) Summarize Pilot Experiences and Optimize Promotion Strategies: Systematically summarize the successful experiences of the green financial reform pilot zones, and conduct a comprehensive evaluation of the differentiated characteristics of pilot regions and their existing development policies. This will clarify the potential impacts of green financial policies on the economy, environment, and industrial structure, avoiding a one-size-fits-all approach to policy promotion.

(2) Implement Tailored Incentive Policies: Fully consider regional differences and increase policy support in the central and western regions and general administrative-level cities. Strengthen the construction of green financial systems to guide social capital toward green industries and technologies. For the eastern and high-level cities, the focus should be on reducing the "crowding-out effect" and promoting the organic integration of green innovation with market mechanisms.

(3) Enhance Green Innovation Incentive Mechanisms: Position green innovation as the core mechanism for economic structural transformation and high-quality growth. This can be achieved through fiscal and tax incentives, intellectual property protection, and the development of technology promotion platforms to enhance enterprises'

capabilities in green technology research and development.

(4) Strengthen Regional Collaboration and Resource Integration: Promote cross-regional cooperation, especially in facilitating innovation technology spillovers between the central and western regions and the eastern regions. Explore the establishment of regional green financial centers to optimize resource allocation efficiency and address the uneven distribution of financial resources.

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Data Availability

The data supporting this study's findings are derived from publicly available sources, including the China Statistical Yearbook (2006–2019), EPS Database, and CNRDS Database. Missing values were handled by excluding incomplete samples. Researchers interested in accessing the data may contact the corresponding author upon request.

Conflicts of Interest

There are no conflicts of interest in this study.

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