DEVELOPMENT STATUS AND ENVIRONMENTAL IMPACT EVALUATION OF CHINA'S GREEN FINANCE

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Abstract. Green finance is a financial activity for supporting environmental improvement, for tackling climate change and for conserving and efficiently utilizing resources, which is also a requirement for sustainable economic development. Existing researches on the green finance policies and policy systems are still in their infancy, which are predominantly qualitative analyses, while empirical studies concerning the green finance policies are scarce. This paper combs the development course of China's green finance, and then evaluates the effectiveness of carbon emissions trading pilot programs through robust regression. The results reveal that China's total carbon emissions are still on the rise, though the emission intensity is declining by years. The carbon emission intensity is lower in the pilot areas with relatively developed economy, where the carbon emissions trading pilot programs are obviously effective in reducing the carbon emissions. Referring to the control variables, the increase of foreign direct investment (FDI) and technology progress (TE) both reduce the intensity of carbon emissions, while the increase of per capita GDP will lead to the deterioration of the environment; Environmental support effort (ENVI) has not yet played a role in slowing down environmental pollution. Thus, China's current green finance policy system should strengthen the reform of policy guarantee and market operation, which has certain reference value for further improving the policy system and promoting the development of green finance.
Keywords: *green finance, robust regression, CO_2 emission intensity, dynamic panel regression, environmental support effort*

Introduction

Green finance, as the product of a combination of financial theory with economic practice, redefines the management policies and business processes of financial industry from the perspectives of environmental protection and sustainable development. While assisting in the economic transition, it can also realize the sustainable development of finance itself. Therefore, green finance is also known as "environmental financing", "sustainable finance", "ecological finance" or "carbon finance". Although the theoretical community has differing descriptions of its meaning, the basic connotation is always how the financial institutions carry out financial activities around improving environment and tackling climate change.

With the rapid and extensive growth of China's economy since the reform and opening up, ecological environment is increasingly deteriorating, which has become a major bottleneck restricting sustainable economic development. Finance, as the core of modern economy, plays an important role in resource allocation. Green finance can shift investment from the energy-intensive and high-polluting industries to the green and environmental, which is a powerful guarantee for promoting sustainable economic

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development and industrial restructuring. However, green finance is an emerging financial industry. Although it is featured with positive externalities, it is difficult to clarify property rights and bring benefits to it, which hinders the development of green finance. Therefore, studying the healthy development of green finance is not only an urgent task, but also a requirement for the sustainable development of China's economy.

Literature review

In recent years, green finance has been studied by many scholars at home and abroad mainly from the following two aspects: One is the connotation of green finance; and the other is the empirical analysis on green finance evaluation. Regarding research on the connotation of green finance, Salazar (1998) argued that green finance is a financial innovation that seeks economic development along the path of environmental protection, with purposes of seeking economic development alongside environmental protection and achieving a balance between economy and environment. In Cowan's (1999) opinion, green finance is a discipline that studies the relationship between environment and financing. According to Labatt and White (2002), green finance is a market-based financial instrument that aims to improve environmental quality and transfer environmental risks. Scholtens (2006) focused on analyzing the transmission mechanism between finance and sustainable development, who pinpointed that the green finance can address resource and environmental issues via the optimal combination of financial instruments. There are also a number of scholars who have done similar researches (Vyas, 2015; Wang and Zhi, 2016; Raberto et al., 2018; Volz, 2018).

Meanwhile, the empirical analyses on green finance evaluation concentrate mainly on three aspects. Firstly is the impact of green finance on financial institutions. Many scholars believe that the financial institutions should implement green financial strategies because by doing so, they can better attain the corporate risk management objectives and make strategic decisions that are conducive to the long-term corporate development, which is an objective requirement for the sustainable development of financial industry (Chami, 2002). There is also an argument that the financial institutions' implementation of green finance policies does not pose significant influence on their profits or risks (Gelema et al., 2011). Thus, clearly, the theoretical community has failed to reach a consensus as to the impact of green finance on the financial institutions. Secondly is the empirical analysis concerning green finance and green financial products. Brennan and Schwartz (1985) initiated the inclusion of environmental factors in the financial instrument pricing, who took into account the natural consumption cost in the corporate options pricing method. On this basis, Cortazar et al. (1998) extended the calculation method of the above model to propose a real options model for optimal timing of corporate investment in environmental technologies based on the corporate operating costs and environmental protection policies. Climent and Soriano (2011) have also done relevant research. Thirdly is the evaluation of green finance and environmental risks. By establishing index systems measuring the relationship between bank channels and green performance, Street and Monaghan (2001) and Cleene and Wood (2004) evaluated the green performance level of banks during operation. There are also a number of scholars who have done similar researches (Hoti and Mcaleer, 2004; Thomas, 2010; Zeng, 2014; Liu et al., 2018).

The above literatures offer substantial implications. In this study, green finance is defined as financial activities that support environmental improvement, tackle climate

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change, and conserve and efficiently utilize resources. It channels funds into projects like environmental protection, energy conservation, clean energy, green transportation and green buildings through tools and policies such as credits, bonds, funds, insurance and carbon finance. Despite respective emphases of the above literatures, the research on the effect of China's green finance policies is still in its infancy, which needs to be deepened urgently.

Development history of China's green finance

The development course of China's green finance can be divided roughly into three stages:

(1) Years 2005-2008: The emerging stage of green finance

At the national policy level, energy conservation, emission reduction and environmental protection received increasing attention during this period. The *Eleventh Five-Year Plan* (2006-2010) put forward clear quantitative targets for the energy conservation and emission reduction. In this stage, green credit policies began to be formulated and issued in succession, such as the *Opinions on Implementing Environmental Protection Policies and Regulations for Preventing Credit Risks* (2007) and the *Green Credit Guidelines* (2008), which mark the sprouting of green finance in China.

(2) Years 2009-2014: The initial developing stage of green finance

During this period, the national green policies kept stepping up. Firstly, the Chinese government made international commitments on greenhouse gas emission control target. Secondly, the energy-saving and emission-reducing policies were launched continuously. Thirdly, ecological civilization was emphasized and the "strictest ever environmental law", i.e. the *Environmental Protection Law* (2014), was introduced.

In this stage, the green credit policy system began to be established, developed and improved gradually. Policies like the *International Experiences in Promoting Green Credit: Equator Principles and IFC's Performance Standards and Guidelines* (2010), the *China Green Credit Development Report 2010* (2011), the *Green Credit Guidelines* (2012), the *Opinions on Green Credit Practice* (2013), the *Green Credit Statistics System* (2013) and the *Key Evaluation Indices for the Implementation of Green Credit* (2014) were introduced. As a result, China formed a rather complete green credit policy system that centered on the *Green Credit Guidelines* with the green credit statistics system and evaluation mechanism as the two major cornerstones.

(3) Year 2015–present: The scale development stage of green finance

The main features of this stage are as follows: Firstly, the green development and ecological civilization policies have been introduced intensively. In 2015, the top-level design scheme for ecological civilization, i.e. *The Overall Plan for the Reform of Ecological Civilization System*, was launched. Subsequently, numerous environmental related policies, regulations, regimens and plans were introduced in succession, including the *Action Plan for Water Pollution Prevention and Control*, the *Action Plan for Air Pollution Prevention and Control*, the *Atmospheric Pollution Prevention and Control Law of The People's Republic of China*, and the *Action Plan for Soil Pollution Prevention and Control*. Secondly, the green finance system has begun to be established.

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In 2015, the People's Bank of China issued the *Energy Efficiency Credit Guidelines*, the *Green Financial Bonds Announcement* and the *Green Bond Support Project Catalogue*, which mark the opening of China's green bond market. The *Guiding Opinions on Building a Green Finance System* released in 2016 marks the establishment of China's top-level green finance framework system, thus making China the first nation in the world to set up a rather complete green finance policy system.

After more than a decade's accumulation, China's achievements in the green finance field have drawn worldwide attention. Countries around the world are increasingly understanding China's concept, listening to China's wisdom, appreciating China's programs, and taking China's development opportunities as their own. The development of China's green finance is characterized by giving equal consideration to the domestic and international green development, and actively leading green development at the international level while continuously progressing the reform of domestic green development towards the deep water zones.

This paper uses empirical method to analyze the impact of China's green finance policies on environmental pollution. The significance could be explained by two points. First of all, it analyzes the formation process of the green finance policy system in China so as to deepen understanding about green finance policy system and combine with green finance industry development course to observe limitations of the policy. Secondly, based on the analysis on green finance policy and literature, the paper begins with "carbon emission permit trading policy" and adopts robust regression method to test policy implementation effects, therefore objectively assessing the advantages and disadvantages of the policy and exploring the validity of this policy in explaining green finance policy. Finally, by reference to empirical analysis, the paper proposes two pertinent countermeasures so as to provide new thought for the further research on green finance and economic sustainable development in China.

Materials and methods

Emerged in China, the green finance originated from the *Notice on the Use of Credit Policies for Promoting Environmental Efforts* promulgated by the China Environmental Protection Administration and the *Notice on Issues Concerning the Implementation of Credit Policies and Strengthening of Environmental Efforts* issued by The People's Bank of China in 1995. Restricted by the economic development level and public ideology at the time, the green finance did not receive enough attention when it was initially introduced. It was not until China's official launch of green credit-related policy in 2007 that the green finance gained further development.

Materials

China's overall ecological environment has been improved positively as its green finance policy matures and functions. During the 13th Five-Year Plan period, China is expected to totally reverse the deterioration of ecological environment. From a macro perspective, the allocation of financial resources is optimized by establishing a green finance system, whose influence is then propagated to the real economy, thus transforming the extensive growth towards a green, comprehensive and intensive direction. From 2007 to 2017, the funds for pollutants discharge reduction increased by years in the national public fiscal expenditure (including central and local governments)

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(see *Figure 1*), which reached 561.733 billion yuan in 2017, suggesting the Chinese government's determination to govern environment.

From a micro perspective, policies on green credit, green bonds and environmental insurance were introduced intensively from 2015 to 2018. The increasingly perfect policy system has promoted the rapid development of related industries effectively while laying a solid foundation for the establishment of a sound green finance system. The green credit supply and green bond issuance in China are increasing by years. *Table 1* presents the status of China's green bond issuance from October 2016 to October 2018. As can be seen, the issuing scale of green bonds has been maintained at higher levels since 2016.

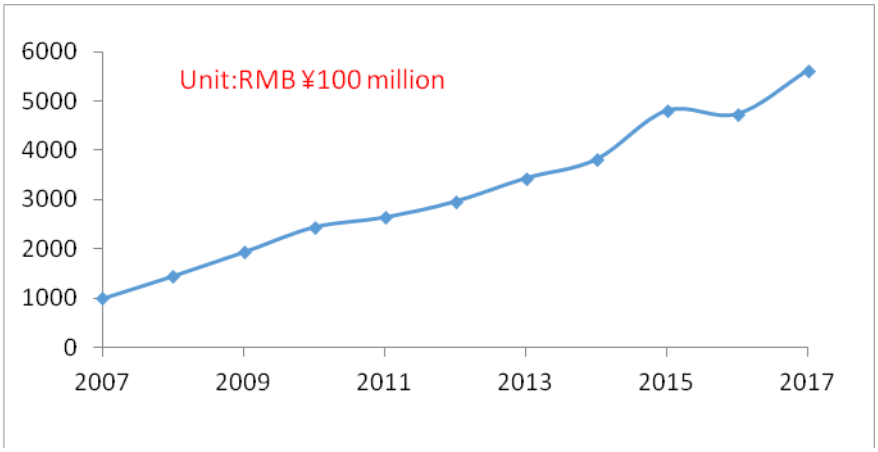

Figure 1. *General public budget fiscal expenditure for pollutants discharge reduction. Data Source: China Statistical Yearbook 2008-2018*

Table 1. *Issuance of green bonds (excluding asset-backed securities) from 2016 to October 2018*

	2016	**2017**	**January-October 2018**
issue number	29	68	65
issuing scale (billion)	1985.3	1908.75	1252.89

In *Figure 2*, the amount of green debt financing instruments managed by Shanghai Clearing House is displayed, which was up to 34.48 billion yuan in December 2018. From the figure, it is also clear that the amount of China's green debt financing has been increasing continuously.

Concerning insurance, China's environmental insurance is primarily the environmental pollution liability insurance, which is also known as the green insurance. In 2014, about 5,000 companies signed for the environmental pollution liability insurance. In 2015, the number of insurance sign-ups was 14,000, with a signing premium of 280 million yuan, offering risk protection of 24.421 billion yuan. In 2016, the premium income from the environmental pollution liability insurance was nearly 300 million yuan, offering risk protection of over 26 billion yuan. In 2017, the environmental pollution liability insurance provided risk protection of 30.6 billion yuan to more than 16,000 companies.

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Methods

The *Notice on Launching Pilot Programs of Carbon Emissions Trading* issued in 2011 has initiated the exploration of issues pursuant to carbon emissions trading in China. As an important supplement to China's green finance system, the *Notice* will have a profound impact on the future of China's green finance industry. In 2013, carbon markets were launched and started trading in seven pilot provinces and municipalities (Beijing, Tianjin, Chongqing, Shanghai, Hubei, Guangdong and Shenzhen). As of now, the trading volume has reached 270 million tons of carbon dioxide, and the transaction amount exceeded 800 million euros, hence making China the world's largest carbon emissions trading market. This paper employs the robust regression technique to empirically analyze the effectiveness of implementing the carbon emissions permit policies.

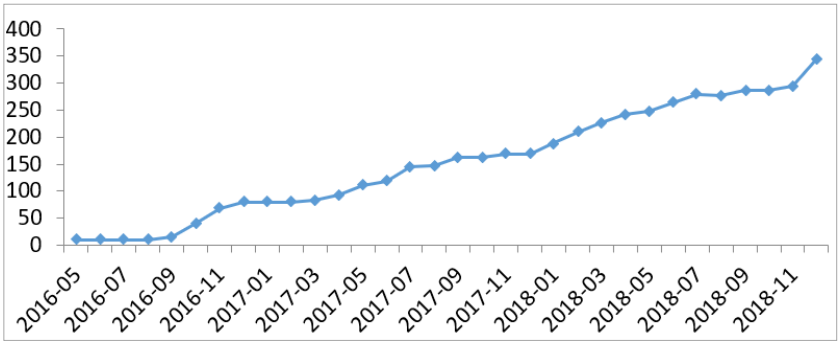

Figure 2. *The amount of green debt financing instruments managed by Shanghai Clearing House. Data Source: http://www.shclearing.com/sjtj/tjyb/*

Econometric model

(1) Traditional Econometric Model

The following dynamic panel regression model is finalized based on the research of green finance in the classic literatures combined with the theoretical analysis of green finance policies herein:

$$CO_{2_{it}} = \beta_1 + \beta_1 D_{it} + \sum \alpha X_{it} + \varepsilon_{it} \quad \text{(Eq.1)}$$

where, CO_2 denotes the intensity of carbon dioxide emissions; D is the dummy variable (D= 0 indicates that the green finance policy is not implemented in the non-pilot or pilot areas, while D= 1 indicates that the green financial policy is implemented in the pilot areas); X is the control variable (including foreign direct investment, technological progress, economic development level and environmental support effort); and i, t represent the region and year, respectively.

Most regressions are based on the ordinary least square (OLS) method at present. However, when many outliers are present in the data, the traditional least squares-based regression is no longer applicable. Robust regression, on the other hand, is a method in statistical robust estimation, whose main idea is to modify the objective function in the classical least squares regression that is highly sensitive to outlier values. Since the data

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in this paper involves 30 provinces of China, there are huge interprovincial differences, so it seems more reasonable to estimate the above model via robust regression.

Common robust regression methods include least median square (LMS) method, M estimation method, etc. This paper adopts M estimation method.

(2) Robust regression algorithm based on M estimation

In case of any abnormal value in sample data, the residual estimated by OLS is often not in normal distribution, but biased tail instead. Considering residual quadratic sum, the role of abnormal value significantly increases, which leads to poorer estimation accuracy. Robust regression method mainly aims to improve the drawback of OLS in its great susceptibility to abnormal value. The basic thought is to minimize residual function $\rho(e_i)$, and derive each regression coefficient. The chosen residual function $\rho(e_i)$ does not endow all sample data with similar impact factor like how OLS chooses residual quadratic sum. On the contrary, it givens different weights according to the size of residual and therefore weakens the impact of abnormal value on regression result.

Common robust regression method is the M estimation method proposed by Huber in 1964. *Eq.2* presents its fundamental principle

$$Y_i = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_p X_{ip} + e_i = X_i'\beta + e_i \ \ (\mathrm{i} = 1,2,\ldots,\mathrm{n}) \tag{Eq.2}$$

where, in β_0, β_1, ..., β_p are regression coefficients and e_1, e_2, ..., e_n are independent identically distributed with $\mathrm{E}[e_i] = 0$.

The M estimation method is exactly to seek β so as to reach the minimum of *Eq.3*.

$$\sum_{i=1}^{n} \rho(e_i) = \sum_{i=1}^{n} \rho(Y_i - X_i'\beta) \tag{Eq.3}$$

For reducing the role of abnormal value in Y_1, Y_2, ..., Y_n, it is necessary to take a function of growth rate of $\rho(x)$ slower than that of x^2, and meet the following conditions.

- $\rho(x)$continuity, $-\infty < x < +\infty$;
- $\rho(0)$=0, $\rho(x) = \rho(-x)$, and $\rho(x) \geq \rho(y)$ under the condition of $|x| \geq |y|$;
- $\lim_{x \to +\infty} \rho(x) x^{-2} = 0$.

Obviously, when $\rho(e_i) = e_i^2$, M estimation is OLS. Consequently, M estimation can be considered as the extension of OLS estimation as shown in *Eq.4*.

$$\rho'(x) = \psi(x) \tag{Eq.4}$$

If the target function solves the partial derivative of parameter β and set its value as 0, then *Eq.5* about parameter k+1 formula will be obtained.

$$\sum_{i=1}^{n} \psi(Y_i - X_i'\beta) X_i' = 0 \tag{Eq.5}$$

For ensuring the validity of above formula, $\rho(x)$meets the conditions as below: p(x) is defined as the non-negative convex function on （-∞，+∞）. $\rho'(x) = \psi(x)$ is valid under all conditions, in which $\lim_{|x| \to \infty} \rho(x) = \infty$.

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Therefore, M estimation property is greatly related to chosen function $\rho(x)$. In measuring β, the choice of initial value is very important. Throughout scale quivariance, *Eq.6* may be simplified as *Eq.6*.

$$\sum_{i=1}^{n} W_i X_i' e_i = 0 \quad \text{(Eq.6)}$$

Eq.6 is a weighted least square (WLS) problem, of which the weight depends on the size of residual e_i, the residual reversely depends on regression coefficient β, and regression coefficient reversely depends on estimated weight W_i. In this case, it is necessary to adopt the iteration method to solve the formula. Moreover, in this process, the key is to choose proper objective function $\rho(x)$ and weight function $W(x)$ so as to decrease residual abnormal value weight, increase the weight of sample data with minor residua, weaken the influence of abnormal value on regression analysis and reinforce regression formula robustness.

(3) Variable setting

According to *Eq.1* and economic principle, the paper chooses the following variables.

Carbon intensity (CO_2): Carbon dioxide emissions are calculated based on the carbon emission coefficient of energies. Considering the GDP variance among provinces, the variable is measured by CO_2 emissions/GDP.

Foreign direct investment (FDI): Measured by RMB-denominated FDI/GDP, FDI brings promotion of the green and energy-saving technologies, which thus may contribute to reducing the carbon intensity.

Technological progress (TE): Technological progress can improve the energy efficiency of industrial enterprises to lower the carbon intensity. The variable is herein measured by the volume of invention patent applications that best reflects the technological level.

Economic development level (Pgdp): It is measured by the natural logarithm of GDP per capita. The higher the level of economic development, the more it contributes to the increase in environmental investments, thus lowering the intensity of industrial pollution.

Environmental support effort (ENVI): It is measured by the regional investment in governing industrial pollution/GDP. The government's efforts to strengthen the environmental protection promote the use of environmental technologies by companies, and prompt the shift of highly polluting companies to areas with weak environmental regulations.

Results

Descriptive statistics for every variable

Considering the availability and consistency of data, this paper selects the panel data of 30 provincial-level regions (excluding Tibet) from 2000 to 2016. The raw data comes from *China Statistical Yearbook*, *China Environmental Statistics Yearbook*, *China Science and Technology Statistical Yearbook*, as well as the statistical yearbooks of various provinces. *Table 2* lists the descriptive statistics for each variable.

Three carbon emissions trading pilots and three non-pilot provinces are selected to explore the variation trends of CO_2 emissions and CO_2 intensity since 2000. In *Table 3*,

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relevant minimums and minimums are listed. The numbers in brackets indicate the years in which the values appear.

It can be seen from the above table that the minimum CO_2 emissions occur in 2000 for all provinces, while the maximums all appear in 2013 and beyond, showing an upward trend of emissions. Regarding the CO_2 intensity, all minimums appear in 2016, while all maximums occur in 2000, so the emission intensity is declining by years.

Table 2. *Descriptive statistics for every variable*

	Mean	**Min**	**Max.**	**s.d.**
CO_2 (Kg/10000 yuan)	3.580	0.752	14.27	2.212
FDI (10000 yuan)	3752484	9930	22573222	4388323
TE	36146	124	512429	71974
Pgdp (Yuan / person)	29432	2759	118198	22861
ENVI (Yuan/10000 yuan GDP)	17.476	0.684	99.185	14.08

Table 3. *Trends of CO_2 emissions and CO_2 emission intensity in some provinces*

	Beijin		Shanghai		Guangdong	
	emissions	intensity	emissions	intensity	emissions	intensity
Min	11489 (2000)	0.752 (2016)	15247 (2000)	1.152 (2016)	26194 (2000)	1.071 (2016)
Max.	19900 (2012)	3.634 (2000)	32473 (2016)	3.196 (2000)	86615 (2016)	2.439 (2000)
	Jiangsu		Sanxi		Heibei	
	emissions	intensity	emissions	intensity	emissions	intensity
Min	23878 (2000)	1.113 (2016)	18673 (2000)	4.122 (2016)	31040 (2000)	2.576 (2016)
Max.	86097 (2016)	2.792 (2000)	55070 (2014)	11.139 (2000)	86420 (2013)	6.175 (2000)

Note: Parentheses are the year.The unit of emission is ton, and intensity is ton/billion yuan

Analysis of empirical results

In this paper, robust regression is performed using *formula (1)* with the control variables FDI, TE, Pgdp and ENVI. The results are shown in *Table 4*.

Table 4. *Regression models results*

Variable	**Coefficient**	**Z-Statistic**	**Prob.**
D	-0.750841	-2.299761	0.0215
Pgdp	1.05811	17.63547	0.0000
FDI	-0.001119	-3.888342	0.0001
TE	-0.851207	-14.1518	0.0000
ENVI	0.066388	13.32519	0.0000

After analyzing the significance (Prob.) and coefficient of the control variables in the empirical model, we find that:

The p values of explanatory variables are all less than 0.05, indicating their significance in the present experiment.

The coefficient of green finance policy(dummy variable D) is negative, suggesting that the green finance policies are helpful for lowering the carbon intensity. This implies that there should be a transmission mechanism whereby the green finance policies promote the development of green finance and the green finance development reduces the carbon intensity.

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Concerning control variables, the coefficients of FDI and TE are negative, suggesting that the promotion of green and energy-saving technologies brought by FDI and the technological advancement in China have led to an improved energy efficiency of industrial enterprises, both of which have lowered carbon intensity. The coefficient of per capita GDP (Pgdp) is positive, indicating that the environmental pollution in China has become increasingly serious with the growth of per capita income. So far, there has been no inflection point on the environmental Kuznets curve in China. The coefficient of environmental support effort (ENVI) is also positive, but very small, which is 0.066, indicating that China's investment in environmental governance has not yet abated the environmental pollution.

Discussion

Foreign green finance practice and experience

Comparing with western developed countries, China has obtained great progress in green finance. But the large gap should not be overlooked. Firstly, foreign green finance starts early. German government had already established the world's first environment policy bank as early as 1974. Later on, large foreign banks represented by Citibank took the lead to formulate and implement a full set of environment assessment standards and mechanisms in 2002, namely the "equator principle". Secondly, green finance products in foreign developed countries are in wide variety and scope, including both fundamental products like green credit and green bond but also derivatives like carbon fund. However, the green finance system in China is rather unsound, and related laws and regulations are imperfect. This may be evidenced by inadequate incentive mechanism, untimely environmental protection information disclosure, insufficient internal impetus of companies, poor innovation of green finance products, and many other internal problems. In consequence, the practice and development experience of foreign green finance provide great reference for the construction and development of green finance in China.

As to the green finance policy practice of foreign developed countries, it should be noted that these countries do not have identical policy and system, but they all combine a series of international standards of international banks like the "equator principle" with domestic reality, and formulate proper green finance implementation tenets and policies. *Table 5* shows the comparison of foreign green finance policy in developed countries.

As shown in *Table 5*, America primarily implements green finance policies by large banks, while Germany and Japan rely on large banks and policy banks. From the perspective of policy, these policies are all based on the equator principle. From the perspective of core system, Germany implement green finance policy by interest subsidy policy. From the perspective of advantages, German government take part in the implementation of green finance policy and offer pertinent guarantee.

Countermeasures to green finance development in China

Based on the above analysis, the following suggestions are put forward for the sustainable development of China's green finance:

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(1) Establishment of a green finance policy guarantee mechanism

The policy guarantee mechanism refers mainly to the institutional construction and policy design by relevant governmental departments. Firstly, the green finance system must be improved by establishing a systematic finance system from the aspects of basic legal system, business standard system, business implementation system and supervision system of green finance. Secondly, the fiscal and taxation support system needs to be improved. According to estimations, the funds required for green development in China account for more than 15% of China's fiscal revenue. Apparently, fiscal funds cannot afford all the demands for green development. In such a context, innovations should be made by "transforming subsides into equity investment, into financing guarantee, into risk compensation, into special incentives and by relieving taxes". By doing so, the fiscal funds are used for stimulating the supply of market-oriented green finance instead of being directly used for green finance supply, thereby ensuring the efficiency and fairness of fiscal fund utilization by market means. Thirdly, the information communication mechanism should be set up. Green finance is not only an issue of eco-environmental protection, but also a financial reform issue involving multiple governmental and market sectors such as the environmental protection departments, the fiscal and taxation departments, the financial regulatory departments, financial institutions and intermediary service agencies. To promote the information communication between various departments, a sound cross-functional coordination mechanism must be established, and a bridge should be built between the government and the market.

(2) Improvement of the market operation mechanism

To play the role of green finance in supporting green industries, we must start from two aspects. On the one hand, the green finance organizational system needs to be improved. First of all, it is necessary to expand the participants of green finance market, and encourage the further greening of existing banks to adjust business operations in accordance with the *Equator Principles*. Meanwhile, the enthusiasm of non-bank financial institutions such as securities, insurance and fund companies should be fully mobilized for participating in the green finance business. Secondly, it is necessary to set up professional green development banks by the national, provincial and municipal governments after learning from international experience. Finally, it is necessary to foster green finance intermediary service agencies, encourage the existing intermediary services to actively participate in green financial operations, and accelerate the cultivation and development of professional intermediaries like the green credit rating agencies, green financial product certification institutions, green asset assessment firms, green financial information consulting services and environmental risk assessment agencies, so as to provide technical support for financing of green projects.

On the other hand, green financial products and instruments need to be innovated. First of all, it is necessary to promote the green credit innovation, such as innovating the mode of mortgage guarantee, tapping the intrinsic values of emission permits, energy efficiency improvement and other intangible assets, and developing innovative tools like emission permit mortgage loans, patent pledge loans and contract energy management financing. Secondly, it is necessary to promote the green insurance business, and comprehensively popularize the compulsory liability insurance system for environmental pollution. Meanwhile, developing other innovative types of green

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insurance is also necessary, such as green auto insurance and green construction insurance, so as to reflect the support for green industries through insurance mechanism. Thirdly, it is necessary to develop a green capital market dominated by green stocks, bonds and funds to form a green financial market structure with diversified participants and financial products. Finally, carbon finance should be developed vigorously. At the end of 2017, the construction of national carbon emissions trading market formally began. Expected to be formally completed in 2020, the market will effectively slow down the growth of China's carbon emissions and bring a new impetus to the sustainable development of China's economy.

Table 5. *Comparison of foreign green finance policy*

America	
Main banks involved	Export-Import Bank of Washington HSBC Citibank
Policy	OECD public method Pollution Prevention and Control measures Environment Credit and Ethical Investment Guiding Principle Equator Principle *IFC Environment and Social Risk Standards*
Core system	Environment assessment procedures and guidelines Environment credit and ethical investment Environment and social risk management mechanism
Advantages	*Guidelines* consistent with *Common Method* Environmental protection should begin with ourselves Expand the concept of environmental protection and affect the market and client International organization authentication Forest protection EPS initiator, core, and leadership role
Germany	
Main banks involved	Dresdner Bank HVB KFW
Policy	Equator Principle Environment, Health and Security Guide Circular Economy and Waste Management Act
Core system	Discount allowance Interest subsidy loan
Advantages	Government participation in the development and design of green credit products Low-interest rate loan accessible to small and medium-sized companies Approval of environmental protection sectors Add new tax categories
Japan	
Main banks involved	JBIC DJB Mizuho Bank
Policy	International finance business instructions Overseas economic cooperation business instructions EEG Equator Principle
Core system	New environment social guiding principle Environmental protection grading loan project
Advantages	Seven basic principles in environment and society Equal attention to reward and punishment Full-process comprehensive governance Guide business banks, and financial institutions to develop green credit business

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Conclusions

In this paper, the history and status quo of China's green finance development are combed first. On this basis, robust regression is employed to evaluate the effectiveness of the "carbon emissions trading pilot policies". The following conclusions are drawn:

China's green finance has undergone three stages of development. With the establishment of the top-level green finance framework system in 2016, China has become the first nation in the world to set up a relatively complete green finance policy system. At the macro level, China's support for environmental protection has been strengthened, and the funds used for emission reduction are growing by years in the public fiscal expenditure. At the micro level, the green credit, green bonds and environmental insurance have shown year-over-year growth.

According to the results of empirical analysis, the CO_2 emissions in various regions of China are on the rise, but the emission intensity is declining, suggesting China's certain achievements in the environmental governance. All the pilot provinces and cities that have adopted the carbon emissions permit policy are economically developed regions of China. They exhibit lower carbon intensity on average as compared to the non-pilot areas, and the green finance pilot policy is effective in significantly reducing carbon emissions. Similarly, the increases in foreign direct investment and technological progress have both contributed to lowering the carbon intensity, while the elevated level of economic development has aggravated the environmental pollution. These conclusions have an explanatory role in answering the issues faced by China's green finance policies. On this basis, we put forward two suggestions: establishing a green finance policy guarantee mechanism and improving the market operation mechanism.

Based on robust regression model, the paper analyzes and assesses the validity of "carbon emission permit trading experimental unit policy". Though some periodical results have been reached, some problems still deserve further research. The first one is data accessibility. As the paper does not collect any data about the application of green credit in specific projects, it does not show the preference of green finance policy to specific industries in China. The second one is about the choice of independent variable in regression analysis model. Because of data accessibility, the paper expresses it with some alternative variables. This lowers the persuasiveness of conclusion. Targeted at these problems, future studies should compare the green finance practice in other countries and make long-term tracking of related statistics in Chinese green finance business to raise useful policy suggestions in favor of the development of green finance in China.

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