Effect Evaluation and Optimization Suggestions of Green Financial Policies based on Big Data Analysis

Shumeng He

College of William & Mary, Williamsburg, VA, USA

Abstract

Under the background of Chinas "dual carbon" strategy, whether green finance can promote technological innovation has become a major focus of public attention. This paper uses data from cities in Chinas three major economic zones from 2015 to 2020 to examine whether green finance promotes urban technological innovation efficiency and the moderating effect of environmental regulation. In recent years, energy conservation and environmental protection have gained widespread attention from all sectors of society, and how to achieve sustainable development is an important issue that the whole society needs to consider. At the beginning of the 21st century, Chinas level of scientific and technological innovation has been continuously improving, and green finance has also developed rapidly. However, there is a significant difference in the development level of green finance and technological innovation efficiency across different regions in China. How to build a green finance system that matches this disparity and promote technological innovation has become an urgent issue for local governments to address, while the grasp of environmental regulation efforts within regions requires continuous practice and exploration.

Keywords

Green financial, technology innovation, environment regulation.

1. Introduction

The 75th United Nations General Assembly was held in September 2020, where President Xi Jinping proposed that pursuing development without emphasizing protection will not lead to a long-term sustainable future. China will increase its efforts in environmental protection, aiming to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060. On March 15,2021, President Xi Jinping chaired the ninth meeting of the Central Finance and Economics Committee, exploring fundamental ideas and key measures for promoting the healthy development of platform economies and achieving carbon peak and carbon neutrality, including strengthening technology and innovation, and promoting financial support for efficient and green development to achieve the "dual carbon" goals[1][2].

2. Conceptual Definition

The earliest sprout of green finance began in the 1980s, for a long time afterward, scholars, financial institutions, and international organizations did not provide a unified definition of green finance. Since 1990, environmental protection has been integrated into the financial sector, aiming to pursue financial economic development while emphasizing environmental protection, thus achieving sustainable development. Therefore, early green finance was also referred to as sustainable finance or environmental finance. Later, with the development of green finance, following the proposal of the G20 Green Finance Comprehensive Report, green finance was defined as: investment and financing activities that can generate environmental

protection benefits and achieve sustainable economic and environmental development. Chinese scholar Ma Jun (2015) et al. defined green finance as: coordinating the economy.

The resources are oriented towards environmental protection, and through environmental protection policies, financial services can be introduced into environmental protection, energy conservation and emission reduction fields, so as to provide corresponding financial policy support for environmental protection activities and realize green financial operations[3][4].

Green finance aims to provide funds for green projects to help businesses while improving the environment and enhancing support for climate change mitigation and efficient resource utilization; secondly, it categorizes green projects into main types, providing guidance for future green financial products such as green credit, green bonds, and green stock indices, defining and classifying them is very meaningful; it is newly clarified that green finance encompasses financial services including investment and financing of green projects, project operations, and risk management, indicating that green finance is not limited to simple financing activities and risk management activities like loans and securities issuance.

The academic community generally believes that green finance integrates financial services into energy conservation and environmental protection, and with the support of green finance, ecological and environmental protection proceeds more smoothly, achieving green operations in the financial industry. However, a few scholars confuse the concepts, including financial activities promoting agriculture and forestry development under the category of green finance. The article studies the impact of green finance on urban technological innovation, thereby defining green finance: Green finance refers to financial services that provide support to energy conservation and environmental protection industries while curbing high-pollution and high-energy-consuming industries[5][7][9].

3. Current Status of Green Finance in China

Since 2007, the green credit policy has been officially promulgated, leading to the vigorous development of green credit. Our country has also begun to use various policy tools to achieve environmental protection goals. With the proposal of the "Guiding Opinions on Building a Green Financial System," the development speed of green finance has been further accelerated. Green financial instruments include green credit, green bonds, green funds, carbon finance, and more, all of which have developed at an extremely fast pace. As various related green financial systems continue to improve, the government has also introduced a series of green policies to support these initiatives.

From the perspective of the participants in green finance, commercial banks were among the earliest entities to engage in green finance, alongside various financial institutions, government agencies, and enterprises. Green credit holds the largest share in green finance, exceeding 90%, making it the primary green finance business for banks. Industrial Bank was one of the first commercial banks in China to adopt the Equator Principles. Under the guidance and assistance of relevant government departments, financial institutions have established green investment funds to facilitate financial and financing support for green projects. With the development of green insurance, more financial institutions are introducing environmental liability insurance. The government actively encourages more social capital to be invested in the construction of green finance, encouraging enterprises to allocate funds to green projects and offering policy incentives, as well as promoting the issuance of green securities. Since 200 7, China has enacted over 600 policies related to environmental and economic affairs. Now our country has developed a complete range of green financial products, specifically: First, the scale of green credit, which accounts for the largest proportion in green finance, continues to expand, with its service scope continuously broadening. By the end of 2021, Chinas green credit balance reached 1.8 trillion US dollars, making it the country with the largest green credit scale globally.

At the same time, the allocation of green credit funds has become increasingly precise, with the proportion of funds directly used for carbon reduction and low-carbon transformation in traditional industries reaching 67.8%; meanwhile, the non-performing asset ratio remains consistently low, significantly lower than the global average of 1.6%. Second, the variety of green bond products has been enriched, aligning with international standards. By the end of 2021, Chinas total green bond issuance had exceeded 1 trillion yuan, making it the country with the highest number of green bond issuances in the world.

4. Model Selection and Variable Settings and Empirical Result Analysis

Introducing the Urban Financial Development System (Urban Area Loan-to-Deposit Ratio), and drawing on the coupling coordination model proposed by Meng Qingsong and Han Wenxiu (2000), the coupling coordination degree of the two systems is used as a proxy variable for green finance. The specific steps are as follows: determine the green investment data and the final financial development data, after standardization processing, obtain the corresponding sequence values v1 and v2, calculate the coupling coordination degree GF=2 as a proxy variable for green finance, the higher the coupling coordination degree, the better the urban green finance development.$\sqrt{(v_1 \cdot v_2) \div (v_1 + v_2)^2} \times (0.5v1+0.5v2)$

In order to verify the hypothesis derived from the theoretical analysis, the following model is constructed according to the literature of previous scholars and combined with the actual situation for empirical analysis.

Model 1: GIi, t= α 0 + α 1 GFi t + α j∑Controlsi t + εi, t

Model 2: GIi, t=β 0+β 1 GFi, t+β 2 ERi, t+β3 (ER×GF) i,t+β j∑GControlsi, t +λi,t

Through relevant theories and in-depth studies by predecessors, it has been found that under environmental regulation, the impact of green finance on urban technological innovation efficiency may be nonlinear. Liu Haiying and Wang Dianwu (2020) et al. used data on corporate green and low-carbon technological innovation to empirically study that the impact of green finance on corporate green and low-carbon technology follows a "U" -shaped curve, characterized by initial suppression followed by enhancement. When the level of green finance development is low, it suppresses corporate technological innovation levels; only when green finance develops to a certain extent can it significantly promote corporate green and low-carbon technological innovation. This paper will examine the nonlinear impact of green finance on urban technological innovation efficiency from an urban perspective under environmental regulation. Therefore, environmental regulation is used as a moderating variable, with its threshold value as a dummy variable, and it is interacted with green finance to construct the following model:

Model 3: GIi, t= γ0 + γ 1 GFit + γ3(GFi, t) ^{2} + γj∑Controlsit + εi, t

Model 4: GIi, t= δ0 + δ 1 GFit + δ 2 ERit + δ 3 GFit × I(ERi, t ≤ θ) + δ 4 GFit × I(ERi, t> θ) + δj ∑GControlsit + λi, t

The study period of this paper is 2015-2020, and the data are from China Science and Technology Statistical Yearbook and other city statistical yearbook. The environmental regulation data are from Peking University Legal Database, and the specific variables and data.

The source is shown in Table 1.

Table 1. Variables studied in this paper

type of variable	Variable name	Variable measurement	computational method	data sources
	Technological innovation output	Number of patent applications and number of invention patents authorized		
Explanatory variable (GI)	environmental factor	Urban GDP, urban science and technology expenditure	Three-stage DEA	China Urban Statistical Yearbook
	Investment in technological innovation	At that time, R&D personnel quantity, R&D internal expenditure pollution investment (pollution control investment/GDP), energy saving ring	Comprehensive efficiency value	China Statistical Yearbook of Science and Technology
	Green investment system	Investment protection (environmental protection and energy conservation fiscal expenditure/fiscal expenditure)	Coupling of the two systems	China Environmental Statistics Yearbook
explanatory variable (GF)			Harmonization	Statistical yearbooks of individual cities
	Financial development system	Loan-to-deposit ratio in urban areas		
regulated variable (ER)	Environmental regulation foreign direct investment	Number of laws and normative documents Foreign direct investment in urban areas		Beida Legal Database
controlled variable	per capita GDP Sulfur dioxide emissions	Per capita GDP in urban areas Sulfur dioxide emissions in urban areas		China Urban Statistical Yearbook

Table 2 shows the descriptive statistics of each variable. The mean value of the green finance variable is approximately 0.35, indicating that the coupling coordination degree between the green finance system and the financial development system is low when the coupling coordination degree is less than 0.3, belongs to low coupling when it is between 0.3 and 0.4, and belongs to primary coupling when it is between 0.4 and 0.5, suggesting that the coupling degree of green finance and financial development in the study sample is at a low level.

Table 2. Descriptive statistics of variables

variable	mean	standard deviation	least value	crest value
green finance	.35042	.0826	.04592	.5686
Urban technological innovation	.0524	.09313	.001	1
Environmental regulation	6.3257	9.4912	0	74
per capita GDP	202664.4	1156033	53060	1.54e+07
foreign direct investment	363373.3	476671.7	7792	3082563
Sulfur dioxide emissions	24508.23	24952.8	978	125432

The coefficient of green finance is significant at the 10% significance level as shown in the first column of Table 3, indicating that green finance promotes urban technological innovation, thus verifying the hypothesis. Green finance constrains the supply of high-pollution and high-energy-consuming funds by raising interest rates and strengthening regulation, increasing their production costs, and forcing the innovation of clean technologies;

Table 3. The impact of green finance on urban technological innovation

	(1) Model 1	(2) Model II	(3) Model III
green finance	0.220* (0.115)	0.219** (0.0900)	0.038 (0.41)
Environmental regulation		0.0231*** (0.0036)	
Green finance * Environmental regulation		-0.0429*** (0.0083)	
Green finance sub-item			0.007***(3.41)
foreign direct investment	2.28e-08 (2.32e-08)	3.73e-09 (1.90e-08)	-.002 (-2.06)
per capita GDP	2.14e-09 (5.16e-09)	(4.94e-09)(4.94e-09)	0 (0.94)
Sulfur dioxide emissions	0 (0.000000324)	0 (0.0296)	0 (-0.26)
cons	-0.0249 (0.0388)	-0.0559* (0.0230)	0.114 (2)02)

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01

From Table 3, the coefficients of green finance and environmental regulation are significant at the 1% significance level, indicating that both green finance and environmental regulation promote urban technological innovation to a certain extent. However, the interaction term is significantly negatively correlated at the 1% significance level, suggesting that environmental regulation inversely moderates the promoting effect of green finance on urban technological innovation, meaning that the higher the intensity of environmental regulation, the lower the promoting effect of green finance on urban technological innovation. Through repeated sampling by boorstrap (Self-Organizing Data) method 1000 times, Table 4 shows that the model passes the single-threshold test at the 5% significance level. However, the results indicate that the dual-threshold and triple-threshold models do not pass the F-statistic test. Therefore, a single-threshold test is used to verify the nonlinear impact of green finance on urban technological innovation efficiency under environmental regulation. The regression results are presented in Table 4.

As shown in Table 4, the single threshold value of environmental regulation is 34, however, according to the mean value of descriptive statistics 6.32, it can be seen that the environmental regulation measurement values of most research subjects are below 34, with fewer exceeding the inflection point. This depends on the regions emphasis on energy conservation and environmental protection, as well as the inherent advantages of economic regions. From the threshold analysis results, it can be known that when the environmental regulation value is less than or equal to 34, the impact of green finance on urban technological innovation efficiency is

not significant. However, when the environmental regulation intensity exceeds 34, the impact coefficient of green finance on urban technological innovation efficiency can be observed 0.818 and is significant at the 1% significance level. This shows that when environmental regulation reaches a certain intensity, green finance can significantly promote urban technological innovation efficiency.

Table 4. Threshold effect test of the impact of green finance on urban technological innovation efficiency under environmental regulation

project	threshold value	F price	P price	10. threshold	5. threshold value	1. threshold value	BS number of times
Single threshold test	34.00*	45.97	0.0940	44.3275	60.3656	99.2840	1000
Double threshold test	34.00	4.00	0.8150	59.9523	86.6662	153.0598	1000
Three threshold tests	14.00	2.78	0.9760	49.3136	66.2694	130.1880	1000

Table 5. Threshold regression results

(1)	
Variables	Urban technological innovation efficiency
foreign direct investment	-0.002 (-2.140)
per capita GDP	0.0001(0.850)
Sulfur dioxide emissions	-0.0007(-0.190)
ER≤34	0.118 (1.500)
ER>34	0.818***(7.050)
Observation Nuber of id R-squared	210 35 0.959 (0.0388)

Note: Standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01

The data used in this article are from the cities of the three major economic zones, which are divided into different city clusters according to the three major economic zones, including the Pearl River Delta Economic Zone city cluster, the Yangtze River Delta Economic Zone city cluster, and the Bohai Rim Economic Zone city cluster. Due to the different geographical locations, economic levels, and industrial structures of the cities in the three major economic zones, corresponding regional heterogeneity analysis is conducted to explore the impact of environmental regulations on green finance on urban technological innovation efficiency. green finance in all three regions can significantly promote urban technological innovation efficiency. However, if the interaction term between green finance and environmental regulations is considered, only the correlation coefficient between the Pearl River Delta Economic Zone city cluster and the Bohai Rim Economic Zone city cluster is significantly positive.

5. Conclusion

Green finance achieves financial greening and completes the sustainable development of economy and environment as well as the sustainable development of finance itself by creating green financial instruments in financial markets and issuing green financial policies by the government. This paper adopts a research method combining qualitative and quantitative analysis to study the technological effects of green finance in cities and considers the moderating role of environmental regulation. It analyzes green finance and environmental regulation, exploring how the interactive relationship between green finance and environmental regulation affects urban technological innovation efficiency. Since green finance and environmental regulation have both positive promotion mechanisms and negative obstruction mechanisms for urban technological innovation efficiency, the technological effects of green finance in cities under environmental regulation are uncertain. In terms of empirical analysis, entropy value method and coupling coordination degree are used to construct green finance indicators, the number of laws and normative documents is used to measure environmental regulation, and then Data Envelopment Analysis (DEA) is employed to measure the urban technological innovation efficiency after excluding environmental factors, studying the three major economic zones of Chinas city clusters from 2015 to The relationship between green finance, environmental regulation and urban technological innovation efficiency in 2020.

References

[1] Cropper M L,Oates W E. Environmentaleconomics:Asurvey[J]. Journal of EconomicLiterature, 1992,30(2):675-740.

[2] Porter M E,Van Der Linde C. Toward a new conception of theenvironment-competitiveness relationship[J]. The Journal of Economic Perspectives,1995,9(4):97-118.

[3] StreetP,Monaghan P E.Assessing the Sustainability of Bank Service Channels:The Case of the Co-operative Bank[M].Sustainable Banking.Routledge,2017.

[4] Wang Y,Shen N.Environmental Regulation and Environmental Productivity:The Case of China [J].Renewable and Sustainable Energy Reviews,2016(62).

[5] Hansen M T,Birkinshaw J.The Innovation Value Chain[J].Harvard Business Review,2007.85(06).

[6] Jeucken M.Sustainable Finance and Banking:The FinancialSector and the Future o f the Planet[M].Earthscan,20 10.

[7] MiaoC,FangD,SunL,et al.Natural Resources Utilization E fficiency Under the Influence of Green TechnologicalInnovation[J].Resources,Conservation andRecycling,2017(126).

[8] Kleer R.GovernmentR&D Subsidies as a Signal for PrivateInvestors[J].ResearchPolicy,2010.39(10).

[9] Feldman MP,Kelley M R.TheEx-ante Assessment of KnowledgeSpillovers: GovernmentR&DPolicy, Economic Incentives and Private FirmBehavior[J].Researchpolicy,2006.35(10).

[10] Peuckert J.What Shapes the Impactof Environmen tal Regulation on Competitiveness? Evidence from Executive Opinion Surveys [J].Environmental Innovation and Societal Transitions,2014(10).

[11] Ma Jun, An Guojun, Liu Jialong. Construction of Financial Service System to Support Green Technology Innovation [J]. Financial Theory and Practice, 2020(05):1-8.

[12] Bian Junjie, Duan Keyi, Kang Fei. Research on the Support Efficiency of Intellectual Property and Financial Interaction for Jiangxi Provinces Supply-side Reform Based on DEA-Tobit Model -- Comparative Analysis between Jiangxi Province and 29 Provinces [J]. Journal of Jiangxi Normal University (Natural Science Edition), 2021,45(01):10-21.

[13] Shao Shuai and Hou Xiaomin. The Impact of Pollutant Discharge Right Trading System on Green Technology Innovation Level [J]. Ecological Economy, 2020,36(11):165-171.