Research on the Impact of Green Finance Development on Green Technology Innovation: Take Green Credit, Green Investment and Green Bonds as Examples

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Abstract: Under the background of the new normal of economy, China's green finance (GF) has entered the fast lane, as well as the scale of green technology innovation (GTI) continues to grow, which has become a new engine to ecological civilization and structural reform on the industrial supply side. Further study on the relevance between GF development and GTI is a significant basis for achieving the strategic goal of comprehensive green transformation in economic society. Based on the theoretical explanation of the effect mechanism of green finance development on GTU, this essay employs the panel data of 30 provincial administrative regions in China from 2010 to 2020 to construct a nonlinear model to analyze whether GF development has a significant effect upon GTI by combining qualitative and quantitative analysis methods. Finally, it synthesizes the theoretical and empirical analysis results and looking forward to put feasible policy recommendations.

1. Introduction

The concept of "adhering to the lucid waters and lush mountains is the silver mountain of gold" is a major decision made by the central government in the face of today's social development and will guide Chinese green development transformation work in the long term. Based on the existing green economy development policies, this essay study the influence of GF on GTI.

2. Theoretical Analysis

According to the 19th Congress proposes, it has comprehensively deepen institutional innovation for green development, adhere to green and coordinated sustainable development, the development of green economy has strengthen, as well as improve the institutional design of green industry; as of the end of 2018, with the China Green Finance Development Report, we know that the green credit (GC) balanced China's banking financial institutions increased significantly year-on-year. In conclusion, it is necessary to conduct research the relationship of GF and GTI.

First, the study conclusion on GF mainly focus on constructing green financial indicators, analyzing the interaction of different green financial instruments, and studying the process of GF. Zeng Xuewen et al.[1] measured Chinese five existing GF products through the weights determined by the expert scoring method. Zhang Lili et al.[2] quantified the process level of GF in China using

the entropy value method, and also measured the efficiency of green finance development in China using the DEA-Malmquist index, and then conducted a static comparison and dynamic analysis of both at the national, inter-provincial and regional levels. Based on the analysis of the mechanism of action, You Zhiting et al.[3] studied the carbon emission reduction impact of GF from both overall and regional aspects, taking GC, green industrial investment and green bonds as examples. Their study shows that the synergistic effect of GC and green bonds shows a negative moderating effect, while other combined forms show a complementary phenomenon. The scholars' findings on green finance can provide empirical support for this study.

Second, the research results on GTI mainly focus on studying the factors affecting GTI from different aspects and making specific recommendations. Qiongwen Cheng et al.[4] empirically analyzed the factors affecting the efficiency of GTI using Tobit model. Besides, the average size of enterprises, the degree of marketization, the degree of openness to the outside world as well as the intensity of environmental regulation are the main factors that support the efficiency of GTI. Sun, Yong et al.[5] explored the spatial and temporal patterns of green technology innovation and its influencing factors using spatial analysis and econometric models. It was found that factors such as industrial structure, regional economic scale, infrastructure level, openness level, innovation dynamics, marketization level and financial and environmental support positively contribute to GTI in the Yellow River Basin.

Finally, research results on GF and GTI have mainly focused on a single perspective to explore the synergistic mechanism of the impact between the two. Shi Wenming et al.[6] pointed out that existing a nonlinear threshold effect of the level of financial process on technological innovation. Sun Yanlin et al.[7] measured the level of GF development in each region from the perspective of enterprises and included GF development, technological promotion and economic growth simultaneously in a panel vector autoregressive (PVAR) model. Tao Ran[8] analyzed the mechanism of green finance-driven GTI based on the triple helix theory, and proposed to establish a horizontal participation and coordination mechanism of green finance-driven GTI.

In summary, there are few studies studying the influence of green financial development on GTI, as well as most of them only study the impact of GC on GTI, with a relatively single perspective, and there is a lack of literature on the influence of green financial instruments on GTI. Therefore, this essay innovatively analysis the influence of GF on green technological innovation from the perspectives of green credit, green investment and green bonds, and focuses on the regional heterogeneity and correlation among green financial instruments to add more research perspectives and methods to the field of green finance.

3. Research Design

3.1. Definition of Variables

3.1.1. Interpreted Variables

Green Patent Application Number (GTP) measures the level of GTI, which concluded that patents are the most direct indicator to measure the output of technological innovation, and patent applications need to be approved by relevant government departments. Therefore, the patent data are more authentic than the research and development investment reported by enterprises themselves. Therefore, the level of GTI is measured by the quantity of green applications (consisting of green invention patents and green new type patents) in each province in the current year, which accounts for the number of national applications in that year.

3.1.2. Explanatory Variables

Green Cred it is a negative indicator, which is measured by the percentage of interest expense of the six major energy-intensive industries in each province to the total interest expense of the industrial industry; Green Investment (GI) is a positive indicator measured by the percentage of investment in environmental pollution control to GDP; In view of the current small scale and small number of green bonds (GB) issued in China, it is difficult to establish a continuous variable, and the green bonds will only be officially issued in 2016. Therefore, the data of green bond issuance after 2016 is derived from the CSMAR financial database. Before 2016, the public bond financing of 336 listed companies in the energy-saving and environmental protection segment of A-share is used as an alternative, and the issuance is matched with the region to which the company belongs. The data is derived from the Wind database. At the same time, the entropy method is used to comprehensively measure the process level of green finance (GF).

3.1.3. Control Variables

According to the existing research literature on green technological innovation, the Controls variables related to regional green innovation are selected. This paper selects the general budget expenditure of local finance, R&D expenditure of industrial enterprises above designated size and the proportion of education expenditure of local finance to GDP of each province in the current year to measure the government intervention level (GOV), regional research expenditure input (RD) and regional education development level (EDU) respectively.

3.2. Sample Selection and Data Sources

The research sample selects the complete panel data of 30 provinces in China from 2010 to 2020. Relevant data are all from CSMAR financial database, Wind database, China Statistical Yearbook, etc. Few of lost values are supplemented by interpolation.

3.3. Model Construction

Based on Jaffe's knowledge production function model, to explore the nonlinear relationship between green financial development and regional green GTI, this paper incorporates the primary and secondary terms of GF, GC, GI and GB, and establishes the basic expression of the influence of green financial development on technological innovation as follows:

$$GTP_{it} = \alpha_{it} + \beta_1 \times GP_{it} + \beta_2 \times GP_{it}^2 + \beta_3 \times C_{it} + \varepsilon_{it} \tag{1}$$

$$GTP_{it} = \alpha_{it} + \beta_1 \times GC_{it} + \beta_2 \times GC_{it}^2 + \beta_3 \times C_{it} + \varepsilon_{it} \tag{2}$$

$$GTP_{it} = \alpha_{it} + \beta_1 \times GI_{it} + \beta_2 \times GI_{it}^2 + \beta_3 \times C_{it} + \varepsilon_{it} \tag{3}$$

$$GTP_{it} = \alpha_{it} + \beta_1 \times GB_{it} + \beta_2 \times GB_{it}^2 + \beta_3 \times C_{it} + \varepsilon_{it} \tag{4}$$

Among them, the following table of variables represents different provinces and different years, which is intercept term, influence coefficient and error term.it α_{it} β ε_{it}

4. Empirical Analysis

As can be seen from Table 1, the relationships between GP, GC, GB and GTP all present inverted U-shape, i.e. negative correlation at the initial stage and positive correlation at the subsequent stage after breaking a certain threshold, while GI and GTP do not present the above-mentioned relationship, and the secondary term of GI is not significant. Therefore, green investment in our country is a

hindrance to GTI at the present stage, which may be explained by the crowding-out effect of green investment on the research and development of regional enterprises due to its over-emphasis on environmental protection, resulting in the obstruction of enterprise innovation. At the same time, we found that RD is significantly positive in the regression, indicating that the current investment in scientific research funds has an essential advantageous correlation with GTI, at the same time the regions can invest more funds to obtain rapid development of technological progress. However, the EDU did not show any relevant level, which is reasonable considering the time lag effect of educational development.

Table 1: Regression Results

	(1) GTP	(2) GTP	(3) GTP	(4) GTP	(5) GTP	(6) GTP	(7) GTP	(8) GTP
GP	-0.045*** (0.002)	-0.381*** (0.000)						
GP^2		0.406*** (0.000)						
GC			-0.048*** (0.001)	-0.554*** (0.000)				
GC^2				0.489*** (0.000)				
GI					-0.379** (0.043)	-1.077* (0.097)		
GI^2						16.764 (0.261)		
GB							-0.813*** (0.004)	-4.451*** (0.000)
GB^2								105.292*** (0.000)
GOV	-0.049 (0.106)	-0.133*** (0.000)	-0.049 (0.107)	-0.145*** (0.000)	-0.062** (0.041)	-0.065** (0.033)	-0.050* (0.099)	-0.071*** (0.020)
RD	2.784*** (0.000)	2.245*** (0.000)	2.752*** (0.000)	2.076*** (0.000)	2.918*** (0.000)	2.894*** (0.000)	2.850*** (0.000)	2.568*** (0.000)
EDU	-0.164 (0.499)	0.018 (0.939)	-0.128 (0.600)	-0.167 (0.451)	-0.289 (0.231)	-0.261 (0.280)	-0.236 (0.326)	-0.044 (0.852)
α	0.041*** (0.000)	0.122*** (0.000)	0.047*** (0.000)	0.201*** (0.000)	0.036*** (0.000)	0.041*** (0.000)	0.036*** (0.000)	0.061*** (0.000)
Sample size	330	330	330	330	330	330	330	330
Pron > F	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R^2	0.504	0.562	0.505	0.595	0.496	0.497	0.502	0.525

Note: * * *, * *, * are significant at 1%, 5% and 10% respectively, and the z value of robust standard error is shown in brackets.

5. Conclusions and Suggestions

Theoretical research and development practice confirm that promoting regional GTI with GF development is an inevitable choice under the current economic development situation. Taking the data of 30 provinces in China from 2010 to 2020 as a sample, this essay deeply explores the influence of regional GF development on GTI, and reveals the influence mechanism of various indicators of green finance. At the same time, it is found that at this stage, due to the low level of GF development

in China, the impact on GTI is in a negative correlation stage, and with its development, after crossing the critical value, it shows a significant promotion effect.

The above conclusions provide a series of empirical evidence for the development of GF and the development of GTI, which can give some policy suggestions:

First of all, establish a diversified green financial system, realise the diversified development of green finance, and further increase green credit while maintaining the core position of green finance in green finance. The development of GB and GI;

The second is to optimise the allocation of green financial resources, which realise the transformation of the quality of China's green financial development, improve the efficiency of China's green financial development, as well as promote the development of GTI. Moreover, the third is to establish a regional coordination mechanism for GTI efficiency. Through the cooperation between enterprises, universities and governments between provinces, the surrounding areas can complement each other and carry out cooperative GTI efficiency projects, and the Internet can be used to establish a national project technology exchange and inquiry platform for projects of the same type. To provide a more high-quality and convenient channel, we will continue to promote the effective improvement of green technology innovation capabilities, so as to empower China's green transformation and development.

Acknowledgements

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