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The Governance Effect of China's Green Finance Policy from an International Perspective

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Abstract: Most of the previous studies on the utility of green financial policies have focused on provincial data, exploring the differences between different provinces at the same time; few have focused on China as the main body, focusing on the positive effects of national-level green financial policies on the rapid development of the economy and society effect. Based on the macro data of 43 countries, this paper uses the SBM model of undesired output to measure the main characteristics of social and economic development. It estimates the net effect of China's green financial policy through the non-parametric synthetic control method. The study found that China's green financial policy has a significant positive effect on the improvement of factor productivity. Further exploration of the predictor variables shows that China's industrial structure and technical level are relatively low, and the use efficiency of green financial funds and government green finance need to be optimized.

Keywords: green finance policy; international comparison; factor productivity; nonparametric synthetic control method

1. Introduction

China has made brilliant achievements in the past 20 years, but with the rapid economic development, severe pollution has also occurred. In the report of the 19th National Congress of the Communist Party of China, the government put forward the goal of "building a beautiful China", and at the same time took "development of green finance" as one of the most important ways to achieve it. The concept of "green finance" mainly refers to the financial industry incorporates environmental factors into business strategies. While pursuing the maximization of project economic benefits, it also hopes to ease the difficulty of loans for environmental protection companies and increase financial support for green companies. Promote and realize green development, and its main realization tools are green loans, green bonds, and green insurance.

China's green finance development started late, but with its vast size and dynamic market economy, it has developed rapidly, inseparable from the guidance and strong support of government policies. On the one hand, the government's "tangible hand" improves policies and regulations, regulates the industry's development path, and maintains a healthy ecology of green finance. On the other hand, through fiscal policy, the government encourages the innovation of green financial products and encourages the issuance of diversified products such as green stocks, green credits, and green funds.

The theory of green finance was born in the 1980s. International organizations, academic institutions, and government agencies have defined it. However, there has not been a unified

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understanding, and there is a lack of relevant research on the development mechanism of green finance. Salazar (1998) believes that green finance is a necessary financial innovation to seek the path of environmental protection and an important bridge connecting the financial industry and the environmental industry [1]. Cowan (1999) believes that green finance should focus on financing the development of the green economy, which belongs to the interdisciplinary subject of green economy and finance [2].

Although the academic community has not reached a unified understanding of the connotation of green finance, they have reached a consensus on the necessity of developing green finance. Graedel and Allenby (2004) established the theoretical basis of finance and environmental protection. From the industry and environmental protection perspective, they put the financial industry as a unique service industry into the theoretical framework of service industry and environmental protection [3].

Since Goldsmith proposed the theory of financial development in 1969, academic circles have carried out in-depth research on the issue of "the relationship between financial development and economic growth" and have achieved fruitful results. Goldsmith (1969) and Mckinnon (1973) respectively conducted theoretical and empirical analyses on the fundamental issue of the contribution of finance to economic development [4,5]. The prevailing view is a significant interaction between financial development and economic growth. Lin Xiao (2011), Xie Xusheng, and Yan Siping (2021) empirically test the impact of green financial development on economic growth and find that the development of green finance can significantly promote economic growth [6,7]. However, from a macro perspective, there are relatively few studies on the issue of "green finance and sustainable economic development" at a deeper level.

To sum up, the existing literature lacks an in-depth analysis of the mechanism between green finance-related policies and sustainable economic development based on quantitative analysis and lacks comparisons with other countries at the macro level. Based on this perspective, this paper hopes to explore the role of China's green financial policy on sustainable economic and social development through empirical research.

The follow-up arrangement of the article is as follows: the second part is the research design, which explains the research hypothesis, measurement model, and data; the third part presents the results of data analysis and test, and makes an in-depth discussion at the end of the article.

2. Rsearch Desigh

2.1. Research Hypothesis

Based on the collection and arrangement of the background and related literature, the core assumptions of this study are as follows:

H0: The green finance policy introduced by China in 2016 is ineffective in improving factor productivity.

H1: The green finance policy launched by China in 2016 positively affects the improvement of factor productivity.

2.2. Research Method

The Synthetic Control Method is an effective method for policy analysis and evaluation. The counterfactual framework is constructed as a hypothetical experimental area without experimental intervention. Compared with Difference-in-differences method, it does not need to meet relatively strict common trend assumptions and conditional independence of policy assumption. Fundamental differences can also be huge due to adjacent regions, making it challenging to find optimal control regions close to the experimental group in all respects. Italian scholar Giovanni Cerulli proposed the method of non-parametric model estimation in 2019 [8]. We use the kernel function estimation

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strategy to calculate the weight of the constructed virtual object. The result is more accurate and robust. Therefore, in this study, we choose to use a non-parametric synthetic control method to construct an uninterrupted China by setting the kernel function and bandwidth to estimate the net effect of green financial policies on factor productivity improvement.

2.3. Research Variables

This paper uses the annual data from 2006 to 2020 for a total of 43 countries, including China, the United Kingdom, the United States, Australia, and so on (missing values in some countries are predicted by regression with data in the past ten years). Table 1 shows the variables and the data sources.

Table 1: Variables and data sources.

Types of variables	variables	definition	Data sources
Dependent variables	CAPITAL	Gross investment in fixed assets	World Bank national accounts data
	LABOR	Employed population	Penn World Table, version 10.0
	ENERGY	Total energy consumption	International-U.S.Energy Information Administration(EIA)
	GDP	Gross domestic production	World Bank national accounts data
	CARBON	Carbon dioxide emissions	International-U.S.Energy Information Administration(EIA)
Control variables	TI	Scale of tertiary industry	Wind
	Tech	The patent application quantity	World Bank national accounts data

2.4. Research Model

Let the total number of samples be N, the first sample is the experimental object, namely China, and the rest are non-experimental objects. In the follow-up study, we use the subscript i to distinguish. The experimental subjects were affected by the policy after T_0, and the non-experimental subjects remained stable throughout the entire experimental period.

We record FP_{it}^{I} as the factor productivity of country i after being affected by the green financial policy in period t and record FP_{it}^{N} as the factor productivity of country i not affected , then the net governance effect of China's green financial policy is

$$\Delta_{it} = \alpha_{it} D_{it} = FP^{I}{}_{it} - FP_{it}^{N} \quad (1)$$

α_{it} refers to the policy effect value. D_{it} is the dummy variable for policy implementation. When $t \geq T_0$, $D_{it} = 1$; when $t < T_0$, $D_{it} = 0$. The estimated governance effect of green finance is transformed into the solved difference between $FP^{I}{}_{it}$ and FP_{it}^{N}.

For China that has implemented a green financial policy at T_0, FP_{it}^{N} $(t = T_0 + 1, \ldots, T)$ does not exist, we use the Synthetic Control Method to construct a credible counterfactual variable $\sum w_i^* FP_{it}^{N}$ by assigning the optimal weight vector W^* to a linear combination of non-experimental objects. The result variable, control variables and predictor variables before policy intervention closely approximate the experimental subjects.

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For the solution of the weights W^*, we use the Non-parametric Synthetic Control Method (NPSCM) to calculate the distance weights between the control group units and the intervention group units with the help of a kernel function.

The probability density function for a random variable is

$$f(x_0) = \lim_{h\to 0} \frac{F(x_0+h)-F(x_0-h)}{2h} \tag{2}$$

h is the interval radius, which refers to the bandwidth in non-parametric estimation. Selecting the correct bandwidth h requires the cross-validation method (Li and Racine, 2004) to solve the minimum root mean square prediction error RMSPE(h) before intervention [9]; l is an

indicative function, here we define if$|h| > 1$, then$l = 0$ to guarantee the accuracy of estimates. In the histogram, the estimator of the probability density function is estimated using the frequency of

$$\hat{f}_{HIST}(x_0) = \frac{\sum_i \frac{l(x_0-h<x_i<x_0+h)}{n}}{2h} = \frac{1}{nh}\sum_i \frac{1}{2} l\left(\left|\frac{x_i-x_0}{h}\right| < 1\right) \tag{3}$$

Table 2: Descriptions of variables and descriptive statistics.

Variables	**Definition**	**Sample size**	**Mean value**	**Standard deviation**	**Maximum value**	**Minimum value**
country	country	43				
fp	Factor productivity	645	0.076	0.18	1	0
tech	Number of national invention patents per year（after unitary）	645	0.45	0.30	1	0
stru	The added value of the tertiary industry accounted for the proportion of GDP in that year	645	0.53	0.092	0.78	0.22

Since the density function estimation based on the histogram is not smooth enough, and the values of each group are different, we use the kernel function estimation to allow overlapping between groups and generalize to a more general situation,

$$\hat{f}(x_0) = \frac{1}{nh}\sum_i K\left(\frac{x_i-x_0}{h}\right) \tag{4}$$

Among them $K(\cdot)$is the kernel function. We choose a robust quadratic kernel (Quadratic/Biweight) in this study.

For the selected control variable X, we can derive the distance weight value matrix of the control group unit i and the policy intervention unit W^*

DOI: 10.54254/2754-1169/3/2022781

$$w_{t,i}^{1} = K\left(\frac{\|X_{t,i} - X_{t,1}\|}{h}\right) \tag{5}$$

Take the average of the weight matrix to get the weight of each unit in the control group

$$\bar{w}_{t,i}^{1}(h) = \frac{1}{t_0 - 1}\sum_{t=1}^{t_0-1} w_{t,i}^{1}(h) \tag{6}$$

Based on the above derivation, the estimated net governance effect of China's green finance policy Δ_{it} is transformed into

$$\Delta_{it} = \alpha_{it} D_{it} = FP^{I}{}_{it} - FP_{it}^{N} = FP^{I}{}_{1t} - FP_{jt}^{N}, j \in [2, N] \tag{7}$$

3. EMPIRICAL ANALYSIS

3.1. Descriptive Statistics

The entire sample period of this study is [1,T] = [2006, 2020], the time point when the policy was introduced is T_0=2016, the pre-intervention period is [2006, 2015], and the intervention period is [2016, 2020]. Table 2 shows the outcome variables, control variables, and descriptive statistics.

3.2. Treatment Effect Analysis

3.2.1. Kernel Function and Selection of Optimal Bandwidth h

Since the quadratic kernel can minimize the critical mean squared error （Min IMSE(h^*)，Integrated Mean Squared Error), we choose the quadratic kernel. This paper hopes to obtain the optimal bandwidth by minimizing the root mean square prediction error (RMSPE). Figure 1 shows the RMSPE calculated by Stata at different bandwidths. We choose the bandwidth h=0.1, and the RMSPE is the smallest at this time.

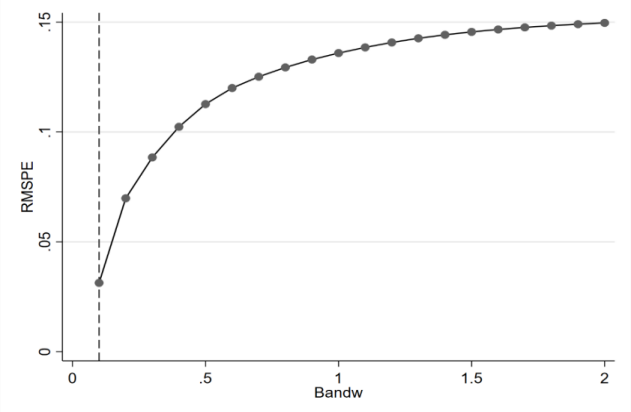

Figure 1: Selection of optimal bandwidth.

3.2.2. Estimated Results of Optimal Weights

Through the Non-parametric Synthetic Control Method, we obtained the weights of the control group fitting China. Among them, 13 countries weigh 0; the three countries with enormous weights are Egypt (9.5095%), India (9.3681%), and Indonesia (7.3938%).

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3.2.3. Evaluation of the Effects of China's Green Finance Policy

By compounding the countries of the control group with the above weights, a fictitious synthetic China is obtained, and the fitting effect is good. As shown in Figure 2, the left side of the vertical solid line is the early stage of policy intervention (2006-2016), and the right side is the later stage of policy intervention (2016-2020). By comparing the trends of the two broken lines, we find that before the implementation of the policy (2006 to 2016), the factor productivity of Synthetic and Actual China was very similar in value and development trend; After 2016, when it was fully rolled out, there were apparent differences between the two trends.

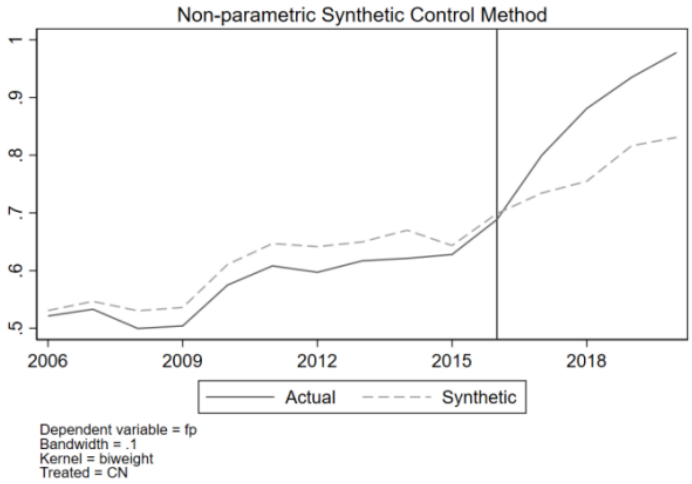

Figure 2: Comparison of synthetic China and real China.

Next, we analyze the effect of the policy, taking the factor productivity difference between real China and synthetic China, and obtain Figure 3. In the early stage of policy intervention, the difference between the mixed group and the actual value was close to 0; however, when the policy was primarily pushed out, there was a significant difference in factor productivity. According to the non-parametric composite control method principle, we approximately believe that this is the net effect of China's green finance policy. As time goes by, the impact of policies on the improvement of factor productivity is also increasing.

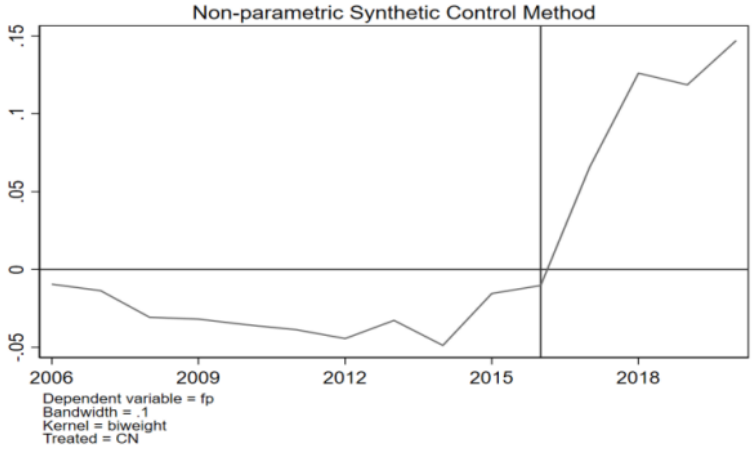

Figure 3: Estimated net effect of green finance policy.

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3.3. Data Analysis Test

3.3.1. Robustness Check

First, the premise of the Non-parametric Synthetic Control Method requires that there is no interaction between the control group and the experimental group. As China's green finance policy is mainly aimed at domestic industries, its primary purpose is to coordinate the contradiction between domestic development and environmental protection. Although China advocates the promotion of green finance in international organizations and on the international stage, the current effect of translating into action is limited.

Second, the non-parametric synthetic control method results are more significant and robust than the traditional synthetic control method. China synthesized by the traditional method of calculating weights without non-parametric estimation is quite different from the actual value in the pre-policy period, exceeding 0.1 from 2009 to 2013, and its analytical value and credibility are significantly reduced.

3.3.2. Placebo Test

Is the positive effect of China's green finance policy on factor productivity improvement driven by accidental factors? We used non-parametric synthetic controls to evaluate effects by changing treatment regions and taking all countries in the control group as subjects to eliminate this doubt. This paper first removes countries with significant mean squared prediction error (MSPE) before the intervention, whose fitting effect is poor, and the effect after policy intervention fluctuates enormously, so the results are not credible. Therefore, we set the standard of "MPSE cannot exceed three times of China," that is, MSPE$\leqslant$0.062628, and the remaining 12 countries are CN, ARG, AUS, BGR, BLR, ETH, MEK, MKD, POL, SVK, TJK, UKR, VNM.

Due to the small sample size of the Non-parametric Synthetic Control Method, it is not suitable to use a large sample theory for statistical inference. We draw on the idea of statistical inference and use the placebo test to observe whether the treatment effect in China is an extreme value in these 13 countries and then draw a judgment on the null hypothesis.

H0: The green finance policy introduced by China in 2016 is ineffective for improving factor productivity.

The net policy effect of 12 countries from 2017 to 2020 is all less than 1, that is, less than the treatment effect of China. If China's green finance policy is ineffective, then among the 13 countries, the probability of getting China's treatment effect is the largest is 1/13=0.0769, i.e., P=0.0769. Therefore, we have greater than 90% confidence to reject the null hypothesis H0 and accept hypothesis H1 and believe that green finance-related policies have indeed played a positive role in improving China's factor productivity.

4. Conclusion

This article uses the non-parametric Synthetic Control Method and the macro data of 43 countries from 2006 to 2020. It affirms the positive effect of China's green financial policy on improving factor productivity and has passed the significance test and strict placebo test. The government's continuous and in-depth promotion and promotion of green finance-related supportive policies have supported empirical research and statistics. By examining the situation of control variables, we find that China's industrial structure and innovation capacity still have a gap with the mixed group. In terms of industrial structure, China's tertiary industry accounted for 45.18%, slightly lower than the 47.18% of synthetic objects. This is closely related to China's national conditions. The profound history of

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China as a big agricultural country and the long-term socialist industrial construction has laid a solid foundation for the primary and secondary industries.

In comparison, the service industry of the tertiary industry has a relatively weak foundation. The proportion needs to be further improved. In terms of innovation ability, the number of related invention patents in China is 0.2243 after normalization, which is significantly lower than 0.3330 in the mixed group. We should pay attention to the flow of green financial funds, not just staying in the At the level of "quantity," more attention should be paid to the quality of use and benefits, such as whether the green loan support for enterprises is used efficiently, whether the technology of the enterprise is optimized, and whether it catalyzes the output of enterprise innovation and invention. Based on the above research analysis, we make the following recommendations:

First, the government should continue to issue laws and regulations to improve the supervision chain further and promote the healthy development of green finance. Although China's green finance market is active and has played a considerable role in promoting the healthy development of society and economy, the system construction in many fields such as supporting laws and regulations, corporate environmental protection information disclosure, and environmental assessment throughout the project financing process is still insufficient. It is complete and needs to be strengthened and improved through continuous legislation and the introduction of measures.

Second, we need to take multiple measures to make a good combination of policies. There are many social problems facing China at present. The government can make good use of the connection between the problems and improve the efficiency of financial use through active coordination and multiple measures.

Third, actively innovate, continuously enrich green financial products, and follow trends and trends. Faced with the impact of big data, blockchain, and other technological innovations on the financial industry, we should have a positive and open attitude and apply it to green financial products.

Fourth, the new normal of the epidemic is both an opportunity and a challenge. Faced with the unprecedented new situation, the government should further play the role of green finance, guide the optimization of industrial structure through support for environmental protection enterprises; take advantage of the stable domestic situation to expand the sources and scope of China's green finance business, and continue to expand International influence.

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