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Research on the Influence of Green Finance on Green Transformation of Manufacturing Industry

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Abstract: *This paper selects the manufacturing data at the provincial level from 2012 to 2021, uses the entropy method to construct the regional manufacturing green transformation index, and uses the five provinces that joined the green finance experimental zone in 2017 as the sample, and uses the double difference method to analyze the promotion effect of green finance policy on the regional manufacturing green transformation. The results show that the establishment of the green finance experimental zone can significantly improve the green transformation of regional manufacturing industry. Therefore, when formulating the development goals of green financial policies, we need to make them from different perspectives. The government must play a leading role, increase its support for manufacturing enterprises and share the potential risks of enterprises in green technological innovation. According to the local economic development level and environmental quality, the direction of key areas of green financial support should be determined in an overall way to avoid the waste of resources.*

Keywords: *Green finance, Manufacturing, Inspection mechanism*

1. Introduction

China will strive to achieve peak carbon dioxide emissions by 2030 and carbon neutrality by 2060, which means that the importance of environmental protection has been pushed to an important position. Promoting the comprehensive green transformation of economic and social development and improving the quality of ecological environment from quantitative change to qualitative change have become the key to the construction of ecological civilization in China. The green transformation of manufacturing industry is an objective need of China's economic transformation and development, but it also faces many difficulties and challenges, which are restricted by many factors such as economic development, industrial structure, energy consumption and technical level. The extensive development mode of manufacturing industry poses a great threat to the sustainable development and environmental protection of China. Therefore, the green transformation of manufacturing industry is an urgent development direction. As a new financing tool, green finance has obvious advantages in alleviating the financing difficulties of enterprises. Green finance, as a strategy of environmental economy, has been widely concerned by all aspects of society. Report to the 20th CPC National Congress of the Communist Party of China emphasized "the development mode of accelerating green transformation", which will help finance support green development more effectively, provide more matching green financial services, and strengthen the synergy among industry, finance and fiscal and taxation policies. The transformation of manufacturing industry is directly related to the development of green finance, and the goal that green finance development can promote the transformation of manufacturing industry is basically clear. But the influence path is fuzzy. Therefore, it is the focus of this paper to study whether green finance promotes the transformation of manufacturing industry and analyze the influencing mechanism.

2. Theoretical analysis

The green transformation of manufacturing industry embodies the specific application of green development concept in manufacturing industry. It is a process to promote the transformation of manufacturing industry to high-quality development mode based on green development concept, and at the same time, it is also to improve the total factor production efficiency of manufacturing industry and realize the efficient and intensive use of energy through technological innovation. Green finance helps to promote the green transformation of manufacturing industry, and can solve the resource and environmental problems through the optimal combination of financial instruments, which is very

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important for the development of renewable energy in China. Green finance is in line with the development direction of modern economy, which not only optimizes macroeconomic development, but also improves microeconomic efficiency. Ghisetti et al. [1] (2017) believe that financial development can bring scale effect, industrial structure optimization and technical effect, promote green enterprise investment, and thus promote the green transformation of manufacturing industry. However, Tamazian and Rao[2](2010) think that traditional financial activities only focus on profit in investment projects and ignore resources and environmental factors, so it is difficult for manufacturing enterprises to invest in green projects. Jin Huan et al. [3](2022) thought that the establishment of the green financial reform and innovation pilot zone significantly inhibited the productivity improvement of enterprises. The policy's inhibitory effect on productivity is mainly reflected in non-heavily polluting enterprises, while heavily polluting enterprises have formed "compensatory benefits" that exceed the cost of complying with the system under the pressure of the policy. Jiang Hongli et al. [4] (2020) take green credit and green investment as the explanatory variables of green finance, and found that both of them can significantly inhibit the output of carbon emissions. Wang Fengrong and Wang Kangshi [5](2018) found that the "green" policy improves the efficiency of green financial allocation, but the financing binding force on polluting enterprises is not significant; Green fiscal policy has no significant influence on the allocation efficiency of green finance; The lack of "green" regulatory policies inhibits the positive effect of financial development on the efficiency of green financial allocation. Ge Pengfei et al. [6] (2018) based on the data samples of countries along the belt and road initiative, concluded that ordinary financial development has a negative effect on green total factor productivity. Only by adhering to the development orientation of green finance can we form a strong reverse pressure on enterprises and promote the transformation of highly polluting enterprises to clean production. Green taxation means that the government uses financial power to regulate the distribution of social resources through financial means. He Wujie, Liang Xiaohong and Chen Hanhua [7] (2020) found that green taxation can directly promote the green transformation of manufacturing industry, and the correlation between green taxation in China and Italy is stronger, but the role of narrow green taxation, that is, sewage charges, has not been reflected; Green tax also has an indirect effect on the green transformation of manufacturing industry, which can promote the green transformation of manufacturing industry by increasing corporate profits. Jiang Chenguang [8] (2011) believes that green finance provides diversified financing means for energy-saving and environmental protection industries, and at the same time inhibits the blind and disorderly expansion of industries with high energy consumption and high pollution.

3. Model Setting and Variable Description

This paper constructs a comprehensive index system to evaluate the green transformation of manufacturing industry, uses the comprehensive index method to measure the green transformation level of manufacturing industry, and on this basis, analyzes its current situation. This paper constructs indicators to measure the green development level of manufacturing industry from four dimensions: economic efficiency, environmental development, energy efficiency and scientific and technological innovation.

Economic benefit dimension. Economic benefit is the ultimate goal of green transformation of manufacturing industry. The contribution of green transformation of manufacturing industry to green development can reflect the effect of green transformation of manufacturing industry to a certain extent. Therefore, economic benefit is used to evaluate the promotion and role of manufacturing enterprises in their own development after green transformation. The economic benefits mainly include the manufacturing contribution rate, manufacturing productivity and job absorption capacity of manufacturing industry, and the manufacturing contribution rate reflects the position of regional manufacturing industry in economic development and its contribution to the economy; Manufacturing productivity reflects the ability of manufacturing industry to create economic benefits under a certain population; The post absorption ability reflects the stability of economic and social construction to a certain extent. The greater the value of the index, the stronger the ability of manufacturing industry to create economic benefits.

Dimensions of environmental development. The purpose and significance of green transformation of manufacturing industry lies in promoting environmental development and reducing the discharge of various wastes that pollute the environment. In terms of pollution discharge, five three-level indicators are selected, namely, the production ratio of general industrial solid waste in manufacturing industry to gross industrial output value, the discharge ratio of chemical oxygen demand to gross industrial output value, the discharge ratio of ammonia nitrogen to gross industrial output value, the discharge ratio of sulfur dioxide to gross industrial output value and the discharge ratio of ammonia nitrogen to gross

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industrial output value. Waste discharge per unit output value, waste water discharge per unit output value and waste gas discharge per unit output value are three secondary indicators to evaluate the pollution discharge degree of manufacturing industry and the trend of environmental development. The greater the index value, the more serious the environmental pollution and the lower the degree of green transformation of manufacturing industry.

Energy efficiency dimension. One angle of green transformation of manufacturing industry is to reduce energy consumption and improve energy efficiency. The energy consumption of manufacturing industry is evaluated from two indicators: electricity consumption per unit output value and energy consumption per unit output value. The greater the index value, the greater the energy consumption intensity of manufacturing industry and the lower the level of green transformation of manufacturing industry.

The dimension of scientific and technological innovation. Green innovation activities in manufacturing industry can't be carried out without green innovation drive, in which the proportion of R&D investment and the level of scientific and technological innovation development are the driving forces to improve the level of green innovation, and the proportion of R&D investment reflects the output effect of scientific research capital investment, while the level of scientific and technological innovation development is the proportion of scientific research personnel in manufacturing industry, reflecting the importance attached by manufacturing industry to scientific research. The scientific and technological innovation ability of manufacturing industry is measured by R&D expenditure ratio to total industrial output value and the proportion of scientific and technological personnel to manufacturing employees. The greater the index value, the stronger the scientific and technological innovation ability.

According to the above-mentioned construction principles and methods, the index system for evaluating the green transformation of manufacturing industry is set as a comprehensive system covering economic benefits, environmental development, energy benefits and scientific and technological innovation. The economic benefits consist of three secondary indicators: contribution rate of manufacturing industry, productivity of manufacturing industry and job absorption. Environmental development consists of three secondary indicators: waste discharge per unit of output value, waste water discharge per unit of output value and waste gas discharge per unit of output value. The energy efficiency consists of two secondary indexes: electricity consumption per unit output value and energy consumption per unit output value. Scientific and technological innovation is reflected by the proportion of research and development investment and the development level of scientific and technological innovation. The whole indicator system consists of 4 first-level indicators, 10 second-level indicators and 12 third-level indicators, as shown in Table 1. In this paper, the entropy method is used to measure the green transition level of manufacturing industry, and the entropy method is used to determine the weight of each index.

Table 1: Measurement of Green Transformation Index System of Manufacturing Industry

Level 1 indicators	Secondary indicators	Two-level index measurement method	unit	attribute
Economic benefit dimension	Manufacturing contribution rate	Total manufacturing profit /GDP	%	+
	Manufacturing productivity	Total manufacturing profit/number of manufacturing employees	Billion yuan/ten thousand people	+
	Post absorption	Manufacturing urban unit employment/total urban employment	%	+
Environmental development dimension	Waste emissions per unit of output value	General industrial solid waste generation/gross industrial output value	Million tons/billion yuan	-
	Wastewater discharge per unit output value	Chemical Oxygen Demand Emissions/gross industrial output value	Million tons/billion yuan	-
		Ammonia nitrogen emissions/gross industrial output value	Million tons/billion yuan	-
	Exhaust emission per unit output value	Sulphur dioxide emissions/gross industrial output value	Million tons/billion yuan	-
		NOx Emissions/gross industrial output value	Million tons/billion yuan	-
Energy efficiency dimension	Electricity consumption per unit output value	Electricity consumption by province/gross industrial output value	KWh/Billion Yuan	-
	Energy consumption per unit output value	Total Energy Consumption/gross industrial output value	Ten thousand tons of standard coal/one hundred million yuan	-
Scientific and technological innovation dimension	Proportion of research and development investment	R&d expenditure/gdp	%	+
	The development level of scientific and technological innovation	Tech Activist/Manufacturing Practitioner	%	+

Through the established index system and entropy weight method, the industrial green transformation

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level index is calculated, which is expressed by MGTL. The value is between 0 and 1. The closer the value is to 1, the higher the green transformation level of manufacturing industry. The average value of green transition water in manufacturing industry of 30 provinces and regions in China from 2012 to 2021 is shown in Table 2.

Table 2: Green Transformation Level of Manufacturing Industry in Provinces from 2012 to 2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average for each year
Anhui	0.4276	0.4313	0.4465	0.4545	0.4667	0.4788	0.4744	0.5087	0.5307	0.5661	0.4785
Beijing	0.3856	0.3925	0.3951	0.3895	0.3933	0.3986	0.3904	0.3922	0.4086	0.3951	0.3941
Fujian	0.4832	0.4699	0.4723	0.4623	0.4673	0.4674	0.4744	0.4856	0.5097	0.5587	0.4851
Gansu	0.2663	0.2696	0.2799	0.2701	0.2884	0.2755	0.2665	0.2627	0.2482	0.2873	0.2715
Guangdong	0.5553	0.5562	0.5572	0.5576	0.5603	0.5644	0.5879	0.5815	0.5915	0.5941	0.5706
Guangxi	0.3110	0.3149	0.3204	0.3122	0.3224	0.3145	0.3027	0.3123	0.2967	0.3318	0.3139
Guizhou	0.2120	0.2429	0.2563	0.2686	0.2921	0.3017	0.3123	0.3368	0.3353	0.3409	0.2899
Hainan	0.2171	0.2095	0.2270	0.2201	0.2301	0.2173	0.2376	0.2310	0.2173	0.2459	0.2253
Hebei	0.3451	0.3567	0.3701	0.3776	0.3922	0.4080	0.3943	0.4090	0.4259	0.4253	0.3904
Henan	0.3844	0.4020	0.4129	0.4171	0.4266	0.4255	0.4314	0.4444	0.4517	0.4717	0.4268
Heilongjiang	0.2991	0.3122	0.3157	0.2994	0.3336	0.3035	0.2587	0.2860	0.2658	0.3001	0.2974
Hubei	0.4080	0.4157	0.4241	0.4245	0.4390	0.4407	0.4629	0.4772	0.4916	0.5176	0.4501
Hunan	0.3891	0.3990	0.4086	0.4261	0.4456	0.4657	0.4993	0.5054	0.5256	0.5593	0.4624
Jilin	0.3520	0.3593	0.3642	0.3670	0.3780	0.3639	0.3269	0.3258	0.3218	0.3387	0.3497
Jiangsu	0.5862	0.5238	0.5305	0.5421	0.5520	0.5591	0.5706	0.6131	0.6240	0.6478	0.5749
Jiangxi	0.3588	0.3735	0.3773	0.3817	0.3996	0.4116	0.4420	0.4667	0.4865	0.4865	0.4184
Liaoning	0.3843	0.3845	0.3849	0.3585	0.3708	0.3801	0.3901	0.3880	0.3977	0.4090	0.3848
Inner Mongolia	0.2884	0.3124	0.3100	0.3166	0.3428	0.2984	0.2545	0.2595	0.2704	0.2843	0.2937
Ningxia	0.2050	0.2291	0.2424	0.2350	0.2684	0.2833	0.3038	0.3342	0.3324	0.3880	0.2822
Qinghai	0.1665	0.1687	0.1703	0.1470	0.1751	0.1570	0.1358	0.1689	0.1669	0.2081	0.1664
Shandong	0.4746	0.4724	0.4771	0.4850	0.4916	0.4965	0.5061	0.4785	0.5102	0.5612	0.4953
Shanxi	0.2946	0.2998	0.3046	0.2767	0.2876	0.3091	0.3050	0.3067	0.3196	0.3443	0.3048
Shanxi	0.3519	0.3618	0.3711	0.3667	0.3787	0.3779	0.3741	0.3785	0.3950	0.4033	0.3759
Shanghai	0.4886	0.4773	0.4753	0.4791	0.4839	0.4746	0.4695	0.4496	0.4728	0.4723	0.4743
Sichuan	0.3400	0.3471	0.3496	0.3483	0.3622	0.3781	0.3888	0.3921	0.3940	0.4015	0.3702
Tianjin	0.5178	0.5254	0.5420	0.5502	0.5474	0.5086	0.5001	0.4626	0.4699	0.4773	0.5101
Xinjiang	0.1877	0.1866	0.1817	0.1725	0.1903	0.1929	0.2047	0.2026	0.1915	0.2273	0.1938
Yunnan	0.3101	0.3059	0.3087	0.3146	0.3178	0.3281	0.3336	0.3660	0.3668	0.3682	0.3320
Zhejiang	0.5678	0.5912	0.6021	0.6232	0.6406	0.6845	0.7587	0.8028	0.8111	0.8029	0.6885
Chongqing	0.3683	0.3781	0.3952	0.4073	0.4250	0.4537	0.4729	0.4894	0.5056	0.5405	0.4436
Pilot area average	0.3763	0.3901	0.3949	0.4007	0.4166	0.4310	0.4611	0.4781	0.4832	0.4903	0.4322

Table 2 reports on the sub-regions of the 2012-2021 annual manufacturing green transition index (MGTL). It can be seen that the green transformation of China's manufacturing industry has obvious regional characteristics. The eastern region has a higher level of green transformation of manufacturing industry than the central and western regions due to its developed economy, higher income of residents, rapid technological progress and more willingness and ability of the government to invest in environmental governance. The average industrial green transformation index of the eastern region is 0.4721, which is significantly higher than the average industrial green transformation index of the central region of 0.3985 and the average industrial green transformation index of the western region of 0.3030. Specifically, from 2012 to 2021, Zhejiang, Jiangsu, Guangdong, Tianjin and Shandong were the top five provinces in the industrial green transformation index, all of which were located in the eastern region. The manufacturing industry green transformation index ranks among the top ten in the country, with seven in eastern China and the rest in central Anhui and Hunan. On the whole, the average value of green transition water of manufacturing industry in each year in all provinces of our country has not reached 0.5, which is still far from the maximum value of 1, indicating that the overall green transition level of manufacturing industry in our country is still low. From the sub-annual data, the average value of each year ranges from 0.3642 to 0.4318, showing a slow growth trend, indicating that the green transformation level of manufacturing industry is increasing year by year, but the speed of improvement is slow. From the situation of each province, it can be seen that the overall level of industrial green transformation in the eastern region is relatively high, and the average value is also the highest among the three regions, indicating that the green transformation degree of manufacturing industry is the highest. However, the green transformation level of manufacturing industry in western regions such as Ningxia, Gansu, Xinjiang, Qinghai, etc. is low, with the MGTL value below 0.3.

The explained variable in this paper is the green transformation of manufacturing industry. The green transformation level of manufacturing industry is calculated by constructing the comprehensive index method of green transformation of manufacturing industry, and MGTL (Manufacturing Green

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Transformation Level) is taken as the proxy variable of green transformation of manufacturing industry. The core explanatory variable in this paper is the double difference variable DID. Among them, DIDit=treati×postt, treati represents the green financial policy, with the province taking value of 1 and the rest taking value of 0; Postt indicates the implementation time of the policy, which will be 1 in 2016 and beyond, and the rest will be 0.

So far, this article has carried on the measurement to the manufacturing industry green transformation. In order to further examine the relationship between green financial policy and green transformation of manufacturing industry from an empirical perspective, 2017 is taken as the policy implementation point and the level of green transformation of manufacturing industry is taken as the substitution variable of green transformation of manufacturing industry, and a measurement model is constructed to test the impact of green financial policy on green transformation of manufacturing industry. In June 2017, five provinces, including Zhejiang, Guangdong, Guizhou, Jiangxi and Xinjiang, established green financial reform and innovation pilot zones. When the plan was formally adopted, the effect of the green financial policy was quickly released, and it was reasonable to use the 2017 data as the starting point for policy implementation. In order to effectively alleviate the endogenous problem, this paper uses the green financial policy issued by each province as a data sample as a "quasi-natural experiment" to construct the following double difference model:

$$MGTL_{it} = \alpha DID_{it} + \gamma\ control_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

Among them: MGTLit represents the green transformation level of the manufacturing industry as the explained variable; DIDit represents the core explanatory variable, the policy impact of green financial policy; Controlit represents a set of control variables other than explanatory variables; μi indicates that no time-invariant factors were observed to control the provincial fixed effect; δ_t represents the time fixation effect; εit represents the random interference term of the model; I and t are time and province respectively. According to the results, the provinces in the experimental group and the provinces in the control group are divided, and the virtual variable is treated as the net impact of green financial policy implementation. α is the most concerned coefficient in this paper. If $\alpha > 0$ and the statistics are significant, it indicates that compared with the control group, the provinces that publish green financial policies significantly promote the green transformation and upgrading of manufacturing industry.

4. Empirical Results and Analysis of Green Finance on Green Transformation of Manufacturing Industry

Table 3: Empirical Results of Green Finance on Green Transformation of Manufacturing Industry

	(1)	(2)
variable	MGTL	MGTL
DID	0.0495***(0.00849)	0.0541***(0.00768)
Control variable	no	be
Fixed time	be	be
Fixed provinces	be	be
constant term	0.386***(0.00173)	0.162***(0.0329)
observed value	300	300
R2	0.956	0.965

Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

In order to test the hypothesis of the parallel trend chart, this paper uses the DID method to empirically test the model, divides the sample period by the year of policy implementation, and analyzes the policy effect by comparing the average treatment effect before and after the implementation of the policy. The specific approach is to add the time dummy variable of 2017 for regression, and the results are shown in Table 3. As can be seen from Table 3, the benchmark regression model (1) is regressed by controlling the individual effect and the time effect of the year in the province, and introducing the control variables such as the level of economic development (pgdp), the level of human resources (um), the degree of openness to the outside world (tra) and the degree of government intervention (govi). Tables 3 (1) and 3 (2) are the regression results after controlling both the firm fixed effect and the year fixed effect, without the control variables and after adding the control variables. The regression results show that the regression coefficient of DID is significantly positive, indicating that the green financial reform and innovation pilot zone policy has significantly promoted the green transformation of manufacturing industry. After the implementation of the green financial policy, compared with non-policy areas, the double differential regression results of the average treatment effect in column (1) show that the net effect is 0.0495 at the significance level of 1%, and the double differential regression results of the average treatment effect in column (2) show that the net effect is 0.0541 at the significance level of 1%, which

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means that the green financial policy significantly promotes the green upgrading and transformation of manufacturing industry. The green financial policy has generated the effects of regional agglomeration and capital deepening through green bonds and green credit. It has precisely targeted to enhance the investment and capability of research and development of high-tech and high-tech industries. The net value of high-tech industries has grown by leaps and bounds. It has pushed the manufacturing industry to shift from labor-intensive to capital-and technology-intensive and promoted the vertical deepening development of the industrial structure.

For the double difference model, the experimental group and the control group need to meet the assumption of parallel trend, so the explained variables of the experimental group and the control group are tested for parallel trend. In this paper, the time trend chart of the green transformation index of manufacturing industry at the provincial level in the experimental group (exp) and the control group (con) is drawn. As shown in Figure 1, the horizontal axis represents the year, and the vertical axis represents the green transformation index of provincial manufacturing industry. Figure 1 shows that before the implementation of the green financial policy, the green transformation index of manufacturing industry in the areas where the policy was implemented and the areas where the policy was not implemented basically maintained a parallel trend. After the introduction of the green financial policy, the growth rate of the green transformation level of manufacturing industry in the areas where the policy was implemented began to significantly exceed that in the areas where the policy was not implemented. From 2012 to 2016, the green transformation index of manufacturing industry met the hypothesis of parallel trend.

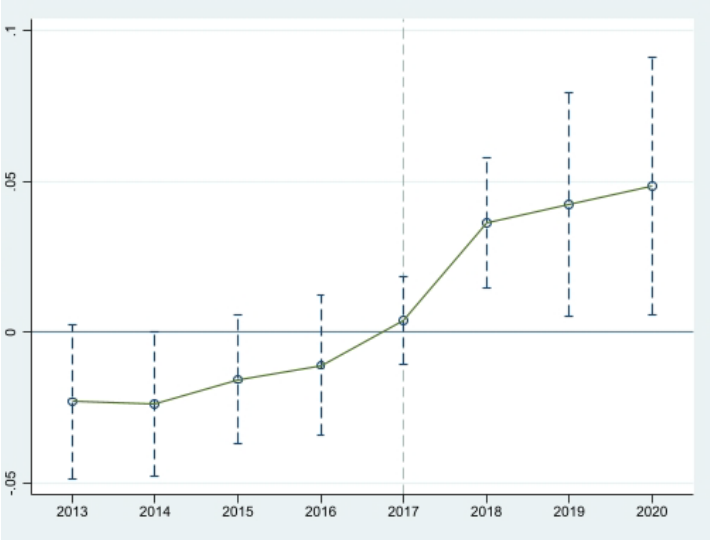

Figure 1: Dynamic effect diagram of parallel trend test

In 2012, the former China Banking Regulatory Commission issued the Green Credit Guidelines, which was the earliest and representative among the green financial policies. Although the introduction of the Green Credit Guidelines does not mean that the green financial policy will be implemented immediately, it does not rule out the nationwide preparations for the implementation of green finance. In order to accurately identify the impact of the introduction of the Guidelines on the development of manufacturing industry, this paper excludes the data from 2012 to 2015, and then returns to Formula 3.1. The DID coefficient of the core explained variable is significant at the level of 1%, and the influence direction of green financial policy on the green transformation and upgrading of manufacturing industry has not changed, indicating that the conclusion of this paper is still stable after excluding the interference of this policy.

5. Main conclusions and policy implications

Based on the panel data of manufacturing industry at the provincial level from 2012 to 2021, this paper constructs a green transformation index of manufacturing industry in provinces and autonomous regions, and takes the five provinces that first joined the green finance experimental zone in 2017 as the sample of the processing group, and uses the double difference method to analyze the promotion effect of green finance policy on green transformation of manufacturing industry. The results show that the

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establishment of the green finance experimental zone can significantly improve the green transformation of regional manufacturing industry.

Based on theoretical analysis and empirical research, the following policy recommendations are put forward:

Improve the green financial system and promote its sustainable development. First of all, we must constantly improve the green financial policy system and strengthen the policy implementation. The basic system of unified standards, norms and statistics of green finance must be continuously developed and improved in accordance with market practice. It needs to be gradually refined and clarified, and has operability. Secondly, the use of policy advocacy, subsidy guidance, tax relief and so on to guide all kinds of capital, especially social capital, to transfer to the green industry, so as to enhance the social main body's internal motivation to commit to the development of green finance. Encourage innovation of green financial products and services and provide diversified green financial products. It is necessary to fully stimulate the enthusiasm of market participants for the innovation of green financial business model in order to effectively improve the performance of green financial business.

Optimize the policy framework to promote the coordinated development of green finance and technological innovation. First, it is possible to consider establishing a joint meeting system of financial departments, science and technology departments and other departments to jointly solve the problem of synergy between green finance and technological innovation under the condition of high economic quality and to improve the top-level design of policies. The second is to strengthen the green financial incentives for technological innovation of enterprises, and use diversified products, low cost and refined services to promote the green technological innovation of enterprises. Third, while developing green finance, it has increased the consideration of green technology innovation and paid attention to the research of its performance, which has effectively guided the transfer of green financial resources to it. According to the level of local economic development and environmental quality, we should avoid the old path of pollution first and treatment first, and make overall plans to determine the direction of key areas of green financial support in order to avoid the waste of resources.

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