

The Impact of Financial Development on the Efficiency of Green Economy

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Abstract

Based on the provincial panel data from 2005 to 2017, Three-stage DEA model and panel threshold model, this paper explores the impact of financial development on the efficiency of green economy. The study found that, on the whole, there is a nonlinear relationship between financial development and green economic efficiency from negative to positive. From the perspective of heterogeneity, there are positive, negative and nonlinear relationships between financial scale, financial structure, financial efficiency and green economy efficiency respectively; The financial development of the eastern region, the central region and the western region can promote the efficiency of green economy, and has a nonlinear relationship of negative first and positive second, as well as a restraining effect.

Keywords

Financial Development; Green Economic Efficiency; Panel Quantile Model.

1. Introduction

The report of the 19th CPC National Congress pointed out that China's economy has shifted from a high-speed growth stage to a high-quality development stage. In order to adapt to the new stage of the economy, we must adhere to quality first, give priority to efficiency, and improve total factor productivity. Therefore, promoting green development and low-carbon development, reducing energy consumption and environmental pollution while economic growth, so as to develop a green economy is the only way to promote the high-quality development of China's economy. As the core of modern economy, the financial industry is the key to the smooth development of every economic activity. Through the transformation of "savings investment", it realizes the allocation of resources, has an important impact on the optimization of industrial structure and technological innovation, and then plays an important role in the development of green economy. Therefore, exploring the relationship between financial development and green economic efficiency, the internal mechanism and heterogeneity of this relationship have important guiding significance for high-quality economic development.

2. Journals Reviewed

Green economic efficiency is the organic unity of resource conservation and good ecology while achieving economic growth (Li Jinlin et al., 2021). While the extensive development mode makes the economy grow at a high speed, the problems of environmental pollution and energy shortage are becoming more and more serious. Green development has become a factor that must be considered in economic development. Therefore, academia has also launched a series of studies on the efficiency of green economy, mainly from the following aspects: first, the measurement of green economic efficiency. Some scholars measure the efficiency of green economy based on parameter method and SFA method, but because SFA method needs to manually set the function form before use, there is great subjectivity, most scholars mainly

based on non parameter method and DEA method, through DEA model Unexpected SBM model and super efficiency SBM model measure the efficiency of green economy (Yang Bin, 2009; Liu Yang and Qin man, 2019; Zhang Tao and Wu Jinshuang, 2021). The second is the analysis of the influencing factors of green economic efficiency. Previous studies have found that the factors affecting the efficiency improvement of green economy mainly include: human capital, industrial structure, financial development, urbanization level, environmental regulation and economic agglomeration (Zhao Lingdi et al., 2016; Yu Wei and Zhang Peng, 2016; Liu Guanchun et al., 2017; Gong Yuanyuan, 2018; Lin Boqiang and Tan ruipeng, 2019)[1].

There are many discussions on the research of financial development on the efficiency of green economy, but there are still differences on the research conclusions of the relationship between the two. The following three viewpoints are mainly formed. First, the improvement of financial development level will significantly promote the efficiency of green economy. Based on the expanded endogenous growth model and China's provincial panel data, Zhang Fan (2017) verified that financial development can promote the growth of green total factor productivity from a theoretical and empirical perspective. Based on the dynamic panel model, Wang Wei and sun Fangcheng (2018) found that the synergy between financial development and environmental regulation in the Yangtze River Economic Belt jointly promotes the growth of green economic efficiency. Xu Zhangyong and Zhu Rui (2020) built a financial development index based on the index system. The study found that financial development promotes the efficiency of green economy by improving the efficiency of green technology and promoting the progress of green technology. Second, financial development will inhibit the efficiency of green economy. Wang xiaoteng et al. (2018) found that in the long run, the excessive improvement of financial efficiency has a negative impact on the efficiency of the green economy. Zhu Guangyin and Wang Simin (2021) found that when the level of human capital is low, financial agglomeration inhibits the improvement of green economic efficiency due to insufficient technology absorption capacity. Third, there is a nonlinear relationship between financial development and green economic efficiency. Liu Yaobin et al. (2017) tested based on the endogenous economic growth model and found that the role of financial deepening on green development may be asymmetric. Gepengfei (2018) found that there is a complex nonlinear relationship between financial development and green TFP. To sum up, the existing literature has actively discussed the green economic efficiency and the relationship between financial development and green economic efficiency, but the conclusions are still inconsistent. Therefore, this paper intends to make further improvements in the following aspects: first, there are few studies on the measurement of green economy efficiency, and the environmental impact is stripped off. This paper uses a Three-stage DEA model to separate environmental impact and random components from efficiency, so as to measure the development level of regional green economy more truly; 2, Further explore the heterogeneity of the impact of financial development on the efficiency of green economy from different levels and regions of financial development, so as to provide a more specific theoretical basis for the development of green economy. The rest of this paper is arranged as follows: the second part is index selection and data sources, the third part is model construction, the fourth part is empirical analysis, and the fifth part is conclusions and policy recommendations[2].

3. Index Selection and Data Source

3.1. Index Selection

3.1.1. Measurement of Green Economic Efficiency

Data envelopment analysis (DEA) is widely used to measure input-output efficiency, mainly because it does not need to set a specific production function, but it implies the assumption of no random error, and has great limitations in dealing with environmental impact factors (Ji

Kewen, 2015). Therefore, after comprehensively considering the advantages and disadvantages of DEA and SFA, Fried et al (2002) combined the two models, A Three-stage DEA model is established, and the effects of random errors and environmental factors on the efficiency value are adjusted at the same time, so as to obtain the more real and effective efficiency value of each decision-making unit. The Three-stage DEA model includes three stages: In the first stage, DEA analysis is carried out based on the original input and output variables. This paper uses the BCC model with variable return to scale to calculate the efficiency value of the first stage of green economy efficiency. In order to realize the comparability of panel data across years, this paper regards the same decision-making unit (DMU) in different years as different DMUs (Xu Yingzhi and Gu Pei, 2019).

$$u_r \geq \varepsilon > 0; v_i \geq \varepsilon > 0; i = 1, 2, \dots, m; r = 1, 2, \dots, s; k = 1, 2, \dots, n \quad (1)$$

Where, x_{ik} , Y_{rk} and represent the i -th input and r -th output of the k -th decision-making unit respectively; V_i and V_r represent the weighting coefficients of the I and R outputs respectively; ε is a set minimum positive number, which ensures that all input-output items obtain positive weights; H_k represents the efficiency value of the k th decision-making unit, which is a relative efficiency; U_k refers to the return to scale index. Through the first stage DEA analysis, the green economy efficiency value of each decision-making unit is obtained, and the input slack (the difference between the actual input and the input under the best efficiency) is also obtained[3]. The second stage is stochastic frontier analysis (SFA). The SFA model is constructed by the input relaxation variables and environmental variables obtained from the above analysis. Assuming that there are p observable environmental variables, the input relaxation variables of each decision-making unit are analyzed by SFA.

3.2. Measurement of Financial Development Level

At present, the measurement of financial development mainly includes two kinds of methods: one is the single index method, and the other is the multi-index method, which constructs the financial development index system and calculates the comprehensive index of financial development. In view of the availability of data and the comprehensiveness of index construction, this paper uses the multi index method to construct the financial development index based on the perspective of financial scale, financial efficiency and financial structure. Learn from Jia Hongwen and Zhao Mingming(2020), etc., financial scale is expressed by the ratio of the sum of loan balance and stock market value to GDP, financial efficiency is expressed by the ratio of loan balance to deposit balance, financial structure is expressed by the ratio of loan balance to stock market value, and then the comprehensive index of financial development is calculated by entropy method[4].

3.3. Control Variable

3.3.1. Degree of Openness

The international trade policy and degree of openness of an economy will have a significant impact on the allocation of capital, technology, resources, etc., thus affecting the economic development of a region. This paper measures the degree of opening to the outside world by the proportion of the total import and export volume of goods of each province (according to the domestic destination and source region) in GDP. The total import and export volume is converted into RMB according to the annual average exchange rate of RMB against the US dollar in that year.

3.3.2. Technology Level (Tech)

On the one hand, the improvement of technology level can promote resource utilization and speed up production efficiency; On the other hand, it can reduce the emission of pollutants, reduce environmental damage, and then significantly promote the efficiency of green economy. This paper uses the number of patent applications per thousand R & D personnel in each province to measure the technical level.

3.3.3. Industrial Structure (Is)

The three industries have great differences in factor input, energy consumption, environmental pollution and so on. Therefore, the differences in industrial structure between provinces will inevitably lead to a certain gap in the development level of green economy. The secondary industry led by industry needs to invest a lot of resources and energy, causing serious environmental pollution, and accounts for a large proportion in the economy, which will significantly inhibit the efficiency of green economy. Therefore, this paper selects the proportion of the output value of the secondary industry to GDP to express the industrial structure.

3.3.4. Foreign Direct Investment (FDI)

On the one hand, FDI inflow will bring advanced production technology to the host country and improve production efficiency. At the same time, through the demonstration imitation effect, it will promote the level of green technology in the host country, reduce environmental pollution and promote green economic efficiency; On the other hand, foreign direct investment will transfer industries with high energy consumption and high pollution to the host country, forming a "pollution paradise" effect and inhibiting the efficiency of green economy. This paper measures the level of foreign direct investment by using the ratio of total foreign direct investment to GDP in each province every year, and converts it into RMB according to the annual average exchange rate of RMB against the US dollar in that year.

3.3.5. Human Capital Level (HC)

On the one hand, the development of human capital can promote the development of clean technology and green technology, and greatly reduce the degree of environmental pollution; On the other hand, human capital has significantly improved production efficiency. Under the background of continuous technological innovation, people can use less resources to produce more products, which greatly reduces the waste of resources and significantly improves production efficiency. This paper measures the proportion of the number of students above high school in each province in the total population of the region at the end of the year. Among them, the number of students above high school is high school and this college. The sum of the number of students in school.

3.3.6. Environmental Planning (ER)

According to the "Porter Hypothesis", appropriate environmental regulation is conducive to enterprises to reduce environmental pollution, increase innovation activities, enhance product competitiveness, and then promote the development of green economy. Others believe that environmental regulation may increase the cost of pollution control and squeeze innovation investment, resulting in a decline in economic efficiency and a waste of resources, which is not conducive to the improvement of the efficiency of the green economy. This paper measures environmental regulation by the proportion of the comprehensive utilization of industrial solid waste in the discharge of industrial solid waste.

3.4. Data Source

Due to the serious lack of data, the sample only includes the panel data of 30 provinces in China from 2005 to 2017 (excluding Tibet, Hong Kong, Macao and Taiwan). The data used are mainly from China Statistical Yearbook, China Financial Statistical Yearbook, statistical bulletin of

foreign direct investment, and the National Bureau of statistics. All time value variables are converted based on 2005, and the missing data are passed Average value or interpolation method.

4. Model Construction

4.1. Model Construction

In order to explore the possible nonlinear relationship between financial development and green economic efficiency, this paper uses the panel threshold model constructed by Hansen (1999). Taking the comprehensive index of financial development as the threshold variable, the threshold value is determined and different financial development levels are divided by automatically identifying the data. The panel threshold model is established as follows:

$$GEE_{it} = \alpha_1 FD_{it} I(FD_{it} < \gamma_1) + \alpha_2 FD_{it} I(FD_{it} < \gamma_2) + \dots + \alpha_{n+1} FD_{it} I(FD_{it} \geq \gamma_n) + \alpha_0 X_{it} + \mu_i + \varepsilon_{it} \quad (2)$$

When using panel threshold model for empirical research, first of all, we should test the existence of threshold effect, determine the number of threshold values and estimate the threshold values, and establish an appropriate threshold effect model. Given any threshold γ , The estimated value of each parameter can be obtained by summing the squares of the residuals:

$$\hat{\gamma} = \arg \min S_1(\gamma) \quad (3)$$

4.2. Characteristic Facts

On the whole, the efficiency of China's green economy is on the rise, with an increase of 52.98% in 2017 compared with 2005, indicating that while pursuing economic development, all provinces should try their best to avoid the waste of resources and environmental pollution. From the comparison of various regions, the eastern region has the highest average efficiency, which is significantly better than the central and western regions, which indicates that the development of green economy among regions in China is uneven, showing significant regional differences, which may be related to the differences in the level of financial development, industrial structure, government supervision and other aspects in various regions. This feature of green economic efficiency needs to be further verified by empirical analysis.

5. Empirical Analysis

5.1. Benchmark Regression

5.1.1. Threshold Effect Test

Taking the financial development composite index as the threshold variable, the threshold estimation is carried out under the assumptions of single threshold, double threshold and triple threshold. Table 3 gives the F statistics and P values of the threshold effect test. It can be seen from the estimation results that the p value of the single threshold test of the financial development composite index is 0.0100, which means that the original assumption is rejected at the significance level of 1%, that is, there is a single threshold; The double threshold and triple threshold tests failed to pass the significance test. Therefore, there is only a single threshold for determining the impact of financial development on the efficiency of green economy, and the threshold estimate is 0.3028.

With the passage of time, China's financial development level has been greatly improved. From 2005, only Beijing and Guangdong were in the high-level stage of financial development, to 2017, eight provinces entered the high-level stage of financial development, which is consistent with the changing trend of green economic efficiency over time in the characteristic facts. It can be seen that there is a high correlation between financial development and green economic efficiency, but the specific causal relationship between the two needs to be further verified.

5.1.2. Threshold Model Estimation

When the comprehensive index of financial development is lower than the threshold value of 0.3028, financial development has an inhibitory effect on the efficiency of green economy; When finance develops.

When the composite index is higher than the threshold value of 0.3028, financial development can promote the efficiency of green economy. This result verifies that there is a nonlinear relationship between financial development and green economic efficiency from negative to positive. The reason is that the environmental effects brought by financial development are mainly divided into scale effect, technology effect and structure effect (Yan Chengliang et al., 2016; Chen Biqiong and Zhang Liangliang, 2014). For the less developed financial system, the financing scale is limited and the capital liquidity is low, which can not alleviate the liquidity risk caused by new technology R & D investment, and can not provide long-term financial support for enterprises, and the technical effect of financial development is reduced; Moreover, the existence of objective factors such as technical defects and incomplete supervision system makes financial institutions fail to fully grasp enterprise information, resulting in information asymmetry between the supply and demand sides of funds. On the one hand, this will lead to adverse selection before financing, and invest funds in enterprises with high pollution and high consumption. On the other hand, it brings moral hazard after financing. In order to pursue short-term economic benefits, enterprises invest in high pollution projects, which aggravates environmental pollution and resource waste. The scale effect is far greater than the structural effect (Xu Zhangyong and Zhu Rui, 2020). Therefore, at this stage, financial development has a significant inhibitory effect on the efficiency of green economy. The developed financial system can effectively disperse risks, provide larger-scale financing, promote R & D and technological innovation, and give full play to technological effects; Moreover, the mature stock market and perfect supervision system have reduced the adverse selection in advance and fully played the post supervision function of financial institutions, thus promoting the rational allocation of funds to high-efficiency industries, and the structural effect is greater than the scale effect (Huang Jianhuan et al., 2014). Therefore, the improvement of the level of financial development at this stage has significantly promoted the efficiency of green economy.

For other control variables, the degree of opening-up is negative at the significant level of 1%, which indicates that at this stage, opening-up does not give full play to the advantages of improving production technology and optimizing industrial structure, but over relies on international trade and ignores strong domestic demand.

It is easy to form technology dependence, reduce innovation activities, and have a negative impact on the efficiency of green economy; The technology level is positive under the significance level of 1%, which shows that technological innovation is an important driving force for the improvement of green economy efficiency, which promotes the development process of green economy by reducing environmental pollution and increasing resource utilization efficiency; The industrial structure is negative at the significant level of 5%, which is consistent with most literature conclusions. The secondary industry is dominated by industry, and there are major problems in environmental pollution, resource consumption and so on. Further optimize the industrial structure, increase the proportion of the tertiary industry, and weaken the dominance of the secondary industry in the economy.

Status is an important measure to promote green economic development; Human capital is positive at the significance level of 1%, which shows that human capital in all provinces has given full play to the role of promoting the research, development, absorption and application of advanced green technologies, and has improved the efficiency of green economy from the aspects of energy conservation, emission reduction and productivity improvement; Environmental regulation is positive at the significance level of 1%, which shows that the strengthening of environmental regulation strengthens the government's supervision over enterprises, forces enterprises to carry out technological innovation, promotes the upgrading of industries, and then improves the efficiency of green economy, which verifies the "Porter Hypothesis", which is consistent with the conclusions of Hu Anjun et al. (2018). The level of foreign capital utilization failed to pass the significance test, which may be because the inflow of foreign direct investment into the host country will promote technological innovation through imitation demonstration effect, and then promote the efficiency of green economy; At the same time, there is a "pollution paradise" effect, which inhibits the efficiency of the green economy, and the two effects offset, so that the inflow of foreign direct investment has no significant impact on the efficiency of the green economy.

5.1.3. Robustness Check

In order to further investigate the robustness of the regression results, this paper re measures financial development. The important manifestation of financial development is the gradual deepening of financial deepening. Therefore, this paper uses the financial deepening rate index of "the proportion of loan balance in GDP of each province" to measure financial development. From the regression results, we can see that there is a single threshold between financial development and green economic efficiency, and there is a nonlinear relationship between them, from negative to positive. This result is consistent with the benchmark regression, which verifies the robustness of the conclusion.

The impact of financial scale on the efficiency of green economy has a double threshold effect, when the financial scale is lower than the first threshold value of 0.0800 financial scale has a significant inhibitory effect on the efficiency of green economy; When the financial scale is between 0.0800 and 0.3900, gold ,financial scale has a significant role in promoting the efficiency of green economy; When the financial scale crosses the second threshold of 0.3900, the impact of financial scale on the efficiency of green economy is not significant, but it is still negative. This shows that in the process of financial scale expansion, there is an optimal value. Only by reasonably expanding the financial scale can we promote the efficiency of green economy. This is mainly because, in the early stage of financial development, the blind expansion of financial scale led to the reduction of financial efficiency, which could not effectively drive the improvement of economic efficiency and the upgrading of industrial structure, and had a restraining effect on the efficiency of green economy; When the financial scale is too large, the financial scale develops to the saturation level, and the driving effect of the financial scale decreases marginally, which has a negative impact on the efficiency of the green economy (Wang Haohan and Pan Yuan, 2018).

The impact of financial structure on the efficiency of green economy also has a double threshold effect. In the three stages, the impact of financial structure on the efficiency of green economy is significantly negative. This may be because, at present, China still allocates funds to various industries and departments mainly through the banking system, and the mismatch between the banking industry and the real economy makes the optimal industrial technology structure determined by the financial structure and the factor endowment structure inconsistent Matching, which leads to the financial system can not effectively promote the industrial technology effect, reducing economic efficiency; At the same time, in the context of the development of green economy, environmental constraints further increase the financial constraints of enterprises, which is not conducive to the environmental governance behavior

of enterprises, which may aggravate environmental pollution and have a negative impact on the efficiency of green economy (Zheng Jie et al., 2021).

Financial efficiency has a single threshold effect on the efficiency of green economy. When financial efficiency is lower than the threshold, financial efficiency has a significant inhibitory effect on the efficiency of green economy; When financial efficiency crosses the threshold, financial efficiency has a significant role in promoting the efficiency of green economy. This is mainly because the early banking institutions blindly expanded the scale of loans and ignored the quality of loans, resulting in the false high deposit loan ratio and the failure to upgrade the industrial structure; When financial efficiency reaches a high level and loans are effectively converted into social investment capital, financial efficiency significantly promotes industrial upgrading (Wang Haohan and Pan Yuan, 2018). Therefore, there is an "inverted U" relationship between financial efficiency and environmental pollution (Hu Zongyi and Li Yi, 2019), and there is a nonlinear relationship between financial efficiency and green economic efficiency from negative to positive.

Characteristic facts and threshold distribution show that there are significant regional differences between China's financial development and green economic efficiency in different regions and provinces. In order to further reveal the possible regional heterogeneity in the relationship between financial development and green economic efficiency, this paper divides the samples into eastern, central and western regions for comparative analysis.

In the eastern region, the impact of financial development on the efficiency of green economy has a double threshold effect. At any stage of financial development, financial development has a significant role in promoting the efficiency of green economy. With the improvement of the level of financial development, this role is gradually enhanced. This may be because the long-term support policies for the financial industry and the rapid economic development in the eastern region have led all provinces to enter a high level of financial development. This stage provides sufficient financial support for the absorption, digestion and even re innovation of OFDI reverse technology spillover effect (Zhang Zhihua and Sun Lin, 2022), which plays an obvious role in promoting the efficiency of green innovation in the region. Moreover, at this stage, the "technological effect" is greater than the "scale effect", and the improvement of the level of financial development has significantly reduced the degree of environmental pollution (Hu Zongyi and Li Yi, 2019). Therefore, in the whole sample period, the financial development in the eastern region has a driving effect on the efficiency of green economy.

In the central region, the impact of financial development on the efficiency of green economy has a single threshold effect, and the two have a nonlinear relationship from negative to positive. This may be because the distribution of the financial development level of provinces and cities in the central region is consistent with the overall sample, and there are provinces and cities with higher and lower financial development levels, so it shows a conclusion consistent with the overall sample.

In the western region, there is a single threshold effect in the impact of financial development on green economic efficiency. Throughout the sample period, financial development has a significant inhibitory effect on green economic efficiency, but this inhibitory effect shows a downward trend with the rise of financial development level. This may be because the overall level of financial development in the western region is low. In order to pursue a single economic growth, a large amount of funds are used for industrial production with serious pollution. With the improvement of the level of financial development, the production scale is gradually expanded, energy consumption is increased, pollutant emissions are increased, and the "scale effect" of financial development is dominant. Therefore, financial development has a significant inhibitory effect on the efficiency of green economy.

6. Conclusion and Policy Recommendations

6.1. Conclusion

Using the panel data of 30 provinces in China from 2005 to 2017, this paper calculates the green economic efficiency of economic growth and environmental protection using a Three-stage DEA model, and explores the impact of financial development on green economic efficiency. The main conclusions are as follows.

6.1.1. There is a Single Threshold Effect between Financial Development and Green Economic Efficiency

When the level of financial development is low, financial development has a significant inhibitory effect on the efficiency of green economy; When the level of financial development is high, financial development can significantly promote the efficiency of green economy. It shows that China should pay attention to the improvement of financial development level, reasonably plan and build a perfect financial market, so that the role of Finance in promoting the efficiency of green economy can be brought into play to a greater extent.

6.1.2. Different Levels of Financial Development have Different Effects on the Efficiency of Green Economy

Financial scale has a double threshold effect on the efficiency of green economy. Only when financial scale is between the two thresholds, can financial scale significantly promote the efficiency of green economy. The impact of financial structure on the efficiency of green economy also has a double threshold effect, but in the three stages, the impact of financial structure on the efficiency of green economy is significantly negative. Financial efficiency has a significant single threshold effect on the efficiency of green economy, and there is a nonlinear relationship between the two. This shows that when promoting financial development, China should appropriately expand the financial scale to achieve the optimal value, reasonably plan the financial structure, and pay attention to the continuous improvement of financial efficiency, so as to give full play to the role of financial development in promoting the efficiency of green economy.

6.1.3. There are Great Differences in the Relationship between Financial Development and Green Economic Efficiency in Different Regions

In the eastern region, the impact of financial development on the efficiency of green economy has a double threshold effect. At any stage of financial development, financial development has a significant role in promoting the efficiency of green economy. With the improvement of the level of financial development, this role gradually increases Strong. In the central region, the impact of financial development on the efficiency of green economy has a single threshold effect, which shows a nonlinear relationship from negative to positive. In the western region, there is a single threshold effect in the impact of financial development on green economic efficiency. Throughout the sample period, financial development has a significant inhibitory effect on green economic efficiency, but this inhibitory effect shows a downward trend with the rise of financial development level. Therefore, when promoting financial development to achieve its positive impact on the efficiency of green economy, we should formulate different policies according to the stage of different regions.

6.2. Policy Recommendations

To sum up, the policy recommendations given in this paper are to reasonably promote the improvement of the level of financial development at this stage, and pay more attention to the improvement of "quality" while improving the "quantity" growth of financial development. At the same time, the differences in local economy, resource endowment, industrial structure and

other aspects should be taken into account in the development process to prevent the negative impact of the "one size fits all" policy.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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