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Adjustment Effect and Optimization Strategy of Credit Structure under the Double Carbon Goal—Research Based on the Power Industry

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Abstract

This paper focuses on the power industry in China, through the construction of production function model, solves the optimization problem of high-carbon and low-carbon enterprises in power industry, and discusses the adjustment and optimization strategy of credit structure in it. The highlight of the article is to look at the impact of the inclination of credit resource allocation to the green and low-carbon field from a more holistic and dialectical perspective. Research shows that the credit mortgage rate adjustment policy is more conducive to the withdrawal of backward production capacity in high-carbon industries, while the interest rate policy is more conducive to expanding production capacity by supporting technological progress in new industries. When adjusting the high-carbon and low-carbon credit interest rates, adopting the "small-then-large" interest rate adjustment path with a gradually increasing range is more conducive to realizing the industrial structure adjustment and ensuring the power capacity supply at the same time. Therefore, in order to avoid the phenomenon of "moving carbon reduction" under the dual carbon goal, banks can consider the strategy of "focusing on interest rate instruments in the early stage and mortgage rate control in the middle and late stages" when formulating credit policies for the power industry, so as to help better realize the continuous transformation of old and new kinetic energy under the dual carbon goal.

Keywords

Low Carbon Transformation, Credit Resource Allocation, Credit Structure, Power Industry Production, Function Model

1. Introduction

1.1. Research Background

China has formally made a commitment to the world to "strive to peak carbon dioxide emissions by 2030 and strive to achieve carbon neutrality by 2060". All regions and industries are actively deploying the "double carbon" target action plan. With the transformation and adjustment requirements of economic and industrial structure, the allocation of financial resources in high-carbon and low-carbon industries is also undergoing structural changes. However, we must beware of sports carbon reduction. From the actual situation, many high-carbon industries still play an important supporting role in economic and social development. Bank credit has a significant impact on the production and operation of all industries. If the credit policy adjusts the credit resource allocation structure between high-carbon and low-carbon industries excessively or too quickly, it is likely to affect the smooth operation of relevant industries and even the economic system.

Electric power is a pillar industry for economic and social development, and thermal power is also a key industry for carbon reduction and control, the replacement of thermal power by clean power has been widely concerned. Therefore, in this paper, focusing on the power industry, we analyze the future power market demand under different transformation and development scenarios. And then we build a production function model to simulate the impact of the credit allocation structure of the power industry on the total power output under different adjustment strategies, calculate the possible output fluctuations, and at last discuss the adjustment and optimization strategy of the credit structure of the power industry.

1.2. Literature Review

The previous literature mainly focused on the research of green credit policy in the international banking industry. Scholtens & Dam (2007) found that green finance can guide enterprises' green business behavior, improve their awareness of social responsibility and also help to improve a bank's reputation. Among green financial instruments, banking credit plays a more direct and effective role. Nandy & Lodh (2012) found that the green credit behavior of banks has promoted the development of social financing subjects to be environment-friendly, based on the empirical research on 3153 bank loans of 1026 companies. Schafer (2017) starting from the green transformation needs of small and medium-sized manufacturing industries in Germany, believes that due to financial and technological constraints, the green financial services of the German banking system have limited support for the green transformation of small and medium-sized manufacturing industries. Kang et al. (2019) found that the green credit policy has effectively promoted the manufacturing manufacturers to improve their pollution reduction capabilities by providing incentives. based on the research on the Korean banking industry.

After China proposed the concept of green development in 2015, research on green finance has developed rapidly. Song (2016) uses a CGE model to study the transmission path and short, medium and long-term impact of China's green credit policy, and believed that the green credit policy can effectively inhibit the investment and output of "two high and one surplus" industries in the short and medium term, but in the long run, the rigid demand for exports and investment has affected the structural adjustment effect of the green credit policy. From the perspective of green credit, He et al. (2019) used an empirical study of 150 renewable energy companies in China to find that through the allocation of credit resources, green credit promotes capital investment in renewable energy industry, thereby significantly improving the green economic development index. Wang et al. (2019) used the DSGE model to compare and analyze the mechanism and effect of the three green credit incentive policies of green credit discount, targeted reserve requirement reduction and refinancing in China, and found that the three policies can produce obvious incentive effect, significantly promote the increase of the scale of green credit, and then effectively increase the output of green projects and reduce the total amount of pollution emissions, Among them, the effect of green refinancing policy is more significant. Zheng (2020) used the DEA model to study the impact of green credit on the development of green economy. The results showed that on the whole, green credit investment had a positive effect on the development of green economy, but it did not achieve scale effectiveness in individual years.

The inadequacy of the existing literature is that when evaluating the effect of green credit policy, it is more from the positive role of green credit in promoting the development of green economy and green industry. Obviously, it is ignored that with the transformation of the allocation structure of financial resources, the economic benefits are antagonistic. Promoting the development of low-carbon industries will also have a restraining effect on high-carbon industries, so the comprehensive impact on the overall economic industry needs to be reconsidered. Therefore, the innovation and highlight of this paper is to look at the impact of the inclination of credit resource allocation to the green and low-carbon field from a more holistic and dialectical perspective. Through setting the scenarios of different adjustment strategies of credit structure, simulate and calculate the changes of total output, and then take the balance of supply and demand as the starting point to explore a more scientific and reasonable adjustment and optimization strategy of credit structure.

2. Future Demand and Transformation Scenario of Power Industry

2.1. Factors Affecting Future Electricity Market Demand

The first important factor is to support the power demand for high-quality economic growth. The rapid development of modern industry, the continuous promotion of new urbanization and Rural Revitalization strategies will drive the growth of power demand. At the same time, the digital economy and digital technology has promoted the accelerated construction of the smart energy system centered on electricity, and promoted the deep integration of electrification, industrialization and informatization. The increasing demand for information and communication, e-commerce, intelligent services, as well as the construction of "new digital infrastructure" such as 5G base stations and big data centers, will produce greater power intensity and further increase the demand of the power market. Electricity plays an increasingly important role in supporting high-quality economic growth. If other factors such as technological progress are not considered, the demand of power market will increase synchronously with economic growth.

Secondly, the goal of green and low-carbon development promotes the transformation of energy structure to "electricity substitution". With the strengthening of environmental pollution control and the requirements of low-carbon development, China has actively promoted the structural reform of the energy supply side. One of the major measures is to improve the electrification level of terminal energy consumption, that is, to strengthen the "substitution of electricity for coal" and "substitution of electricity for oil" in terminal energy consumption, especially in key industries such as industry, construction and transportation. At present, China's electric energy accounts for nearly 27% of terminal energy consumption. According to the State Grid, by 2025 and 2030, the proportion of electric energy in terminal energy consumption will be more than 30% and 35% respectively. The improvement of electrification will also lead to the continuous increase of power demand.

Thirdly, technological progress will help slow down the growth of power demand. With technological progress, the level of energy efficiency, that is, the efficiency of converting terminal energy into effective energy services, will be improved. Theoretically, when the improvement rate of power efficiency level exceeds the growth rate of actual power demand, the total terminal power demand will decline. In addition, the technological progress of non electric clean energy such as hydrogen energy and biomass energy will gradually promote the substitution of such energy for electric energy. Therefore, the progress of energy conservation and energy use technology may slow down the growth of power demand to a certain extent.

2.2. Power Demand under the Transformation Scenario of Terminal Energy System

Considering emission reduction targets, terminal energy structure, technological progress and other factors, three transformation scenarios are set. Meeting the needs of high-quality economic development in the future, the State Grid builds an economic energy environment integration model, and predicts the changes of the electricity demand of the whole society in the next 40 years under the three scenarios (**Figure 1**).

Under the conventional transformation scenario, the substitution of electric energy is advancing steadily, the level of energy efficiency is improving steadily, and the power demand is also showing a steady upward trend. Under the accelerated electrification scenario, the promotion of electric energy substitution accelerates, the electrification level of the whole society continues to rise rapidly, and the growth of power demand is greater than that in the conventional transformation scenario. The deep emission reduction scenario is based on the electrification acceleration scenario. In addition to the rapid rise of electrification level, energy conservation, energy consumption and non-electric clean energy technologies have also been greatly improved, which promotes the continuous improvement of energy efficiency and slows down the growth of power demand. Therefore, the power demand curve under the deep emission reduction scenario is below the electrification acceleration scenario, and there is a downward trend after 2050.

After all, the high-quality economic and social development and the improvement of the electrification rate of terminal energy have a greater and more direct impact on power demand, while the mitigation effect of the improvement of energy efficiency brought by technological progress on power demand will take a long time to show. Therefore, power demand will maintain a relatively high growth rate until 2030. From the electricity demand data in **Figure 1** we can calculate that the average annual growth rate of electricity demand in the whole society will be around 4% in the next 10 years.

2.3. Clean Transformation of Power Structure

The contribution of the power sector to carbon emission reduction is reflected in two aspects, and on one hand, to improve the electrification level of terminal energy consumption and replace the direct use of terminal fossil energy. On the other hand, in order to improve the cleaning rate of power structure, that is, gradually replace traditional thermal power generation with hydropower, wind power, nuclear power, photovoltaic power generation, etc., so as to reduce the use of fossil energy in power generation. In recent years, the total investment and installed capacity of China's four clean energy sources have shown a rapid growth trend (**Figure 2**). Clean energy has also become a key supporting area of green credit for banks. According to The People's Bank of China, by the end of 2020, the loan balance of clean energy industry was 3.2 trillion yuan, an increase of 13.4% over the beginning of the year, accounting for about 27% of the balance of green loans.

Although clean power transformation can effectively reduce carbon dioxide emissions in power production, clean power generation depends heavily on geographical conditions and resource endowments, and the development, utilization, energy storage and other related technologies of clean energy still need to

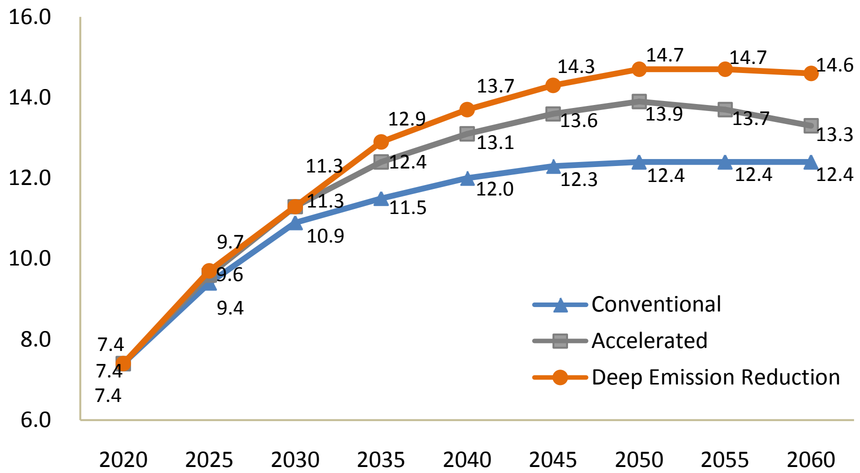

Figure 1. Electricity demand in the future (Unit: Trillion KW·h). Data source: State Grid Energy Research Institute, "China's energy and power development outlook 2020".

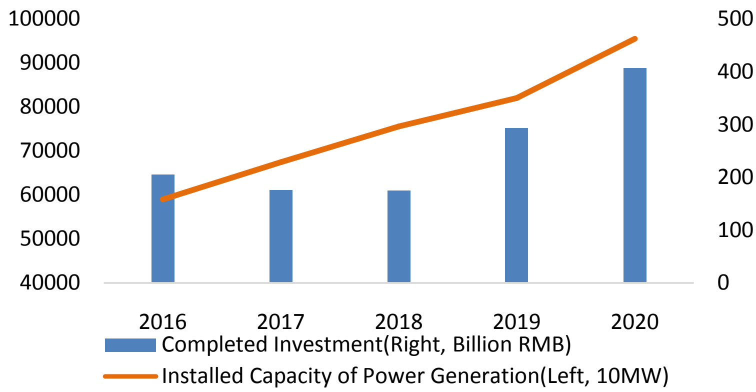

Figure 2. Total investment & installed capacity of the four clean energy sources. Data source: China Power Statistical Yearbook, National Energy Administration.

be improved. According to the statistics of the national energy administration, although the current installed capacity of clean power sources accounts for more than 40% of the total installed capacity of power sources, the actual power generation accounts for only about 30%. Facing the steady growth of social electricity demand in the future, thermal power may still play a supporting role in power supply for a long time, and the transformation of clean power supply needs to be carried out step by step.

3. Model Derivation of Credit Structure Adjustment in Power Industry

Under the dual carbon goal, bank credit policies need to support the low-carbon transformation and development of the power industry on the basis of meeting social electricity demand. Theoretically, banks can actively adjust the structure of credit resources through the mortgage rate and loan interest rate of enterprises. Raising or reducing the mortgage rate means that the bank's credit policy is loose or tight, and the amount of credit will increase or decrease accordingly. When the bank raises or lowers the loan interest rate, the credit policy will be tightened or relaxed accordingly, and the credit supply will be reduced or increased. The effect of banks' adjustment of credit supply structure through mortgage rate and interest rate may be different. Therefore, by constructing the production function of high-carbon and low-carbon electronics industry, solving its optimization problem under credit constraints, establishing the relationship between bank credit structure adjustment and industrial output changes, and then simulating the effect of policies.

The power industry has the typical characteristics of resource intensive and technology intensive. Different from the industry monopoly characteristics of transmission and distribution and dispatching, power generation and sales are close to the market form of full competition. The power industry is distinguished by high-carbon and low-carbon standards, so the high-carbon power industry refers to the traditional thermal power industry, and the low-carbon power industry refers to the new power generation industry dominated by "wind, water and nuclear power". The total output (power generation) of the power industry is the sum of the output of each sub industry,

$$Y = Y_H + \sum Y_L^i \tag{1}$$

Among them, Y is the total output of the power industry, Y_H is the output of the high-carbon thermal power industry, and Y_L^i is the output of class i (wind, light, water, nuclear) which are the low-carbon thermal power industry. As a power production department in the economy, power manufacturers convert production factors into final output to provide products and services consumed or saved by residents. For each sub industry, given the production function

$$Y_{i,t} = A_{i,t} f\left(K_{i,t}, L_{i,t}\right) \tag{2}$$

where, $A_{i,t}$ is the total factor productivity of industry i, representing the technical level, $K_{i,t}$ and $L_{i,t}$ are respectively the capital and labor factor inputs of industry i. In this paper, in a perfectly competitive market environment, manufacturers face the problem of maximizing profits in each period under given technology and financing constraints, that is

$$\max \Pi_{i,t} = P_{i,t}Y_{i,t} - W_{i,t}L_{i,t} - R_{i,t}K_{i,t} - \left(i_{i,t} - 1\right)D_{i,t} - T_{i,t} \tag{3}$$

where, $\Pi_{i,t}$ is the corporate profits of industry i, and Cobb Douglas function is adopted as the production function of power enterprises, which is $Y_{i,t} = A_{i,t}K_{i,t}^{\alpha_i}L_{i,t}^{\beta_i}$. Assume production follows Hicks neutral. $P_{i,t}$ refers to the production product price of enterprises in industry i, and here we use the power grid price. $W_{i,t}$ and $R_{i,t}$ are the prices of enterprise labor and capital factors in industry i, $D_{i,t}$ is the credit obtained from banks for industry i enterprises. $i_{i,t}$ is the cost of bank credit capital for industry i enterprises. Therefore, $\left(i_{i,t} - 1\right)D_{i,t}$ is interest expenditure and $T_{i,t}$ is tax expenditure.

The exogenous technology level $A_{i,t}$ follows an AR (1) process, which is

$\log\left(A_{i,t}\right)=\rho_i\log\left(A_{i,t-1}\right)+\varepsilon_{i,t}$, where $-1<\rho_i<1$, ensuring the convergence of the path of technology evolution. At the same time, enterprises face credit constraints,

$$D_{i,t}\le\gamma_i\frac{\left(1-\delta_i\right)K_{i,t}}{i_{i,t}} \tag{4}$$

When the enterprise's own capital is insufficient, it can obtain credit funds from the financial sector to supplement production, and the amount of credit funds obtained is a certain proportion of its capital stock, which is γ_i, also the mortgage rate or loan to value ratio (LTV). The higher the index value is, the looser the bank's credit policy to enterprises and the larger the bank's credit line. δ_i is the capital depreciation rate of industry i enterprises.

Lagrange function is constructed to solve the optimization problem. Enterprises determines $K_{i,t}$, $L_{i,t}$, $D_{i,t}$, and get the first-order conditions as follows,

$$P_{i,t}\alpha_iA_{i,t}K_{i,t}^{\alpha_i-1}L_{i,t}^{\beta_i}-R_{i,t}-\lambda_{i,t}\left[\gamma_i\left(1-\delta_i\right)\frac{1}{i_{i,t}}\right]=0 \tag{5}$$

$$P_{i,t}\beta_iA_{i,t}K_{i,t}^{\alpha_i}L_{i,t}^{\beta_i-1}=w_{i,t} \tag{6}$$

$$i_{i,t}-1=\lambda_{i,t} \tag{7}$$

The above expressions are element requirement expressions. The logarithmic linearization method is used to carry out the first-order approximate expansion, ignoring the change of labor input, and the expression of the change rate of each variable is sorted out as follows.

$$\widetilde{Y_{i,t}}=\rho_{1i}\widetilde{R_{i,t}}+\rho_{2i}\widetilde{A_{i,t}}+\rho_{3i}\widetilde{i_{i,t}}+\rho_{4i}\widetilde{P_{i,t}} \tag{8}$$

where, $\rho_{1i}=\frac{\alpha_i\Delta_{2i}}{\Delta_{1i}\alpha_i-\Delta_{2i}-\Delta_{3i}+\Delta_{4i}}$, $\rho_{2i}=\frac{\Delta_{4i}-\Delta_{2i}-\Delta_{3i}}{\Delta_{1i}\alpha_i-\Delta_{2i}-\Delta_{3i}+\Delta_{4i}}$, $\rho_{3i}=\frac{-\alpha_i\left(\Delta_{1i}-\Delta_{2i}-\Delta_{3i}\right)}{\Delta_{1i}\alpha_i-\Delta_{2i}-\Delta_{3i}+\Delta_{4i}}$, $\rho_{4i}=\frac{-\alpha_i\Delta_{1i}}{\Delta_{1i}\alpha_i-\Delta_{2i}-\Delta_{3i}+\Delta_{4i}}$, $\Delta_{1i}=\alpha_i\overline{i_iY_iP_i}$, $\Delta_{2i}=\overline{i_iK_iR_i}$, $\Delta_{3i}=\gamma_i\left(1-\delta_i\right)\overline{i_iK_i}$, $\Delta_4=\gamma_i\left(1-\delta_i\right)\overline{K_i}$.

The economic meaning of formula (8) is that the output fluctuation of each sub industry can be expressed as a linear expression of the changes in the rate of return on capital, technological progress, loan interest rate and the price of finished products. According to the following calculation, $\rho_{1i}>0$, $\rho_{2i}>0$, $\rho_{3i}<0$, $\rho_{4i}<0$, which means that with the improvement of the industrial capital return, the efficiency of technological progress and the decline of the price of finished products, the output also increases. When banks raise the loan interest rate (i.e. the cost of using funds) by changing, enterprises may reduce their output due to reducing investment. Banks adjust the credit structure by adjusting the loan interest rate $i_{i,t}$ and mortgage rate γ_i of each sub industry. The adjustment of loan interest rate will directly bring changes in output, and the adjustment of loan mortgage rate will affect output by changing the coefficients $\left\{\rho_{1i},\rho_{2i},\rho_{3i},\rho_{4i}\right\}$.

Finally, we take the proportion of power generation of each sub industry as the weight to sum up and describe the fluctuation of the total output of the power industry. The proportion of power generation in the previous period is used as the current weight for dynamic weight calculation, which is $w_{i,t} = Y_{i,t-1}/Y_{t-1}$, the aggregate output fluctuation is shown in formula (9).

$$\widetilde{Y_t} = \sum w_{i,t} \widetilde{Y_{i,t}} = \sum \left[w_{i,t} \left(\rho_{1i} \widetilde{R_{i,t}} + \rho_{2i} \widetilde{A_{i,t}} + \rho_{3i} \widetilde{i_{i,t}} + \rho_{4i} \widetilde{P_{i,t}} \right) \right] \quad (9)$$

4. Simulation of the Effects of Credit Adjustment

According to Ye (2013), the carbon emission intensities of coal-fired, gas-fired, hydropower, wind power and photovoltaic power generation in China are 1.018, 0606, 0.12, 0.06 and 0.15 kg CO_2-e/kwh respectively. Therefore, under the requirements of the double carbon target, the overall direction of credit structure adjustment of the power industry should be to steadily withdraw from the high carbon thermal power industry and increase the support of the new power generation industry. According to the relationship deduced and constructed in the third part of this paper, based on the historical data of each power sub industry, depict the differences in industry characteristics, predict and simulate the impact of bank credit adjustment on the output fluctuation and carbon emission level of the power industry from the current to 2060 on the premise of meeting the power demand of the whole society.

4.1. Parameter Selection and Data Source

The five power industries are characterized respectively. Parameter values are shown in **Table 1**. First, using the proportion of the average power generation of the industry in recent 3 years as the weight of each industry, we get $w_{i,0}$, and $\sum w_{i,0} = 1$. According to Zhu (2015), we assume that in the thermal power industry, $\alpha_{\text{thermal}} + \beta_{\text{thermal}} = 1$, while for the other for industries, $\alpha_i + \beta_i = 2$. Since the power generation industry has the characteristics of capital intensive, the capital output elasticity α_{thermal} is taken as 0.67, and for the other 4 industries, α_i are taken as 1.2. We calculate the average output and capital stock of each sub industry in recent three years as the output $\overline{Y}$ and capital input $\overline{K}$ under the steady state, and take logarithm. Take the average grid electricity price of each sub industry in recent three years as the production and output price $\overline{P_i}$, also take logarithm. Take the listed companies in the industry as the sample to depict the characteristics of each sub industry, and take the average ROE of them in recent three years as the average return on capital of the industry $\overline{R_i}$ (excluding dividend and other factors). Calculate the average asset liability ratio in recent three years as the mortgage rate of industry loans γ_i. Calculate the ratio of average interest expenditure and debt amount in recent three years as the average cost of credit funds $\overline{i_i}$. Calculate the capital depreciation rate δ_i according to the characteristics of the construction cycle of each sub industry project. As the technical level follows the AR (1) process, $\overline{A_i} = 1$. Data on output, capital

Table 1. Values of relevant parameters.

Parameter	Sub Industries				
	Thermal	Wind	Hydro	Photovoltaic	Nuclear
$w_{i,0}$	0.6787	0.0612	0.1778	0.0343	0.0480
α_i	0.67	1.2	1.2	1.2	1.2
β_i	0.33	0.8	0.8	0.8	0.8
$\bar{i}_i$	1.050	1.060	1.050	1.050	1.040
$\bar{Y}_i$	10.829	8.325	9.470	7.699	8.121
$\bar{P}_i$	1.316	1.666	0.982	2.152	1.374
$\bar{K}_i$	6.632	6.753	6.579	5.416	6.059
$\bar{R}_i$	0.0135	0.0213	0.0336	0.0009	0.0139
γ_i	0.6615	0.6163	0.5641	0.6086	0.7091
δ_i	0.0625	0.0500	0.0286	0.0500	0.0370

stock and electricity prices come from the National Bureau of Statistics, and financial data on sample listed companies are obtained from Wind.

According to Table 1 we have the coefficients in Equations (8) and (9), and then obtain the quantitative equation of the whole and the respective output fluctuation. The results show that the hydropower industry has the greatest impact on the output fluctuation, followed by wind power, thermal power, nuclear power and photovoltaic. The output of new power generation industry is generally more sensitive to interest rate changes than that of thermal power industry, and the contribution of technological progress to the increase of output is also significantly higher than that of thermal power industry.

As mentioned above, under the conventional transformation scenario, technological progress and industry iteration are carried out smoothly, and electric energy is gradually replaced. In this scenario, it can be simply considered that the technology level and capital return of the power industry maintain the existing form. But in reality, on the one hand, the traditional thermal power industry may be transformed and upgraded through technological progress. On the other hand, the introduction of new power generation technology and the gradual production of early-stage construction may lead to a substantial increase in production capacity. For example, technological progress may greatly reduce the wind rejection rate of the wind power industry, improve the efficiency of wind energy utilization, and effectively improve production capacity. In order to simplify the calculation, this paper does not consider the transformation and upgrading scenario of the thermal power industry, assuming that there is a great possibility of technological progress in the new power industry in the future, and considering that there is an incubation period for the production of new technologies, the technology change rate from 2020 to 2025 is set at 0, and the annual average growth rate of the technology level of the new power generation industry from 2025 to 2060 is 2%.

The on grid electricity price of the power industry shows a development law of rising first and then declining. In recent years, the on grid electricity price of various power generation and electronics industries in China has also entered the downward channel. Limited to data sources, taking the average change rate of on grid electricity price of each sub industry from 2015 to 2018 of the national energy administration as an example, it can be seen that the on grid electricity price of thermal power industry (integrated gas and coal-fired power generation) has decreased by 7.2% annually, that of wind power industry has decreased by 2.98%, that of hydropower industry has decreased by 2.6%, that of nuclear power industry has decreased by 2.52% annually, and that of photovoltaic power generation has decreased by 3.98% annually, which is taken as the initial price change, Since then, the price decline in each period has declined at a rate of 60% every five years.

4.2. Impact of Interest Rate Adjustment

Consider three different adjustment paths of bank credit interest rates—linear adjustment, large-then-small, and small-then-large. In the case of linear adjustment, assuming that the average annual loan interest rate for the thermal power industry increases by 2% (about 0.01 percentage point per year based on the current calculation), the loan interest rate for other new power generation industries decreases by 2% year by year; Under the large-then-small adjustment path, the decline of loan interest rate will be gradually reduced every five years, that is, the loan interest rate for thermal power industry and other new power generation industries will be increased and reduced by 4% from 2021 to 2025, 3.5% from 2026 to 2030, 3% from 2031 to 2035, 2.5% from 2036 to 2040, and 2% from 2041. The adjustment range will remain unchanged thereafter; On the contrary, for the small-then-large path, it increases and decreases by 0.5% every five years, from 0% to 2% in 2040, and then remains unchanged at 2%. The dynamic weight change is iterated according to the output of each period (the same below). **Figure 3** shows the fluctuation of total output under different adjustment speeds. It can be seen from the figure that, on the premise of meeting the growth rate of electricity demand in the whole society as predicted in **Figure 1**, the large-then-small is more smooth, but it may face the problem of power shortage in the early stage of adjustment, which shows that the rapid withdrawal of banks from the thermal power industry in the early stage will indeed bring about a substantial decline in production capacity, and at this time, the production capacity of emerging industries has not kept up; The output fluctuation range of the "small-then-large" strategy is larger, but it can ensure the power demand in the short term. Therefore, under the conventional transformation scenario, the bank's exit policy for the thermal power industry should be relatively slow in the early stage, and gradually strengthen the credit adjustment with the increase of emerging power.

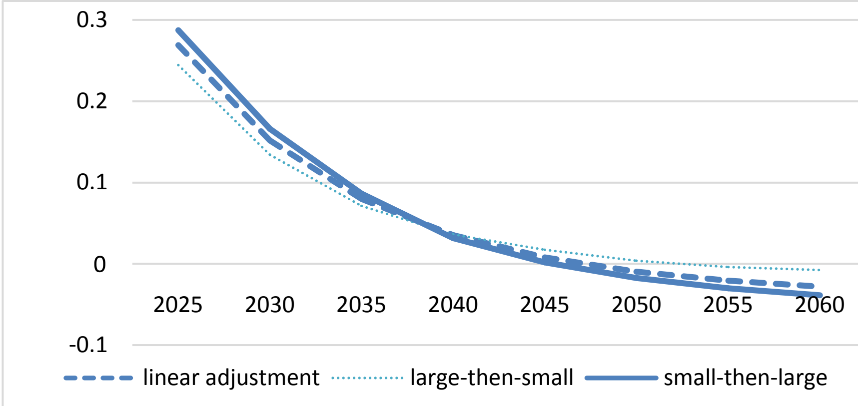

Figure 3. Impact of interest rate adjustment on output of power industry.

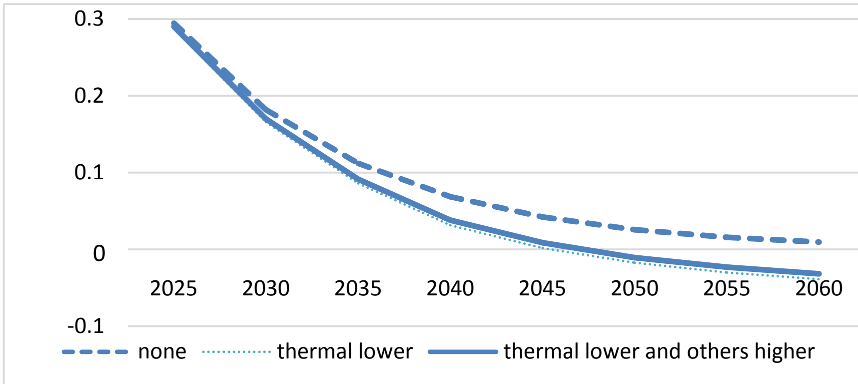

Figure 4. Impact of credit mortgage rate adjustment.

4.3. Impact of Bank Credit Mortgage Rate Adjustment

Consider that banks adjust the credit structure by controlling the loan mortgage rate. Figure 4 shows three situations: no adjustment, only a 4% reduction in the mortgage rate of thermal power industry loans year by year, and a 4% reduction in the mortgage rate of thermal power industry and other industries at the same time. It can be seen from the simulation that the implementation of the tightening policy on the total amount of credit in the thermal power industry will significantly squeeze out the output of the industry, but at the same time, the increase in the mortgage rate of other emerging power generation industries has not significantly improved the production capacity. There may be two reasons for this phenomenon. First, from the current situation, the mortgage rate level of emerging industries is already at a higher level than that of the thermal power industry, so the marginal effect of adjustment through mortgage rate is small. Second, there is an asymmetric feature between the withdrawal of existing capacity and the increase of new capacity, that is, the capacity changes caused by the rise and fall of mortgage rate in the same proportion are different. Therefore, for the withdrawal of backward old production capacity in high-carbon industries, adopting the credit mortgage rate adjustment policy can have a better effect.

5. Conclusion and Policy Recommendations

By constructing the production function of high-carbon and low-carbon enterprises in the power generation industry, this paper simulates the impact of changes in the total output of the power industry under different credit policy adjustment strategies of banks. Research shows that the credit mortgage rate policy is more conducive to the withdrawal of backward production capacity in high-carbon industries, while the credit interest rate policy is more conducive to expanding production capacity by supporting technological progress in emerging industries. When adjusting the interest rate of high-carbon and low-carbon credit, adopting the "small-then-large" interest rate adjustment path with a gradually increasing range is more conducive to realizing the structural adjustment of high-carbon and low-carbon industries while ensuring the supply of total power capacity. Based on the above research conclusions, this paper puts forward the following policy recommendations.

First, reasonably match the loan interest rate and mortgage rate policies to help the power industry "stand before break". When formulating credit policies for the power industry, banks can consider the strategy of focusing on interest rate adjustment in the early stage and mortgage rate adjustment in the middle and late stages to actively manage credit supply, especially when adjusting credit interest rates, pay attention to that the adjustment range in the early stage should not be too high, so as to better realize the continuous transformation of old and new kinetic energy under the dual carbon goal.

Second, provide reasonable and effective financial support for the transformation of high-carbon industries. Banks should take the goal of helping customers in high-carbon industries achieve low-carbon transformation, study the impact of climate goals on different industries, issue transformation schedules and road maps for different industries and fields. For high-carbon customers who may be eliminated, risk assessment and effective risk control should be taken in advance.

Third, focus on strengthening financial support for low-carbon technology. The core of low-carbon transformation lies in technological progress and application and production. We should improve our professional understanding of the field of low-carbon technology, and carry out professional analysis on the current situation, scale, characteristics, cycle law, investment income expectation and possible risk points of the industry. In view of the possible problems of large investment scale, high uncertainty and financing difficulties of small and medium-sized enterprises in low-carbon technology research and development, we should appropriately break through the traditional financial model, formulate supporting credit preferential policies, and set up special funds and other supporting measures.

Fourth, stabilize the direction of green transformation risk management and innovate the carbon financial product support system. Compared with the original traditional high-carbon industries, green low-carbon industries rely more on technology, and the risk concentration increases. In supporting the development of new technologies, banks should consider not only the production and construction cycle, but also the risk of R&D failure or failure to land as scheduled. Banks and other financial institutions need to pay attention to risk prevention and control, grasp the overall risk level and direction, optimize the allocation of the proportion of financial support for high and low carbon industries, balance the overall social carbon emission reduction and smooth transition and transformation of the economy, and the support of green industries and the requirements of risk prevention and control, step by step, strictly control risks, and build specialized, targeted Refine the financial support plan and risk control specifications in stages.

Research on the dual carbon goal deserves continuous attention in the future. We make an effort to study the relationship between credit adjustment and output change under the dual carbon goal, while there are still some limitations that could be improved in the further. First of all, this paper focus on the most representative power industry, therefore, we build a partial equilibrium model to solve this problem. In the future, we can further try a general equilibrium model to carry out a more comprehensive simulation. Secondly, this paper has insufficient consideration of technological progress, and under the dual carbon target, both clean energy and traditional industries have higher requirements for technology, which can be further improved in future research. In addition, relevant practical research should be strengthened on the basis of theoretical research as a reference for decision-making.

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Conflicts of Interest

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

References

He, L., Zhang, L., Zhong, Z., Wang, D., & Wang, F. (2019). Green Credit, Renewable Energy Investment and Green Economy Development: Empirical Analysis Based on 150 Listed Companies of China. *Journal of Cleaner Production, 208,* 363-372. https://doi.org/10.1016/j.jclepro.2018.10.119

Kang, H., Jung, S. Y., & Lee, H. (2019). The Impact of Green Credit Policy on Manufacturers' Efforts to Reduce Suppliers' Pollution. *Journal of Cleaner Production, 248,* Article ID: 119271. https://doi.org/10.1016/j.jclepro.2019.119271

Nandy, M., & Lodh, S. (2012). Do Banks Value the Eco-Friendliness of Firms in Their Corporate Lending Decision? Some Empirical Evidence. *International Review of Financial Analysis, 25,* 83-93. https://doi.org/10.1016/j.irfa.2012.06.008

Schäfer, H. (2017). *Green Finance and the German Banking System*. Social Science Electronic Publishing. https://doi.org/10.2139/ssrn.2959931

Scholtens, B., & Dam, L. (2007). Banking on the Equator: Are Banks that Adopted the Equator Principles Different from Non-Adopters? *World Development, 35,* 1307-1328. https://doi.org/10.1016/j.worlddev.2006.10.013

Song, X. (2016). A General Equilibrium Empirical Study on the Transmission Path of Green Credit in China. *Financial Regulation Research, No. 5,* 87-97.

Wang, Y., Pan, D., & Peng, Y. (2019). Research on Green Credit Incentive Policy Based on DSGE model. *Journal of Financial Research, 11,* 1-18.

Ye, B. (2013). *Research on the Cost of Carbon Emission Reduction in China's Power Industry Based on Optimal Allocation of Resources.* Harbin Institute of Technology.

Zheng, Y. (2020). Research on the Impact of Green Credit Input on the Output of Green Economic Benefits in China Under the Strategy of Sustainable Development—Based on DEA Model Method. *Shanxi Agricultural Economy, No. 4,* 152-153.

Zhu, Z. (2015). Environmental Performance Evaluation of Listed Power Companies in China (2011-2013)—Based on SBM Model Considering Unexpected Output. *Journal of Industrial Technological Economics, 34,* 83-90.