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The linkage mechanism of carbon finance promoting low-carbon development from the perspective of dual carbon policy

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Abstract. This paper summarizes the current research progress on carbon finance and low-carbon development of resource-based industries. Based on the analysis of the current development status and trend of carbon finance and carbon trading at home and abroad, as well as the current status and trend of low-carbon development of China's resource-based industries, combined with relevant research theories, it analyzes the linkage mechanism of carbon finance and low-carbon development of resource-based industries, The linkage effect mechanism of carbon finance and low-carbon development of resource-based industries is further analyzed through empirical analysis, which shows that there are differences between the linkage effects of different carbon financial instruments and low-carbon development of resource-based industries. According to the differences in their linkage mechanisms, the countermeasures and suggestions for optimizing the linkage effects of the two are proposed. It has important theoretical and practical significance for the innovation and development of carbon finance and the low-carbon development of resource-based industries.

Keywords: linkage mechanism; carbon finance; low-carbon development; dual carbon policy.

1. Introduction

As early as 1962, the American writer Rachel Carson had already written the book "Silent Spring", which mainly described the ecological damage caused by the abuse of chemicals in agriculture, and the relationship between man and nature. contradictory phenomenon. The author begins with an allegory, mainly depicting a beautiful village, but the environment of the village is deteriorating, and also writes about land, sea, and air. In fact, it mainly reveals the hazards of chemical pesticides in an all-round way. This book not only aroused people's attention to wild animals, but also aroused public attention to environmental issues and aroused people's environmental awareness. At the same time, the issue of environmental protection has also received continuous attention and has been mentioned in front of governments of various countries.

For a long period of time afterward, countries signed the "Declaration on the Human Environment" after participating in the "Congress on the Human Environment", and countries slowly started the cause of environmental protection. However, after nearly half of the world's development, the demand for resources due to rapid economic progress has greatly exceeded the normal supply of the earth. For example, coal is a non-renewable resource. Obviously, the amount of coal on the earth cannot continue to support the current high-speed development industry indefinitely. As far as coal reserves are concerned, although my country's current reserves are relatively abundant, the problem is that not all coal resources can be mined, and not all mined coal can be utilized to the maximum. , my country's related industries are also using imported coal resources, and imported coal resources have the advantage of lower cost, it is difficult to compete with them.

At present, a slight slowdown in economic growth, low capacity utilization, and an imbalance between supply and demand in the energy industry are huge problems facing my country's energy, and this problem is especially obvious in terms of coal mine production capacity. Some commentators pointed out that the golden age of the coal industry has passed, and serious overcapacity and imbalance between supply and demand have become the most prominent problems. The urgent problem that the coal industry needs to solve at present is mainly to reduce the use of resources and improve the efficiency of resource use. In addition, we must also reduce

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pollutant emissions, create the highest production capacity with the lowest consumption, and strive to reduce environmental pollution. In the first half of 2016, according to data, the output of raw coal above designated size nationwide was 1.34 billion tons, which was about 120 million tons less than last year. From the data analysis point of view, it was a sharp drop of 8.4 percentage points year-on-year. This is good news for the coal industry. Only by continuing to reduce consumption and increase utilization can the current situation of the coal industry be alleviated and the industry be urged to develop health.

From 1990 to 2009, relevant data from 40 countries and regions showed that in the model of "low-carbon production-low-carbon life". The number of countries (regions) and regions was increasing. In 1990, there were 4 countries of this type, in 2000, the number increased to 7, and in 2009, it increased to 10. Let's look at another type, the high-carbon production-high-carbon life model. The number of countries and regions developed under this model has generally shown a declining pattern.

Through this comparative change, we can see that the high-carbon production-high-carbon life model is gradually being eliminated, while the low-carbon production-low-carbon life development model is becoming the pursuit of many countries (regions). It should also be noted that behind this model transformation is the support of economic strength. It should also be noted that in high-income economies, some countries and regions have experienced severe regional differentiation in terms of the process and effect of low-carbon development.

For example, Western European countries such as France and Italy, and Asian countries or regions such as Hong Kong and Japan , the above areas are usually densely populated and highly developed, and their economic development model is low-carbon production-low-carbon life. However, countries such as Canada, the United States, and Australia, which are sparsely populated but rich in resources, still adopt a high-carbon development model. For the successful experience of low-carbon development, China can learn from Japan and Hong Kong, China. And some middle-income economies, such as Brazil, the economic development model of Brazil is high-carbon production-low-carbon life style, and the changes in the past two decades have been very small. On the one hand, the small change shows that the economic development is stable; and on the other hand, it shows that the overall economy of Brazil has not changed from low-carbon production to low-carbon life. Development status of moderately developed countries (regions).

In industrial economics, there are few studies on carbon finance and industrial low-carbon development, and research on the combination of low-carbon development and carbon finance in resource-based industries is still in its infancy. Through this paper, the related research on carbon finance and low-carbon development of resource-based industries has been enriched, and its research space is broad. In addition, countries are paying more and more attention to the coordinated development of industry and environment. At present, research on the linkage effect of carbon finance development and industrial low-carbon development has gradually become a frontier field of scientific research. Therefore, from a low-carbon perspective, this paper studies the relationship between resource-based industries and carbon finance, which can enrich the research on low-carbon development under the constraints of resource and environmental conditions.

Provide an important guarantee for sustainable development for the development of carbon finance and resource-based industries, and provide decision-making basis for decision-making departments. According to development plans such as sustainable economic development and industrial optimization and upgrading, the research and design of carbon finance and resource-based industry development paths are of positive significance for resource-based regions to choose sustainable development strategies and realize industries from high-carbon development models to low-carbon development. as a financial activity. The service areas of carbon finance are also very extensive, including the provision of carbon index transactions, as well as the provision of carbon financial derivative transactions, and of course, bank loans and other businesses.

After a period of development, the development scope of carbon finance has expanded to all aspects of the market, especially the carbon market itself, which has penetrated into every field. The

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rapid development of carbon finance, of course, has attracted the attention of many people, and it has also triggered economic and social thinking on carbon finance. Especially for us in China, to develop a resource-saving and environment-friendly green economy, it is even more necessary to vigorously introduce the thinking mode of carbon finance. Establishing a reasonable carbon financial economic system is the top priority and an inevitable choice for our development. Therefore, under this circumstance, we can see that economic activities under the guidance of the concept of carbon finance have gradually started.

2. Methodology

The data in this paper mainly come from the "China Statistical Yearbook", "China Energy Statistical Yearbook", "China Financial Statistical Yearbook" and "China Clean Development Mechanism Official Website" from 2001 to 2015, taking 2000-2014 as the research period. Through the Granger causality between carbon finance factors and endogenous factors, the causal relationship between carbon finance and the endogenous factors affecting the low-carbon development of resource-based industries is revealed, so as to deduce the linkage path of carbon finance and low-carbon development of resource-based industries.

Selection of low-carbon development indicators

At present, the development of low-carbon economy has begun to be hindered. Facing the goal of low-carbon industrial structure, reducing carbon emissions in the development process is the core of industrial development. Carbon emissions are mainly established in accordance with the fourth assessment report of IPCC. CO2 is considered to be the most important man-made greenhouse gas in the current society, and its production mainly comes from the combustion of fossil fuels, etc. with use. Therefore, based on this, the relevant carbon emissions referred to in the research process of this paper are mainly based on the CO2 emissions of relevant fossil energy (raw coal, crude oil and natural gas, etc.) in the combustion of primary energy. On this basis, as mentioned above, since my country currently lacks specific data that directly reflects carbon emissions, here we can only measure indirectly. This article will use coefficients based on the consumption of related energy and the carbon emission system of related energy. Make reasonable calculations. On this basis, further consult relevant literature and materials, and at the same time, further consider the correlation algorithm combined with the degree of recognition and the source of relevant variable data. The following table lists the current main carbon emission index calculation methods in my country , see Equation 1.

$$CE = \sum_i E \times S_i \times F_i \quad (1)$$

In the above formula:

CE----total carbon emissions;

E-------corresponding consumption of type i fossil energy,

S-------Conversion coefficient of standard coal corresponding to the i-type fossil energy,

F-------the corresponding carbon emission coefficient of the i-type fossil energy

This paper mainly counts the consumption of raw coal, crude oil and natural gas, and calculates the carbon emission related indicators of resource-based industries. At present, the carbon emissions among countries do not have corresponding uniformity to a certain extent. Based on my country's basic developmental conditions, a more reasonable development data is selected, as shown in Tables 1 and 2.

Table 1 Conversion relationship between fossil energy and standard coal

Energy Varieties	raw coal	crude oil	natural gas
standard coal conversion factor	0.7143kgstandard coal/kg	1.4286kgstandard coal/kg	1.3330kgstandard coal/cubic meter

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Table 2 Carbon emission coefficients of various energy sources (kg carbon/kg standard coal)

Energy Varieties	raw coal	crude oil	natural gas
U.S. Department of Energy	702 carbon/kg standard coal	478carbon/kg standard coal	389carbon/kg standard coal
Japanese Institute	0.756 carbon/kg standard coal	0.586carbon/kg standard coal	0.449carbon/kg standard coal
National Development and Reform Commission Energy Research Institute	0.7476kg carbon/kg standard coal	0.5825kg carbon/kg standard coal	0.4435kg carbon/kg standard coal

Selection of carbon finance indicators

For the corresponding variables that exist in the relevant financial service system, the following three methods are often used at present. The first is the financial system development index proposed by Goldsmith in 1969. The common method is to make a reasonable comparison between the total value of financial assets and the gross domestic product; the second is the financial deep LGR index proposed by Mckinnon in 1973 , the method is mainly based on a reasonable comparison between the currency stock and the gross national product; the third is to use the financial deposit and loan indicators often used by Chinese scholars, using the financial deposit and loan amount and It is obtained from the effective comparison between the two gross national products.

However, in view of the fact that China still lacks financial assets and corresponding currency stocks to a large extent, there is a relatively direct correlation statistical data, so the research method based on this Go-style indicator and the McMurray indicator is not suitable for my country's basic analysis to a certain extent. national conditions. At the same time, the proportion of credit lines in GDP in relevant regions of my country often reflects to a certain extent the relatively effective support that financial institutions in the region can provide to related industries or projects. At the same time, it is difficult to withdraw the loan amount provided by financial institutions for low-carbon projects in resource-based industries. Therefore, I choose green loans issued by financial institutions as the relevant indicators, and choose a more appropriate loan financing rate as an alternative measurement indicator for the indirect financing rate of low-carbon projects in resource-based industries. The formula for calculating the loan financing rate is:

$$\text{Loan Financing Ratio (LGR)} = \text{Green Loans of Financial Institutions/GDP} \quad (2)$$

The definition of loan interest rate is the ratio of interest to principal within the specified period of time of the loan. my country's People's Bank of China uniformly manages interest rates, and the interest rates specified by the Central People's Bank of China will be implemented after approval by the State Council. Therefore, loan interest rates are a major standard for financial policies. The distribution proportion of its profits among borrowing companies and banks will be affected by the loan interest rate, which will have a great impact on the economic benefits of the borrower and the lender. Generally, increasing the loan interest rate will reduce the capital stock of the enterprise, and vice versa, it will increase the capital stock of the enterprise early, so it will affect the financing level and ability of the enterprise.

With the advancement of my country's interest rate marketization, financial institutions mostly adopt the method of raising the benchmark interest rate for the loan interest rate of general industries and enterprises, and adopt the benchmark interest rate for the resource-based industry low-carbon projects and enterprise loan interest rates supported by the national macro-control Even a floating approach is implemented. At the same time, it is difficult to extract loan interest rates for

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low-carbon projects. Therefore, this paper chooses the three-year to five-year benchmark interest rate for medium- and long-term loans issued by the central bank from 2000 to 2014 as a substitute value.

With the rapid and leap-forward development of related securities markets, the proportion of direct financing generated by industrial development has shown a trend of rapid increase. In my country's A-share market, resource-based industry companies represented by PetroChina, Sinopec, China Shenhua, Chalco, and Yangtze Power have held a high market value for a long time. For example, when PetroChina was included in the Shanghai Composite Index, its single enterprise The market value accounts for 23.53% of the total market value of the Shanghai market. At the same time, affected by the national macro-control policies, most of the listed financing projects approved by the China Securities Regulatory Commission are also in line with environmental protection and low-carbon requirements. Therefore, due to the availability of relevant data, in the research process of this paper, the stock financing rate is selected as an alternative measure of the direct financing rate of low-carbon projects in resource-based industries. The calculation formula of SGR index is:

$$\text{Equity Funding Ratio (SGR)} = \text{Equity Funding Amount/GDP} \quad (3)$$

From the perspective of measuring and accounting the trading level of carbon emissions, we mainly use the measurement method pointed out by Liu Jiafu (2012). CERG will use the annual estimated carbon emission reduction data based on CDM projects to reflect the current carbon emissions in my country. emissions trading levels. Specifically, the number of CDM projects in my country over the years and the estimated emission reductions per year are shown in Table 3:

Table 3 Number of CDM Projects and Estimated Annual Carbon Emission Reduction in China Unit: 10,000 tons

years	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of CDM projects	237	773	769	530	520	712	1316	127	46
Estimated annual carbon emission reduction	63.795	140.322	109.252	75.189	64.587	9144.708	16581.020	1161.875	145.462

It should be noted that since the official statistical data of my country's CDM projects and their estimated annual emission reductions are only available from 2005, the starting year in Table 5-3 of this paper is 2006. For the level of carbon emissions trading, we make the following definitions:CERG=CER⁄GDP.

Among them, GDP represents the gross domestic product over the years, and CER represents the estimated emission reduction of CDM projects each year. Generally speaking, there is a positive correlation between a country's GDP and total domestic energy consumption. Therefore, on the basis of considering the conversion coefficient, the carbon emissions trading level (CERG) can be understood as the Included emission reductions based on CDM projects. According to relevant principles, we can know that the greater the value of a country's CERG, the more CDM-based carbon trading has been carried out, which also reflects the higher the development level of a country's carbon finance. The greater the carbon emission reduction.

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3. Results

After analyzing the linkage mechanism between carbon finance and carbon emissions of resource-based industries, in order to understand the linkage strength and direction between carbon finance and carbon emissions of resource-based industries, it is necessary to further explore the linkage effect between the two. Therefore, this paper Based on the linkage mechanism between carbon finance and carbon emissions from resource-based industries, we will use OLS regression, VAR model construction, impulse response and other statistical methods to further analyze the linkage relationship between the two and reveal the linkage effect of the two.

(1) Linkage effect analysis

The analysis of the linkage mechanism between loan financing rate and carbon emissions shows that, on the one hand, the relationship between loan financing rate and carbon emissions is "loan financing rate→energy utilization technology progress→economic scale/industrial structure/carbon emission technology progress→carbon reduction On the other hand, the loan interest rate and the stock financing rate have an impact on the loan financing rate. Therefore, the loan interest rate and the stock financing rate are controlled variables, and the loan financing rate is the core explanatory variable. Carbon Emissions is the explained variable. After considering lagging factors, a regression model is established, see formula 4.

$$CE_1 = \alpha_0 + \alpha_{1t}LGR_1 + \alpha_{2t-1}LGR_{t-1}..... + \alpha_{2t}R_t + \alpha_{2t-1}R_{t-1}..... + \alpha_{3t}SGR_t + \alpha_{3t-1}SGR_{t-1}..... + \varepsilon \quad (4)$$

Among them, α_0 is the intercept item,, α_{1t}、α_{1t-1} …. are the estimated parameters of the loan financing rate in the current period and the lagged period respectively,, α_{2t}、α_{2t-1} are the estimated parameters of the loan interest rate in the current period and the lagged period, α_{3t}、α_{3t-1} are the estimated parameters of the stock financing rate in the current period and lagging period respectively, and, ε is the set of other unobserved influencing factors.。

In order to avoid false regression, the original data of each sequence is firstly tested for stationarity. The results show that they are all non-stationary sequences, and the integration test is carried out. The results show that LGR, R and CE are second-order integration. SGR is the first-order integration, and then according to the formula 6-6, select the first-order lag, the second-order lag and the third-order lag respectively for regression, and compare the stationarity of the regression residual in each lag period, and find that the second-order lag The residual stability of the regression is the best, as shown in Table 6-9, indicating that there is no pseudo-regression in the second-order lag. Choose the second-order lag for regression, and the regression results are shown in Table 4.

Table 4 residual ADF test

variable	ADF test value	test type (c,t,k)	P value	standard	is it stable
LGR	-2.165	(c,t,2)	0.481	AIC	unstable
SGR	-1.077	(c,t,2)	0.903	AIC	unstable
R	-2.257	(c,t,2)	0.431	AIC	unstable
CE	-2.282	(c,t,2)	0.416	AIC	unstable
D2LGR	-4.781	(c,t,2)	0.008	AIC	stable
DSGR	-4.795	(c,t,2)	0.007	AIC	stable
D2R	-3.980	(c,t,2)	0.037	AIC	stable
D2CE	-3.887	(c,t,2)	0.015	AIC	stable
ε	-4.149	(c,t,2)	0.037	AIC	stable

Table 5 OLS estimation results

	variable	P value

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α_0	-150566.2	0.000
LGR	21797.34	0.2648
LGR(-1)	41926.40	0.0558
LGR(-2)	28787.34	0.0756
R	1200.780	0.6846
R(-1)	5537.739	0.1025
R(-2)	2455.257	0.2838
SGR	223967.3	0.0637
SGR(-1)	80131.69	0.5668
SGR(-2)	135953.8	0.3012
Adjusted R-squared	0.958	

The regression results show that the loan financing rate has no significant impact on carbon emissions in the current period, but there is a significant impact in the lagging period, and the impact is positive. The main reason is that the implementation of the credit system can rapidly increase the capital stock of enterprises. Enterprises use capital for technological research and development, and the effect of technological progress lags behind. However, although technology has improved and played a role, due to the "energy rebound effect "Yes, technological progress has shown a positive effect.

(2) Impulse response analysis

In order to further reveal the impact of loan financing rate on carbon emissions, the impulse response is made on the basis of establishing a VAR model for loan financing rate and carbon emissions. The results show that the impact of changes in the loan financing rate on carbon emissions has no effect in the current period, and begins to work after a lag of one period. The effect gradually increases and reaches its peak in the 13th and 14th periods.

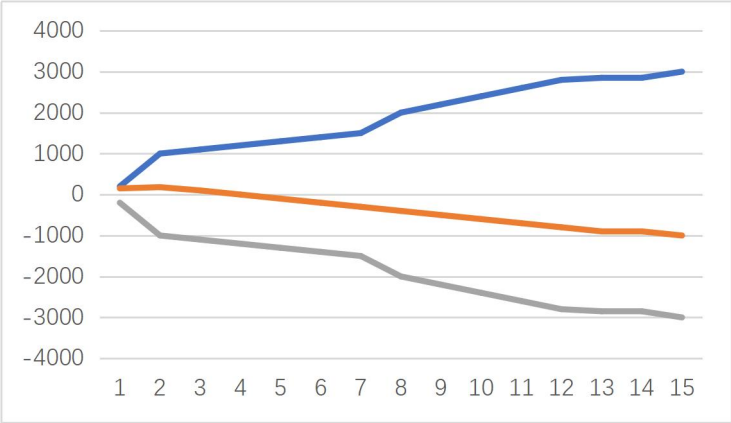

Figure 1 Pulse diagram of LGR versus CE

4. Conclusion

The analysis results of the linkage effect of carbon finance and carbon emissions of resource-based industries show that: the loan financing rate and loan interest rate affect carbon emissions through the intermediary factor of "energy utilization technology progress→economic scale/industrial structure/carbon emission technology progress". The amount of production has a significant positive impact with a lag, but there are differences in the impact period. The analysis results show that the loan financing rate and loan interest rate first have a direct impact on the "technical progress factor", then indirectly affect the scale factor and structural factor, and finally have an impact on carbon emissions. Neither the loan financing rate nor the loan interest rate will

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have a significant impact on carbon emissions in the current period, and will start to have a significant impact after a lag of one period.

The reason may be that at present, China is in the process of transforming from the middle level of the industrial economy to the high level. The resource-based industry is still the main body of China's economic structure. Most of the large and medium-sized state-owned enterprises in China are resource-based enterprises. Under the realistic background, it is more convenient for large and medium-sized state-owned enterprises to increase capital through financial policies. After resource-based enterprises quickly increase capital, there will be two capital operation situations. One is to invest capital in new industries, such as the real estate industry.

Over the past 20 years in China, state-owned enterprises have invested in the real estate industry and promoted the rapid development of China's real estate industry. This is a testament to the fact that state-owned large and medium-sized enterprises have obtained a large amount of capital accumulation through financial policies and changed their capital operation methods. This capital operation method has stimulated the development of China's industrial economy, expanded the demand and consumption of resources, and directly or indirectly promoted the expansion of the scale of resource-based industries.

The other capital operation mode is to invest capital in technology research and development, including resources or energy. There will inevitably be a "lag" phenomenon in the investment, application and promotion of technological progress in the utilization of technological progress and production links or terminal waste pollutant treatment technology. Although at the micro level, technological progress can achieve the effect of energy saving and emission reduction, but in our country Under the huge market demand, although technological progress has been achieved, in the face of the continuous expansion of demand scale, resource-based enterprises blindly expand their production scale to meet market demand, making the reduction of carbon emissions by technological progress appear relatively weak, resulting in "Energy rebound effect". In general, the implementation of financial policies can theoretically promote the efficiency of energy conservation and emission reduction. Due to the lagging impact of technological progress and the effect of the macroeconomic environment, carbon financial policies cannot truly mobilize it to promote energy conservation and reduce emissions.

There are differences in the impact cycle of the loan financing rate. The credit policy represented by the loan financing rate will reach its peak in the 13th and 14th periods of the lag, and its impact cycle is about 30 years. However, the interest rate policy represented by the loan rate still has not reached the The peak value shows that its efficiency is relatively weak, and its cycle exceeds 30 years. In general, the carbon finance policy has not played an effective role in promoting the low-carbon development of resource-based industries, and its effect on energy conservation and emission reduction is relatively weak. The stock financing rate has a lagging positive effect on carbon emissions through the intermediary factor of "economic scale→energy utilization technology progress→economic scale/industrial structure/carbon emission technology progress". The intensity of the effect is small and the cycle is long.

The analysis results show that the level of carbon emissions market transactions has a significant negative effect on carbon emissions through structural factors, and the linkage path is the shortest and most effective. It works in the current period, that is, carbon emissions market transactions can effectively restrain the increase of carbon emissions. Changes in carbon emissions have a lagging effect on carbon emissions market transactions, and the effect is significant. The longer the lag period, the stronger the effect. In other words, the level of carbon emissions market transactions closely follows the carbon emissions of resource-based industries or enterprises in previous years.

The low-carbon development of resource-based industries and carbon emission market transactions can effectively promote the low-carbon development of resource-based industries, which means that resource-based industries need carbon emission market transactions. It has important display significance.

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This paper selects relevant indicators of carbon finance and low-carbon development of resource-based industries, and discusses the linkage path and linkage effect of carbon finance and low-carbon development under dual carbon policy. There are differences in the linkage paths between them. The carbon financial system did not play a positive role in carbon finance. It did not show the role of promoting the low-carbon development of resource-based industries, but instead produced a negative inhibitory effect, and there is a "lag". In the carbon finance market, stock financing has not produced the positive effect of "carbon finance". But the carbon emission market transactions have played a positive role in carbon finance, effectively promoting the low-carbon development under dual carbon policy.

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