Research on the Effect of Carbon Finance Development on Industrial Structure Upgrading in Northeast China

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Abstract: *Under the background of carbon peak and carbon neutralization, combined with global research results and regional characteristic advantages, we give play to the role of carbon finance to explore the characteristic road of industrial structure upgrading in Northeast China under the "double carbon" mechanism. Taking the northeast region as an example, this paper selects the data from 2009 to 2019 and uses the factor analysis method to calculate the development level of carbon finance in the northeast region. Through the analysis of panel data model, this paper studies the empirical effect between the development of carbon finance and the upgrading of industrial structure in the northeast region. The results show that the development of carbon finance can promote the upgrading of industrial structure and optimize the carbon emission in the whole life cycle of industry in the northeast region. It plays a positive role in helping the regional economy achieve sustainable growth. Although the economy of Northeast China lags behind other parts of the country, the development of carbon finance in Liaoning Province is relatively the best. The differences among the three northeast provinces are mostly attributed to economic level, policy factors and so on. Finally, four policy suggestions are put forward, which can provide reference for other regions to use carbon finance to promote the upgrading of industrial structure. We will increase incentives for the development of carbon finance, strengthen the training of financial talents, accelerate the research and innovation of products related to carbon finance, and strengthen the use of clean energy.*

Keywords: *Northeast region, Carbon finance, Analysis of panel data model, Upgrading of industrial structure*

1. Introduction

Since the industrial revolution, with the deepening of industrialization, global climate change has seriously threatened human survival and development. With the change of international climate policy and the signing of the United Nations Framework Convention on climate change and the Kyoto Protocol, "carbon finance" market began to rise. In 2020, China put forward the double carbon goal at the 75th United Nations General Assembly. "Carbon peaking" and "carbon neutralization" were included in the government work report for the first time in 2021, and were listed as one of the key tasks in 2021.

Place is an important unit and carrier of "carbon peak" and "carbon neutralization". Northeast China is an important industrial and agricultural base in China, and is related to the overall situation of national development. Northeast China faces many challenges in energy consumption and economic transformation, carbon dioxide and greenhouse gas emission reduction. Although China has actively promoted the regional coordinated development strategy and revitalized the old industrial base in Northeast China for a long time, the situation is not optimistic.In 2019, the carbon emission of Northeast China accounted for about 9.95% of the national carbon emission, while it accounts for only 5.1% of the national GDP. Northeast China is still dominated by extensive industrial production mode, with a single industrial structure, and the overall level of industrial structure lags behind other developed regions in China. During the 14th Five Year Plan period, whether there can be substantial progress in the adjustment of industrial structure in Northeast China is an important symbol to measure whether there is a new breakthrough in the revitalization of Northeast China.

An in-depth study of the development of carbon finance and its impact on the upgrading of industrial

structure is very important for achieving the dual carbon goal, reducing unnecessary waste of resources and promoting high-quality development.

After fully considering the actual situation of Northeast China, this paper decides to study the impact of carbon finance development on industrial structure upgrading from a regional perspective, calculate the development level of carbon finance in Northeast China by using factor analysis method, quantitatively analyze the impact of carbon finance development level on industrial structure in Northeast China through panel data model, and put forward feasible suggestions according to the results.

2. An empirical analysis of the impact of carbon finance development on the upgrading of industrial structure in Northeast China

2.1. A Calculation of the development level of carbon finance in Northeast China

a. Selection and calculation of carbon finance development level indicators

This paper designs the criterion layer of the index system from five aspects: economic development level, financial environment, energy efficiency, science and technology and government strength. We select indicators according to the principles of rationality, comparability, typicality and availability, and select six indicators: tertiary industry structure optimization, carbon emission loan intensity, total energy consumption, carbon emission intensity, number of regional patent authorizations and government financial support to establish an indicator layer to measure the development level of carbon finance in Northeast China. See Table 1 for specific calculation methods.

Table 1: Indicator system for measuring the development level of carbon finance in Northeast China

Target layer	Datum layer	Index layer
Development level of carbon finance	Economic development level	Optimization of tertiary industry structure
	financial environment	Carbon emission loan intensity
	energy efficiency	Total energy consumption
		Carbon emission intensity
	Science and technology	Number of regional patent licenses
	Government strength	Government support

The optimization of tertiary industry structure is the ratio of the added value of tertiary industry to GDP, which can reflect the development level of circulation industry, service and modernization in Northeast China. The higher the ratio, the higher the development level of carbon finance; Carbon emission loan intensity mainly refers to the carbon emission of the loan balance of financial institutions at the end of the year, which reflects the financial support of financial institutions for carbon emission. If the ratio of this indicator is lower in the region, it means that the development level of carbon finance is getting better and better; The total energy consumption is the main source of carbon emissions. The higher the energy consumption, the higher the carbon emissions, and the lower the development level of carbon finance; Carbon emission intensity refers to the carbon dioxide emission generated when the unit GDP increases. Carbon emission intensity can reflect the relationship between economic growth and carbon emissions; The number of regional patents can represent the ability of Northeast China to study low-carbon technologies. The more the number, the higher the ability, the higher the development level of carbon finance; Financial support means that the internal expenditure of R & D funds is equivalent to the proportion of GDP. The greater the government support, the more scientific research projects, which will correspondingly improve the development level of carbon finance.

b. Calculation of the development level of carbon finance in Northeast China based on factor analysis

This paper will use the provincial panel data of the carbon development level of the three northeastern provinces from 2009 to 2019 for empirical research. The data comes from the relevant basic data of China Statistical Yearbook, China Financial Statistical Yearbook, China energy statistical yearbook and China Science and technology statistical yearbook. Then, the dimensionality reduction method is used for quantitative processing through SPSS.

The test results of KMO and Bartlett are shown in Table 2. According to table 2, the kmo test result is 0.596, which is at the "general" level according to the kmo test standard. At the same time, the approximate chi square of the test is large enough, and the accompanying probability is 0.000, which is less than the significant level of 0.05, indicating that it has passed Bartlett's sphericity test. Based on the above two points, factor analysis can be used to evaluate the level of carbon finance.

Table 2: KMO and Bartlett's tests

Kaiser Meyer Olkin sampling suitability quantity		0.596
Bartlett's sphericity test	Approximate chi square	64.144
	degree of freedom	15
	Significance	0.000

The output results of SPSS factor analysis are shown in Table 3: the cumulative contribution rate of the two factors is 88.539%, exceeding the standard of 85%, so the two public factors can be used to analyze the original data for evaluating the development level of carbon finance in Northeast China. The comprehensive score can be calculated according to the two factor score, and the comprehensive score=(60.876*F1+24.664*F2)/88.539 [9].

Table 3: Interpretation of total variance

component	Initial eigenvalue			Extract the sum of squares of loads			Sum of squares of rotating loads		
	total	Percentage of variance	Cumulative%	total	Percentage of variance	Cumulative%	Percentage of variance	Percentage of variance	Cumulative%
1	4.051	67.512	67.512	4.051	67.512	67.512	3.653	60.876	60.876
2	1.082	18.028	85.539	1.082	18.028	85.539	1.480	24.664	85.539
3	.715	11.914	97.453						
4	.114	1.894	99.348						
5	.024	.398	99.746						
6	.015	.254	100.000						

From figure 1 and table 4, we can get the comprehensive score of the development level of carbon finance in Northeast China. According to the chart, we can see that in the early 2009, the development level of carbon finance in Heilongjiang Province was better than that in Jilin Province and Liaoning Province. The development level of carbon finance in Northeast China increased continuously with the development of economy, but the growth rate of carbon finance development level in Heilongjiang Province was relatively slow. After 2014, Liaoning Province and Jilin province came from behind. In 2019, the development level of carbon finance in Liaoning Province has leapt to the first of the three northeastern provinces, followed by Jilin Province and finally Heilongjiang Province.
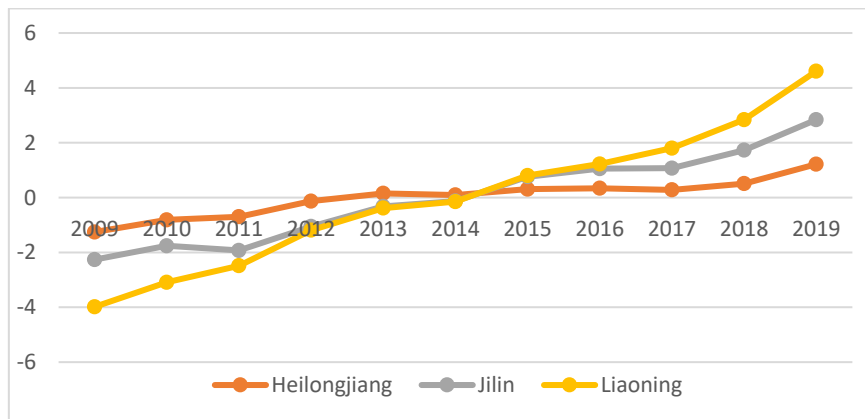

Figure 1: Development level of carbon finance in Northeast China

Table 4: Comprehensive score of carbon finance development level

particular year	Heilongjiang	Jilin	Liaoning
2009	-1.255635492	-1.006579282	-1.721490484
2010	-0.813309353	-0.94459686	-1.330828394
2011	-0.700119904	-1.226693085	-0.558728178
2012	-0.131654676	-0.923893715	-0.133883154
2013	0.152877698	-0.47693441	-0.060634012
2014	0.094604317	-0.221129909	-0.020346984
2015	0.308033573	0.451404766	0.044763365
2016	0.338848921	0.714194991	0.169558199
2017	0.279976019	0.792562109	0.730321075
2018	0.510071942	1.219072296	1.1117592
2019	1.216546763	1.622339074	1.769509366

2.2. The empirical effect of Panel Data model on the upgrading of industrial structure

a. Panel data model setting

Before setting relevant models, relevant variable indicators should be defined first. In order to better measure the change degree of industrial structure, this paper selects the change value of industrial structure (IST) as the index to measure the upgrading of industrial structure.

$$IST = \sum_{i=1}^{3} |Q_i - Q_{I0}|$$

Among them, Q_i represents the ratio of the added value of the i industry to the current year's GDP, and Q_{i0} represents the ratio of the added value of the i industry to the current year's GDP in 2008.After defining the change value of industrial structure as the variable index, the panel data model is set to analyze the relationship between the development level of carbon finance and the change value of industrial structure (IST) in the three northeastern provinces-Heilongjiang Province, Jilin Province and Liaoning Province.

In terms of data selection, this paper selects the data of three provinces from 2009 to 2019 years. From the perspective of time series, the number of time series data is rare. For this reason, this paper selects the panel data model to prove and analyze the data. The specific settings of relevant models are as follows:

$$y_{it} = \beta_1 + \beta_2 x_{it} + \mu_{it}, I = 1,2,…,N, t = 1,2,…,T$$

Now explain the model setting: N represents the total number of cross-section members in the panel data, T represents the total number of observation periods of each cross-section member in the formula, β_2 represents the specific degree of the impact of carbon finance level on the change of industrial structure, and the residual term is selected for use in this paper μ to show.Among them, $\mu_{it}=\mu_i + v_{it}$, μ_i is a constant variable of time dimension that will not change with the period of observation. When constructing the model, the model cannot be guaranteed to be completely accurate, and there is the possibility of missing variables, measurement errors, and some uncertain factors. Therefore, the disturbance term v_{it} is introduced, which will change with the change of observation period and observation individual. Next, through μ_i to determine which model should be used to discuss the impact of the development level of carbon finance on the change of industrial structure.

When $\mu_i=0$, the least two multiplication, namely OLS, shall be selected;

When μ_i is a fixed non-zero number, the disturbance term v_{it} follows the independent and identically distributed, and the fixed effect model (Fixed Effect Model) is selected;

When μ_i changes randomly, it follows the independent and identical distribution, and the random effect model (Random Effect Model) is selected. Besides, the impact of carbon finance development level on industrial structure is shown in Table 5.

According to R^2,the goodness of fit adjustment value, it is not difficult to find that the fitting effect obtained by selecting the fixed effect model is the best. According to the Hausman test, we can obtain x^2 statistic is 5.52, P-value is 0.0632, so the original hypothesis can be rejected accordingly, and establish fixed effect model. What is more, P value, it can also be judged that the fixed effect model is correct, and the fitting degree R^2=0.632 is relatively high, so the fixed effect model is selected.

According to the least square method, we know that the result of model estimation is:

$$IST = 0.358 + 0.071CAR + \mu_i + v_{it}$$

Through the empirical result model, it can be found that the development level coefficient of carbon finance is a positive value. At the same time, according to the research results, it can be found that the goodness of fit of the fixed effect model is relatively high. Through this experimental result, it can be found that the change value of industrial structure in each province of the three northeastern provinces will increase with the improvement of the development level of carbon finance in each province. According to the above empirical analysis, it is concluded that there is a positive relationship between the development level of carbon finance and the change value of industrial structure.

b. Analysis of panel data model results

(1) Through the relevant research on the change value of industrial structure and the relevant analysis

of the development level of carbon finance in this paper, it can be concluded that when taking provinces as units, if a province has a high level of economic development, high energy utilization efficiency, a large proportion of clean energy in the total energy consumption, a large amount of government support in relevant aspects and a large number of patent applications for relevant projects, the lower the intensity of carbon emission or carbon emission related loans, the higher the development level of carbon finance in the province. However, due to the characteristics and historical background of the secondary and tertiary industries in the three northeastern provinces, the government support has little impact on the development of carbon finance in the three northeastern provinces, which can be almost ignored. Such influence will promote the development of relevant scientific and technological research enterprises, environment-friendly enterprises and relevant high-tech research industries. Under this background and conditions, it can promote the upgrading of the industrial structure of the three northeastern provinces.

Table 5: Panel data model analysis results of the impact of carbon finance development level on industrial structure

Varizble name	Pooled Regression Model			Random Effect Model			Fixed Effect Model		
	Estimated	Standard error	T-value	Estimated	Standard error	T-value	Estimated	Standard error	T-value
Intercept α	0.358	0.00	38.45	0.358	0.00	38.45	0.358	0.01	41.09
β	0.071	0.01	6.60	0.071	0.01	6.60	0.071	0.01	7.05
R^2	0.584			0.632			0.6320		
Adjustment R^2	0.571			0.584			0.5940		
F statistic	43.56			43.56			49.75		
P-value	0.0000			0.0000			0.0000		
Hausman test				x^2statistic= 5.52P =0.0632					
Fixed Effect Model							F=3.2 P=0.0554		

(2) In the article "The impact of carbon finance development on industrial structure upgrading-Comparative Analysis Based on Urban Agglomeration", Peng Yuwen and Zou Mingxing selected Beijing, Tianjin, Hebei, Yangtze River Delta and Hubei, Henan, Hunan urban agglomeration as sample areas for empirical analysis and research. It is found that there are obvious differences in the changes of industrial structure of urban agglomeration in the three regions. Different from the Yangtze River Delta, Beijing, Tianjin, Hebei and other more developed regions, the three northeastern provinces show different industrial structure characteristics due to their special industrial characteristics and historical background. The reason is that the soil in the northeast is fertile and suitable for the development of agricultural production. Therefore, the growth rate of the primary industry in the three northeastern provinces is close to the national level, and the Heilongjiang Province is higher than the national level. Contrary to the level of the primary industry, the secondary industry in the three northeastern provinces has experienced serious negative growth, which is also one of the reasons for the slow and stagnant economic growth in the three northeastern provinces in recent years. Among the three provinces, the growth rate of the tertiary industry in Liaoning and Heilongjiang is normal in the country, but the growth rate of the tertiary industry in Jilin is slow due to the low level of urbanization. From the perspective of social-economic basis, during the sample selection period, the economic development of the three northeastern provinces was slow, so the change value of industrial structure presented by the model showed a positive change, but relatively mild.

(3) The economic activity of the three northeastern provinces is low. With the brain drain and slow economic development, the economic environment has no advantages. During the period of planned economy, the urbanization of the three northeastern provinces as the development base of heavy industry, has a relatively leading level of industrialization. However, with the reform and opening up, China's economy has turned to export-oriented development, the economic development speed of the three northeastern provinces is gradually lower than the national level, resulting in the serious backwardness of urbanization and modernization, the slow development of high and new technology, and the serious loss of the advantages of industrial supporting manufacturing and heavy industry. This has led to serious air pollution in the three northeastern provinces, low share of clean energy in total energy consumption, and the development level of CDM emission reduction mechanism is far lower than that of developed cities in Beijing, Tianjin and Hebei. As a result, the industrial structure and economic activity of the three northeastern provinces are very low, which leads to the low level of carbon finance in the three northeastern provinces, unable to fully and efficiently complete waste gas treatment, and unable to make full use of the huge carbon emissions in the northeast to develop carbon trading and carbon finance. Therefore, the transformation of industrial structure, the development of carbon economy and the

revitalization of economy in the three northeastern provinces also need to find new progress points, optimize the industrial structure and speed up the development of the financial industry.

3. Suggestions on developing carbon finance in Northeast China

3.1. Increase preferential measures for the development of carbon finance

Northeast China started late in the field of carbon finance. Therefore, the government will strengthen the policy of carbon finance innovation in Northeast China and support the development of carbon finance derivative industries. The state can control market risks, relax policy restrictions and controls on various carbon finance innovation products as much as possible, fully activate the carbon finance market, open up carbon asset financing channels for emission enterprises, and support carbon finance innovation to serve the real economy and industrial transformation and development; At the same time, the state should give preferential policies in terms of Taxation, examination and approval for the development of emerging carbon financial institutions; The state provides financial and scientific research funding support for research in the field of carbon finance.

3.2. Strengthen the training of financial talents

The development of carbon finance has more breadth and depth to explore. The so-called "technical industry has specialization", and the development of carbon finance needs to cultivate relevant financial talents. The subject matter of carbon finance is a virtual product. Its trading rules are strict, the development procedures are complex, the sales contracts mostly involve overseas customers, the contract term is long, and the technical requirements for risk rating are high. Non professional institutions are not competent for the development and implementation of carbon finance projects. For example, the clean development mechanism or the joint implementation mechanism involves the certification of emission reduction units. If the emission reduction project cannot be certified, it will lead to delivery risk and reduce the expected return on investment. In order to ensure the attractiveness of the project to investors, it is necessary to be familiar with the needs of emission reduction units and the certification standards and procedures of the country where the specific project is located, and understand the policies and laws of relevant countries; At the same time, we also need to rate and provide guarantee for delivery risk and policy risk. Such comprehensive financial institutions and compound talents are very scarce in China at present.

3.3. Accelerate the research and innovation of products related to carbon finance

According to the development history of domestic carbon financial market and carbon trading history, China's current carbon financial trading market is still relatively immature and in the early stage of development. Therefore, in order to promote the development of domestic carbon finance market, reduce the environmental pollution of the old industrial bases in the three eastern provinces, and promote the economic development of the three eastern provinces. Carbon emission exchanges and other relevant financial institutions in the three eastern provinces should increase the innovation of carbon finance related products and organically combine financial derivatives with carbon emission trading, so as to promote the development of carbon finance in the three eastern provinces and promote the economic revitalization of the three eastern provinces.

3.4. Strengthen the use of clean energy

The proportion of clean energy in energy consumption is very important for optimizing the energy consumption structure of the three eastern provinces, optimizing the industrial structure, reducing environmental pollution, developing emission reduction mechanism, environment-friendly enterprises and related high and new technologies. Therefore, the three northeastern provinces should increase the use of renewable energy and reduce the proportion of highly polluting non renewable energy and fossil energy in total energy consumption. From a practical point of view, the urbanization level of the three northeastern provinces is lower than the national level, and the three northeastern provinces are cold in winter, so the straw will be burned in the three northeastern provinces in winter, and a large number of fossil energy such as coal will be used, which leads to serious air pollution in the three northeastern provinces in winter. In this regard, we suggest that the government and relevant departments issue relevant policies and instructions to ensure the standardization of coal mining and sales, deal with the

non-standard development and huge amount of chaos of private small coal mines, and actively support the development of renewable and clean energy, such as wind, hydropower, solar and solar power generation.

References

[1] Wang Y L, and Wang M Y. "Development prospect of China's carbon finance trading market." Economic Review .09(2015): 88-90. doi: 10.16528/j.cnki.22-1054/f.201509088.

[2] YE Y M, and Zhang X F. "Analysis on the influencing factors of the development of carbon finance transaction in China." Shanghai Finance. 07(2010): 31-35.

[3] Peng Y W,and Zhou M X. "The impact of carbon finance development on Industrial Structure Upgrading -- a comparative analysis based on Urban Agglomeration." Enterprise Economy.06 (2019): 15-20. doi: 10.13529/j.cnki.enterprise.economy.2019.06.002.

[4] Du L, Ding Z G, and Li B. "Adjustment and upgrading of industrial structure: the boost of Carbon Finance Trading Mechanism -- An Empirical Study Based on EU data." Journal of Tsinghua University (PHILOSOPHY AND SOCIAL SCIENCES EDITION) 27.05 (2012): 143-150+161. doi: 10.13613/j.cnki. qhdz.002121.

[5] Liu Y Z."Analysis and path of China's provincial carbon finance development level and influencing factors."Inquiry into Economic Issues. 07(2014): 118-123.

[6] Yang D G, and Liu J F. "The impact of China's Carbon Finance on industrial structure and energy consumption structure -- An Empirical Study from the perspective of CDM." Jilin University Journal Social Sciences Edition 52. 05(2012): 98-105. doi: 10.15939/j.jujsse.2012.05.020.

[7] Mei X H."Research on the impact of China's carbon finance market on regional industrial structure --An Empirical Analysis Based on Panel Data econometric model." Technoeconomics & Management Research. 01(2015): 108-111.

[8] DUu L,and Li B."Using the carbon finance system to promote the adjustment and upgrading of industrial structure." Economist. 06(2012): 45-52. doi: 10.16158/j.cnki.51-1312/f.2012.06.010.

[9] Li L, Dong B J,and Lou C Y. "An empirical study on the relationship between the development level of carbon finance and the upgrading of industrial structure in Beijing Tianjin Hebei region." Journal of Commercial Economics. 06(2018): 166-169.