

Research on the Upgrading Path of Carbon-intensive Industries Driven by Financial Innovation

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Abstract. This paper systematically analyzes the upgrading and path of carbon-intensive industrial structure by financial innovation. Through the identification of carbon-intensive industries, the panel data of related industries from 2012 to 2021 is constructed and empirical analysis, and the path is studied through the intermediary effect model. The research shows that financial innovation promotes the upgrading of carbon-intensive industrial structure and functions through technological innovation and capital allocation. Therefore, it is necessary to accelerate the process of financial innovation, promote the upgrading of carbon-intensive industries through financial innovation, and reduce carbon dioxide in related industries Emissions.

Keywords: financial innovation, carbon-intensive industry, industrial upgrading, and regulation effect

1 Introduction

With the aggravation of environmental deterioration and a series of catastrophic consequences, reducing the release of greenhouse gases and combating climate change has become one of the common concerns of all countries and regions around the world. In order to better implement this initiative to promote the economic development from relying on large consumption of natural resources to a more efficient way (such as economical production) — This is what China is working on; but also because we need to accelerate the efficient use and management of energy-intensive industries to control CO₂ emissions is particularly important at this stage. In contrast, while "financial progress" is not equivalent to "financial growth"; it is a dynamic and lasting process, because its essence is to explore new possibilities and create new things^[1]. The upgrading of industrial structure includes two aspects: advanced industrial structure and rationalization of industrial structure. As the core of modern economy, finance wants to upgrade the carbon-intensive industrial structure without financial innovation, which supports industrial structure upgrading through capital allocation and industrial structure upgrading through scientific and technological innovation. Therefore, with financial innovation and carbon-intensive industrial structure upgrading as the core, the research to achieve the goal of carbon neutrality and carbon peak will provide a theoretical basis for the transformation of economic growth mode.

2 Literature Review

2.1 The concept of carbon-intensive industries

Carbon-intensive industries refer to the industries that produce a large amount of carbon dioxide emissions in the production process^[1]. Different industries produce a certain amount of carbon dioxide in the production process, but carbon-intensive industries directly or indirectly emit more carbon dioxide than other industries^[2]. These industries are often seen as the main source of greenhouse gas emissions, with a negative impact on climate change. Due to the more serious climate problem, some scholars have studied carbon-intensive industries from different aspects and divided carbon-intensive industries from different perspectives, but so far there is no clear division of carbon-intensive industries in the academic circle.

2.2 Industrial structure upgrading aspect

To achieve sustainable economic growth in China, the most important factor is to promote industrial upgrading. This is a long-term process, and the role of financial innovation in promoting industrial upgrading cannot be replaced^[3]. Many scholars have studied the upgrading of industrial structure in this respect, but a unified definition has not been formed. Industrial upgrading refers to the change from low technology and low added value to high technology and high added value, including the transfer of resources between different industries, as well as the resource conversion between low efficiency and efficient enterprises in the same industry. From the perspective of innovation, technological innovation is the driving force to improve production efficiency. The purpose of enterprise continuous research and development to promote technological innovation is to obtain more output and obtain greater profits with less expenditure.^[4] And industrial upgrading includes three aspects: upgrading-intensive industries to capital or technology-intensive industries; upgrading traditional industries to high-tech industries; and low value-added industries to high value-added industries.

2.3 Financial innovation promotes industrial structure upgrading

Financial innovation can improve the liquidity and allocation efficiency of financial capital, improve the efficiency of credit resource allocation and industrial financing constraints, and bring unprecedented impact on the transformation and upgrading of industrial structure^[5]. People promote the upgrading of industrial structure by conducting financial innovation from different perspectives. Financial innovation plays a great role in promoting technological progress, so as to promote the increasing transmission mechanism of social wealth. The deepening of finance and the establishment of the financial system promote economic growth and the increase of residents' income. The "income effect" of residents changes th]. Thered structure, thus affecting the supply and promoting the adjustment and upgrading of the industrial structure^[6]. Some scholars demonstrate through the threshold effect that there is a significant negative correlation between financial innovation and carbon emissions, and the reduction effect of carbon emissions is continuously enhanced with the deepening of industrial structure upgrading; economic growth and foreign trade degree increase carbon^[7]. There is a significant regional heterogeneity between financial innovation and industrial upgrading^[8]. Financial development plays an important role in driving the upgrading of industrial structure; technological innovation plays a nonlinear role in industrial structure, and the driving effect in the eastern region is greater than that in the

western region. In the threshold effect of industrial structure upgrading, the threshold value of financial development.^[9]

To sum up, financial innovation plays a significant role in promoting industrial structure upgrading, and financial innovation can promote industrial upgrading through different paths. So far there are a lot of scholars industrial structure upgrade has carried on the comprehensive study, but in carbon intensive industry definition and research of carbon intensive industry upgrading, this innovation is based on the carbon intensity definition carbon intensive industries, and the financial innovation to promote the path between the carbon intensive industrial structure upgrade. In summary, three hypotheses are proposed: Hypothesis 1: financial innovation promotes the upgrading of carbon-intensive industrial structure; Hypothesis 2: long-term technology has a positive effect on the upgrading of carbon-intensive industries; Hypothesis 3: technological innovation of carbon-intensive industries plays a positive role in promoting the upgrading of industrial structure.

3. Financial innovation promotes the upgrading of carbon-intensive industrial structure

3.1 Selection of indicators

Explained variable: industrial upgrading (upindustry). The total output value, coal consumption and total profit indexes calculate the industrial upgrading index by entropy method, in which the total output value and total profit are positive indicators, and the coal consumption is negative indicators.

The explanatory variables: Financial innovation (fin). In China, financial assets are divided into trading assets and investment assets. The former usually refers to the narrow currency (m1), while the latter includes m2, stock market value, insurance income and bond transaction amount. Financial innovation in this article = investment financial assets / total financial assets, and

$$Fin = \frac{FA - m1}{FA}$$

Adjustment variables: technical innovation. The technical innovation indicators of the number of patents, research and development time and research and development funds are calculated by entropy method, and the number of patents, research and development time and research and development funds are all promoting technological innovation, so they are all positive indicators.

Control variables: The degree of openness of trade (Open) can be measured by the ratio of total imports and exports of goods to gross domestic product, the annual GDP per capita (aGDP) to the ratio of the total population of the year, and by the government tax (taxre) and the production price index (ppi).

3.2 Model design

Referring to Cao Wei's adjustment effect model, three regression equations are constructed based on the above relationship between industrial upgrading and financial innovation, as well as the relationship between technological innovation and industrial upgrading.

In order to test the relationship between financial innovation and industrial upgrading, a regression model is constructed:

$$\text{upindustry} = \alpha_0 + \alpha_1 \text{fin} + \alpha_3 \text{control} + \varphi_i + \varepsilon_{it}$$

In order to test the relationship between technological innovation and industrial upgrading, the regression model 2 is constructed:

$$\text{upindustry} = \beta_0 + \beta_1 \text{tech} + \beta_2 \text{control} + \varphi_i + \varepsilon_{it}$$

In order to test the regulatory role of technological innovation, build a regression model 3:

$$\text{upindustry} = \gamma_0 + \gamma_1 \text{tech} + \gamma_2 \text{fin} + \gamma_3 \text{c_tech} * \text{c_fin} + \varphi_i + \varepsilon_{it}$$

In c_tech * c_fin, it is the centralized treatment mentioned above to avoid the commonness between regulatory variables and tech and fin; φ is an individual effect and ε is a random disturbance term. The size of observation is α_i in Equation 1; The magnitude of β_i observed is coefficient in Equation 2; Equation 3 adds the interaction term of technological innovation and financial innovation, if γ_3 is significant, proves the regulatory effect.

4. Empirical study

Starting from the carbon intensive companies cited in the paper, select 12 industries in the industrial field data samples, covering the 2012-2021 period, and in the three regression model, using Stata data analysis tools to confirm our guess, specific contains descriptive statistics, multivariate regression analysis and stability check steps.

4.1 Descriptive statistical analysis

Descriptive statistical analysis data are presented in Table 1. Of the 12 carbon-intensive industry observations, The average value of industrial upgrading was 0.346. And with a standard deviation of 0.146, This shows that the overall level of the carbon-intensive industry upgrading index is relatively high, The difference between different industries is small; The mean value for financial innovation was 0.897, The standard deviation was 0.0396, this shows that the difference in financial innovation between different carbon-intensive industries is small; The mean value of the technological innovation index is 0.201 standard deviation is 0.221, and the gap between the maximum value and the minimum value is large, This shows that the technological innovation indicators between carbon-intensive industries differ greatly.

Table 1: Descriptive statistics

VARIABLES	mean	sd	min	max
upindustry	0.346	0.164	0.146	0.876
fin	0.897	0.0396	0.840	0.999
tech	0.201	0.221	9.98e-05	0.979

Open	0.362	0.0486	0.318	0.453
ppi	100.6	5.047	93.90	110.7
taxre	0.303	0.0497	0.218	0.376
aGDP	5.811	1.309	3.962	8.136

4.2 Regression analysis

To enhance the accuracy of the prediction model, we use the random influence model (if the Hausman results over 0.1 support the original hypothesis at 1% probability; otherwise, if the value is lower than 0.1, there is obvious evidence against the original hypothesis at 1% probability, the fixed influence model). The test result was a P-value of 0.0019, less than 0.1, so the hypothesis was rejected and a fixed-effect model was chosen. Multiple regression analysis of the panel data was performed using Stata17.0 data analysis software and the results are shown in Table 2.

Table 2. Regression results for the fixed effects

	Model 1	Model 2	Model 3	Model 4
fin	0.513*** (0.091)	0.482*** (0.182)		0.381** (0.152)
Open		0.390 (0.257)	0.382* (0.225)	0.372* (0.213)
ppi		0.001 (0.001)	0.002** (0.001)	0.001 (0.001)
aGDP		-0.012 (0.017)	-0.015 (0.015)	-0.025* (0.014)
taxre		0.548 (0.633)	0.558 (0.553)	0.711 (0.524)
tech			0.363*** (0.057)	0.236*** (0.071)
inter				1.007** (0.394)
_cons	-0.114 (0.082)	-0.440** (0.193)	-0.162 (0.136)	-0.362** (0.161)

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

The results of model 1 and model 2 regression in Table 3 both verify the relationship between financial innovation and the upgrading of carbon-intensive industries. The difference is that the former has no control variables, while the latter has control variables. According to the empirical results in Table 3, both are significant at the 1% level, indicating that the relationship between financial innovation and the upgrading of carbon-intensive industries is stable. Model 2 tests the overall effect of financial innovation on the upgrading of carbon-intensive industries, Of which the coefficient of financial innovation is 0.482, Significant at the 1% level, And the significant positive relationship between China's financial innovation and carbon-intensive industrial upgrading, So the hypothesis one is true; Model 3 examines the relationship between technological innovation and technological innovation in carbon-intensive industries, Where the technological innovation coefficient is 0.363, And were significant at the 1% level, Therefore,

technological innovation has a positive role in promoting the upgrading of carbon-intensive industries, Hypothesis 2 is verified; Model 4 tests the role of technological innovation in financial innovation and carbon-intensive industrial upgrading, Its results show the coefficient of financial innovation at 0.381 and significant at the 1% level, The interaction term coefficient of 1.007 was significant at the 5% level, This shows that technological innovation plays a positive regulatory role in the impact of financial innovation on the upgrading of carbon-intensive industries, That means that the technological innovation of carbon-intensive industries in China will enhance the positive impact of financial innovation on industrial upgrading, Verify that hypothesis 3 holds.

4.3 Robustness test

In order to ensure the robustness of technological innovation, based on the components of technological innovation, excluding the number of patents and development time of the two factors, research and development funds as a measure of technological innovation, and the research and development funds take logarithmic processing, using Stata17 data analysis software to further model three and four empirical analysis, the results see table 3. Model 3 tests the relationship between technological innovation and technological innovation in carbon-intensive industries, where technological innovation coefficient is 0.363 and significant at 1% level, so technological innovation has a positive effect on carbon intensive industry upgrading, and verifies hypothesis 2; Model 4 tests the role of technological innovation between financial innovation and carbon intensive industry upgrading, showing that the coefficient of financial innovation is 0.381 significant at 1% level, and the interaction term coefficient is 1.007 significant at 5% level, This is the analysis of the regression model mentioned above in this table for comparison with the new model 3 and Model 4. The coefficient of the technology innovation variable (lnh) is 0.032, which is significant at the 5% level, indicating that the r & D funds can also be used as an indicator of technological innovation. The new model 4 is the new variable of technological innovation (lnh) and the regression model of the interaction term with fin. The coefficient of its interaction term is 0.456, and both are significant at the 5% level. Therefore, replacing the financial innovation index to test the stability of the model, both in terms of relationship and significance, once again verifies that technological innovation plays a positive regulatory role in the financial innovation in promoting the upgrading of carbon-intensive industrial structure.

Table 3. Stability test

	Model 3	Model 4	New model 3	New model 4
tech	0.363*** (0.057)	0.236*** (0.071)		
Open	0.382* (0.225)	0.372* (0.213)	0.332 (0.259)	0.306 (0.210)
ppi	0.002** (0.001)	0.001 (0.001)	0.002** (0.001)	0.002 (0.001)
aGDP	-0.015 (0.015)	-0.025* (0.014)	-0.003 (0.017)	-0.022 (0.014)
taxre	0.558	0.711	0.440	0.695

	(0.553)	(0.524)	(0.637)	(0.517)
fin		0.381**		0.268*
		(0.152)		(0.152)
inter		1.007**		
		(0.394)		
lnh			0.032**	0.065***
			(0.014)	(0.013)
inter2				0.456***
				(0.066)
_cons	-0.162	-0.362**	-0.453**	-0.906***
	(0.136)	(0.161)	(0.209)	(0.189)

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

5 Conclusion

First China's upgrading of carbon-intensive industries has a significant positive relationship with financial innovation, that is, when the higher the degree of financial innovation is, it plays a better role in promoting the upgrading of carbon-intensive industries. Then ,the upgrading of carbon-intensive industries in China has a significant positive relationship with the technological innovation of the industry, that is, the higher the degree of technological innovation of carbon-intensive industries, the more substantial the progress of industrial upgrading in the industry, which can reduce energy consumption and improve profits. Finally, technological innovation of China's carbon-intensive industries plays a positive regulatory role in promoting the upgrading of carbon-intensive industries through financial innovation. Through the innovation of the external financial industry, these industries can further promote the industrial upgrading of the industry.

References

- [1] Yuna Di. Research on the export strategy of China's carbon-intensive industries —— Based on the perspective of EU carbon leakage [J]. Soft Science, 2016 (11): 29-39
- [2] Chuanjiang Liu, Xiaomeng Zhao. Is there any industrial heterogeneity in the strong "Porter hypothesis"?—— Based on the perspective of industrial carbon intensity segmentation [J]. Chinese Population, Resources and Environment, 2017 (6): 2
- [3] Xiaoqiu Wu. Industrial Iteration and Financial Innovation based on technological Progress [J]. Modern Finance Guide, 2022, (12): 10-11..
- [4] Xudong Zhuang,Junshan Duan. Financial innovation, resource allocation and high-quality economic development —— Analysis and evidence under the background of building a financial power [J]. Research of Financial Economics, 2024,39 (01): 60-74.
- [5]BENCIVENGA V R,SMITH BD.Financial intermediation and endogenous growth [.Review of Economic Studies,1991.58(2):195-209
- [6]Fisher,A.G.B.A Note on Tertiary Production[J].The Economic Journal,1952,62(248):820-834.

- [7]Yan Chen. Research on the impact of financial innovation on carbon emissions from the perspective of carbon neutral: —— Take Wenzhou city as an example [J]. Special Economic Zone Economy, 2024, (01): 115-118.
- [8]Jie Xue . Research on the influence of Fintech on industrial structure upgrading [J]. Technology Entrepreneurship Monthly, 2024,37 (02): 88-93.
- [9]Wei Li. Technological innovation and industrial structure upgrading: the threshold effect of financial development [J]. North China Finance, 2023, (11): 61-74.