The Impact of Industrial Structure Upgrading on Carbon Emissions:

A Perspective on Foreign Direct Investment

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Abstract. Under the backdrop of the "dual carbon" goal, this paper, based on the panel data of each province in China from 2011 to 2022, uses the mediation effect model to explore the relationship between industrial structure upgrading and carbon emissions, the mediating role of FDI, and regional heterogeneity. The research findings are as follows: 1) Industrial structure upgrading has a positive promoting effect on carbon emissions. That is, as the level of industrial structure improves, carbon emissions first increase and then decrease; 2) Industrial structure upgrading further expands carbon emissions by increasing the amount of foreign direct investment in the region; 3) The positive promoting effect of industrial structure upgrading on carbon emissions is most obvious in the western and eastern regions, with a greater promoting effect on the western region. Therefore, this paper believes that it is necessary to promote high-quality industrial development, improve and optimize the mechanism for guiding foreign direct investment, implement differentiated and personalized management, and thereby formulate corresponding policies.

Keywords: Industrial Structure, Carbon Emissions; Foreign Direct Investment; Mediating Model

1 Introduction

The upgrading of the industrial structure is closely related to carbon emissions. Foreign direct investment is currently an important link connecting the domestic and international circulations in China. Under the constraints of the dual-carbon goals, the core path for upgrading the industrial structure is to promote the transformation of the industrial system. In order to better leverage the enabling role of FDI and clarify the mechanism of their interactions, this paper aims to explore the impact of industrial structure upgrading on carbon emissions, as well as the mediating transmission effect of FDI, and conduct an empirical analysis.

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2 Literature Review

The improvement of advanced industrial structure level can promote carbon emission intensity reduction. This emission reduction effect can also drive the simultaneous emission reduction in surrounding areas [1]. However, the economic growth driven by industrial structure upgrading will also make the local area demand for low-energy consumption industries, thereby increasing carbon emissions [2]. SCHIPPER analyzed the carbon emission factors of the manufacturing industries in 13 IEA countries and believed that the industrial structure does not have a significant impact on carbon emissions [3]. The positive emission reduction effect of industrial structure upgrading on carbon emissions is mainly achieved through technological innovation and technology dissemination. In terms of technological innovation, a reasonable industrial layout helps to encourage the progress of clean production technologies and management levels, reduce redundant construction and resource waste, promote the development of a sustainable economy, and thereby reduce the carbon emission intensity [4]; in terms of technology dissemination, the advanced industrial structure will also promote the popularization and use of clean technologies and low-carbon technologies, alleviate the dependence of economic growth on coal and oil [5].

Existing studies have shown that FDI has a dual impact on China's carbon emissions. On the one hand, FDI through the technology spillover effect introduced more advanced production technologies and processes from developed countries, which to a certain extent reduced China's carbon emission intensity and improved environmental quality. Research in the Pearl River Delta region of Guangdong Province in China found that there is a significant negative correlation between the scale of foreign direct investment and carbon emissions, that is, as the scale of FDI expands, the carbon dioxide emissions in this region gradually decrease [6]. However, on the other hand, a large amount of FDI flowed into China's pollution-intensive industries, which also brought environmental pressure. Therefore, China needs to formulate stricter environmental access systems and selectively utilize foreign capital [7]. Further research has found that the impact effect of FDI on carbon emissions in the eastern region is better than that in the central and western regions [8], possibly due to the higher economic development level, more complete education system and stricter environmental regulation policies in the eastern region.

3 Theoretical Model and Research Hypothesis

Environmental Kuznets Curve theory indicates that relationship between economic development level and environmental pollution is not linear. Industrial structure upgrading significantly influences carbon emissions. Changes in the industrial structure will consume relevant resource elements and increase carbon emissions. However, any industry will go through different stages. Carbon emission intensities in different stages have essential differences. Based on this theory, this paper proposes Hypothesis 1.

H1: Industrial structure upgrading has a non-linear impact on carbon emissions.

As the level of industrial structure improves, the regional industrial supporting system gradually becomes more complete and the consumption potential expands continuously. Furthermore, energy consumption and carbon emissions increase. In order to expand the scale of FDI introduction, local governments may lower the environmental access threshold. Later, many high energy-consuming and carbon-emission foreign industries inflow, ultimately exacerbating regional carbon emissions. Based on this, this paper proposes Hypothesis 2.

H2: Industrial structure upgrading can further intensify carbon emissions by promoting FDI inflows.

Resource Base Theory further indicates that different regions have essential differences in resource endowment, which will lead to significant differentiation in the impact of the same economic behavior. Regions with higher economic development level usually have higher industrial structure, and will gradually transfer polluted industries to lower-gradient regions. Based on this, this paper proposes the following Hypothesis 3.

H3: The impact of industrial structure upgrading on carbon emissions has significant regional heterogeneity.

4 Model Setting and Descriptive Statistics

4.1 Research Design

To demonstrate the relationship among industrial structure and carbon emission intensity, this paper constructs a regression model as shown in Equation (1).

$$Carbon_{it} = \beta_0 + \beta_1 Ind_{it} + \theta Controls_{it} + \varepsilon_{it} \tag{1}$$

Among them, $Carbon_{it}$ represents the dependent variable, indicating the carbon emission intensity of province i in year t; Ind_{it} is the core explanatory variable, representing the level of industrial structure upgrading; $Controls_{it}$ is a series of control variables, and ε_{it} is the random disturbance term.

Considering that the relationship between industrial structure and carbon emissions may not be a simple linear one, this paper continues to add the square term of the industrial structure level to the model.

$$Carbon_{it} = \beta_0 + \beta_1 Ind_{it} + \beta_2 Ind_{it}^2 + \theta Controls_{it} + \varepsilon_{it} \tag{2}$$

To explore the mechanism of the impact of industrial structure upgrading on carbon emission intensity, this paper starts from the perspective of foreign direct investment (FDI) level and constructs the following models (3) and (4).

$$FDI_{it} = \gamma_0 + \gamma_1 Ind_{it} + \theta' Controls_{it} + \varepsilon_{it} \tag{3}$$

$$Carbon_{it} = \beta_0'' + \beta_1'' Ind_{it} + \beta_2'' FDI_{it} + \theta'' Controls_{it} + \varepsilon_{it} \tag{4}$$

4.2 Variable Selection and Data Source

Dependent variable carbon emission (Carbon), is measured by the logarithm of the carbon emissions in the industrial production process of the region. Core explanatory variable Ind, is represented by the ratio of the output value of tertiary industry to secondary industry. The mediating variable FDI is measured by the logarithm of the actual utilization of foreign direct investment. Furthermore, this article also selects a series of control variables, including infrastructure level (Inf, railway mileage in thousands of kilometers), fiscal support (GI, general public budget expenditure as a proportion of GDP), and technological innovation level (Tec, fiscal expenditure on science and technology as a proportion of general public budget expenditure). The data sources are the China Statistical Yearbook and the statistical yearbooks of each province, etc. The descriptive statistics of each variable are shown in Table 1.

Table 1. Descriptive Statistics of Variables (N=319)

Variable	Mean	Std. Dev.	Min	Max
Carbon	9.111	0.521	7.584	9.906
Ind	1.307	0.739	0.549	5.297
Inf	0.434	0.406	0.047	6.255
GI	0.256	0.110	0.105	0.758
Tec	0.022	0.015	0.005	0.068
FDI	9.315	1.426	5.645	13.248

5 Empirical Results

5.1 Benchmark Regression

Table 2 presents the baseline regression results. With additional control variables continuously adding, the coefficients of industrial structure on carbon emissions are always significant, indicating that industrial structure upgrading has a positive promoting effect on carbon emissions. Further, by adding Ind^2 to the model, the results are shown in column (5) of Table 2, which shows an inverted U-shaped relationship. This might be because in the early stage of industrial structure upgrading, relevant increasing costs will lead to an increase in energy consumption and carbon emissions. When the industrial structure continues to transform towards a higher-end direction, carbon emissions turn from rising to falling. Hypothesis 1 holds.

Table 2. Baseline Regression Results (N=319)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Carbon	Carbon	Carbon	Carbon	Carbon
Ind	0.258***	0.248***	0.244***	0.234***	0.349***
	(0.036)	(0.034)	(0.033)	(0.034)	(0.047)
Ind^2					-0.028***
					(0.006)

Inf		0.068***	0.069***	0.068***	0.061***
		(0.017)	(0.014)	(0.012)	(0.007)
GI			-0.819**	-0.774**	-0.765*
			(0.373)	(0.359)	(0.388)
Tec				2.213**	1.826*
				(0.949)	(0.936)
Constant	8.773***	8.758***	8.971***	8.924***	8.846***
	(0.047)	(0.045)	(0.106)	(0.101)	(0.107)
Zone fixed			Yes		
R^2	0.269	0.291	0.314	0.320	0.340

Note: Robust standard errors are in parentheses; ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively, as in the table below.

5.2 Robustness Tests

This paper further employs the following three methods for robustness tests: (1) Excluding the special pandemic year 2020. (2) Excluding the four municipalities directly under central government in China (Beijing, Tianjin, Shanghai, and Chongqing). (3) To ensure that the regression results are not influenced by certain outliers, this paper replaces all continuous variables with 1% and 99% quantile replacements. Results in Table 3 are not changed, which means that the conclusion drawn above is valid.

Table 3. Robustness Test Results

VARIABLES	(1) Excluding year2020 samples	(2) Exclude municipalities directly controlled	(3) Winsorizing
Ind	0.184***(0.047)	0.301***(0.035)	0.206***(0.031)
Controls, Zone fixed		Yes	
Constant	8.800***(0.095)	8.918***(0.126)	8.822***(0.083)
N	290	275	319
R^2	0.344	0.347	0.367

5.3 Mechanism Analysis

To verify hypothesis 2, this paper explores mediating mechanism of foreign direct investment. The results are shown in Table 4. The coefficient in column (1) of Ind is 1.612 and is significant, indicating that Ind has a significant positive promoting effect on FDI; column (2) shows that the coefficient of FDI on Carbon is significantly 0.059, indicating that foreign direct investment promotes industrial carbon emissions. Ind helps to expand the level of foreign investment in the region, thereby increasing carbon emissions. Thus, hypothesis 2 is established.

Table 4. Regression Results for the Mediation Mechanism Test

VARIABLES	(1) FDI	(2) Carbon
FDI		0.059**(0.023)
Ind	1.612***(0.279)	0.138***(0.043)
Constant	7.854***(0.572)	8.458***(0.220)
Controls, Zone fixed	Yes	
N	319	319
R^2	0.616	0.355

5.4 Heterogeneous Analysis

This paper refers to the relevant national regulations to divide the entire country into four regions and conducts regression analysis separately. The results are shown in Table 5. For eastern and western regions, the coefficients of the industrial structure are 0.138 and 0.373 respectively. The promoting effect on carbon emissions is the greatest in the western region. For the central and northeastern regions, although the coefficients are both positive, they are not significant. Therefore, Hypothesis 3 is verified.

Table 5. Heterogeneity Analysis

Variable	(1) Eastern	(2) Central	(3) Western	(4) Northeastern
Ind	0.138***(0.020)	0.193(0.100)	0.373***(0.105)	0.082(0.284)
Constant	9.039***(0.096)	9.361***(0.313)	8.623***(0.269)	8.583***(0.257)
Controls	Yes			
Zone Fixed	Yes			
N	110	66	110	33
R^2	0.433	0.420	0.328	0.484

6 Conclusion and Suggestion

This study mainly reaches the following three conclusions: 1) The upgrading of the industrial structure has a positive promoting effect on carbon emissions. As the level of the industrial structure improves, carbon emissions first increase and then decrease. 2) The industrial structure upgrading further expands carbon emissions by increasing the foreign direct investment. 3) The positive promoting effect of industrial structure upgrading on carbon emissions is most obvious in the western and eastern regions, with a greater promoting effect on western region. Based on this, this paper proposes the policy suggestions: Firstly, efforts should be made to promote high-quality industrial development. Secondly, the mechanism for guiding foreign direct investment should be improved to reduce indirect transmission of high-carbon emissions. Finally, differentiated and personalized management should be implemented. Eastern enterprises can share relevant pollution control experience with western enterprises..

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