The Impact of Outward Foreign Direct Investment on Carbon Emission toward China’s Sustainable Development

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Abstract: It is of practical significance to evaluate whether enhancing outward foreign direct investment (OFDI) can promote carbon mitigation under the new urbanization background toward China’s sustainable development and carbon neutrality. The impact of OFDI on carbon emissions is investigated from the dual perspectives of the urbanization threshold and the mediating path by using panel data from China’s 30 provinces during the period of 2003–2015 and considering both population and land. The results show that there is a significant impact from interprovincial OFDI on CO₂ emissions with the double threshold effect of urbanization, and that OFDI expansion will increase CO₂ emissions with urbanization; however, the different stages of urbanization show inverted U-shaped characteristics that first rise and then fall. The optimization of industrial structures has not passed the mediating effects test during the sample period, while the rationalization of the industrial structure provides a mediating effect in the primary stage of urbanization and a suppressing effect in the high level stage of urbanization. Import dependence only shows a masking effect in the intermediate stage of urbanization, while the technical level shows an intermediary effect in the primary stage of urbanization and a masking effect in the intermediate stage. The intensification of OFDI has brought different effects on economic and social production in various regions of China under urbanization, which has further affected regional carbon emissions. Discussing these effects would help to provide constructive suggestions for the regional coordination of development, new urbanization construction and urban low carbon transformation.

Keywords: outward foreign direct investment; carbon emission; urbanization threshold; sustainable development; carbon neutrality

1. Introduction

The IPCC Fifth Assessment Report has noted that global temperature has increased by 0.85 °C over the past 130 years and that human activity is the main cause of global warming. The emissions of fossil fuels and changes to land development have increased carbon dioxide concentrations by 40% when compared with the preindustrial era. With the growing emphasis on the environment in recent years, increasing pollutant emissions and environmental degradation have heightened public anxiety and concerns from public officials. In this context, carbon emissions have become key to studying the Earth’s greenhouse effect [1,2]. As a large developing country, the contradiction between China’s economic development and the demands for environmental protection have grown stronger in recent years. China has become the world’s largest energy consumer, with its urban areas accounting for 75% of the total energy consumption and generating 85% of energy-related carbon emissions [3]. With this ongoing development, increases in energy consumption and carbon dioxide emissions have largely led to domestic environmental degradation [4,5]. Due to the dual pressure from environmental demands and international reaction to carbon
emissions, China promised at the 2015 United Nations Climate General Assembly that CO\textsubscript{2} emissions per GDP will peak in 2030 and then fall by 60–65% from 2005 levels. Therefore, a key to completing this task is to analyze the drivers of high carbon dioxide emissions in China and to explore reasonable ways to reduce those emissions.

As urbanization has become an inevitable trend for social development and modernization, especially as the world enters a new round of large-scale urbanization, it has become an inevitable trend for social development and modernization. Building a new type of urbanization can strengthen the resource guarantees of the city and its environmental protection capacity, which is significant for the promotion of sustainable development [6,7]. Urbanization can promote sustainable urban development by reasonably controlling the speed of urban expansion, by effectively coordinating urban and rural development, by formulating scientific development strategies and by improving the living standards of residents [8]. Numerous studies have focused on the relationship between urbanization and carbon emissions [9,10]. Some scholars have proposed that the process of urbanization is directly related to increased emissions [11,12]. Sheng and Guo [13] have concluded that urbanization has positive impacts on carbon dioxide emissions both in the short- and long-term. Considering that urbanization is a multidimensional evolutionary process, some articles have explored the impacts on carbon emissions from the perspectives of the rapid population growth and the significant changes to land use caused by the accelerated urbanization process [14,15]. Moreover, there has been research concerning the environmental impact of urbanization. Inmaculada and Antonello [16] have argued that if urbanization reaches a certain level the effect on emissions will be negative, thus contributing to reduced environmental damage. Xu and Lin [17] have confirmed that there is an inverted U-shaped relationship between urbanization and CO\textsubscript{2} emissions in the eastern region of China, but a positive U-shaped pattern in the central region. Consequently, in order to achieve the low carbon development goal it is a necessary to seek a novel urbanization routine for sustainable economic and environmental development.

Since the beginning of the 21st century, transnational investment has become increasingly important for the circulation of production factors. China’s outward foreign direct investment (OFDI) has officially entered a stage of rapid growth and has reached record highs [18]. Together, economic globalization and the deepening of international trade have promoted the rapid development of urbanization [19]. Urbanization is a product of economic development, and as Wang [20] has argued, the mode of economic development has been transformed into a major driving force of the urbanization process. Other scholars have proposed that OFDI is related to the economic growth of China. Zhang [21] has proposed that there is a short- and long-term stable positive relationship between China’s economic growth and OFDI. Therefore, using economic development as a link can demonstrate the correlation between OFDI and urbanization. Urbanization, which can drive the expansion of domestic demand, and OFDI, which can stimulate the increase of investment, provide important supports for sustainable economic development.

Due to the increasing requirements of sustainable development and environmental protection in the 21st century, the interaction between OFDI and carbon emissions has become an important issue. Some scholars have proposed that developed countries use OFDI to transfer high-polluting and high energy industries into developing countries in order to meet their national emissions reduction targets [22,23]. The rise of emerging economies has made developing countries an important body for global OFDI, and some scholars have argued that developing countries can reduce their carbon emissions by acquiring cleaner production technologies and methods from developed countries [24–26]. In fact, while OFDI has brought growth to China’s economy [27,28], the impact on the environment is still under discussion. From the perspective of the research results, Zhou et al. [29] have shown that China’s OFDI does bring a green spillover effect, but it also shows great cross-provincial heterogeneity. From the perspective of the research path, some scholars argue that OFDI has an impact on the industrial structure, the trade structure and on the technical level, and further affects China’s environmental pollution [30–32].
In summary, current studies on urbanization, carbon emissions and OFDI are abundant, but few studies have incorporated the three into a unified framework that considers carbon emissions and OFDI from an integrated urbanization perspective. Therefore, and in distinction from the existing studies that take different countries as research samples, this paper selected provinces and cities with different endowments and significant regional differences in China between 2003 and 2015 to explore the regional characteristics of the OFDI impact on carbon emissions from a more micro perspective. First, a comprehensive urbanization index was obtained by constructing a multidimensional indicator system on urbanization. Second, the existence of the comprehensive urbanization threshold of the study sample was tested in a relevant manner, and on this basis the sample interval was divided according to the comprehensive urbanization threshold. This paper introduces urbanization as a threshold in a novel way so to analyze the impact of regional OFDI on carbon emissions in different spatial and temporal stages. Finally, the mediation effect model was used to examine the mediation effect of the above-mentioned grouped samples, and the effect of interprovincial OFDI on carbon emissions was analyzed. One of the possible contributions of this paper is to take the industrial structure, the trade structure and the technological progress as intermediary variables so to analyze the path of OFDI to carbon emissions. The following research assumptions are presented in this paper: First, there is a threshold effect of interprovincial OFDI on carbon emissions; second, the impact of interprovincial OFDI on carbon emissions varies at different levels of urbanization; third, interprovincial OFDI plays a role in carbon emissions through the industrial structure, the trade structure and the technological level, and these pathways work differently under different urbanization thresholds.

2. Mechanism Analysis

This paper uses the classical IPAT model to analyze the impact mechanism of interprovincial OFDI on carbon emissions. The IPAT model is the original environmental economic model, which is expressed as \( I = P \times A \times T \). Using the form of the IPAT model for reference, carbon emissions represent the environmental pressure \( I \), \( P \) represents the threshold of the level of urbanization, \( A \) represents the economic structure, including the industrial structure and trade structure and \( T \) represents the technological level. In the context of the threshold of urbanization, the impact mechanism is summarized as the industrial structure effect, trade structure effect and technology effect. The specific mechanism analysis is as follows:

1. The industrial structure effect: The existing research mainly expounds on the impact of OFDI on the industrial structure from three aspects. First, OFDI adjusts the internal structure of enterprises. While conducting OFDI, transnational corporations in emerging economies can obtain new advantages suitable to their own development and which can have a profound impact on the industrial structure of the region. Second, OFDI adjusts the interior of industry. In the pursuit of profit, the improvement of the efficiency of one manufacturer will surely have a demonstration effect or a threat effect on other manufacturers in the industry, and may also produce a driving force or pressure on the supply and demand chain of the upstream and downstream industries. Third, OFDI adjusts the structural transfer between industries. As the development model and the industrial structure of each region are different, OFDI may cause the industry to transfer, which in turn may either be gradient or reverse gradient. While regional production is closely related to carbon emissions based on the energy consumption, changes in the industrial structure will directly or indirectly affect regional carbon emissions.

2. The trade structure effect: OFDI adjusts the trade structure mainly through trade creation effects (i.e., export-induced and reverse imports) and trade substitution effects (i.e., export substitution and import transfer). The theory of marginal industrial expansion holds that companies would transfer industrial production to countries with lower costs in order to pursue profits. This may result in becoming export-induced (i.e., the home country exports related products to the investing country) or in import transfers (i.e., reducing
the need to import related products to other countries under the original home country production conditions). However, because the home country transfers the production of products in its mature or standardized stage to the host country so to provide markets and capital for the development of other domestic industries, the reverse import (i.e., the import of the product from the home country to the host country) or export substitution (i.e., the production base directly transferred to the host country to reduce the original export of the home country) is thus formed. Changes in the trade structure affects the supply and demand of energy consumption in the home country, which then changes the carbon emissions.

(3) The technology effect: Technology spillovers under the international trade route mainly include FDI technology spillovers and OFDI reverse technology spillovers, both of which will improve the technology level of the receiving country. There are two ways for technological progress to impact carbon emissions in different regions. First, technological progress will influence the indirect effects of carbon emissions by affecting economic growth. On the one hand, the progress of production technology will promote the expansion of regional production, and may further drive the increase of total energy consumption thereby leading to the continuous expansion of regional carbon emissions; on the other hand, it may also reduce carbon emissions for reasons such as scale production. Second, the technological progress will have a direct effect on carbon emissions. Due to the path dependence of technological progress itself, whether technological progress will increase carbon emissions or promote carbon emission reduction depends on whether the original profitable technology is dirty or clean technology.

As a global production factor allocation method, OFDI can produce various economic effects on the home country and have a profound impact on the home country’s industrial structure, trade structure, and technology level. On this basis, the flowing form of this production factor is bound to have an action mechanism on the energy consumption, but the direction and magnitude of this impact must be analyzed according to the specific conditions of the different regions.

3. Model Construction, Variable Selection and Data Description

3.1. Model Building

Based on the IPAT model, the STIRPAT model (Stochastic Impacts by Regression on PAT) proposed by York not only retains the essence of the IPAT model but also introduces random fluctuation factors. Its basic form is as follows:

$$I_i = \alpha \cdot P_i^a \cdot A_i^b \cdot T_i^c \cdot e_i$$

(1)

where I represents the environmental pressure, P represents the population size, A represents the economic status, and T represents the technical level. In specific empirical studies, in order to better complement the random variables and to eliminate heteroscedasticity, the variables in Formula (1) are generally treated by logarithm, and the form is as follows:

$$\ln I = \ln \alpha + \ln P + \ln A + \ln T + \ln e$$

(2)

The per capita CO$_2$ emissions are used to represent the environmental pressure, and related variables are supplemented based on Formula (2). The basic form is as follows:

$$pco_{2it} = \alpha_{it} + \beta \ln ofdi_{it} + \sum \phi_{i} controls_{it} + \epsilon_{it}$$

(3)

where the per capita CO$_2$ emission ($pco_{2it}$) is the explanatory variable which represents the per capita carbon dioxide emissions of province $i$ in the period $t$, the outward foreign direct investment ($lnofdi_{it}$) is the core explanatory variable which represents the external direct investment of province $i$ in the period $t$, controls represents all control variables, $\alpha$ is a constant term and $\epsilon$ is a random error term.
As this article examines the impact of interprovincial OFDI on carbon emissions under the threshold effect of urbanization, the threshold variable is added to Equation (3). Assuming that there is a double threshold, the basic model is as follows:

\[
pco_{2it} = \alpha_{it} + \beta_1 \ln\text{ofdi}_{it} T(\text{curb} \leq \rho_1) + \beta_2 \ln\text{ofdi}_{it} T(\rho_1 < \text{curb} \leq \rho_2) + \beta_3 \ln\text{ofdi}_{it} T(\text{curb} > \rho_2) + \sum \varphi_i \text{controls}_{it} + \epsilon_{it} \tag{4}
\]

Equation (4) represents the impact model of the provincial OFDI on per capita carbon emissions under the comprehensive urbanization threshold.

3.2. Variable Description and Data Description

(1) Outward foreign direct investment (\(\ln\text{ofdi}\)): As the core explanatory variable of this paper, OFDI mainly selects nonfinancial OFDI in various provinces and cities as the proxy variable.

(2) Calculation of energy carbon emissions (\(pco_2\)): The per capita CO\(_2\) emissions of each province are selected as the explanatory variables. From the perspective of energy consumption, the CO\(_2\) emissions in this paper are mainly calculated through the consumption of various types of fossil energy. The basic formula is as follows:

\[
\text{CO}_2_{it} = \sum E_{jit} \ast K_j \ast EF_j \ast 44/12 \tag{5}
\]

Equation (5) represents the CO\(_2\) emission scale of each province and city, where \(j\) represents the type of energy, \(K_j\) represents the standard coal coefficient of \(j\) energy, \(EF_j\) represents the carbon emission coefficient of \(j\) energy and 44/12 represents the mass ratio of carbon dioxide molecules and carbon elements.

In the selection of fossil energy, this paper mainly provides statistics on carbon, oil, natural gas and electricity consumption. Since electricity consumption does not generate carbon dioxide, this paper mainly provides statistics on the first three kinds of energy. Table 1 shows the carbon content and the effective carbon dioxide emission coefficients of different types of fossil fuels.

(3) Measurement of the comprehensive urbanization threshold (\(\text{curb}\)): According to the research, population expansion in the process of urbanization will have an impact on carbon emissions [33]. Moreover, the divergence of land use types will have separate effects on carbon emissions [15,34]. Therefore, this paper establishes a comprehensive urbanization index system based on population urbanization and land urbanization. As shown in Table 2, this paper selects the entropy method to measure the index system and to obtain the relative objective values of each index.
Table 2. Comprehensive index system of urbanization.

| First-Level Indicators | Secondary Indicators | Tertiary Indicators (Ij) | Indicator Properties | Index Weight (Wj) |
|------------------------|----------------------|--------------------------|----------------------|------------------|
| Population urbanization (50%) | Proportion of nonagricultural population | Positive | 8.870 |
|                        | Population density | Positive | 37.457 |
|                        | Proportion of employment in secondary and tertiary industries | Positive | 7.709 |
| Population quality | College students per 10,000 people | Positive | 12.275 |
| Citizens’ lives | Real GDP per capita | Positive | 20.204 |
|                        | Resident Engel coefficient | Negative | 2.942 |
|                        | Beds per 10,000 people | Positive | 10.543 |
| Land urbanization (50%) | Built-up area | Positive | 5.660 |
|                        | Park green area per capita | Positive | 6.802 |
|                        | Residential area, industrial, mining and transportation land | Positive | 0.489 |
| Land investment | Average land employees | Positive | 10.102 |
|                        | Average land power consumption | Negative | 18.549 |
| Land output | Land average secondary and tertiary industry output value | Positive | 33.202 |
|                        | Land average fiscal revenue | Positive | 25.196 |

(4) Control variables: In addition to the scale of OFDI, carbon emissions are also affected by other explanatory variables. With reference to the previous research, the following variables are added to the econometric model in this paper: ① Energy consumption structure (coals). Energy consumption is the most direct factor affecting carbon emissions, and the change to the energy consumption structure plays a key role in the degree of regional carbon emissions [35]. ② Population structure (urban). The expansion of the population has put forward new requirements for regional employment, production and living. In the process of population agglomeration to cities, it not only promotes urbanization but also increases various costs [36]. ③ Environmental governance costs (envir). Legal means such as environmental regulation in environmental governance, and economic measures such as economic sanctions, will have an effect mechanism on carbon emissions [37–39]. ④ Technical progress (rts). Acemoglu et al. [40] have distinguished this effect into indirect and direct effects in the research on the impact of technological progress on carbon emissions. Indirect effects depend on the effects of economic growth on carbon emissions, while direct effects are due to the path dependence of technological progress. ⑤ Attention to science and education (edth). Attention to science and education refers to the expenditure of public finance on science and education in the region. On the one hand, the expenditure on science and education measures the degree of regional attention to science and technology. On the other hand, it may have a subtle influence on people’s behavior, such as showing a preference for green products. ⑥ Industrial condition (indus). There is no doubt that the secondary industry has a huge demand for energy consumption and transformation, and the upgrading of industrial structure has become the key to responding to the slogans of low carbon development [41–43].

(5) Intermediate variables: ① Industrial structure. Referring to the research of Gan et al. [44], the industrial structure is divided into advanced industrial structure (shigh) and rational industrial structure (sreason). The ratio of the output value of the tertiary industry to the output value of the secondary industry is used to measure the advanced industrial structure [45]. The Theil index is selected to measure the rationalization of the industrial structure. When the value of the Theil index is 0, it indicates that the industrial structure is the best and in the state of Pareto optimal. The larger distance from 0, the more unreasonable the industrial structure. ② Trade structure. Numerous studies illustrate the impact of import and export trade on carbon dioxide emissions [46–48]. This article
divides trade effects into import effects and export effects which are expressed by import dependency (import) and export dependency (export), respectively. ③ Technical level (pth). Undoubtedly, as a key factor of economic progress, technological innovation capacity has a significant impact on ecological environment construction [49,50].

Table 3 gives the names, surrogate letters, measurement methods and data sources of the main variables used in this paper. Table 4 gives the descriptive statistical characteristics of the above related variables.

Table 3. Details of main variables and data sources. (These data are collected from open sources, and we are willing to share the data if needed.)

| Variable         | Name                          | Surrogate Letters | Measurement Methods                                      | Data Sources                      |
|------------------|-------------------------------|-------------------|---------------------------------------------------------|----------------------------------|
| Explained variable | CO₂ emissions scale  | pco2               | Ratio of CO₂ emissions to total regional population     | China Energy Statistics Yearbook, China Statistical Yearbook |
| Core explanatory variables | Outward Foreign Direct Investment | Inofdi            | Logarithm of regional OFDI                             | World Bank Database, China Outward Direct Investment Bulletin |
|                   | Energy consumption structure | coals             | Proportion of regional coal converted into standard coal in total energy consumption | China Energy Statistics Yearbook |
|                   | Population structure         | urban             | Proportion of nonagricultural population                | China Statistical Yearbook       |
|                   | Environmental governance cost | envir             | Proportion of environmental pollution treatment investment in regional GDP | China Environmental Statistics Yearbook |
| Control variable | Attention of science and education | edth             | Proportion of education and technology expenditure in public finance expenditure | China Statistical Yearbook       |
|                   | Technical progress           | rds               | R&D staff full-time equivalent (thousand person-years)  | China Statistical Yearbook       |
|                   | Industrial condition         | indus             | Proportion of regional industrial production to regional GDP | China Statistical Yearbook       |
| Threshold variable | Comprehensive urbanization    | curb              | Comprehensive urbanization indicator system             | Calculated                      |
|                   | Advanced industrial structure | shigh             | The ratio of the output value of the tertiary industry to that of the secondary industry | China Statistical Yearbook       |
|                   | Rational industrial structure | season            | Theil Index                                             | China Statistical Yearbook       |
|                   | Import dependency            | import            | Imports as a percentage of GDP                          | China Statistical Yearbook       |
|                   | Export dependency            | export            | Exports as a percentage of GDP                          | China Statistical Yearbook       |
|                   | Technique level              | pth               | Number of patents granted per capita                    | China Science and Technology Statistics Yearbook |

Table 4. Descriptive statistical characteristics of variables.

| Variable | Symbol | Mean | Sd  | Min  | Median | Max   |
|----------|--------|------|-----|------|--------|-------|
| pcO₂     | pco2   | 7.870| 5.340| 1.358| 6.313  | 30.365|
| lnofdi   | lnofdi | 10.608| 2.232| 4.262| 10.970 | 15.432|
| coals    | coals  | 61.360| 15.831| 13.971| 63.648 | 90.866|
| urban    | urban  | 49.011| 15.714| 15.580| 47.300 | 89.600|
| envir    | envir  | 1.319| 0.634| 0.163| 1.192  | 4.231 |
| edth     | edth   | 17.706| 3.171| 1.498| 19.814 | 25.207|
| rds      | rds    | 59.824| 95.647| 0.245| 18.130 | 520.303|
| indus    | indus  | 40.214| 8.344| 4.769| 41.604 | 56.492|
| curb     | curb   | 18.880| 12.031| 4.275| 16.121 | 86.697|
| shigh    | shigh  | 0.920| 0.473| 0.494| 0.806  | 4.035 |
| season   | season | 0.318| 1.365| 0.994| 0.233  | 27.051|
| import   | import | 17.441| 28.031| 0.584| 7.193  | 404.059|
| export   | export | 15.693| 18.517| 0.578| 7.704  | 89.268|
| pth      | pth    | 4.519| 7.124| 0.082| 1.710  | 43.312|
4. Empirical Analysis and Discussion of Results

4.1. Existence Test of Comprehensive Urbanization Threshold

Based on the panel threshold regression model proposed by Hansen, this paper estimates first the threshold value and then tests the significance of the threshold effect and the authenticity of the threshold estimation.

Significance test of the threshold value: Assuming no threshold effect exists, the null hypothesis is $H_0: \theta_1 = \theta_2$.

$$F = \frac{(S_0 - S_1(\hat{\theta}))}{\hat{\sigma}^2}$$  

Equation (6) represents the test statistic of the threshold significance, where $S_0$ and $S_1$ represent the sum of squares of residuals with and without threshold effects, respectively. If the sum of squared residuals is less than the sum of squared residuals under the threshold value, that is $F_1 > F_0$, then reject the null hypothesis that there is no threshold effect.

Authenticity test of the threshold value: Assuming that the threshold value is equal to the true value, the null hypothesis is $H_0: \hat{\rho} = \rho$.

$$LR(\rho) = \frac{(S_1(\rho) - S_1(\hat{\rho}))}{\hat{\sigma}^2}$$  

Equation (7) represents the test statistics of the threshold authenticity, where $S_1(\rho)$ and $S_1(\hat{\rho})$ respectively represent the sum of the squared residuals when the threshold variable is an arbitrary value and a threshold value. When $LR(\rho) \leq -2 \ln(1 - \sqrt{1 - \alpha})$ ($\alpha$ is the significance level), accept the null hypothesis.

Table 5 reports the significance and authenticity test results of OFDI and per capita CO$_2$ emissions under the comprehensive urbanization threshold. The double threshold effect of comprehensive urbanization is significant at the level of 1%, respectively. Based on this, the double threshold model of comprehensive urbanization can be established according to the threshold effect test results. The smaller threshold value is 12.645 and the larger threshold value is 20.440. Those less than the critical value of 12.645 indicate primary urbanization, intermediates between them are intermediate urbanization and those greater than 20.440 represent advanced urbanization.

Table 5. Results of urbanization threshold effect test.

| Threshold                | Threshold Estimate | 95% Confidence Interval | F Value | p Value | BS Times |
|--------------------------|--------------------|-------------------------|---------|---------|----------|
| Comprehensive Urbanization | Single threshold   | 14.268                  | [12.300, 15.054] | 24.823 ** | 0.023    | 300      |
|                          | Double threshold   | 12.645                  | [10.594, 24.571] | 14.387 *** | 0.007    | 300      |
|                          | Triple threshold   | 20.440                  | [15.728, 17.057] | 5.802    | 0.220    | 200      |

*** and ** indicate significance at 1% and 5% significance levels, respectively.

4.2. Estimated Results of Comprehensive Urbanization Threshold

Table 6 shows the regression results of interprovincial OFDI on per capita CO$_2$ emissions under the double threshold of comprehensive urbanization.

As shown in column (1) of Table 6, the panel for the dual fixed effect model of regression of the entire sample shows that the impact of interprovincial OFDI on per capita CO$_2$ emissions is significantly positive. At the current stage, the economic development is still an important driving force for social progress, the pursuit of economic scale is still the direction for most of regions and the expansion of reproduction is still the main path on which regional development depends, i.e., China’s OFDI expansion will cause a significant increase in per capita CO$_2$ emissions. As shown in columns (2)–(4) of Table 6, the comprehensive dual threshold of urbanization divides the sample into three groups that all have significant positive effects on per capita CO$_2$ emissions, though the force intensity of each group is different. Among the groups, the interprovincial OFDI of intermediate urbanization has the largest impact on per capita CO$_2$ emissions. From the perspective of...
the investment scale, the intermediate urbanized areas have advantages over the primary urbanized areas on the economic scale and have higher production needs. Therefore, the expansion of the OFDI scale in intermediate urbanization can further boost regional production which will inevitably lead to a greater consumption of energy. Thus, the positive effect of OFDI on carbon emissions in intermediate urbanization is stronger than that in primary urbanization. From the perspective of the investment direction, the industrial structure of high level urbanized areas are significantly better than in intermediate level urbanized areas. The investment direction of OFDI may be more inclined toward some emerging industries with relatively low energy consumption, low emissions and low pollution, and thus the reproduction in advanced urbanization areas is relatively cleaner. At the same time, in terms of the feedback mechanism of OFDI, whether from the perspective of the technical level or of human capital, the absorbing and processing capacity of the same information in different levels of urbanization are also distinct. Advanced urbanization areas can better absorb and apply the technology and information obtained from feedback, such that the impact of interprovincial OFDI on per capita CO\textsubscript{2} emissions is less in advanced urbanization areas than in intermediate urbanization areas.

Table 6. Urbanization threshold model regression results.

|             | Fixed Effect Model | Primary Urbanization | Intermediate Urbanization | Advanced Urbanization |
|-------------|--------------------|----------------------|--------------------------|-----------------------|
| lnofdi      | 0.806***           | 0.516**              | 0.928***                 | 0.433**               |
|             | (0.269)            | (0.188)              | (0.192)                  | (0.154)               |
| edth        | −0.124             | 0.00769              | −0.0565                  | −0.137*               |
|             | (0.0973)           | (0.0525)             | (0.0674)                 | (0.0755)              |
| rds         | −0.00115           | −0.00423             | −0.00511                 | 0.00154               |
|             | (0.00213)          | (0.0245)             | (0.00509)                | (0.00172)             |
| urban       | 0.0766***          | 0.0463**             | 0.0683                   | 0.0128                |
|             | (0.0199)           | (0.0175)             | (0.0375)                 | (0.0552)              |
| coals       | 0.159***           | 0.0213               | 0.139***                 | 0.158***              |
|             | (0.0472)           | (0.0642)             | (0.0393)                 | (0.0400)              |
| envir       | 0.885*             | −0.0545              | 1.196*                   | 0.336                 |
|             | (0.487)            | (0.251)              | (0.655)                  | (0.302)               |
| indus       | 0.00574            | 0.0407               | −0.00469                 | −0.0109               |
|             | (0.0446)           | (0.0351)             | (0.0166)                 | (0.0734)              |
| Constant    | −13.35***          | −3.538               | −13.94***                | −2.037                |
| term        | (4.441)            | (3.910)              | (3.806)                  | (2.900)               |
| obs         | 390                | 115                  | 168                      | 107                   |
| R2          | 0.514              | 0.622                | 0.622                    | 0.355                 |

***, ** and * indicate significance at 1%, 5% and 10% significance levels, respectively.

4.3. Mediating Effect Test Based on Comprehensive Urbanization Threshold

In order to explore the impact mechanism of interprovincial OFDI on per capita carbon emissions in different regions and periods, this paper introduces a mediation effect model.

\[
Y = \alpha_1 + cX + \epsilon_1 \tag{8}
\]

\[
Z = \alpha_2 + aX + \epsilon_2 \tag{9}
\]

\[
Y = \alpha_3 + c'X + bZ + \epsilon_3 \tag{10}
\]

Equations (8)–(10) represent the mediation effect model, where X, Y and Z represent explanatory variables, explained variables and intermediate variables; \(\alpha\) represents the intercept term and \(\epsilon\) represents the error term of the model; a, b, c and c’ represent the regression coefficients of the model. The product ab of a and b represents the mediation effect of the mediation variable Z and is equal to the indirect effect. The improved mediation effect model was proposed by Wen et al [51], which used the bootstrap method rather than
the Sobel method to avoid its harsh assumptions. The improved method proposes that if the symbols of the indirect effect (ab) and the direct effect (c') are opposite then the total effect (c) will be masked, which is called the suppressing effect, and its opposite is called the intermediary effect [52]. This article adopts this improved mediation effect procedure.

Table 7 shows the sequential test results of the impact path of interprovincial OFDI on carbon emissions through the industrial structure effect, the trade structure effect and the technological level under the double urbanization threshold. Table 8 shows the test results of the mediating variables that do not meet the conditions by using the bootstrap method.

### Table 7. Results of mediating effect tests under urbanization threshold.

| Inofdi | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       |
|--------|-----------|-----------|-----------|-----------|-----------|-----------|
|        | pco2      | pco2      | pco2      | pco2      | pco2      | pco2      |
| Primary urbanization | 0.516 ** (0.188) | 0.508 *** (0.174) | 0.626 *** (0.183) | 0.517 ** (0.182) | 0.409 ** (0.153) | 0.389 ** (0.184) |
|        | shigh 0.00404 (0.0179) | 2.049 (1.327) | 0.0174 ** (0.0707) | 6.286 ** (2.684) | 0.00441 (0.326) | 2.049 (1.327) |
| Mediating variable | sreason 0.00404 (0.0179) | 2.049 (1.327) | 0.0174 ** (0.0707) | 6.286 ** (2.684) | 0.00441 (0.326) | 2.049 (1.327) |
|        | import 0.0127 (0.0326) | 0.0559 (0.0326) | 0.127 * (0.0668) | 0.0559 (0.0326) | 0.0127 (0.0326) | 0.0559 (0.0326) |
|        | export 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) |
|        | pth 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) |
|        | R2 0.636 | 0.689 | 0.637 | 0.693 | 0.655 |

| Intermediate urbanization | pco2 0.928 *** (0.192) | 0.935 *** (0.186) | 0.926 *** (0.193) | 0.930 *** (0.190) | 0.943 *** (0.191) | 0.946 *** (0.197) |
| Mediating variable | shigh 0.00884 (0.0240) | 0.00884 (0.0240) | 0.00884 (0.0240) | 0.00884 (0.0240) | 0.00884 (0.0240) | 0.00884 (0.0240) |
|        | sreason 0.0127 (0.0326) | 0.0559 (0.0326) | 0.0127 (0.0326) | 0.0559 (0.0326) | 0.0127 (0.0326) | 0.0559 (0.0326) |
|        | import 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) | 4.155 (3.904) |
|        | export 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) | 0.120 * (0.0667) |
|        | pth 1.060 ** (0.438) | 1.060 ** (0.438) | 1.060 ** (0.438) | 1.060 ** (0.438) | 1.060 ** (0.438) | 1.060 ** (0.438) |
|        | R2 0.625 | 0.622 | 0.623 | 0.626 | 0.624 |

| Advanced urbanization | pco2 0.433 ** (0.154) | 0.464 ** (0.174) | 0.422 *** (0.142) | 0.449 *** (0.147) | 0.342 *** (0.110) | 0.462 ** (0.160) |
| Mediating variable | shigh 0.0138 (0.0536) | 2.211 *** (0.529) | 0.0138 (0.0536) | 2.211 *** (0.529) | 0.0138 (0.0536) | 2.211 *** (0.529) |
|        | sreason 0.00139 (0.00789) | 8.144 (6.090) | 0.00139 (0.00789) | 8.144 (6.090) | 0.00139 (0.00789) | 8.144 (6.090) |
|        | import 0.488 (2.377) | 0.488 (2.377) | -0.026 (0.0180) | -0.026 (0.0180) | 0.488 (2.377) | 0.488 (2.377) |
|        | export 1.693* (0.843) | 1.693* (0.843) | 1.693* (0.843) | 1.693* (0.843) | 1.693* (0.843) | 1.693* (0.843) |
|        | pth R2 0.430 | 0.406 | 0.371 | 0.371 | 0.358 |

***, ** and * indicate significant levels of significance at 1%, 5% and 10%, respectively.
Table 8. Bootstrap testing of mediation variables.

| Mediating Variable | Observed Coef. | Bootstrap Std. Err. | Z | p > | Bias-Corrected 95% Conf Interval |
|-------------------|----------------|---------------------|---|-----|---------------------------------|
| **Primary urbanization** | | | | | |
| sigh | 0.0025 | 0.0324 | 0.08 | 0.939 | [−0.0476, 0.0544] |
| import | −0.0424 | −0.0306 | −1.39 | 0.166 | [−0.1297, 0.0044] |
| export | −0.0110 | 0.0176 | −0.62 | 0.532 | [−0.0750, 0.0085] |
| **Intermediate urbanization** | | | | | |
| sigh | −0.0008 | 0.0276 | −0.03 | 0.977 | [−0.0295, 0.0123] |
| season | −0.0100 | 0.1249 | −0.08 | 0.936 | [−0.0655, 0.3205] |
| import | −0.2035 | 0.1092 | −1.86 | 0.062 | [−0.5251, 0.0454] |
| export | −0.0590 | 0.0838 | −0.70 | 0.481 | [−0.3316, 0.0042] |
| pth | −0.1858 | 0.0886 | −2.10 | 0.036 | [−0.4051, −0.0523] |
| **Advanced urbanization** | | | | | |
| sigh | 0.0293 | 0.0472 | 0.62 | 0.534 | [−0.0662, 0.1262] |
| season | 0.2530 | 0.1363 | 1.86 | 0.063 | [0.0157, 0.5557] |
| import | 0.0732 | 0.05939 | 1.23 | 0.218 | [−0.0117, 0.2501] |
| export | −0.0134 | 0.0735 | 0.18 | 0.855 | [−0.1218, 0.1747] |
| pth | −0.0061 | 0.0232 | −0.26 | 0.792 | [−0.0971, 0.0136] |

Data source: calculated by Stata.

(1) According to the OLS test results of provincial OFID on per capita CO\textsubscript{2} emissions in the primary urbanization stage, in the mediating effect inspection process the rationalization of the industrial structure and the technical level pass the test, which in turn means that the coefficients a and b are significant. The ab symbol of the industrial structure rationalization is opposite to that of c\textquotesingle, which shows a suppressing effect, and the absolute value of the ratio of indirect and direct effects is 17.47%. The industrial structure rationalization (Theil) coefficient a is −0.0174 and passes the significant level of 0.01; thus, the industrial structure is more reasonable (i.e., the smaller the Theil index) with the increase of OFDI in the primary urbanized areas. The estimated coefficient b of regional per capita CO\textsubscript{2} emissions is 6.286, which also passes the significant level of 0.01; thus, the more reasonable the industrial structure (i.e., the smaller the Theil index), the less the per capita CO\textsubscript{2} emissions.

The suppressing effect of the rationalization of the industrial structure can be explained as follows: provincial OFDI weakens the positive total effect of OFDI on per capita CO\textsubscript{2} emissions in the primary urbanization stage to a certain extent by making the industrial structure more reasonable. The direction of the ab symbol of the technical effect and the c\textquotesingle symbol is the same, which shows a mediating effect that accounts for 24.65% of the total effect. The estimated coefficient a for patents per 10,000 people is 0.12, which passes the significant level of 0.05, and the estimated coefficient b for per capita CO\textsubscript{2} emissions is 1.06, which passes the significant level of 0.01. The indirect effect of the technological level is the mediating effect, which means that interprovincial OFDI further expands carbon dioxide emissions through the regional technological progress. This mediating effect of the technological level can be explained as follows: on the one hand, as most of the original production technologies in primary urbanization areas are dirty technologies with high energy consumption, the original technology path dependence directly leads to the increase of CO\textsubscript{2} emissions; on the other hand, the production expansion caused by the progress of the regional technology level indirectly leads to the increase of CO\textsubscript{2} emissions. For the other mediating variables of the industrial structure, the import dependence and the export dependence all include 0 in the 95% confidence interval of the bootstrap test and the p value exceeds 0.1, thus the bootstrap test is not significant.

(2) According to the OLS test results of provincial OFID on per capita CO\textsubscript{2} emissions in the intermediate urbanization areas, there are no mediating variables that pass the sequential test program, and the bootstrap tests are required for all the intermediate variables. The 95% confidence interval of the deviation correction for the advanced industrial structure and the rationalized industrial structure contains 0 and the p value is much greater than 0.1, which means that the industrial structure effect does not pass the bootstrap test. Similarly, the indirect effect of the export dependence is not significant and the import dependence is significant at the level of 0.1, which passes the Bootstrap test, while c\textquotesingle is also
significant. Among these, when the import dependence is used as a mediating variable, \( ab \) and \( c' \) are different and the indirect effect is a suppressing effect accounting for 0.26% of the direct effect. The trade creation effect dominated by the reverse import can explain the suppressing effect of import dependence as an intermediary variable on per capita carbon emissions. For the purpose of seeking resource, the interprovincial OFDI in the intermediate urbanization areas may invest in countries with cheap labor advantages and production endowment advantages. Therefore, setting up factories abroad has become one of the guidelines for OFDI. In this case, reverse imports will occur because this type of resource-seeking production transfer is generally a relatively low end and high energy consumption industry, which suggests that there may be a decrease in production energy consumption in the region, which will in turn reduce regional CO\(_2\) emissions. The 95% confidence interval of the technical level deviation correction does not include 0, and the \( p \)-value is less than 0.05, thus passing the bootstrap test and appearing as a suppressing effect that accounts for an absolute value of 1.93% of the direct effect. Contrary to the role of the primary urbanization areas, the indirect effects of the technological effects as mediating variables appear as suppressing effects in the intermediate urbanization stage. Similarly, this suppressing effect can be explained from the direct and indirect effects of the technical level on CO\(_2\) emissions: on the one hand, due to the path dependence of technology, the production technology in the intermediate urbanization areas may be relatively clean technology, and the new technology brought by the technological upgrading obtained by interprovincial OFDI will also be clean technology, which directly reduces the CO\(_2\) emissions in the intermediate urbanization areas; on the other hand, because of the expansion of production in the intermediate urbanization areas is not a simple increase in quantity, but a large scale production level, and thus the CO\(_2\) emissions will also be reduced.

(3) According to the OLS test results of provincial OFDI on per capita CO\(_2\) emissions in the advanced urbanization areas, if no mediating variable passes the sequential test, then the bootstrap tests are required. The deviation correction confidence interval for the rationalization of the industrial structure does not include 0 and passes the significance level of 0.1, meaning the bootstrap test is significant. The coefficient of the indirect effect \( ab \) is positive and has the same sign as \( c' \), which shows a mediating effect accounting for 2.61% of the total effect. With the continuous increase of interprovincial OFDI, the industrial structure has reached a more reasonable state and this state will promote regional carbon emission reductions in the primary urbanization stage, but it will become a driving force for carbon emissions growth in the advanced urbanization stage. With the deepening of the urbanization process, and although the industrial structure of advanced urbanization areas shows a trend of continuous optimization, the speed of the population transfer process also shows a sharp increase. The Theil index, which represents the rationalization of the industrial structure, covers the two major factors of the industrial structure and the employment structure. In the case of the unchanged industrial structure, a large change in the number of employments may also make the industrial structure more reasonable, but the expansion of the absolute production scale in this context also increases the energy consumption of production and further triggers higher CO\(_2\) emissions. At the same time, the ever expanding cost of population crowding and environmental governance will also bring more indirect CO\(_2\) emissions pressures. Therefore, the rapid population expansion makes the relationship between urbanization, industrial structure and carbon emissions more complex. At the advanced urbanization stage, although the industrial structure and the employment structure are more reasonable, the carbon pressure caused by the population influx cannot be blocked. The 95% confidence interval of the deviation correction between the export dependence and the import dependence includes 0, the bootstrap test is not passed and the indirect effect of the trade structure does not exist. Similarly, the technological effect does not exert an indirect effect during the advanced urbanization stage.
5. Conclusions and Inspiration

5.1. Conclusions

Under the dual pressure of the increasing demand for carbon emissions reduction at home and abroad, it is vital to realize that the development of economy and environment is an inevitable requirement for the development of a new type of urbanization. On the basis of the comprehensive measurement of the threshold of urbanization, this paper selected interprovincial panel data during the period of 2003–2015 and studied the impact and path of interprovincial OFDI on per capita CO$_2$ emissions under the urbanization threshold. The main conclusions are as follows:

(1) At the present stage, due to the expansion effect of urbanization, the impact of interprovincial OFDI on carbon emissions shows a significant positive correlation. The threshold effect of comprehensive urbanization exists and will be significant. Under the dual threshold of comprehensive urbanization, the force of interprovincial OFDI on carbon emissions is the largest in the intermediate urbanization stage, followed by the primary urbanization stage, and the least in the advanced urbanization stage. The magnitude of this positive effect is characterized by an inverted U-shape that rises and then falls.

(2) Through the division of the urbanization threshold, this paper verified whether the indirect effects of the industrial structure effect, the trade structure effect and the technology effect existed under different urbanization thresholds. A more rational industrial structure at the stage of primary urbanization would help to reduce carbon emissions (i.e., the cover effect), while the technological progress brought on by interprovincial OFDI may increase carbon emissions to some extent (i.e., the intermediate effect); the interprovincial OFDI at the intermediate urbanization stage weakens the positive effect of OFDI itself on the carbon emissions via the decline of import dependence and in the improvement of the technological level (i.e., the cover effect); in the advanced urbanization stage, the interprovincial OFDI will increase carbon emissions through the path of the industrial structure rationalization (i.e., the intermediate effect).

The novel contribution of this paper is the use of the industrial structure, the trade structure and the technological progress as intermediary variables so to analyze the path of OFDI on carbon emissions and by choosing provinces with significant differences to study, thereby hoping to explore the regional characteristics of the impact of OFDI on carbon emissions from a micro perspective. However, as the subject of this paper was the impact of provincial OFDI on regional carbon emissions, and thus did not discuss the emissions of other pollutants, there was a limitation in the single representation.

5.2. Inspiration

The above-mentioned research conclusions have profound policy implications for the realization of the balanced development of economy and environment in different urbanization stages. The following suggestions are put forward:

First, to continue to promote urbanization and improve the quality of urbanization in multiple dimensions. The inverse U-shaped impact of the interprovincial OFDI on carbon emissions under the threshold of urbanization indicates that with the continuous advancement of urbanization, the increasing effect of the interprovincial OFDI on carbon emissions will exhibit a downward trend. Although the direction of this impact remains positive, from the experience of developed countries this downward trend comes with the hope of breaking through the zero point and achieving a coordination of urbanization, thus facilitating an opening up and leading to a reduction in carbon emissions. Moreover, by considering the reality of the rapid development of urbanization, the carbon emissions reductions caused by a reasonable degree of industrial structure may still be weak due to the impact of massive population congestion costs. Therefore, the advancement of urbanization cannot be a blind process. We should continue to improve the level of urbanization from multiple dimensions while simultaneously realizing green and quality development.
Second, to reduce the application of dirty technology and promote the research and development of clean technology. In the primary stage of urbanization, OFDI increases carbon emissions through the technical effects, which are partly caused by the use of dirty technologies. Therefore, this requires that cities in the primary stage increase the research and development of clean technology while fundamentally changing their technical attributes. In the intermediate urbanization stage, the improvement to the technology effect has achieved carbon emissions reductions, which also requires improvement to the number and quality of talents while increasing the applicability of clean technology so to use that technology to continue to support carbon emissions reductions.

Finally, to pay attention to the industrial structure, the trade structure and the technological development of the region itself. Each city should avoid the homogenization and simplification of regional industrial structures, use comparative advantages to develop advantageous industries and form a diversified industrial pattern. In addition to the transfer of low end industries to countries or regions with low production costs, it is also necessary to focus the OFDI investment on technology and markets while focusing on more trade methods so to create more trade channels for the realization of carbon reduction. Technological progress is not only the driving force of production, but also of green production. The promotion of new urbanization requires the intermediate support of technological progress to achieve true low carbon development.

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