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Impacts of Foreign Direct Investment and Industrial Structure Transformation on Haze Pollution across China

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Abstract: With the development of economic globalization, some local environmental pollution has become a global environmental problem through international trade and transnational investment. This paper selects the annual data of 30 provinces in China from 2000 to 2017 and adopts exploratory spatial data analysis methods to explore the spatial agglomeration characteristics of haze pollution in China's provinces. Furthermore, this paper constructs a spatial econometric model to test the impact of foreign direct investment (FDI) and industrial structure transformation on haze pollution. The research results show that the high-high concentration area of haze pollution in China has shifted from the central and western regions to the eastern region and from inland regions to coastal regions. When FDI increases by 1%, haze pollution in local and neighboring areas will be reduced by 0.066% and 0.3538%, respectively. However, the impact of FDI on haze pollution is heterogeneous in different stages of economic development. FDI can improve the rationalization level of industrial structure, and then inhibit the haze pollution. However, FDI inhibits the upgrading level of industrial structure to a certain extent, and then aggravates the haze pollution. The research in this paper provides an important decision-making basis for coordinating the relationship between FDI and environmental pollution and realizing green development.

Keywords: FDI; industrial structure transformation; haze pollution; spatial durbin model; China

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1. Introduction

With the development of economic globalization, some local environmental pollution has become a global environmental problem through international trade and transnational investment. Since reforming and opening up, China's economy has achieved rapid development and has become one of the important driving forces of global economic growth. With the process of economic globalization, foreign direct investment (FDI) has continuously poured into China. China has become the world's second largest foreign capital inflow country, and FDI has made important contributions to China's economic growth. According to data from the National Bureau of Statistics, China's actual use of FDI in 2000 was US$59.35 billion, and by 2019, China's actual use of FDI reached US$138.14 billion.

At the same time, more foreign capital has entered China's high-energy consumption industries. An unreasonable industrial structure and extensive economic development mode have led to large energy demands and low energy utilization efficiency. The massive use of energy and discharge of pollutants in the production process has caused haze pollution. China's haze pollution has become more and more serious, and the highly polluted areas have gradually shown the characteristics of spatial agglomeration, mainly concentrated in the Beijing-Tianjin-Hebei region, the Yangtze River Delta region and the related neighboring central region, and the three provinces in the northwest region (Figure 1). The direct impact of FDI on environmental pollution depends on the purpose of introducing FDI in a country or region. If the country uses the environment as a cheap input element and lower environmental protection standards to attract FDI, it will increase energy consumption and pollution emissions, which will intensify environmental pollution; if the country attracts FDI to learn foreign advanced production technologies and emission reduction technologies, it will help to improve the country's clean production efficiency, thereby reducing the environmental burden (Gong and Liu, 2020 [1]). In addition, FDI indirectly affects environmental pollution by affecting the industrial structure of a country or region. The direction of its impact depends on whether FDI helps promote the transformation and upgrading of the country's industrial structure.

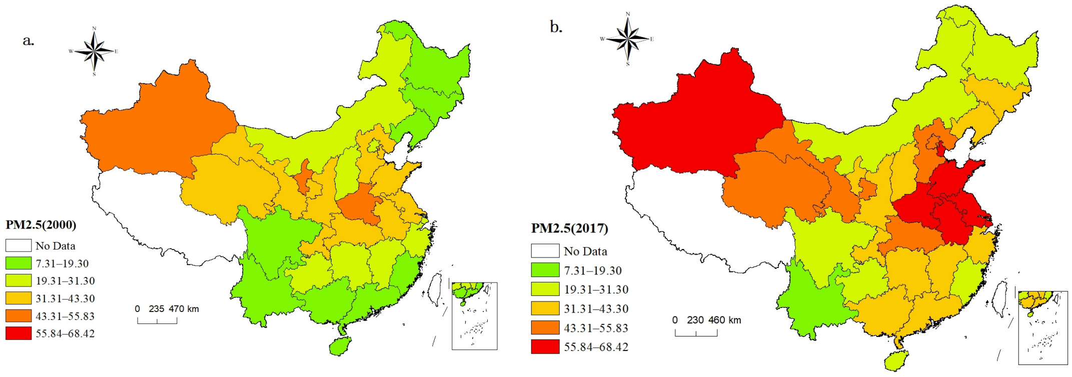

Figure 1. Spatial distribution map of China's provincial haze pollution (PM2.5 ($\mu g/m^3$)) in (**a**) 2000 and (**b**) 2017.

Under the context of China's current ecological civilization construction and deepening opening up, it is particularly important to coordinate the relationship between FDI and haze pollution, and to explore the industrial structure mechanism of FDI's impact on haze pollution. Promoting the transformation and upgrade of China's industrial structure by introducing FDI is an important measure to achieve green development. Therefore, can FDI curb haze pollution in China? Can FDI promote the transformation and upgrading of industrial structure and indirectly curb China's haze pollution? This needs to be further studied.

Based on the research of existing scholars, the impact of FDI on environmental pollution is mainly divided into three perspectives: the first one is the "Pollution Heaven Hypothesis", which was first proposed by Walter and Ugelow (1979) [2]. Based on this hypothesis, some scholars believe that in the early stages of economic development, developing countries relax environmental protection standards in order to attract a large amount of foreign investment to develop their own economies. A large number of foreign capital pours into resource-intensive and highly polluting industries, which intensifies the development of natural resources and environmental pollution in the host country (Ren et al., 2014 [3]; Bakhsh et al., 2017 [4]; Abdo et al., 2020 [5]). Seen from the economic development stages, in the early stages, FDI aggravates environmental pollution through the spillover effect of productive innovation. In the transitional stages, FDI curbs environmental pollution through ecological innovation spillover effects (Huo et al., 2019 [6]). The second one is the "pollution halo" effect theory, that is, FDI from developed countries brings advanced production technology and higher environmental protection standards to the host country. This helps to improve production technology and product environmental protection standards, producing a technology spillover effect that is conducive to alleviating the environmental pollution of the host country (Antweiler et al., 2001 [7]). This hypothesis was confirmed by some scholars through empirical tests (Hassaballa, 2014 [8]; Deng and Xu, 2016 [9]; Gong and Liu, 2020 [1]). A few scholars believe that overall FDI can effectively alleviate urban environmental pollution, but there is regional heterogeneity (Jiang et al., 2018 [10]; Wang et al., 2020 [11]). The third is the comprehensive environmental effect theory. Based on the research of Grossman and Krueger (1995) [12], some scholars put forward that FDI can affect the host country's environmental pollution through three channels: scale effect, structure effect, and technology spillover effect. The combined effect of the three effects is the effect of FDI on the host country's environmental pollution. Some scholars verified this theory by empirical analysis (Sheng and Lv, 2012 [13]).

Previous research also explored impact of industrial structure transformation on environmental pollution. Grossman and Krueger (1995) [12] proposed that economic activities can affect regional environmental pollution through three effects. Among them, the structural effect refers to the continuous evolution of the economic structure and industrial structure, which has a dynamic impact on environmental pollution. In the empirical research of many scholars, there are three main views: the first is that the transformation and upgrading of industrial structure has a significant impact on environmental pollution, and the increase in the proportion of the added value of the tertiary industry and the secondary industry helps to alleviate environmental pollution (Huang et al., 2012 [14]). A few scholars have measured the transformation of industrial structure using two aspects of rationalization and upgrading of industrial structure (Cheng et al., 2019 [15]), and consider the spatial weighting term of industrial structure, that is, the impact of industrial structure transformation in adjacent areas on local environmental pollution. The research results shows that the upgrading of industrial structure in adjacent areas helps to alleviate local environmental pollution (Han et al., 2016 [16]). The second is that some scholars, with the help of the Environmental Kuznets Curve (EKC) hypothesis, believe that industrial structure transformation and environmental pollution have an inverted "U"-shaped relationship (Grossman and Krueger, 1995 [12]; Dai and Hui, 2019 [17]). The third is that the impact of industrial structure transformation on environmental pollution is not significant. Some scholars believe that China is in a period of transition from secondary industry to tertiary industry, and industrial optimization and upgrading have not been completed. In addition, due to the lagging development of the service industry with high added value and low pollution, the tertiary industry has not shown its mitigation effect on environmental pollution (Zhang and Chen, 2009 [18]).

However, there are three aspects that can be further explored: firstly, the focus of introducing FDI in the initial stage of economic development is different from that in the economic transition period. The former adheres to the idea of "environment giving way to economy", while the latter puts forward higher requirements on environmental protection standards while developing the economy. Therefore, the impact of FDI on environmental pollution may be different in different periods. Secondly, regarding research methods, static panel data models or dynamic panel data models that consider time lags are mostly used. The spatial spillover effects of haze pollution and the joint spatial spillover effects of FDI and industrial structure transformation on haze pollution are rarely considered. There may be an estimation bias. Thirdly, most scholars use FDI and industrial structure as isolated factors that affect haze pollution to conduct empirical analysis, and few discuss the industrial structure effect of FDI on haze pollution. Furthermore, most scholars measure the industrial structure from the perspective of industrial added value, using the proportion of each industry or the proportion of the national economy while ignoring the degree of reasonable allocation of production factors among industries, which has certain limitations in portraying industrial structure indicators.

Can FDI and industrial structure transformation reduce haze pollution? In different stages of economic development, is the impact of FDI on haze pollution with heterogeneous characteristics? Can FDI indirectly affect haze pollution by promoting the transformation of industrial structure? No consensus has been reached on these issues, and few literatures have demonstrated the heterogeneous impact of FDI on haze pollution under different stages of economic development. Therefore, this paper uses the exploratory spatial data analysis (ESDA) method to study the spatial agglomeration effect of haze pollution in China's provinces. Based on the research framework of the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model and the EKC hypothesis, this paper constructs the static and dynamic spatial Durbin models (SDM) and empirically analyzes the impact of FDI and industrial structure transformation on haze pollution. Finally, the industrial structure mechanism of FDI's influence on haze pollution is analyzed. Through empirical analysis, we found that: (1) China's provincial haze pollution has significant spatial agglomeration characteristics; (2) FDI and industrial structure transformation and upgrading can curb haze pollution; (3) during the period of economic development and economic transition, FDI can promote and inhibit haze pollution respectively; (4) FDI can indirectly affect haze pollution by affecting the transformation of industrial structure.

The contribution of this paper is reflected in the following three ways: (1) this paper divides the sample into two sub-samples in the initial stage of economic development and the transitional stage of economic development and further analyzes the heterogeneity of the impact of FDI on haze pollution; (2) this paper empirically tests the temporal and spatial evolution characteristics of haze pollution, and the spatial spillover effect of FDI and industrial structure transformation on haze pollution, to provide a corresponding basis for joint prevention and control of haze pollution; (3) based on the perspective of industrial structure transformation and upgrading, this paper empirically tests the action mechanism of FDI affecting haze pollution through industrial structure transformation and upgrading.

2. Methods

2.1. Variable Selection and Data Description

(1) Explained variable: Haze concentration (lnPM). The Atmospheric Composition Analysis Group (ACAG) of Dalhousie University draws on the calculation ideas of Donkelaar (2016) [19] and others, and combines the aerosol optical depth (AOD) obtained by satellite-mounted equipment with the GEOS-Chem chemical migration model. The regional air composition quality has been estimated, and the raster data processed as $PM_{2.5}$ have been published on its official website (Data source of $PM_{2.5}$ concentration: http://fizz.phys.dal.ca/~atmos/martin/?page_id=140 (accessed on 29 April 2020)). This paper uses ArcGIS software to parse the raster data into the average $PM_{2.5}$ concentration data of 30 provinces in China (excluding Tibet, Hong Kong, Macau and Taiwan) from 2000 to 2017. Using $PM_{2.5}$ concentration instead of haze pollution has been used by most scholars in the past (Feng and Wang, 2020 [20]; Gan et al., 2020 [21]).

(2) Explain variables. ① Foreign Direct Investment (ln*FDI*). The *FDI* stock can fully reflect the impact of the previous foreign direct investment on current haze pollution. Based on this, this paper uses the perpetual inventory method to calculate the *FDI* stock (Yan and Qi, 2017 [22]); the calculation formula is:

$$FDI_{i,t} = FDI_{i,t-1}(1-\rho) + I_{i,t} \tag{1}$$

Among them, $FDI_{i,t}$ is the FDI stock of province i in year t, $\rho = 9.6\%$ is the depreciation coefficient, and $I_{i,t}$ is the FDI flow of province i in year t.

② Industrial structure transformation. The transformation of industrial structure refers to, on the one hand, the trend of continuous rational allocation of production factors among different industries and, on the other hand, the evolution of the industrial structure from low-level to high-level. Drawing lessons from Zhang's (2020) [23] research, this article measures the transformation of industrial structure from two dimensions: the rationalization of industrial structure and the upgrading of industrial structure.

Measurement of the rationalization of industrial structure (ER). Based on the research of Yu (2015) [24], this paper uses the reciprocal of Theil index to measure the rationalization level of industrial structure. The calculation formula is as follows:

$$ER = \frac{1}{TL} = \frac{1}{\sum\limits_{i=1}^{3}\left(\frac{Y_i}{Y}\right)\ln\left(\frac{Y_i}{L_i}/\frac{Y}{L}\right)} \tag{2}$$

Among them, TL is the Theil index, Y_i and L_i are the output value and the number of employees in industry i, and Y and L are the total output value and the total number of employees. The smaller the value of TL is, the more reasonable the industrial structure is, and the more reasonable the allocation of production factors among industries is, and $TL = 0$ indicates that the economic system reaches an equilibrium state. On the contrary, the smaller the value of TL, the larger the value of ER and the higher the level of rationalization of industrial structure.

Measurement of the upgrading of industrial structure (ES). The increase in the proportion of the tertiary industry in the national economy is one of the specific manifestations of the industrial structure upgrading (Wu, 2006 [25]). Referring to the research of Gan et al. (2011) [26], this paper selects the proportion of the added value of the tertiary industry and the added value of the secondary industry to measure the high-level level of the industrial structure.

(3) Control variables. Drawing lessons from previous scholars' research, this article selects seven control variables: per capita output, the quadratic term of per capita output, financial development, urbanization, technological progress, population density, and human capital (Yin et al., 2019 [27]; Enhaz et al., 2020 [28]; Nasrollahi et al., 2020 [29]; and Tachie et al., 2020 [30]). The descriptive statistical results of each variable are shown in Table 1.

Table 1. Descriptive statistics of variables.

Variable	Definition	Observations	Mean	S. D.	Max	Min	Source
lnPM	PM2.5 concentration ($\mu g/m^3$)	540	3.571	0.463	4.437	1.991	ACAG
lnFDI	FDI stock (billion yuan)	540	7.844	1.249	9.110	0.366	CEInet Statistics Database
ER	Rationalization of industrial structure	540	6.746	7.803	59.187	1.136	China Statistical Yearbook
ES	Upgrading of industrial structure (%)	540	0.961	0.487	4.237	0.494	China Statistical Yearbook
lnPGDP	Actual output per capita (yuan)	540	9.769	0.750	11.718	7.887	China Statistical Yearbook
$(\ln PGDP)^2$	The square term of actual output per capita (yuan)	540	95.998	14.697	137.303	62.200	China Statistical Yearbook
FE	Financial institution loan to deposit ratio (%)	540	1.359	0.223	2.196	0.843	Almanac of China's Finance and Banking
lnUR	Urbanization level (%)	540	3.855	0.298	4.495	3.144	China Statistical Yearbook
lnRD	R & D investment flow (ten thousand yuan)	540	4.372	1.635	7.759	−0.186	China Statistical Yearbook on Science and Technology
lnPD	Population density (person/square kilometer)	540	5.418	1.262	8.249	2.003	China Statistical Yearbook
lnHR	Average years of education of the labor force	540	2.201	0.141	2.604	1.810	China Labour Statistical Yearbook

2.2. Spatial Correlation Analysis

(1) Global spatial autocorrelation test. The global Moran index I uses the spatial unit information of variables and calculates the spatial correlation of variables through mathematical expressions. This paper examines whether there is a spatial spillover effect of haze pollution in China's provinces by measuring the global Moran index I. Its calculation formula is:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{S^2 \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}} \tag{3}$$

Among them, $S^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \overline{x})^2$ is the sample variance, $\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, x_i is the haze concentration value of province i, and w_{ij} is the spatial weight matrix. The Moran index I is between -1 and 1. When the index is greater than 0, it indicates that the haze pollution has a positive spatial autocorrelation, that is, the provinces with high haze concentration tend to have high haze concentrations in neighboring provinces. For provinces with low haze concentration, the haze concentration of neighboring provinces is mostly low. When the index is less than 0, it means that the haze pollution has a negative spatial autocorrelation and its performance is opposite to the positive spatial autocorrelation. When the index is equal to 0, it means that the haze pollution does not have spatial autocorrelation and its spatial distribution is random. Haze pollution is not only affected by geographical distance factors but also by social and economic spatial spillovers. Therefore, this paper constructs three spatial weight matrices based on the 0–1 adjacency criterion, geographic distance, and economic distance. The construction methods are as follows:

0–1 adjacency space weight matrix W_1: the basic idea is that if two regions are adjacent, they have spatial correlation, otherwise they have no spatial correlation.

$$W_{1,ij} = \begin{cases} \text{1 When area i is adjacent to area j} \\ \text{0 When area i and area j are not adjacent} \\ \text{0 When i = j} \end{cases} \tag{4}$$

Geographical distance spatial weight matrix W_2: based on the first law of geography, "the spatial correlation between units gradually decreases with the increase of distance"; this paper constructs an inverse distance spatial weight matrix:

$$W_{2,ij} = \begin{cases} 1/d_{ij} \; i \neq j \\ 0 \; i = j \end{cases} \tag{5}$$

Among them, d_{ij} represents the straight-line Euclidean distance between the provincial capitals of provinces i and j.

Economic distance spatial weight matrix W_3: based on the geographical distance spatial weight matrix, this paper adds economic weights to construct the economic distance spatial weight matrix, which is expressed as follows:

$$W_{3,ij} = W_{2ij} \times diag(\overline{Y}_1/Y, \overline{Y}_2/Y, \cdots \overline{Y}_n/Y) \tag{6}$$

Among them, $\overline{Y}_i = \frac{1}{t_1 - t_0 + 1}\sum\limits_{t_0}^{t_1} Y_{it}$ is the regional average GDP of province i during the observation period and $\overline{Y} = \frac{1}{n(t_1 - t_0 + 1)}\sum\limits_{i=1}^{n}\sum\limits_{t_0}^{t_1} Y_{it}$ is the average of all provinces' GDP in the observation period.

(2) Local spatial autocorrelation test. The global Moran Index I analyzes the correlation of China's haze pollution as a whole, but may ignore local atypical features (Anselin, 1995 [31]). For example, for provinces with severe haze pollution, their neighboring provinces have lighter haze pollution; for provinces with lighter haze pollution, their neighboring provinces have severe haze pollution. Therefore, this paper uses the local Moran index I to test the local spatial correlation of the provincial haze pollution, and its calculation formula is:

$$I_i = \frac{(x_i - \overline{x})}{S^2}\sum_{j=1}^{n} w_{ij}(x_j - \overline{x}) \tag{7}$$

Among them, I_i is the local Moran index, which measures the spatial correlation between i province and its neighboring provinces (or provinces with relatively close economic distance), and x_i, $\overline{x}$, S^2, and w_{ij} are set as the global Moran index I.

2.3. Model Construction

This article draws on the STIRPAT model constructed by Dietz and Rosa (1997) [32] to study the impact of population and economic activities on environmental pollution changes:

$$I_i = aP_i^b A_i^c T_i^f e_i \tag{8}$$

Among them, I_i represents environmental pollution, P_i is population size, A_i is wealth per capita, T_i is technical level, and e_i is a random error term.

In this paper, haze concentration (ln*PM*) is used to represent air pollution in the model. Meanwhile, based on the research framework of EKC hypothesis, the primary and secondary terms of regional GDP per capita are incorporated into explanatory variables as output levels to measure whether there is an inverted "U" shaped relationship between economic development and environmental pollution. Based on this, this paper takes the logarithm of both sides of Equation (8) and expands the variables to obtain:

$$\begin{aligned}\ln PM_{it} = \alpha_{it} + \beta_1 \ln FDI_{it} + \beta_2 ER_{it} + \beta_3 ES_{it} + \beta_4 \ln PGDP_{it} + \beta_5 (\ln PGDP_{it})^2 + \beta_6 \ln FE_{it} \\ + \beta_7 \ln UR_{it} + \beta_8 \ln RD_{it} + \beta_9 \ln PD_{it} + \beta_{10} \ln HR_{it} + \varepsilon_{it}\end{aligned} \tag{9}$$

Among them, α_{it} is the intercept term, β_1 to β_{10} are the elastic coefficients of the explanatory variables, and ε_{it} is the random error term. The definition of each variable is the same as above.

In order to explore the spatial spillover effects of *FDI* and industrial structure on haze pollution, the spatial econometric model constructed in this paper based on Equation (9) is as follows:

$$\begin{gathered}\ln PM_{it} = \rho W_{ij} \ln PM_{it} + \beta_1 \ln FDI_{it} + \beta_2 ER + \beta_3 ES + \gamma_i \sum X_{it} + \lambda_1 W_{ij} \ln FDI_{it} \\ + \lambda_2 W_{ij} ER_{it} + \lambda_3 W_{ij} ES_{it} + \eta_i W_{ij} \sum X_{it} + \alpha_i + \varphi_t + u_{it} \\ u_{it} = \delta W_{ij} u_{it} + \varepsilon_{it}\end{gathered} \tag{10}$$

Among them, $\varepsilon_{it} \sim N(0, \sigma^2 I_n)$; ρ is the spatial lag coefficient of haze pollution; γ_i is the coefficient of the control variable; λ_i is the spatial lag coefficient of the explanatory variable; η_i is the spatial lag coefficient of the control variable; δ is the spatial error coefficient; W_{ij} is the spatial weight matrix; X_{it} is the control variable, α_i and φ_t represent space fixed effects and time fixed effects, respectively; and u_{it} is a random disturbance term. The meaning of the remaining variables is the same as above.

The current research on haze pollution shows that regional haze pollution is not only affected by the social and economic activities between regions in the current period but also by the level of haze between regions in the previous period (Shao et al., 2016 [33]). In view of this, this paper further builds a dynamic SDM model to test the time lag effect and time-space lag effect of haze pollution, which can be expressed as:

$$\begin{aligned}\ln PM_{it} = \tau \ln PM_{i,t-1} + \rho W_{ij} \ln PM_{it} + \upsilon W_{ij} \ln PM_{i,t-1} + \beta_1 \ln FDI_{it} + \beta_2 ER_{it} + \beta_3 ES_{it} \\ + \gamma_i \sum X_{it} + \lambda_1 W_{ij} \ln FDI_{it} + \lambda_2 W_{ij} ER_{it} + \lambda_3 W_{ij} ES_{it} + \eta_i \sum W_{ij} X_{it} + u_{it}\end{aligned} \tag{11}$$

Among them, τ and υ are the time lag coefficient and time-space lag coefficient of haze pollution, respectively, and the meaning of the other variables is the same as above.

2.4. Applicability Test of Spatial Panel Model

Before conducting empirical research, a trial test of the spatial measurement model is needed. This paper draws on Elhorst's spatial panel model applicability test method to test Formula (10) [34], and the test results are shown in Table 2. First, it can be seen from the LM test results that the three spatial weight matrices all reject the null hypothesis at the 5% significance level, that is, both the SLM model and the SEM model are applicable to this article. Furthermore, the null hypothesis is that the SDM model can be reduced to the SLM model and the SEM model is rejected at the 1% significance level, which could be seen from the LR test and Wald test. Second, the results of Hausman's test show that fixed effects should be selected at the 1% significance level. In addition, Baltagi (2001) [35] once proposed that when the sample is randomly selected, a random effects model should be selected. When the regression analysis is limited to some specific individuals, a fixed effects model would be more appropriate. This paper selects the panel data of 30 provinces in China for regression analysis of specific individuals, so it is more appropriate to choose fixed effects model in regression. Furthermore, from the joint significance test, this paper should choose the SDM model with fixed effects in time and space.

Table 2. Applicability test results of the spatial panel model.

Test Statistics	**Economic Distance Spatial Weight Matrix W_3**		**Geographic Distance Spatial Weight Matrix W_2**		**0–1 Adjacency Spatial Weight Matrix W_1**	
	Chi-Square Value	***p* Value**	**Chi-Square Value**	***p* Value**	**Chi-Square Value**	***p* Value**
LM-lag	25.086	0.000	26.567	0.010	31.192	0.000
R-LM-lag	10.093	0.015	11.403	0.008	18.057	0.000
LM-error	859.285	0.000	230.562	0.000	490.833	0.000
R-LM-error	846.339	0.000	224.063	0.000	476.644	0.000
LR test for SAR	88.83	0.000	68.28	0.000	64.44	0.000
Wald test for SAR	85.39	0.000	71.02	0.000	65.87	0.000
LR test for SEM	96.72	0.000	92.88	0.000	94.94	0.000
Wald test for SEM	107.09	0.000	97.49	0.000	97.58	0.000
Hausman test	188.90	0.000	67.06	0.000	106.62	0.000
Joint significance test	LR statistics		df		*p* value	
Time period fixed effect	1274.34		18		0.000	
Spatial fixed effect	73.94		30		0.000	

This paper uses the maximum likelihood estimation method (MLE) to estimate the static SDM model and draws on the quasi-maximum likelihood estimation method (QMLE) proposed by Lee and Yu (2010) [36] to estimate the dynamic SDM model to reduce endogenous problems caused by natural factors effectively. In addition, as one of the two main methods to estimate the spatial econometric model, Han-Phillips generalized moment estimation (GMM) can select the appropriate instrumental variables from the time trend of variables when estimating the dynamic spatial econometric model without introducing external instrumental variables, which can better solve the endogenous problem (Han and Phillips, 2010 [37]). The GMM method is widely used in the estimation of dynamic panel models (Barrell and Nahhas, 2018 [38]). Based on this, this paper uses Han-Phillips GMM method to estimate the dynamic SDM model for robustness test. In this paper, the regression analysis of Equations (10) and (11) is based on the economic distance spatial weight matrix W_3.

3. Results

3.1. The Spatial Agglomeration Characteristics of Haze Pollution in China's Provinces

China's provincial haze pollution has a positive spatial autocorrelation (Table 3), that is, provinces with high haze pollution are clustered together and provinces with low haze pollution are clustered together. There were 7 and 9 provinces with haze pollution in the second and fourth quadrants (atypical observation areas, that is, low-high and high-low agglomeration) in 2000 and 2017 (Figures 2 and 3). The scatter diagram further shows that the positive spatial autocorrelation of China's haze pollution is stable from the internal structure (Anselin, 1996 [39]; Pan, 2012 [40]). Therefore, it is very important to include spatial correlation into the research scope of China's provincial haze pollution.

Table 3. Moran's I Index of China's Haze Pollution from 2000 to 2017.

Year	**Economic Distance Spatial Weight Matrix W_3**			**Geographic Distance Spatial Weight Matrix W_2**			**0–1 Adjacency Spatial Weight Matrix W_1**		
	Moran's I	**Z Value**	***p* Value**	**Moran's I**	**Z Value**	***p* Value**	**Moran's I**	**Z Value**	***p* Value**
2000	0.089	3.578	0.000	0.259	3.070	0.002	0.452	3.949	0.000
2001	0.095	3.735	0.000	0.314	3.627	0.000	0.498	4.304	0.000
2002	0.094	3.727	0.000	0.273	3.226	0.001	0.468	4.093	0.000
2003	0.112	4.253	0.000	0.268	3.201	0.001	0.470	4.140	0.000
2004	0.071	3.074	0.002	0.231	2.795	0.005	0.420	3.720	0.000
2005	0.070	3.027	0.002	0.197	2.431	0.015	0.423	3.732	0.000
2006	0.094	3.731	0.000	0.259	3.084	0.002	0.453	3.979	0.000
2007	0.082	3.397	0.001	0.228	2.762	0.006	0.444	3.902	0.000
2008	0.070	3.031	0.002	0.198	2.437	0.015	0.406	3.592	0.000
2009	0.065	2.907	0.004	0.174	2.196	0.028	0.365	3.271	0.001
2010	0.074	3.149	0.002	0.187	2.335	0.020	0.396	3.525	0.000
2011	0.085	3.472	0.001	0.235	2.818	0.005	0.469	4.088	0.000
2012	0.071	3.079	0.002	0.188	2.356	0.018	0.394	3.515	0.000
2013	0.101	3.921	0.000	0.245	2.912	0.004	0.472	4.104	0.000
2014	0.081	3.353	0.001	0.202	2.508	0.012	0.388	3.471	0.001
2015	0.103	4.002	0.000	0.220	2.681	0.007	0.434	3.829	0.000
2016	0.111	4.214	0.000	0.254	3.022	0.003	0.474	4.137	0.000
2017	0.093	3.701	0.000	0.233	2.800	0.005	0.451	3.944	0.000

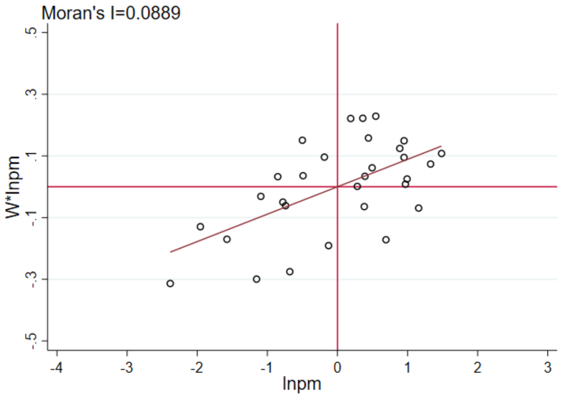

Figure 2. Moran scatter plot of haze pollution in 2000.

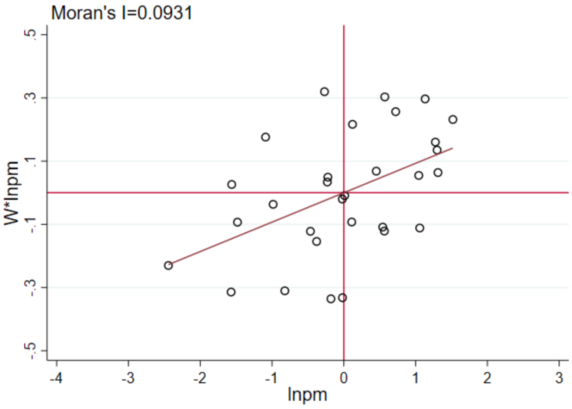

Figure 3. Moran scatter plot of haze pollution in 2017.

From the perspective of dynamic evolution, the high-high concentration area of haze pollution in China has shifted from the central and western regions to the eastern region, and from inland regions to coastal regions, and the number of provinces has increased.

In 2000, the provinces with high concentration of haze pollution were mainly Shandong, Henan, Shaanxi, Ningxia, and Gansu, while the provinces with low concentration of haze pollution were Hainan, and there were no provinces with atypical observation area (Figure 4). In 2017, Shandong, Henan, Hebei, Beijing, Tianjin, Jiangsu, Shanghai, and Anhui were the main provinces in the high concentration areas of haze pollution, Sichuan was in the low concentration area, Xinjiang was in the high-low concentration area, and Inner Mongolia and Fujian were in the low-high concentration areas (Figure 5). All agglomeration areas are significant at the 10% level. Overall, China's haze pollution is currently concentrated in the Beijing–Tianjin–Hebei region, the Yangtze River Delta, and the adjacent central regions. Low-low agglomeration areas are distributed in a small amount in the Southwest and Hainan Province. Therefore, the spatial agglomeration effect of China's haze pollution is relatively stable in the long run.

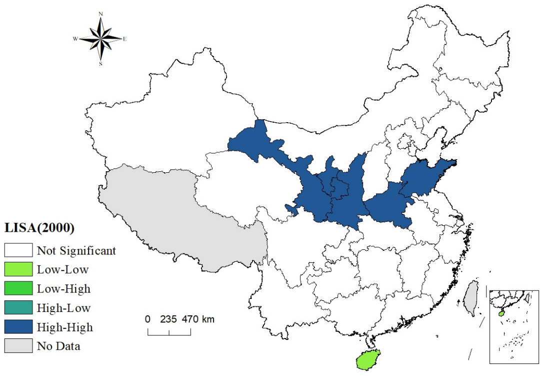

Figure 4. LISA agglomeration map of haze pollution in 2000.

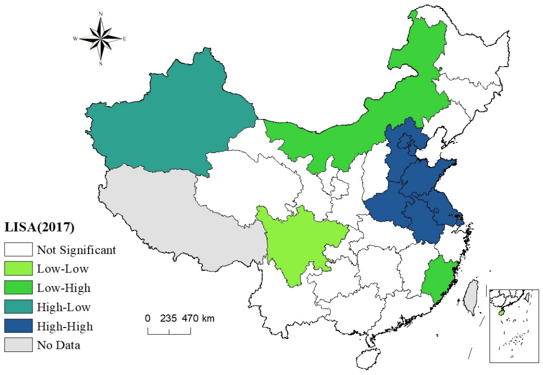

Figure 5. LISA agglomeration map of haze pollution in 2017.

3.2. *The Impact of FDI and Industrial Structure Transformation on Haze Pollution*

China's provincial haze pollution has a spatial spillover effect and a temporal superimposition effect, indicating that the increase in haze pollution in neighboring areas will increase local haze pollution, and the haze pollution in a given period will affect the haze pollution in the next period. However, considering both the time and space dimensions, the time-space lag coefficient (υ) is significantly negative, indicating that the haze pollution in the neighboring areas of the previous period had a restraining effect on the current period. The spatial lag coefficients (ρ) of Model 4 and Model 6 are both positive at the 1% significance level, indicating that the haze pollution in neighboring areas or economically close areas presents a "spillover effect" on the local area (Table 4). The time lag coefficients (τ) of both Model 5 and Model 6 are positive at the 1% significance level, indicating that haze pollution has a time "superimposition effect", that is, the haze pollution level of the previous period will have a positive impact on the current period (Table 4).

Table 4. Regression results of the impact of FDI and industrial structure transformation on haze pollution.

Variable	Static SDM				Dynamic SDM	
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5 (GMM Estimate)**	**Model 6 (QMLE Estimate)**
W*lnPM(ρ)	0.4932 *** (0.1051)	0.4878 *** (0.1059)	0.4877 *** (0.1056)	0.4780 *** (0.1071)		0.6246 *** (0.0821)
$\text{lnPM}_{t-1}(\tau)$					0.3526 *** (0.0528)	0.3300 *** (0.0422)
W*$\text{lnPM}_{t-1}(\upsilon)$						−0.9606 *** (0.2667)
lnFDI		−0.0597 *** (0.0122)		−0.0580 *** (0.0118)	−0.0343 (0.0392)	−0.0098 ** (0.0041)
ER			−0.0041 ** (0.0018)	−0.0036 ** (0.0018)	−0.0016 (0.0027)	−0.0027 * (0.0016)
ES			−0.3191 *** (0.0633)	−0.3318 *** (0.0671)	0.4462 (0.5271)	−0.3275 *** (0.0795)
lnPGDP	−0.7008 ** (0.3116)	−0.2738 (0.3209)	−0.9993 *** (0.3416)	−0.5100 * (0.2672)	−1.0820 * (0.6012)	−0.3646 (0.3225)
$(\text{lnPGDP})^2$	0.0369 ** (0.0146)	0.0152 (0.0152)	0.0541 *** (0.0159)	0.0295 ** (0.0137)	0.0628 ** (0.0301)	0.0210 * (0.0127)
FE	−0.1274 *** (0.0412)	−0.1107 *** (0.0405)	−0.1468 *** (0.0408)	−0.1282 *** (0.0400)	−0.1974 *** (0.0629)	−0.1157 *** (0.0368)
lnUR	−0.0499 (0.1070)	−0.0616 (0.1046)	0.0546 (0.1140)	0.0254 (0.1112)	−0.0693 (0.1085)	−0.0729 (0.1128)
lnRD	−0.0675 ** (0.0272)	−0.0697 *** (0.0267)	−0.0254 (0.0291)	−0.0227 (0.0284)	−0.0862 ** (0.0400)	−0.0133 (0.0263)
lnPD	−0.3208 ** (0.1538)	−0.1839 (0.1522)	−0.4826 *** (0.1670)	−0.3703 ** (0.1641)	−0.5244 * (0.2409)	−0.4840 *** (0.1553)
lnHR	−0.2949 ** (0.1460)	−0.2768 * (0.1529)	−0.1700 * (0.0915)	−0.1629 ** (0.0784)	−0.4252 ** (0.2011)	−0.1557 (0.1284)
W*lnFDI		−0.1537 * (0.0816)		−0.1363 * (0.0704)	0.2219 *** (0.0639)	−0.1271 ** (0.0525)
W*ER			−0.0413 *** (0.0115)	−0.0374 *** (0.0113)	−0.0079 (0.0103)	−0.0181 * (0.0097)
W*ES			−0.7064 * (0.3729)	−0.7225 ** (0.3171)	−0.8127 *** (0.2814)	−0.8007 * (0.4236)
R^2	0.2653	0.2642	0.2888	0.2975	0.2802	0.1889
Log−Likelihood	517.9684	531.8647	535.2941	550.0711	395.9116	-2.383×10^4

Note: *, **, *** mean significance at the levels of 10%, 5%, and 1%, respectively; the values in parentheses are robust standard errors. The following table is the same.

Whether based on local effects or spatial spillover effects, FDI and the transformation of industrial structure have a significant inhibitory effect on haze pollution. In addition, FDI can significantly improve the level of rationalization of local and neighboring industrial structures, thereby suppressing haze pollution. However, FDI in the sample period suppressed the trend of industrial structure upgrading in the local and neighboring areas and thus promoted haze pollution. The direct effect of FDI on haze pollution is −0.0660 and is significant at the level of 1%. That is, every 1% increase in FDI will lead to a 0.0660% drop in $PM_{2.5}$ concentration in the region. The indirect effect of FDI on haze pollution is negative at the 5% significance level, indicating that FDI has a significant spatial spillover effect on haze pollution, that is, foreign direct investment activities in nearby areas have a significant inhibitory effect on haze pollution in the region (Table 5). The direct and indirect effects of the rationalization of industrial structure (ER) and advanced industrial structure (ES) are both significantly negative (Table 5), indicating that the rationalization and upgrading trends of industrial structure both suppress local and neighboring haze pollution effect. The interaction coefficient of FDI and rationalization of industrial structure, and the spatial lag coefficient of the interaction, are negative at the significance levels of 5% and 1%, respectively (Table 6), and the direct and indirect effects of the interaction are significantly negative (Table 7), indicating that FDI can significantly improve the rationalization level of industrial structure in local and adjacent areas and then inhibit haze pollution. The interaction coefficient and spatial lag coefficient of FDI and the upgrading of industrial structure are positive at the significance levels of 1% and 5%, respectively (Table 6). After considering the spatial feedback effect, the direct and indirect effects of the interaction between FDI and the upgrading of industrial structure are both positive at the significance level of 1% (Table 7), which indicates that FDI inhibits the upgrading trend of industrial structure in local and adjacent areas during the sample period and further promotes the haze pollution.

Table 5. Decomposition results of the impact of FDI and industrial structure transformation on haze pollution.

Variable	Direct Effect	Indirect Effect	Total Effect
lnFDI	−0.0660 *** (0.0201)	−0.3538 ** (0.1518)	−0.4198 ** (0.1904)
ER	−0.0057 *** (0.0015)	−0.0812 ** (0.0392)	−0.0869 *** (0.0231)
ES	−0.6411 *** (0.2019)	−1.3029 * (0.6858)	−1.9440 ** (0.8014)

Table 6. Regression results of FDI affecting haze pollution through industrial structure transformation.

Variable	Model 7	Model 8
W*lnPM(ρ)	0.5013 *** (0.1037)	0.4969 *** (0.1039)
lnFDI	−0.0596 *** (0.0132)	−0.0595 *** (0.0126)
ER	−0.0021 *** (0.0007)	
ES		−0.2997 *** (0.0916)
lnFDI*ER	−0.0010 ** (0.0004)	
lnFDI*ES		0.0180 *** (0.0571)
W*(lnFDI*ER)	−0.0112 *** (0.0032)	
W*(lnFDI*ES)		0.0263 ** (0.0126)
Control variable	YES	YES
R^2	0.2446	0.2795
Log−Likelihood	520.5188	521.7562

Table 7. Decomposition of the effects of FDI on haze pollution through industrial structure transformation.

Variable	Direct Effect	Indirect Effect	Total Effect
lnFDI*ER	−0.0012 *** (0.0003)	−0.0137 *** (0.0045)	−0.0149 *** (0.0043)
lnFDI*ES	0.0303 *** (0.0093)	0.0451 ** (0.0207)	0.0754 *** (0.0221)

3.3. Robustness Test Results

As shown in Table 8, this paper uses Han–Phillips GMM Estimation (model 5) for dynamic SDM model to verify the robustness of temporal spillover effect of haze pollution in model 6, and MLE estimation (model 4) for static SDM model to verify the robustness of spatial spillover effect of haze pollution in model 6. Furthermore, based on geographical distance space weight matrix W_2 and 0–1 adjacency space weight matrix W_1, this paper conducts regression on FDI, industrial structure, and their crossover terms, respectively, to test their robustness. The results are shown in Table 8. From the test results of columns (1) to (4) of the regression results, it can be seen that the coefficient symbol of the spatial lag term, the coefficient symbol of the core explanatory variable, and the coefficient symbol of the interaction term of haze pollution are basically consistent with the results in Tables 4 and 6.

Table 8. Robustness test results.

Variable	Geographic Distance Spatial Weight Matrix W_2		0–1 Adjacency Spatial Weight Matrix W_1		Economic Distance Spatial Weight Matrix W_3	
	(1)	(2)	(3)	(4)	(5)	(6)
W*lnPM	0.5754 ***	0.5889 ***	0.6301 ***	0.6461 ***	0.4570 ***	0.4707 ***
	(0.0548)	(0.0539)	(0.0412)	(0.0405)	(0.1112)	(0.1090)
lnFDI	−0.0475 ***	−0.0476 ***	−0.0451 **	−0.0480 ***	−0.0484 ***	−0.0485 ***
	(0.0125)	(0.0136)	(0.0205)	(0.0139)	(0.0122)	(0.0146)
ER	−0.0008 *	−0.0016	−0.0026 *	−0.0036 **	−0.0043 **	−0.0043 **
	(0.0004)	(0.0015)	(0.0015)	(0.0016)	(0.0018)	(0.0019)
ES	−0.2801 ***	−0.2320 ***	−0.2711 ***	−0.2811 ***	−0.3273 **	−0.3107 *
	(0.0934)	(0.0710)	(0.0935)	(0.0998)	(0.1407)	(0.1828)
W*lnFDI	−0.0912 **	−0.0946 **	−0.0827 *	−0.0873 **	−0.1263 **	−0.1278 *
	(0.0409)	(0.0421)	(0.0486)	(0.0386)	(0.0574)	(0.0752)
W*ER	−0.0127 ***	−0.0184 **	−0.0091 **	−0.0118 *	−0.0410 ***	−0.0377 ***
	(0.0036)	(0.0083)	(0.0039)	(0.0062)	(0.0110)	(0.0136)
W*ES	−0.5717 ***	−0.5689 ***	−0.4890 **	−0.4981 **	−0.6197 ***	−0.5973 ***
	(0.1971)	(0.2017)	(0.2126)	(0.2084)	(0.2295)	(0.2058)
lnFDI*ER		−0.0016 **		−0.0020 ***		−0.0017 **
		(0.0007)		(0.0007)		(0.0008)
lnFDI*ES		0.0233 ***		0.0297 ***		0.0204 ***
		(0.0082)		(0.0107)		(0.0071)
W*lnFDI*ER		−0.0094 **		−0.0061		−0.0113 *
		(0.0042)		(0.0041)		(0.0062)
W*lnFDI*ES		0.0340 *		0.0389 **		0.0406 **
		(0.0169)		(0.0171)		(0.0184)
WS					−0.2561 ***	−0.2613 ***
					(0.0772)	(0.0759)
lnPR					−0.0271 **	−0.0206 ***
					(0.0117)	(0.0074)
lnHU					0.1953	0.1960
					(0.1302)	(0.1352)
Control variable	YES	YES	YES	YES	YES	YES
R^2	0.2629	0.2732	0.2678	0.2603	0.2786	0.2840
Log−Likelihood	578.3159	596.1228	614.6468	626.6640	563.2393	573.7932

Natural factors such as the atmospheric environment may have an impact on haze pollution, leading to the estimation bias of the model. This paper selects three control variables of annual average wind speed (WS), average annual precipitation (PR), and average annual relative humidity (HU) and adds them to model 4 for regression analysis. In order to solve the possible heteroscedasticity of the data, this paper takes the logarithm of precipitation and relative humidity. The data of the three natural factors variables are all from the China Meteorological Data Network (CMDN) (data source of meteorological variables: http://data.cma.cn (accessed on 23 April 2021)). This paper uses the Spline Interpolation method to convert the data of more than 2000 monitoring stations into provincial annual data. The descriptive statistics of the data are shown in Table 9. It can be seen from columns (5) and (6) that after adding the natural factor variables, the coefficient symbol of FDI and industrial structure transformation and the crossover term have not changed (Table 8). This shows that the estimation results in this paper are still robust after considering natural factors such as wind speed, precipitation, and relative humidity. The influence coefficients of wind speed and precipitation are both significantly negative, indicating that the increase in wind speed and precipitation can help reduce haze pollution. The increase of wind speed is helpful to haze diffusion, while the increase of precipitation is helpful to reduce pollutants in the air. The influence coefficient of relative humidity is positive but not significant.

Table 9. Descriptive statistics of meteorological variables.

Variable	Definition	Observations	Mean	S. D.	Max	Min	Source
WS	Annual average wind speed (m/s)	540	2.357	1.153	7.000	0.480	CMDN
lnPR	Average annual precipitation (mm)	540	6.721	0.534	7.711	3.963	CMDN
lnHU	Annual average relative humidity (%)	540	4.188	0.193	4.489	3.584	CMDN

3.4. Heterogeneity Analysis Results

Along with economic development and changes in economic policy trends, the impact of FDI on China's haze pollution is first promoting and then suppressing. In the early stage of economic development and the transition period of economic development, the trend of reasonable and advanced industrial structure has a significant inhibitory effect on haze pollution in local and adjacent areas, which is consistent with the benchmark regression results. In the early stage of economic development, the direct and total effects of FDI on haze pollution are both positive at least at a 5% level of significance. However, in the transitional period of economic development, the direct and indirect effects of FDI on haze pollution are both negative at the 1% significance level (Table 10).

Table 10. The result of a phased estimate.

Variable	Direct Effect	Indirect Effect	Total Effect
	Early stage of economic development (2000−2007)		
lnFDI	0.0502 *** (0.0132)	0.2421 (0.1624)	0.2923 ** (0.1276)
ER	−0.0021 *** (0.0008)	−0.0582 *** (0.0223)	−0.0603 *** (0.0213)
ES	−0.9281 *** (0.3314)	−1.6205 ** (0.7161)	−2.5486 ** (1.1232)
	Transition period of economic development (2008−2017)		
lnFDI	−0.1271 *** (0.0488)	−0.4720 *** (0.1627)	−0.5991 *** (0.2013)
ER	−0.0783 *** (0.0279)	−0.1068 ** (0.0368)	−0.1851 *** (0.0649)
ES	−0.4613 *** (0.1531)	−1.1079 *** (0.4085)	−1.5692 *** (0.5626)

4. Discussion

FDI has an inhibitory effect on haze pollution. FDI affects the environmental quality of the host country in three ways. Firstly, in the early stage of economic development, the host country uses foreign capital to vigorously explore its own natural resources and labor, which exerts great pressure on the ecological environment, and the people's income level has been rapidly increased. Then, the people's demand for a high-quality life "forces" environmental governance and strengthens the control of environmental pollution. Secondly, in the early stage, FDI mostly flows into the industrial industry, which has promoted the rapid development of China's secondary industry. Then, the proposal of "service oriented economic structure" prompted FDI to flow more to the tertiary industry, which is cleaner and environment friendly, to promote the transformation of China's industrial structure. Thirdly, FDI brings advanced production equipment and pollution treatment technology, and has a technology spillover effect on its upstream and downstream industries. In addition, the products produced by foreign-funded enterprises tend to implement the environmental protection standards of their home countries. Therefore, under the combined effect of the above three effects, FDI has a significant mitigation effect on haze pollution.

FDI indirectly affects haze pollution by acting on the transformation of industrial structure. In recent years, FDI flowed into China in large quantities, which promoted the flow of production factors between industries and regions, alleviated the distortion degree of factor market to a certain extent, helped to improve the rationalization level of industrial structure, and further gave play to the haze reduction effect of the rationalization of industrial structure. However, China's FDI is mainly resource seeking in the sample period, and more FDI enters into labor-intensive and resource intensive industries, which is not conducive to the development of industrial structure in an advanced direction, and finally shows the characteristics of high pollution and high energy consumption, thus promoting haze pollution (Gong and Liu, 2020 [1]).

The characteristics of the heterogeneous impact of FDI on haze pollution. In the early stage of economic development, China adhered to the idea of "environment giving way to economy" and introduced FDI. Local governments developed the economy by introducing FDI, ignoring the importance of environmental protection. Local governments have lowered environmental protection standards and have not taken systematic punishments for high-polluting foreign-funded enterprises (Huo, 2019 [6]). In the end, FDI flows more to high-emission, high-pollution, and high-energy-consuming industries, which intensifies haze pollution. In the transitional period of economic development, the concept of sustainable development is well learned by people. In 2007, the report of the Seventeenth National Congress of the Communist Party of China first proposed the construction of ecological civilization, requiring the basic formation of an industrial structure that conserves energy and resources and protects the ecological environment. At this time, China put forward higher technical standards and environmental protection standards when introducing FDI, to manage the technology spillover effect of FDI, promote the innovation and popularization of cleaner production technology, and consequently suppress haze pollution.

5. Conclusions and Policy Implications

5.1. Research Conclusions

This paper uses annual data on FDI, industrial structure transformation, and haze pollution from 30 provinces in China from 2000 to 2017. First, exploratory spatial data analysis methods are used to test the spatial correlation and spatial agglomeration of haze pollution in China's provinces. Furthermore, based on the research framework of STIRPAT model and EKC curve, this paper constructs static and dynamic SDM models and introduces three spatial weight matrices to test the impact of FDI and industrial structure transformation on haze pollution. The results are shown below:

China's haze pollution has a significant positive spatial autocorrelation. Most provinces are characterized by high-high agglomeration, which is specifically manifested in spatial "spillover effect" and temporal "superimposed effect". However, the time-spatial lag effect with the consideration of both space and time factors is significantly negative, that is, the haze pollution in neighboring areas in the previous period has an inhibitory effect on local haze pollution.

In general, FDI can effectively restrain China's haze pollution, but it has time heterogeneity. Due to the different goals and concepts of China's introduction of FDI at different stages, FDI has promoted and inhibited China's haze pollution in the initial stage of economic development and the transition period of economic development.

The transformation of industrial structure has a restraining effect on haze pollution. The rationalization of industrial institutions promotes the optimal allocation of production factors among industries, and the upgrading of industrial structure promotes the overall transfer of industries and the optimization and upgrading of their own industries. Both have emission-reduction effects. Specifically, the rationalization of the industrial structure has less inhibitory effect on haze pollution than the upgrading of industrial structure has.

FDI promotes the rational allocation of production factors among industries, can improve the level of rationalization of the industrial structure, and thereby suppress haze pollution. However, FDI has restrained the advanced level of the industrial structure to a certain extent, which has intensified haze pollution.

5.2. Policy Implications

China's haze pollution has significant spatial "spillover effect" and temporal "superimposed effect", which require the adoption of "joint prevention and control" policies to strengthen long-term cooperation between regions. Any unilateral control activities will make it difficult to achieve more significant results due to the spatial "spillover effect" of haze pollution, and any slack governance in one period will increase the level of haze pollution in the next period.

FDI has a significant mitigation effect on haze pollution now. When introducing FDI, on the one hand, local governments should strengthen the identification of foreign-funded enterprises' emissions, include $PM_{2.5}$ in the FDI evaluation system, and strictly control the entry of foreign-funded enterprises with high emissions in the local area; on the other hand, local governments should actively introduce advanced technology, energy conservation, and emission reduction technology of cleaner production enterprises with foreign capital to enter the local area, and give full play to the structure of FDI effect and technology spillover effect, to promote local industrial structure transformation and improve local production technology and consequently achieve the goal of reducing smog and improving the environmental protection standards of local production.

In the process of industrial structure transformation, governments at all levels should formulate relevant policies to promote the coordinated development of the industrial structure to rationalization and upgrading. On the one hand, all regions should improve the aggregation quality of the industrial structure, promote the continuous dynamic adjustment of production factors among industries to achieve the reasonable allocation of production factors among industries, promote the coordinated coupling of production resources and industrial structure, and then maximize the haze emission reduction effect of the rationalization of the industrial structure; on the other hand, all regions need to formulate and make use of reasonable industrial policies to promote the development of industrial informatization and upgrading, and provide a good policy environment and development space for strategic emerging industries and modern service industries and consequently promote the continuous upgrading of industries and reduce pollution emissions.

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