Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 4, No. 1, 2022

The Impact of Agglomeration of Producer Services on Pollution Emission: Empirical Analysis Based on 260 Cities in China

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Abstract: Since the 1980s, industrialization and urbanization have driven China's rapid economic growth, but this growth has also exacerbated the deterioration of the ecological environment. Under the background of the current prominent structural problems and the "dual carbon" goal, it is particularly important to realize the development layout of green economy. As one of the important economic development models, the agglomeration of producer services can not only promote the improvement of economic efficiency, but also promote the upgrading of industrial structure, thereby realizing the coordinated development of environment and efficiency. Based on the panel data of 260 prefecture-level cities in China from 2007 to 2018, this paper constructs a Spatial Durbin Model to empirically analyze the effect and impact mechanism of producer service agglomeration on pollution emissions. The study found that China's urban pollution emissions have a significant positive spatial correlation, and the increase of pollution emissions from surrounding cities will increase the city's pollution situation. In addition, on the whole, the increase in the degree of agglomeration of producer services significantly reduces pollution emissions, and there is a spatial spillover effect. Finally, the mechanism test shows that knowledge spillover and industrial structure upgrading are important channels for the agglomeration of producer services to reduce urban pollution emissions.

Keywords: Agglomeration of producer services; Pollution emission; Spatial Durbin model; Spillover effect.

1. Introduction

In terms of the development process of the global economy, economic growth is often accompanied by environmental pollution problems, and some developed and developing countries have also experienced a period of exchanging resources for development. Since the reform and opening up, socialist economic construction has continued to advance, and China's economy has made great progress. China's GDP reached 114.4 trillion yuan in 2021, a huge increase from 367.87 billion yuan in 1978. However, the long-term development model of high energy consumption and high emission in industry has also brought a series of pollution problems. According to the Environmental Performance Index (EPI) released by Yale University in 2020, China ranks only 120th among 180 economies. In recent years, under the background of promoting the construction of a beautiful China, although the pollution emissions have been reduced to a certain extent, the environmental situation is still severe, and the pressure on energy conservation and emission reduction is increasing day by day.At present, China regards the construction of ecological civilization as an important strategy of governing the country. General Secretary Xi also often emphasizes that "lucid waters and lush mountains are invaluable assets". It is very important to shift from the environment serving economic development to the environment integrating economic development, and promoting the realization of green economic transformation.

To put the economy on the track of green development, the key is the transformation of production mode, which depends on the optimization of the industrial structure. At the same time, in the process of industrial transformation and upgrading, the role of producer services has become increasingly prominent. With the accelerated development of information technology, the world economy is increasingly shifting towards a service-oriented direction. Although China's service industry started late, its growth momentum is strong, the proportion of the service industry is continuously increasing, and the internal structure is also developing in a high-level direction. In particular, the producer service industry has shown great development potential in recent years, it is the fastest growing part of the service industry and an important starting point for "softening" the manufacturing structure. In 2017, the "Outline of Service Industry Innovation and Development (2017-2025)" issued by the National Development and Reform Commission clearly pointed out that the development of the producer service industry should be accelerated to provide strong support for regional industrial upgrading.

With the continuous development of the industry, many producer service enterprises brreak through the restrictions between regions, gather and expand their scale in the regions conducive to their development, forming a significant spatial agglomeration effect. With the continuous formation and rapid development of producer service industry clusters in various regions, while creating huge economic benefits of scale, it also promotes technological innovation and promotes the green upgrading of industries in agglomeration areas. However, under the dual pressure of structural contradictions and pollution prevention, can the agglomeration of producer services still play an active role in promoting pollution reduction? Can it be an effective way to reduce pollution emissions? What is the reference for the spatial layout of the development of producer services? The further study of these problems is conducive to clarify the relationship between agglomeration and economy and environment, and has important guiding significance for realizing the "win-win" of economic development and ecological improvement.

Based on the panel data of 260 prefecture-level cities in China from 2007 to 2018, this paper sets up a Spatial Durbin

Model with two-way fixed effects in space and time, empirically analyzes the impact of producer service agglomeration on urban pollution emissions, and uses the mediation effect model to further test its mechanism of action. The marginal contribution of this paper has three points: First, in terms of research perspective, it focuses on the agglomeration of producer services, which provides a new perspective for the research of pollution reduction. Second, in terms of research objects, taking city-level data as the sample, most of the existing studies use provincial macro-level data for empirical analysis, ignoring the individual heterogeneity between cities. Third, in terms of research methods, the Spatial Durbin Model is used. Most of the existing studies are to construct classical panel regression or threshold regression model, and lack of understanding of the spatial correlation of variables. Considering the spatial dependence of each variable, this paper incorporates spatial factors to construct a Spatial Durbin Model.

2. Theoretical Analysis and Research Assumptions

Concentrated manufacturers are more efficient than scattered manufacturers, that is, when firms in the same industry gather in a certain place, their resources and endowments will be concentrated in this region. The end result is that the scale of production in the region continues to increase, thereby forming economies of scale, helping to reduce transaction costs, and prompting companies to invest the saved costs in innovative research and development, thereby improving the level of green technology. According to the theory of new economic geography, in order to reduce transportation costs, upstream and downstream enterprises tend to be geographically concentrated. The agglomeration of a large number of productive service enterprises in the same geographical space brings about the relative concentration of production factors such as talents, capital and technology, forming a large-scale factor market, shortening the distance between supply and demand, and helping to reduce information search costs and transportation costs, so as to reduce the pollution emission in the process. This paper proposes the following hypothesis:

H1: The agglomeration of producer services can help reduce pollution emissions.

2.1. Knowledge Spillover Effect

Producer service industry is characterized by intensive knowledge and technology, which makes it easier to form the diffusion and dissemination of knowledge and technology. The agglomeration of producer service industry has shortened the spatial distance between enterprises in the agglomeration area, and each enterprise has more opportunities in science, technology and information exchange. At the same time, the acquired knowledge is spread to other enterprises. The agglomeration improves the efficiency of diffusion and produces knowledge spillover effect. And the knowledge spillover from the agglomeration of producer services creates an atmosphere for collective learning and technical exchange. As a knowledge, capital and technology intensive industry, the producer service industry has higher requirements for the professional knowledge learning and accumulation of enterprise employees, and mutual learning is a prominent feature of knowledge, which means that any enterprise is both a receiver and a disseminator of knowledge. However, the dissemination of knowledge will be affected by the number of enterprises and the size of the spatial distance. Therefore, the agglomeration of producer services in a specific area is conducive to enterprises participating in learning and exchanges through formal or informal means, so as to form the effect of knowledge accumulation and collective learning. And due to geographical proximity, it is easier to share and accumulate knowledge, so that manufacturing enterprises continue to improve the transformation efficiency of technology in the process of "learning by doing", promote the improvement of production efficiency, thereby reducing energy consumption and pollution emissions in the production process. This paper proposes the following hypothesis:

H2: The agglomeration of productive services may affect pollution emissions through the effect of knowledge spillovers.

2.2. Industrial Structure Upgrading Effect

In the early stage of industrialization, industrial enterprises mainly controlled thesupply and marketing links, corresponding to the upstream and downstream of the value chain respectively, and relied on low cost to obtain price advantages. However, driven by technological progress and intensified market competition, the main focus of competition among enterprises is no longer limited to price. At this time, the financial services, marketing, R&D and design, legal services and other links at both ends of the value chain have outstanding performance in enhancing the competitiveness of enterprises, and these links belong to the producer service industry. The continuous development of the producer service industry is gradually changing the development path of China's over-reliance on high energy consumption, high pollution and low efficiency, making it continue to extend to both ends of the value chain, promoting the optimization and adjustment of the industrial structure, ffectively reducing the energy consumption and pollution emissions in the agglomeration area, and realizing the transformation of the economy to low-carbon development.

First of all, the agglomeration of producer services has led to the expansion of market demand and the further refinement of industrial division of labor. Manufacturing enterprises will outsource the basic production links and start to get involved in the high-end of the value chain and invest in clean technology research and development, which has promoted the green adjustment of the industrial structure. Secondly, from the perspective of demand, the characteristics of capital-intensive industries make agglomeration development greatly broaden the investment and financing channels, especially the agglomeration of the financial industry, which is conducive to the cross period rational allocation of funds, guiding the rapid economic development, and the obvious trend of high-end consumer demand, which puts forward higher requirements for the green characteristics of products and technological innovation, and promotes the realization of green and high-quality development. This paper proposes the following hypothesis:

H3: The agglomeration of producer services may affect pollution emissions through the effect of industrial structure upgrading.

3. Research Design

3.1. Model Design

This paper is based on the STIRAPT stochastic model building equation for econometric modeling:

$$lnpol_{it} = \beta_0 + \beta_1 lnagg_{it} + \beta_2 lnpop_{it} + \beta_3 lnPGDP_{it} + \beta_4 lntech_{it} + \beta_i lnX_{it} + \varepsilon_{it}$$

In the above formula, *pol* is the pollution emissions; *agg* is the agglomeration degree of urban producer services; *pop* is the population density, *PGDP* is the per capita GDP; *tech* is the per capita science and technology expenditure; X represents other control variables that affect urban pollution emissions; ε is Random error.

Considering the positive spatial correlation of urban pollution emissions, on the basis of the above formula, a spatial panel Durbin model is constructed to analyze the spatial correlation effect between the agglomeration of producer services and pollution emissions:

$$lnpol_{it} = \rho \sum_{j=1}^{n} W_{ij}\, lnpol_{it} + \beta_1 lnagg_{it} + \beta_i lnX_{it} + \gamma_0 \sum_{j=1}^{n} W_{ij}\, lnagg_{it} + \gamma_i \sum_{j=1}^{n} W_{ij}\, lnX_{it} + \mu_i + v_t + \varepsilon_{it}$$

Where, W is the spatial weight matrix, X is the set of other control variables that affect urban pollution emissions, including population density, per capita GDP, and per capita science and technology expenditure, and μ_i and v_t represent regional and time effects, respectively.

3.2. Spatial Weight Matrix Setting

The geographical proximity makes the natural endowment conditions between adjacent regions similar, and the interconnection of infrastructure, the flow of production factors and the transmission of information are also relatively convenient, so that the social and economic activities between regions will inevitably affect each other and have a certain spatial correlation. In terms of spatial statistics, the spatial weight matrix can be used to express the abstract spatial relationship between research objects to define the positional relationship between spatial objects. In order to comprehensively consider the geographic distance and economic connection of spatial units, this paper selects the economic geographic distance matrix, which is helpful to describe the asymmetry of spatial effects more accurately. The specific form is as follows:

$$W = \begin{cases} (\overline{Q_i} \times \overline{Q_j})/d_{ij}^2, & i \neq j \\ 0, & i = j \end{cases}$$

In the above model, $\overline{Q_i}$and $\overline{Q_j}$ respectively represent the real per capita GDP of regions i and j, , and d_{ij} represents the geographic distance between the two regions.

3.3. Variable Description

(1) Explained variable: Considering the diversity of environmental pollution and avoiding the limitation of selecting a single pollution discharge index, this paper comprehensively selects industrial wastewater discharge, industrial sulfur dioxide discharge and industrial smoke (powder) dust discharge. These three indicators can basically reflect the discharge of major pollutants in the process of industrialization in China. With the help of the entropy method, a comprehensive index of environmental pollution is constructed to reflect the pollution discharge status of each city.

(2) Core explanatory variable: Based on the number of urban unit employment, using the method of location entropy to measure the agglomeration degree of producer service in China. Specifically, that is, the ratio of the urban unit employment of producer services in city i to the total urban unit employment of the whole industry in city i and the total urban unit employment of producer services in all cities to the total urban unit employment of the whole industry in all cities.

Table 1. Variable description

variable type	Variable indicator	variable	Variable calculation instructions
Explained variable	pollutant emissions	pol	Constructing a comprehensive index of environmental pollution with the help of entropy method
core explanatory variable	Agglomeration of producer services	agg	Measured by the method of location entropy
mediated variables	knowledge spillover effect	$know$	Ratio of the number of college teachers per 10,000 people in cities to the average number of college teachers per 10,000 people in all cities in China
	Industrial Structure Upgrading Effect	$stru$	Proportion of added value of tertiary industry in GDP
control variables	population density	pop	The number of people in the unit administrative area
	economic scale	$PGDP$	real per capita GDP
	technological level	$tech$	Per capita science and technology expenditure in local fiscal expenditure
	environmental regulation	reg	Green coverage rate of built-up areas in municipal districts
	foreign direct investment	fdi	The proportion of foreign capital actually used in GDP in that year
	government intervention	gov	Proportion of government expenditure in regional GDP
	Internet penetration	int	The number of Internet access per 10,000 people

(3) Mediated variables: Select the ratio of the number of college teachers per 10,000 people in cities to the average number of college teachers per 10,000 people in all cities in China as a proxy variable for knowledge spillover effect. And the proportion of the added value of the tertiary industry to GDP is used to measure the effect of industrial structure upgrading. The larger the ratio, the more optimized the industrial structure.

(4) Control variables: In order to reduce the estimation error caused by omitted variables, this paper introduces other control variables that may affect the pollution emissions. Drawing on the practice of previous literature, the control variables introduced include population density, economic scale, technological level, environmental regulation, foreign direct investment, government intervention, and Internet penetration. The detailed variable descriptions are shown in Table 1:

3.4. Data Source and Descriptive Statistics

The data used in this article are mainly from "China Urban Statistical Yearbook", "China Environmental Statistical Yearbook" and the wind database from 2008 to 2019. Some missing data are supplemented by the statistical yearbooks of provinces and cities and the statistical bulletins of local cities. In the selection of research samples, cities with changes in administrative regions were firstly eliminated, and cities with more missing data were also discarded. Finally, 260 cities at the prefecture level from 2007 to 2018 were selected as samples, and the logarithm of all control variables was taken. The variable descriptive statistics are shown in Table 2:

Table 2. Descriptive statistics of main variables

variable	observations	average	standard deviation	minimum	maximum
pol	3120	0.876	0.105	0.058	1.000
agg	3120	0.798	2.288	0.052	2.875
pop	3120	5.836	0.878	1.574	8.960
PGDP	3120	1.268	0.649	-0.833	3.246
tech	3120	4.131	1.259	0.687	9.409
reg	3120	3.651	0.223	0.880	5.957
fdi	3120	2.725	1.714	-4.613	7.624
gov	3120	2.742	0.404	1.475	5.001
int	3120	7.100	0.870	-0.504	10.509
know	3120	0.717	1.055	-4.016	1.981
stru	3120	3.629	0.240	2.468	4.394

4. Empirical Results Analysis

4.1. Spatial Effect Test

The global autocorrelation is mainly used to test the distribution characteristics of data in the overall space, which is usually measured by Moran's I.

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

In the above model, $S^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2 = \frac{1}{n}(x_i - \bar{x})^T(x_i - \bar{x})$, n is the number of cities and w_{ij} is the spatial weight matrix. Moran's I is used to test the similarity between adjacent objects in the study area, and its value range is always between -1 and 1. Greater than 0 indicates that there is a positive spatial correlation, less than 0 indicates that there is a negative spatial correlation, and tends to 0 indicates that there is no spatial correlation, the larger the absolute value, the stronger the spatial correlation.

Table 3. Global Moran's I of pollution emissions

years	Moran's I	Z	P-value
2007	0.038	5.574	0.000
2008	0.028	4.234	0.000
2009	0.032	4.310	0.000
2010	0.038	5.551	0.000
2011	0.059	6.872	0.000
2012	0.080	7.169	0.000
2013	0.083	7.429	0.000
2014	0.098	10.847	0.000
2015	0.102	11.523	0.000
2016	0.058	6.185	0.000
2017	0.092	9.912	0.000
2018	0.083	7.363	0.000

Since the global Moran's I index mainly tests the spatial correlation from the overall level, it is difficult to detect the spatial correlation pattern of pollution emissions between different geographical regions. Therefore, the spatial

distribution trend is intuitively displayed through the local Moran's I index[1]. Its calculation is published as follows:

$$I_i = \frac{(x_i - \mathrm{x})}{S^2} \sum_{i=1}^{n} w_{ij} (x_j - x)$$

Due to space limitations, this paper only reports the local Moran's I scatter plots in 2007, 2012, and 2018. It can be seen that the slopes of the fitted straight lines are all positive, which indicates that the pollution emissions of 260 cities in China show a positive spatial correlation, that is, there is a significant spatial dependence. The local Moran index of most cities falls within the first and third quadrants, indicating that the pollution emission status is adjacent to "high-high" and "low-low", that is, when the pollution emission level of these cities is relatively high, its neighbouring cities also have high pollution emissions and vice versa.

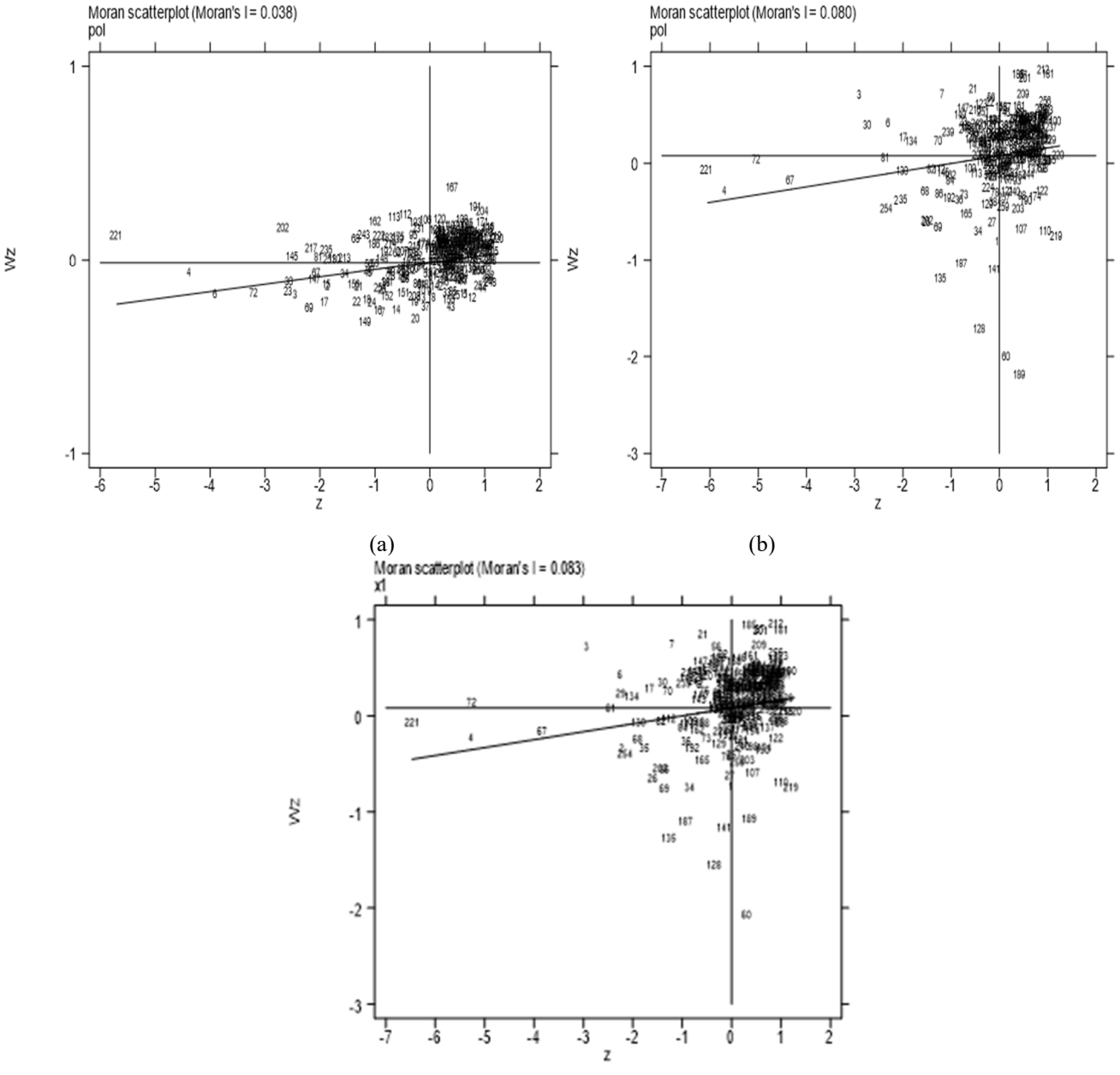

Figure 1. Moran scatter diagram of pollution emissions

4.2. Analysis of Spatial Econometric Regression Results

As shown in Table 4, while reporting the estimation results of the Spatial Durbin Model, this paper further compares the three cases for the consideration of different control over time and space effects. It can be seen that the maximum likelihood estimation value and goodness of fit of the double fixed effect model are significantly higher than those of the other two forms. Through the above analysis, the Spatial Durbin Model with two-way fixed effect is finally selected in this paper.

Table 4. Estimation results of Spatial Durbin Model

	spatial fixed effects	time fixed effects	two-way fixed effects
lnagg	-0.028***(-3.11)	-0.091**(-2.09)	-0.031***(-3.56)
lnpop	0.015(0.60)	-0.005*(-1.77)	0.017***(3.67)
lnPGDP	-0.009*(-1.65)	-0.074***(-4.38)	0.026*(1.86)
lntech	-0.005*(-1.85)	0.010**(2.14)	-0.011***(-2.84)
lnreg	-0.007(-0.85)	0.025**(1.98)	-0.006(-0.71)
lnfdi	0.009***(4.25)	-0.024***(-10.48)	-0.009***(-4.53)
lngov	0.003(0.24)	-0.013(-1.02)	0.011(0.97)
lnint	-0.010**(-2.32)	-0.001(-0.22)	-0.011**(-2.43)
W*lnagg	-0.041*(-1.81)	-0.140***(-5.83)	-0.052**(-2.30)
W*lnpop	0.357***(4.98)	-0.023**(-2.52)	0.351***(4.88)
W*lnPGDP	0.038(1.57)	0.086**(2.50)	0.008**(2.28)
W*lntech	0.016*(1.70)	-0.032***(-2.87)	-0.014**(-2.45)
W*lnreg	-0.029*(-1.65)	-0.025(-0.87)	-0.024(-1.37)
W*lnfdi	-0.012***(-2.83)	0.001(0.21)	-0.008*(-1.68)
W*lngov	-0.023(-0.91)	0.084***(2.79)	0.052*(1.76)
W*lnint	0.027***(3.59)	0.040***（2.88）	0.024**(2.21)
ρ	0.111***(3.58)	0.107***(2.97)	0.083**(2.43)
R^2	0.028	0.135	0.319
log-likelihood	3631.002	1565.223	3727.885
Observations	3,120	3,120	3,120

Note: * means p<0.10, ** means p<0.05, *** means p<0.01, z values are in parentheses.

The third column of the table above shows the regression results of the spatio-temporal two-way fixed effect Spatial Durbin Model under the economic geographical distance matrix. Among them, the spatial lag coefficient ρ of pollution emissions is significantly positive and significant at the level of 5%, indicating that the spatial spillover effect of urban pollution emissions in China is obvious.

From the specific regression results, the coefficient of producer services agglomeration is significantly negative, indicating that producer service agglomeration effectively promotes pollution reduction. Every 1% increase in local producer services agglomeration will lead to a 0.031% reduction in pollution emissions. The estimated results of the lag term (W*lnagg) show that every 1% increase in the agglomeration of producer services in surrounding cities will lead to a reduction of 0.052% in pollution emissions in the city. From the above analysis, it can be seen that the agglomeration of producer services has a significant effect on pollution reduction, and there is an obvious spatial spillover effect.

4.3. Effect Decomposition of Spatial Durbin Model

LeSage and Pace pointed out that using the partial differential method to decompose the effect can effectively compensate for the possible errors in the interpretation of the spatial spillover effect by the point estimation method[3]. Therefore, the impact of each factor on pollution emissions is further decomposed into direct effects, indirect effects and total effects. The following table shows the estimated results of the effect decomposition:

Table 5. Effect decomposition of Spatial Durbin Model

	direct effect	indirect effect	total effect
lnagg	-0.025***	-0.040**	-0.066***
	(-4.29)	(-2.06)	(-4.55)
lnpop	0.013***	0.198***	0.211***
	(3.16)	(4.64)	(4.50)
lnPGDP	0.024***	0.005**	0.029**
	(2.89)	(2.31)	(2.48)
lntech	-0.008***	-0.011	-0.019**
	(-3.22)	(-1.40)	(-2.41)
lnreg	-0.001	-0.010	-0.011
	(-0.29)	(-1.02)	(-1.59)
lnfdi	-0.007***	-0.006*	-0.013
	(-5.03)	(-1.86)	(-0.16)
lngov	0.010	0.034*	0.044**
	(1.35)	(1.89)	(2.08)
lnint	-0.007**	0.016**	0.009
	(-2.42)	(2.36)	(1.06)

Note: * means p<0.10, ** means p<0.05, *** means p<0.01, z values are in parentheses.

From the results in Table 5, it can be seen that the three effects of producer service agglomeration on urban pollution emissions are all significantly negative, indicating that it can significantly reduce pollution emissions in this city and surrounding cities. Specifically, its direct effect coefficient on urban pollution emissions is -0.025, indicating that the

agglomeration of producer services has a certain positive effect on the city's pollution reduction.

The indirect effect coefficient on surrounding cities is -0.040, and it is significant at the level of 5%, indicating that when other conditions remain unchanged, the pollution emission index of adjacent cities will decrease by 0.040% for every 1% increase in the agglomeration of producer services, which means that its impact on pollution has a spatial spillover effect, that is, the impact on pollution emissions can effectively spread to surrounding areas. This conclusion further confirms that the emission reduction effect of producer services agglomeration has global characteristics.

4.4. Mechanism Test

The previous article has examined the environmental effects of producer services agglomeration in detail, so, what mechanism does the agglomeration of producer services use to reduce pollution emissions? In order to further reveal the internal relationship between producer services agglomeration and pollution emissions, and further test and clarify the transmission path of this impact, this paper intends to adopt the mediation effect model, combined with the theoretical analysis of the impact mechanism in Chapter 2, to introduce knowledge Spillover and industrial structure are used as mediating variables to test possible action paths.

$$lnpol_{it} = \theta_0 + \theta_1 lnagg_{it} + \theta_2 lnX_{it} + \mu_{it} \quad (a)$$

$$lnM_{it} = \alpha_0 + \alpha_1 lnagg_{it} + \alpha_2 lnX_{it} + v_{it} \quad (b)$$

$$lnpol_{it} = \beta_0 + \theta_1' lnagg_{it} + \beta_1 lnM_{it} + \beta_2 lnX_{it} + \varepsilon_{it} \quad (c)$$

In the above formula, M is the mediating variable, and X is the set of relevant control variables. Table 6 reports the results of the mediation effect estimation.

Table 6. Analysis of mechanism test results

	knowledge spillover effect			industrial structure upgrading effect		
	lnpol	lnknow	lnpol	lnpol	lnstru	lnpol
	(1)	(2)	(3)	(4)	(5)	(6)
lnagg	-0.029***	0.032***	-0.021***	-0.029***	0.034***	-0.017***
	(-3.10)	(2.68)	(-3.09)	(-3.10)	(3.24)	(-2.67)
lnM			-0.002**			-0.014***
			(-2.24)			(-2.78)
control variable	YES	YES	YES	YES	YES	YES
time fixed effect	YES	YES	YES	YES	YES	YES
city fixed effect	YES	YES	YES	YES	YES	YES
R^2	0.161	0.072	0.087	0.161	0.078	0.086
Observations	3,120	3,120	3,120	3,120	3,120	3,120

Note: * means p<0.10, ** means p<0.05, *** means p<0.01, t values are in parentheses.

According to the regression results in the above table, when knowledge spillover is taken as the mediating variable, column (1) shows that producer services agglomeration significantly reduces urban pollution emissions, and further takes knowledge spillover as the explained variable, column (2) shows that producer services agglomeration significantly promotes knowledge spillover. After controlling the mediating variable, the coefficient of knowledge spillover variable in column (3) is significantly negative at the level of 5%, It shows that knowledge spillover significantly reduces pollution emissions, and the coefficient of producer services agglomeration is lower than the corresponding coefficient in formula (1), which shows that knowledge spillover plays an important intermediary role in the process of producer services agglomeration reducing urban pollution emissions, that is, producer services agglomeration improves environmental pollution by promoting knowledge spillover. Similarly, when industrial structure is used as an mediating variable, the agglomeration of producer services can improve environmental conditions by promoting the upgrading of industrial structure.

5. Conclusions and Policy Recommendations

Based on the panel data of 260 prefecture level cities in China from 2007 to 2018, this paper systematically measures the agglomeration degree of producer services and pollution emissions, and uses the Moran's I to test the spatial correlation of pollution emissions. Finally, based on the STIRPAT model, a spatial Durbin model is constructed to empirically analyze the effect and impact mechanism of producer services agglomeration on pollution emissions. The main conclusions are as follows:(1) Exploratory data analysis shows that urban pollution emissions in China are "high-high" and "low-low" adjacent, that is, there is a significant positive spatial correlation, and the increase in pollution emissions from surrounding cities will aggravate the city's pollution. (2) At the national level, the increase in the degree of agglomeration of producer services has significantly reduced pollution emissions, and has obvious spillover effects, which are shown to have an inhibitory effect on pollution emissions in the city and neighboring cities. (3) Mechanism research shows that knowledge spillover and industrial structure upgrading are important channels for the agglomeration of producer services to reduce urban pollution emissions.

The research conclusions of this paper have certain reference significance for the formulation of national innovation policy. First, accelerate the development of producer services and give full play to the agglomeration effect. The producer services are characterized by high knowledge intensity and are closely related to the manufacturing industry, further deepening the professional division of labor, and its resource allocation efficiency is much higher than that of other industries, which can promote the optimization of industrial structure and green technology innovation, and achieve the same direction as pollution reduction. Second, speed up the construction of a cross-regional environmental governance mechanism. In the previous study, it is found that China's pollution emissions have a pattern of "high-high" agglomeration and "low-low" agglomeration, that is, pollution emissions have a positive

spatial dependence. Therefore, when carrying out pollution control work, we should break through the limitations of the region, strengthen inter-regional cooperation, jointly promote environmental protection and governance, and avoid the situation of independent governance. Third, continue to vigorously promote pollution prevention and control. It is urgent to change the work tenet of "focusing on economic benefits and neglecting environmental protection" in the past, so that green GDP becomes the primary criterion for government performance appraisal. It is necessary to attach importance to the construction of producer service industry clusters, accelerate the development of modern service industries to improve support for traditional manufacturing, constantly promote the adjustment of industrial structure, promote industrial upgrading, and fundamentally resolve the problem of industrial overcapacity.

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