Knowledge Mapping of China Air Pollution Management Research from a Management Perspective: Visualization Analysis Based on CiteSpace

Yi Chen*, **Shengqin Yuan***

School of Public Administration, Sichuan University, Chengdu, Sichuan, China
*Corresponding Author.

Abstract: This paper utilizes the China National Knowledge Infrastructure (CNKI) as a data source, employing the search criteria 'Subject=Air Pollution Management or Title=Air Pollution Management'. A total of 259 periodical papers were retrieved and analyzed using CiteSpace, a bibliometric analysis software. A systematic analysis of the basic characteristics of the retrieved literature is conducted, covering aspects such as general overview, authors, institutions, and frequently cited works. The current research hotspots are visualized through keyword co-occurrence, keyword clustering, and keyword time-trend analysis. It is found through research that air pollution prevention and control has received sustained attention in recent years, forming a rich theoretical foundation. From a management perspective, it has become a key issue of concern in the academic community, forming three distinct research stages. However, the academic cooperation of air pollution prevention and control research is slightly insufficient, and the theoretical research on regional joint prevention and control needs to be deepened, and the research methods and theoretical models for air pollution prevention and control need to be standardized.

Keywords: Air Pollution Management; Citespace; Visual Analysis; Knowledge Map

1. Introduction

In the current global environmental discourse, air pollution stands as a pressing and significant challenge, with its widespread presence and profound impacts that cannot be overlooked. According to authoritative data, an alarming 86% of urban dwellers globally reside in areas with substandard air quality, and fine particulate matter (PM2.5) alone claims approximately 1.8 million lives annually, underscoring its dire threat to human health[1]. Looking ahead, as climate change intensifies, extreme weather events such as heatwaves, heavy precipitation, and droughts are projected to increase in frequency, duration, and intensity, further complicating air pollution and heightening the challenges of its management[2].

In China, amidst rapid economic growth, the high-input, high-energy-consumption development model has fueled economic prosperity but also given rise to severe air pollution problems[3]. Presently, China confronts formidable air pollution challenges, with a significant proportion of disease cases and deaths nationwide attributed to it, particularly in Beijing and its surrounding regions where this proportion soars to approximately 40%, highlighting the regional concentration and severity of the issue[4].

The health risks posed by air pollution translate into substantial economic burdens, encompassing hefty medical expenses and environmental remediation costs[5,6]. Additionally, they indirectly hinder the sustainable development of regional economies by stifling innovation and discouraging new market entrants[7,8]. This ripple effect underscores the urgency and significance of addressing air pollution.

After nearly six decades of legislative exploration and practice, China has established a relatively comprehensive legal framework for pollution prevention and control[9]. From a political system perspective, the mobility and promotion mechanisms of officials profoundly influence corporate environmental behavior and the intensity of officials' environmental

governance efforts, thereby exerting a profound impact on the overall effectiveness of environmental governance[10]. In terms of governance tools, scholars such as Wang have demonstrated through cooperative emission reduction game models the positive effects of regional collaborative governance in reducing air pollution control costs and enhancing governance outcomes[10]. Meanwhile, in policy effect evaluation, Yang Wenju and his colleagues have effectively addressed the limitations of static assessments in reflecting environmental technological changes and performance dynamics through dynamic environmental performance assessment methodologies[11].

Furthermore, academia has delved into the research progress of air pollution control through methods such as bibliometric analysis. Zhang and his team have constructed a theoretical framework for green development in the manufacturing industry from an innovative technology perspective using bibliometric analysis[12]. Luo and colleagues, focusing on an international perspective, have unveiled the temporal-spatial evolution characteristics and frontier hotspots of air pollution control research in non-Chinese regions through bibliometric tools[13]. Huang and his team have innovatively employed VOSviewer and SciMAT tools to explore the intricate relationship between the COVID-19 pandemic and air pollution[14]. Wu and his collaborators, by integrating bibliometric analysis and network analysis, have provided a multidimensional panoramic analysis of urban environmental governance[15].

This study aims to reveal the immediate achievements and dynamic trends of China's air pollution control research by thoroughly analyzing dimensions such as paper output, author groups, research institutions, highly influential papers, and keyword distributions. Concurrently, it will systematically expound on the hot topics at various stages of research development and outline the historical evolution trajectory of China's air pollution control research. This endeavor not only contributes to integrating air pollution governance into the realm of management studies and sharing Chinese insights and experiences with global air pollution research but also holds profound significance in fostering the integration of theoretical research

and practical application, enhancing environmental protection efforts, and even providing other nations with referential governance pathways.

2. Materials and Methodology

2.1 Materials

China national knowledge infrastructure (CNKI) was selected as the source of retrieved literature, and the retrieval time was September, 2023. The search commenced with the selection of the 'Advanced Scholar Search' option, employing the following search parameters: search scope - academic journals; subject - air pollution management or title - air pollution management; journal source - CSSCI. A total of 541 publications were retrieved, out of which 282 were categorized under non-management and non-research domains, such as conference reviews and news reports, and were thus excluded. Ultimately, 259 articles were shortlisted as the research data sources and were exported in RefWorks format.

2.2 Bibliometric Analysis

This paper uses the bibliometric analysis method, which, boasting the merits of objectivity, quantification, and modelling[16], aids in elucidating the hotspots, development history and trends of air pollution control research. CiteSpace developed by Professor Chaomei Chen of Drexel University, U.S.A., is a pivotal tool for bibliometric analysis research. We imported the sampled publications, sourced from the China Academic Journals Network Publishing Database (CNKI), into CiteSpace. The analysis covers a span from 1998 to 2023 to ensure the inclusion of all relevant articles. We designated the time slice as '1 year' for analyzing authors, research institutions, research contents, among others, and constructed the author co-occurrence network, keyword co-occurrence network, and keyword clustering network.

3. Results and Analysis

3.1 Analysis of Publications

In the articles selected, the earliest literature on air pollution control emerged in 1996. From then until 2013, the number of articles published each year in the Chinese research on

air pollution control was less than 10 indicating a slow onset of research development. As shown in Figure 1, from 2014 to 2017, there was a dramatic increase in the number, peaking at 35 articles per year in 2016. In the subsequent years, although there was a slight decline in the overall trend, the number of articles consistently remained at a high level, and articles published in 2014-2022 accounting for 92.66% of all samples.
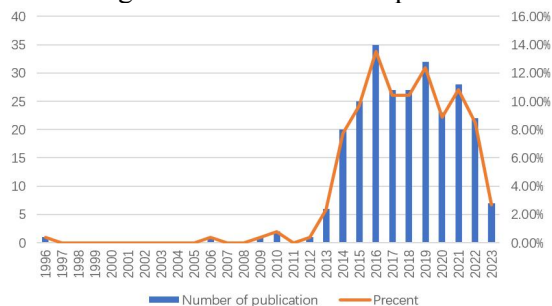

Figure 1. Annual Publications from 1996 to 2023

3.2 Analysis of Authors and Institution

Regarding the number of publications, notable authors in the field of air pollution control research in China include Wu Jiannan with 10 papers, Zhao Xinfeng with 5 papers, Zhang Wei with 5 papers, Yu Junhong with 4 papers, and Jiang Ling with 4 papers. The research on air pollution management has been carried out from multiple dimensions and involves a variety of disciplines such as management, economics, law, and engineering. Many researchers chose to collaborate on their studies, among which Zhang Wei and Jiang Ling, as well as Zhao Xinfeng and Yuan Zongwei, have formed relatively close collaborations.

In terms of the distribution of issuing institutions (Table 1), research on China air pollution governance is predominantly conducted at institutions such as the Central University of Finance and Economics (CUFE), Shanghai Jiao Tong University (SJTU), Nankai University (NKU), among others, of which the School of Government and Management of the Central University of Finance and Economics (CUFE) has issued the most articles with 16 papers.

Table 1. Top 10 Most Productive Institutions on Air Pollution Management

Number	Institution	Publications
1	School of Government, Central University of Finance and Economics	16
2	School of International and Public Affairs, Shanghai Jiao Tong University	10
3	Zhou Enlai School of Government, Nankai University	9
4	China Institute for Urban Governance	7
5	School of Economics and Management, Beijing University of Technology	5
6	School of Public and Management, Tsinghua University	5
7	School of Public Adimiistration, Beihang University	5
8	College of Public Administration, Huazhong University of Science and Technology	4
9	School of public and administration, Xi'an Jiaotong University	4
10	School of Economics and Management, Northwest University	4

3.3 Analysis of Highly Cited Literatures

Publications with a high frequency of citations can reflect the topical and major issues in the field of China air pollution control research[17]. The following table (Table 2) demonstrates the top 10 articles with the highest citation frequency in the sample literature. The topics of these papers are centered on cross-regional collaborative governance and intergovernmental cooperation, but the entry point is broader, covering the establishment of cooperation and alliances in the preliminary stage, the selection of policy tools and strategies in the intermediate stage, and the evaluation of effectiveness and efficiency in the subsequent stage. Among them, Wang Weiquan's 'The Research on Cooperative Governance of Air Pollution: Based on the Case of Beijing Area' has the highest citation frequency of 263 times.

Table 2. Top 11 Cited Papers about Air Pollution Management

Rank	Title	Author	year	Citations
1	The Research on Cooperative Governance of Air Pollution: Based on the Case of Beijing Area	Wang Weiquan	2014	263
2	Governance Mechanism of Air Pollution and Its Effects--Evidence from Chinese prefecture-level Cities	Li Wenjing; Zhang Manni	2016	185
3	Analysis on the Formation and Stability of Cooperation Management Alliance of Air Pollution Control Among Local Governments: Based on the Evolutionary Game	Gao Ming; Guo Shihong; Xia Lingling	2016	166

4	Study on the Jing-Jin-Ji Regional Intergovernmental Air Pollution Control Policy Coordination	Zhao Xinfeng; Yuan Zongwei	2014	161
5	The Study of Air Pollution Regional Linkage Control and Prevention System Under the Vision of National Governance—A case of Beijing, Tianjin and Hebei	Xie Baojian; Chen Ruilian	2014	147
6	From Territory Principle to Cooperation Management: the Transformation: Air Pollution Control Model of Beijing, Tianjin	Tao Pinzhu	2014	140
7	Air Pollution Abatement Efficiency and Selection of Environmental Policy Tools: Empirical Evidence of 29 Provinces or Municipalities	Zheng shiming; Luo Kaifang	2017	134
8	Inter-provincial cooperative game model of Beijing, Tianjin and Hebei province air pollution control	Xue Jian; Xie Wanlin; Li Changmin	2014	131
9	Accountability Audit of Natural Resource and Air Pollution Control: Harmony Tournament or Environmental Protection Qualification Tournament	Huang Rongbing; Zhao Qian; Wang Liyan	2019	122
10	Network Analysis of Regional Environmental Governance under Inter-government Cooperation: An Example of the Regional Air Governance in Beijing-Tianjin-Hebei Area	Sun Tao; Wen Xuemei	2018	119

3.4 Analysis of Keywords
Table 3. Top 18 Keyword Occurrences

Number	Keyword	Frequency
1	Air pollution	87
2	synergistic governance	27
3	Beijing-Tianjin-Hebei	23
4	Atmosphere management	10
5	Regional governance	8
6	Cooperative governance	7
7	Environmental pollution	7
8	Local government	7
9	Evolutionary game	6
10	Policy tool	6
11	Joint prevention and control	5
12	intergovernmental cooperation	5
13	Haze	5
14	Benefit allocation	4
15	DID model	4
16	Air quality	4
17	Haze control	4
18	environmental governance	4

Keywords summarize information about the topic of the study and are an essential element of the bibliometric analysis method. The keyword co-occurrence network generated using CiteSpace can reflect the hotspots in this research area. In the table (Table 3), each node represents a keyword, the larger the area of the node, the higher the frequency of the keyword it represents in the papers. Keywords with high frequency included 'air pollution' (87 times), followed by 'coordinated management' (27 times) and 'Beijing-Tianjin-Hebei' (23 times), 'air pollution' (10 times), and the rest of the keywords are less than 10 times.

3.5 Keyword Clustering Analysis
The LLR (Log-Likelihood Ratio) algorithm in CiteSpace was employed to cluster keywords based on the keyword co-occurrence network, resulting in 10 distinct clusters: air pollution, synergistic governance, cooperative governance, environmental pollution, atmospheric pollution, regional governance, policy tools, joint prevention and control, policy effects, and environmental protection products(Figure 2). A Q-value of 0.6475 and an S-value of 0.9085 were obtained, indicating that the clustering structure is both significant and credible.

Table 4. Summary of Seven Clusters Achieved by Keyword Co-Occurrence

dimension	Cluster label	degree	Top keywoords ranked by LLR
I	#0air pollution	48	collaborative governance; air pollution control; Jing-jin-ji
	#3environmental pollution	19	influencing factors; local government; haze control; pm2.5
	#4atmosphere pollution	15	governance mechanism; evolutionary game; simulation; regional air pollution
II	#1 synergistic governance	26	ecology; intergovernmental cooperation; inter-administration; regional government
	#2 Cooperative governance	19	Jing-Jin-Ji; benefit coordination; policy network; social network
	#5 Regional governance	14	coordination mechanisms; national governance; value; regional interaction
	#6Policy tools	10	collaborative degree; integration degree; collaborative innovation; government regulation

	#7Joint prevention and control	8	G20 Summit; collaborative mechanisms; institutional change; legalization
III	#8policy effective	7	DID method; DDD method; ministry of ecology and environment of the People's Republic of China; environmental protection interviews
	#9Eco-friendly products	5	Total emission control; Ninth Five-Year Plan; treatment and disposal technologies; environmental protection industry

The clustering results can be further categorized into three dimensions (Table 4). The first dimension is the object of air pollution governance and its extension. The first dimension encompasses clusters #0 (air pollution), #3 (environmental pollution), and #4 (atmosphere pollution). All three clusters delve into the theme of cross-regional synergistic governance. Additionally, cluster #3 specifically includes targeted research on PM2.5 and haze governance, while cluster #4 contains investigations on the factors influencing air pollution and the associated governance mechanisms.

The second dimension is the means of air pollution management. This dimension encompasses #1 synergistic governance, #2 cooperative governance, #5 regional governance, #6 policy tools, and #7 joint prevention and control. According to the New Regionalism theory, regional governance is defined as 'a collaborative mechanism among governments, non-governmental organizations, and other stakeholders, emphasizing stable network relationships among relevant actors in policy'[18]. Cross-regional governmental collaborative governance is of great significance in air pollution prevention. From a geographical point of view, the diffusion range of air pollutants does not overlap with administrative regions. Through the air basin theory, Wang Jinnan pointed out that the 'air watershed' does not coincide with the administrative boundaries, and each administrative region may play the dual role of pollutant emitters and receivers[19]. Moreover, from the perspective of local administration, air pollution exhibits strong spillover effects. Its cost is challenging to internalize, and responsibility is hard to define. This scenario often leads to 'free-riding' behaviour among local officials in air pollution control by transferring pollution sources, ultimately resulting in the ineffectiveness of the overall regional air pollution treatment[20].

These studies have also pointed out that the construction of a joint prevention and control system for air pollution control in China still needs to be improved. Horizontally, administrative regions generally lack the internal motivation to participate in joint prevention and control due to varying governance philosophies and the challenge of balancing interests. Additionally, there are underdeveloped legal and institutional frameworks[21], and inconsistencies in the establishment of institutions[22]. Vertically, the 'paternalistic' mentality of the government and differences in the implementation capacity of grassroots governments have also hindered the occurrence of inter-governmental cooperation[23]. These shortcomings have led to many environmental legacy problems, poor operationalization of laws and regulations, unavoidable free-rider behaviour, and 'fragmentation' of governance[24].

To deepen intergovernmental collaboration and the precise implementation of governance policies, academia has conducted extensive and profound expansions in the study of policy instruments. Researchers have adopted diversified classification strategies to analyze policy instruments. Based on differences in policy action modes, policy instruments are meticulously categorized into market-oriented and administrative intervention types[25]. The former focuses on the regulatory role of market mechanisms, while the latter emphasizes the direct involvement of administrative forces. Another classification dimension, based on the degree of coercion of policy instruments, divides regional air pollution control instruments into regulatory, market incentive, and voluntary participation categories[26,27]. This classification provides a more detailed depiction of the varying degrees of constraint imposed by policy instruments during implementation.

At the theoretical level, Zhao Xinfeng et al. proposed a comprehensive analytical framework encompassing eight core elements to systematically evaluate the aforementioned three types of policy instruments: static economic efficiency, environmental damage

costs, dynamic social efficiency, instrument implementation effectiveness, regional environmental equity, institutional practical feasibility, geographical pollution conditions, and economic development compatibility[26]. This framework provides a solid foundation for theoretical research on policy instruments.

In practical applications, Zheng Shiming and other scholars have used empirical research methods to reveal the positive effects of regulatory and market incentive policy instruments in enhancing air pollution control efficiency. Simultaneously, they pointed out the limitations and challenges faced by voluntary policy instruments in pollution control[27]. This discovery offers vital insights for policymakers to select appropriate policy instruments in actual operations.

The assessment of air pollution control encompasses two primary dimensions: policy effectiveness and environmental protection products. Regarding policy effectiveness, researchers frequently employ Data Envelopment Analysis (DEA) and Super-Efficient SBM (Super-SBM) models to evaluate outcomes. Additionally, they utilize Difference-in-Differences (DID) and Triple Difference (DDD) models to measure changes in governance efficiency. The evaluation units vary, ranging from detailed analyses at the provincial level to cross-regional efficiency comparisons (e.g., among central, western, and eastern regions). Some studies focus on the effects of single policies, such as the "Air Pollution Prevention and Control Action Plan" or the "Environmental Protection Tax Law of the People's Republic of China," while others explore the comprehensive impact of multiple policies. Furthermore, research in this field extends to identifying key factors influencing the efficiency of air pollution control. As for environmental protection products, their evaluation emphasizes multiple dimensions, including the advancement of pollution control and disposal technologies, the efficiency of emission reduction technologies, and the overall development level of the environmental protection industry.
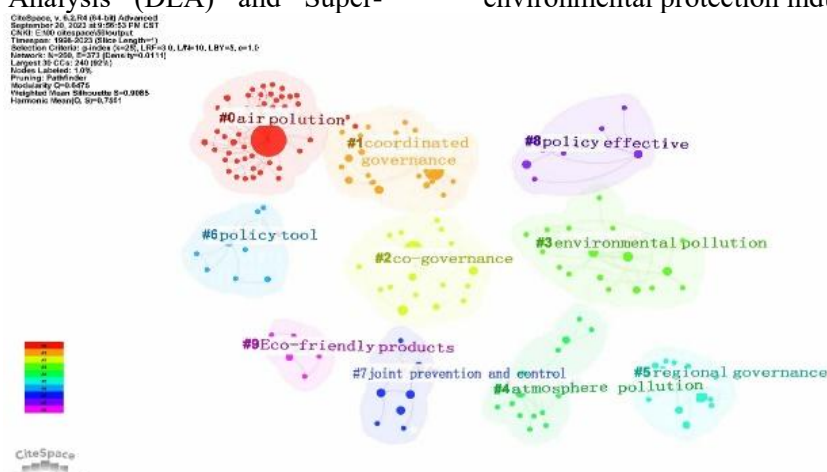

Figure 2. Keyword Co-occurrence Network Generated from CiteSpace

3.6 Burst Detection Analysis of Keywords

According to the hotspot analysis and bursts presented in (Figure 3), the start year and end year of the burst duration as well as the intensity of the burst can be visualized, presenting the trend of the research hotspot in the field.

The research development in the field of air pollution control can be clearly divided into three landmark stages, each of which is distinctively characterized by its unique research focus and achievements from the preceding stage.[28]

First Stage: Foundation Period of Total Emission Control (1998-2013)

From 1998 to 2013, the research emphasis on air pollution control was firmly placed on total emission control strategies. This stage not only laid a solid foundation for subsequent in-depth studies but also accumulated valuable governance experience through systematic total emission regulation practices. The implementation of total emission control strategies effectively promoted comprehensive monitoring of pollution sources and scientific regulation of total emissions, paving the way for the exploration of regional collaborative governance models.
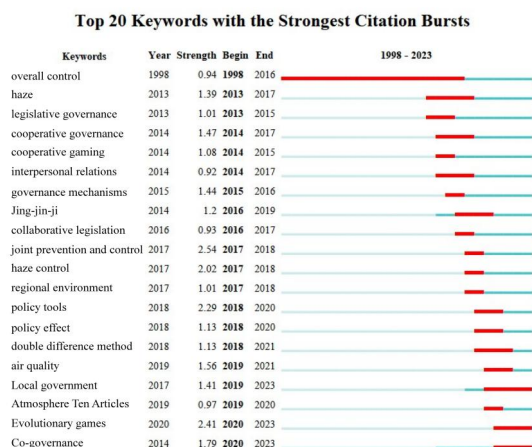
Top 20 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	1998 - 2023
overall control	1998	0.94	1998	2016	
haze	2013	1.39	2013	2017	
legislative governance	2013	1.01	2013	2015	
cooperative governance	2014	1.47	2014	2017	
cooperative gaming	2014	1.08	2014	2015	
interpersonal relations	2014	0.92	2014	2017	
governance mechanisms	2015	1.44	2015	2016	
Jing-jin-ji	2014	1.2	2016	2019	
collaborative legislation	2016	0.93	2016	2017	
joint prevention and control	2017	2.54	2017	2018	
haze control	2017	2.02	2017	2018	
regional environment	2017	1.01	2017	2018	
policy tools	2018	2.29	2018	2020	
policy effect	2018	1.13	2018	2020	
double difference method	2018	1.13	2018	2021	
air quality	2019	1.56	2019	2021	
Local government	2017	1.41	2019	2023	
Atmosphere Ten Articles	2019	0.97	2019	2020	
Evolutionary games	2020	2.41	2020	2023	
Co-governance	2014	1.79	2020	2023	

Figure 3. Top 20 Keywords with the Strongest Citation Bursts

Second Stage: Fog and Haze Response and Legal Strengthening Period (2013-2016)

After entering 2013, with the frequent occurrence of persistent severe haze events in multiple regions across China, the severity of air pollution issues became unprecedentedly prominent. According to the statistics from the Ambient Air Quality Standards (GB 3095-2012), only 4.1% of the 74 major cities met the standards in 2013, a figure that profoundly revealed the deteriorating reality of air quality and posed a severe threat to the stable operation of the socio-economy and public health. In this context, the Chinese government responded swiftly by issuing the Action Plan on Air Pollution Prevention and Control and a series of accompanying laws and regulations, aiming to vigorously address PM2.5 and other air pollutant issues. During this stage, research developed at a rapid pace, with scholars focusing on the mechanisms of regional air pollution joint prevention and control and the selection of policy tools. Through the expansion of theoretical perspectives such as cooperative game theory, intergovernmental relations, and collaborative legislation, a deeper understanding of the complexity of air pollution governance was achieved. Concurrently, empirical research on regional air quality assessment, policy effect evaluation, and policy tool analysis also made significant progress, expanding the connotation of collaborative governance from solely intergovernmental coordination to the broader scope of multi-stakeholder collaboration involving enterprises and the public.

4. Conclusions and Prospects

Through a systematic review of relevant literature in the Chinese Social Sciences Citation Index (CSSCI) database under the framework of China National Knowledge Internet (CNKI), this study found that China's systematic research on air pollution management can be traced back to the end of the 20th century, and since 2014, the number of publications has soared, peaking in 2022 before fluctuating slightly downwards. This phenomenon reflects the rapid growth and maturation process of the research field. From the perspective of research entities, there is a notable trend of interdisciplinary and cross-institutional collaboration, albeit the current level of cooperation between institutions still needs improvement. The highly cited literature exhibits a high degree of thematic concentration but a wide range of entry points, comprehensively covering multiple dimensions of collaborative governance, demonstrating the depth and breadth of research.

The evolution trajectory of research themes clearly showcases the transformation of air pollution control strategies from broad "total emission control" to more refined "haze" management and "legal" construction. Especially after 2014, the concept of "collaborative governance" has been further refined, giving rise to sub-topics such as "collaborative legislation" and "intergovernmental relations," which have gradually integrated into discussions on "policy tools" and "policy means." Currently, introducing emerging theories (e.g., evolutionary game theory) to analyze the internal logic of cross-regional collaborative governance, exploring coordination strategies for horizontal and vertical government relations, and constructing a more comprehensive policy system and multi-stakeholder participation mechanism have become the frontiers of research on air pollution control in China.

Based on an in-depth analysis of the current research status, future research on air pollution control can be further deepened and expanded in the following three aspects:

(1) Strengthen multidisciplinary integration: Given the complexity and multidimensionality of air pollution issues, it is necessary to further enhance cross-disciplinary cooperation among science, technology, economics, sociology, and other disciplines to comprehensively

examine the essence of the problem, comprehensively design control measures, and achieve efficiency and sustainability in governance practices.

(2) Deepen research on regional collaborative governance: While current research on regional collaborative governance is mostly concentrated in specific regions such as Beijing-Tianjin-Hebei, future efforts should be based on the geographical distribution characteristics and transmission patterns of air pollution, scientifically delineating collaborative management regions, expanding nationwide, and forming a more systematic and comprehensive regional air pollution control system.

(3) Standardize research methods and model construction: Establishing a sound evaluation system for air pollution control effects and an analytical framework for policy tools can not only provide solid theoretical support for domestic air pollution control efforts but also contribute valuable theoretical and practical experience to international air pollution governance, thereby promoting the improvement and development of the global environmental governance system.

References

[1] The Lancet Planetary, H., *The air that we breathe.* The Lancet Planetary Health, 2022. **6**(1): p. e1.

[2] IPCC, *SummaryForPolicymakers.* 2022.

[3] Tang, Y., et al., *Digital finance and air pollution in China: Evolution characteristics, impact mechanism and regional differences.* Resources Policy, 2023. **86**: p. 104073.

[4] Qin, Y., et al., *Does urban air pollution have an impact on public health? Empirical evidence from 288 prefecture-level cities in China.* Urban Climate, 2023. **51**: p. 101660.

[5] Yazdi, S.K. and B. Khanalizadeh, *Air pollution, economic growth and health care expenditure.* Economic Research-Ekonomska Istrazivanja, 2017. **30**(1): p. 1181-1190.

[6] Greenstone, M. and R. Hanna, *Environmental Regulations, Air and Water Pollution, and Infant Mortality in India.* American Economic Review, 2014. **104**(10): p. 3038-72.

[7] Ai, H., et al., *How does air pollution affect urban innovation capability? Evidence from 281 cities in China.* Structural Change and Economic Dynamics, 2022. **61**: p. 166-178.

[8] Chao, S., C. Huang, and W. Chen, *The impact of air pollution on startups and structural transformation: Evidence from newly registered enterprises in China.* Journal of Cleaner Production, 2023. **422**: p. 138537.

[9] Feng, L. and W. Liao, *Legislation, plans, and policies for prevention and control of air pollution in China: achievements, challenges, and improvements.* Journal of Cleaner Production, 2016. **112**: p. 1549-1558.

[10] Shao, W.-C. and L.-C. Chou, *Political influence and air pollution: Evidence from Chinese cities.* Heliyon, 2023. **9**(7): p. e17781.

[11] Yang, W., *The Dynamic Environmental Performance of Regional Industry in China : An Empirical Analysis with DEA.* Journal of Quantitative & Technological Economics, 2009. **26**(06): p. 87-98+114.

[12] Zhang, S., et al., *Green manufacturing for achieving carbon neutrality goal requires innovative technologies: A bibliometric analysis from 1991 to 2022.* Journal of Environmental Sciences, 2023.

[13] Luo, W. and J. Zhu, *Researches on air pollution control abroad: Spatial − temporal characteristics and hotspot frontier.* Journal of Arid Land Ｒesources and Environment, 2020. **34**(02): p. 115-121.

[14] Wong, W.M., X. Wang, and Y. Wang, *The intersection of COVID-19 and air pollution: A systematic literature network analysis and roadmap for future research.* Environmental Research, 2023. **237**: p. 116839.

[15] Wu, F., et al., *Responding climate change: A bibliometric review on urban environmental governance.* Journal of Cleaner Production, 2018. **204**: p. 344-354.

[16] Tian, Y. and H. Chang, *Bibliometric Analysis of Research Progress on Ecological Vulnerability in China.* Acta Geographica Sinica, 2012. **67**(11): p. 1515-1525.

[17] Yan, C., Z. Yang, and L. Lai, *The Change of Discourse System of Chinese*

Administrative Science and Its Logic——
—Visual Analysis Based on "Chinese
Public Administration" from 1985 to 2020.
Journal of Gansu Administration Institute,
2012(01): p. 42-50+125.

[18] Liu, X., *Cross Regional Coordination*
Mechanism of the Urban Agglomeration.
Nanjing Journal of Social Sciences,
2014(05): p. 70-76.

[19] Wang, J., M. Ning, and Y. Sun, *Study on*
Theory and Methodology about Joint
Prevention and Control of Regional Air
Pollution. Environment and Sustainable
Development, 2012. **37**(05): p. 5-10.

[20] Yuan, K., H. LI, and Z. Lin, *Does*
Constraining Assessment Enhance the
Officials'Incentives to Ｒeduce Emission?
Modern Economic Science, 2014. **36**(6): p.
1-10+122.

[21] Hu, Z., G. Li, and J. Gao, *Air Pollution*
Regional Linkage Control and Prevention
from the Perspective of Environmental
Regulation——The Scheme Design,
State Evaluation and Influencing Factors
Analysis. China Industrial Economics,
2019(05): p. 24-42.

[22] Wei, N. and G. Meng, *Mechanism and*
Institutional Logic of Cross-regional
Collaborative Governance of Air
Pollution——Based on the Cooperative
Practice of Jing-Jin-Ji egion. China Soft

Science, 2018(10): p. 79-92.

[23] He, J., *Inter － Governmental*
Cooperative Governance: Formation
Logic, Theoretical Concept and Policy
Tools. Journal of Shanghai Normal
University(Philosophy & Social Sciences
Edition), 2011. **40**(06): p. 41-48.

[24] Wang, W., *The Research on Cooperative*
Governance of Air Pollution: Based on the
Case of Beijing Area. Journal of Public
Management, 2014. **11**(01): p. 55-64+140.

[25] Wu, Y. and X. Zhao, *Research on Change*
of Policy Instruments for Air Pollution
Governance in Beijing-Tianjin-Hebei
Region——Data from Policy Text 2004-
2017. Chinese Public Administration,
2018(10): p. 78-85.

[26] Zhao, X. and Z. Yuan, *Policy Tools in the*
Governance of Regional Air Pollution: the
Practice Course and the Optimal Choice
in Chian. Chinese Public Administration,
2016(07): p. 107-114.

[27] Zhang, S. and K. Luo, *Air Pollution*
Abatement Efficiency and Selection of
Environmental Policy Tools: Empirical
Evidence of 29 Provinces or
Municipalities. China Soft Science,
2019(09): p. 184-192.

[28] Protection, M.o.E., *2013 China*
Environmental Status Bulletin. 2014.