The Strategies of Air Quality Improvement in Urban Governance: A Case Study of Beijing

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Abstract. In recent years, the economy of China has a rapid development. Meanwhile, there are a few problems exposed that are harmful to human health, especially environmental problems and air pollution in Beijing are concerned by all citizens. Since 2013, under the guidance of national governance policy, the Beijing government has been paying high attention to dealing with air pollution and officially launched air pollution control activities. With the cooperation and joint efforts of government, enterprises and academic institutions, air governance has achieved remarkable results, which reduced the index of air pollutants in terms of PM2.5, sulfur dioxide, nitrogen dioxide, and PM10. This paper will summarize the core countermeasures including the policy effect launched by the government, and the promotion effect of shared transportation modes by enterprises. Based on the measurements taken by government and enterprises, this paper analyzes the effects of different strategies. In addition, the suggestions for air quality control will be presented.

Keywords: Air governance, environmental governance policy, shared transport.

1. Introduction

Air pollution is considered by the Chinese government and citizens as one of the most severe environmental challenges. Nitrogen oxides, volatile organic compounds and other pollutants contained in vehicle emissions produce a large amount of secondary particulate matter, which becomes an important source of PM2.5, and it is used to measure air quality. Aside from the environmental regulations implemented by major city governments, the introduction of shared bicycle platforms also has an impact on urban governance. For instance, there was a certain positive effect on improving local air quality in 2016 when the enterprises of OFO Sharing Bicycle and Mobike entered Beijing. Besides, other pollutant indices in terms of PM2.5, sulfur dioxide, nitrogen dioxide, and PM10 have decreased, which is also related to the entry of shared bicycle platforms to an extent. According to past studies, the promotion of using bicycle-sharing platforms combined with big data is a significant way to improve air quality. Since it alleviates urban traffic congestion, reduces urban carbon emissions and provides residents with a healthier lifestyle. The following part will review the research on improving air quality written by other scholars.

This paper presents a case study at the first based on the causes and countermeasures of air pollution in Beijing. With the acceleration of industrialization, urbanization, and the development of urban transportation, the amount of emission of air pollutants is increasing. It leads to various threats to public health such as acid rain, the greenhouse effect and so on [1]. Yanmin Yang believes that the main causes of urban air pollution include industrial production pollution, transportation pollution, daily life pollution, and construction dust pollution [2]. In addition, transportation pollution primarily refers to vehicle emissions such as nitrogen oxides, carbon monoxide, and solid suspended particulate matter, which lead to forming acid rain, endanger human health, and shorten the service life of buildings [2]. The governance policies introduced by local governments are effective, but the implementation of policies has a lag. Moreover, the bicycle-sharing mode provides a supplementary means of governance, and it plays an irreplaceable role.

Based on past research above, the effect of bicycle-sharing mode on improving air quality will be discussed. On the one hand, it has been detected that the license plate tail number restriction policy is implemented in major cities in China especially in Beijing. However, Cao Jing et al proposed in the research that there is a quite limited effect on improving air quality in Beijing as the license plate tail number restriction policy has been launched for years. The reason is that the policy will change individuals' behavior on purchasing a second car or delaying the use of old cars. It could result in a loss of social welfare [3]. On the other hand, the increasing usage of public transport and bike-sharing has a more obvious effect on improving air quality. Renjun Chen et al. proposed that the implementation of sharing bicycles and railway transportation significantly reduced emissions of carbon monoxide and PM2.5, among which the popularity of sharing bicycles significantly reduced emissions of carbon monoxide and nitrogen dioxide [4]. Guangyu Cao et al proposed that the joint presence of sharing bike companies has reduced the urban PM2.5 index by 3.832 micrograms per cubic meter. Moreover, it is more obvious in decreasing in vehicle emissions [5]. Qianbing Xiao pointed out that the settlement of OFO sharing bicycles improved the air quality slightly and the effect is not significant from the comprehensive breakpoint. However, combined with the subway, the effect will be more remarkable [6]. Monazaam et al. claimed that air and noise pollution will be reduced when replacing cars and motor vehicles with bicycles [7]. In the study of the impact of sharing bicycles on air quality in Shanghai, Yongping et al mentioned that the input of shared bicycles has significantly reduced the release of carbon dioxide and nitrogen oxides in the city, especially in the morning and evening peak hours [8].

Table 1. Air pollutant index in Beijing from 2013 to 2019

	2013	2014	2015	2016	2017	2018	2019
PM2.5 (ug/m^3)	89.5	85.9	80.6	73	58	51	42
Sulfur dioxide (ug/m^3)	26.5	21.8	13.5	10	8	6	4
Nitrogen dioxide (ug/m^3)	56	56.7	50	48	46	42	37
PM10 (ug/m^3)	108.1	85.9	101.5	92	84	78	68
Days of air quality compliance	176	172	186	198	226	227	240

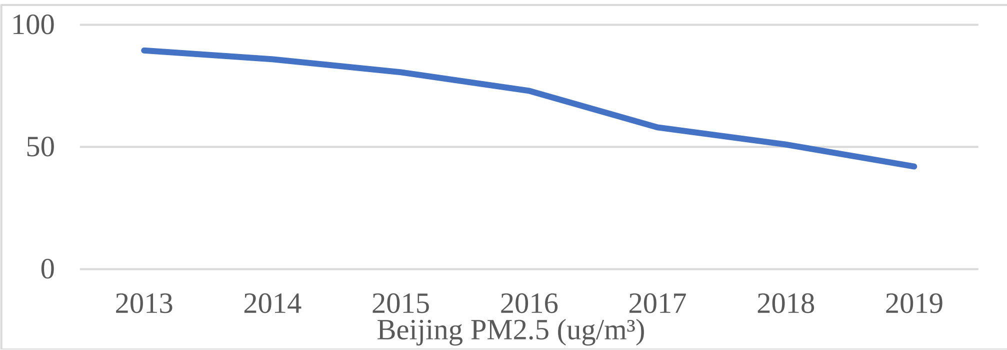

Fig. 1 PM2.5 index in Beijing from 2013 to 2019 (Picture Credit: Original)

2. The Background of Air Governance in Beijing

As shown in Table 1, in 2013, the air quality had been up to standard for only 176 days in Beijing, less than half of the whole day. There are four main pollutant indexes, that use PM2.5 air concentrations as a representative, it up to 89.5 micrograms per cubic meter. The urban economy has grown rapidly, but at the same time, it caused a lot of bad influence, the base of economic development faced threats, and people's lives and health were also at risk. 2013 was a meaningful year for the work in air pollution prevention in Beijing, this year Beijing took the lead in implementing the national air quality standards, PM2.5 replaced PM10 as the main air pollutant, and it became the key to air management. Around air quality management, the Beijing municipal government has taken ten actions for air quality management, including upholding and improving system building, implementing economic leverage, reducing coal usage, controlling car usage and encouraging green commuters. Since 2013 the government conscientiously implemented the policy for air quality management. At the same time, public transport was constantly improving, the shared bicycle platforms settled in Beijing, and the government promoted the Green Travel Plan, this policy had a positive influence on improving the air quality in Beijing. As for 2019, the pollutant index had significantly decreased, The PM2.5 decreased to 42 micrograms per cubic meter, compared with the same period of the previous year it decreased by over 50%. The number of days that air quality reached the standard is 240 days, compared with the same period of the previous year of over 35%, accounting for more than 65% of the total number of days in the whole year. It shows the significant achievement of air quality management in Figure 1. After 2019, further deepening measures, keep improving the management of air quality in Beijing. This paper mainly analyzes the impact of various policies and bicycle-sharing on air quality management in Beijing.

3. Policy Effects of Air Governance

3.1. Tail Number Restriction Policy

In 2013, the Beijing municipal government led the establishment of a collaborative group on the prevention and control of atmospheric pollution in Beijing, Tianjin, Hebei, and surrounding areas. During the APEC, for the first time, a regional air quality consultation was attempted and a collaborative group for the prevention and control of air pollution in Beijing, Tianjin, and Hebei was set up, establishing the air pollution coordination control mechanism for Beijing, Tianjin, Hebei and surrounding areas. In December 2014, Beijing, Tianjin, and Hebei coordinated for blue sky protection campaign. After 2016, Beijing and its surroundings have focused on the protection of the air environment to achieve the concerted development of Beijing-Tianjin-Hebei and formulate and implement policies on environmental management. The air quality management policy in Beijing has a significant macro effect, because of the various directions and considerations about the variables and factors that enter the mix, it is difficult to remove confounding variables. Therefore, this paper focuses on the tail number limited policy and observes the impact of this policy on air governance.

The tail number limited policy has a limited impact on the air quality management, and it will bring some social cost. During the test of the Olympic games in 2007, it was the first time that the Beijing government used the tail number restriction policy. During the 2008 Olympic games, the government implemented the even-odd license plate policy for two months. During the period of 2013 to 2019, it has successively implemented specific regulations for different tail number restrictions. The government has been questioned and criticized by various parties for questioning whether the tail number limited policy can effectively solve the problem of urban congestion and improve air governance. Xiaoguang Zhao and the others compared the data between before the Olympic games opened and after implementing the policy, and it shows at the beginning of implementing the policy, the concentration of inhalable particulate matter in the air of Beijing decreased [9]. Jing Cao states that the air quality improved after the Olympic games, but it is mainly due to the reduction of the output from the polluting industries [3]. Otherwise, the author found that the tail number limited policy encourages people to buy their second car, people may delay the use of old cars when replacing them with new ones. The tail number limited policy nominally restricts car usage and traffic, but it did not achieve the goal of effectively controlling the emission of pollutants. Moreover, the implementation of this policy needs to be compared with the achievement of the city’s air quality control, to observe the social welfare has decreased or not [3].

3.2. Reasons for the Limitations of the Policy Effects

Firstly, there are multiple reasons that cause air pollution and vehicle emissions, and dust emissions are part of the source. In the index for measuring air pollution, the concentration of PM2.5, nitrogen dioxide, and sulfur dioxide in the air is used to be the standard of measurement. To be specific, PM2.5 mainly comes from the primary emission and secondary emission conversion of coal, vehicles and so on. Nitrogen dioxide mainly comes from vehicles and fossil fuel combustion emissions. Sulfur dioxide is an air pollutant directly related to coal combustion. The production of heavily polluting industries, such as thermal power, steel, coal and metallurgical industries, is currently the main source of air pollution. As a result. Compared to the tail number restriction policy, the effect will be more significant if policies are aimed at the main source of air pollution.

Secondly, the core target of the tail number limit policy is not to reduce air pollution. Although the policy improves the air quality slightly, it was originally designed to alleviate urban traffic congestion.

Thirdly, there is no obvious terrain segmentation between Beijing and other surrounding urban areas, which also causes the pollution diffusion caused by meteorological factors. In addition, there are seasonal differences in meteorological factors. The air humidity, maximum wind speed and temperature in different seasons are not the same. At present, most of the research on the restriction policy of Beijing tail number mainly on the difference in air quality between before and after the 2008 Beijing Olympic Games, and it lacks consideration of meteorological factors.

4. Corporate Effects of Air Governance

4.1. Overview of Corporate Effects on the Entry of Sharing Bike Platforms

In 2016, OFO Sharing Bicycle and Mobike entered the Beijing market and green travel mode was promoted in steps. The entry of sharing bike platforms has a certain improvement effect on urban air quality. Guangyu Cao pointed out in the research that the joint presence of bike-sharing companies has reduced the PM2.5 index by about 3.832 micrograms per cubic meter. The decline of the main pollutant of car emissions is more obvious [5]. Junren Chen proposed that the use of bicycle-sharing decreased the emission of carbon monoxide and nitrogen dioxide [4]. However, the bicycle-sharing system has a limited effect on air pollution control, and the combination with public transport has a more prominent improvement [4]. Qianbing Xiao pointed out that the settlement of OFO sharing bicycles improved the air quality slightly and the effect is not significant from the comprehensive breakpoint. However, combined it with the subway, the effect will be more remarkable [6].

4.2. Reasons for the Limitations of the Corporate Effects

There is a "secondary governance" issue with the entry of shared bicycles. The number of bicycle-sharing platforms deployed in a short period of time is relatively small, and to some extent, it has played a role in alleviating urban traffic congestion. However, from the overall perspective of the city, the amount of investment may not be enough to meet people's travel needs, and the positive impact on urban transportation is mild, and the pressure it brings is also mild. However, in the long run, when the overall number of shared bicycles deployed far exceeds people's needs, it will bring about secondary costs in managing shared bicycles. For example, if too many shared bicycles occupy normal motor vehicle driving roads, more management personnel need to be dispatched to regularly maintain shared bicycles. This cost needs to be measured against the urban air quality governance benefits brought by the platform's entry into the city.

Table 2. Comparison of per capita taxi ownership/number of buses/urban road area in Beijing from 2013 to 2019

	2013	2014	2015	2016	2017	2018	2019
Population density (person/square kilometers)	1295	1323	1333	1324	1324	1313	1312
Per capita taxi ownership (vehicles/10000 people)	31.6	31.1	31.2	31.5	32	32.5	33.2
Number of taxis at the end of the year	67046	67546	68284	68484	69484	70035	71517
Per capita number of buses (vehicles/10000 people)	11.2	11	10.7	10.4	11.8	10.6	11
Number of buses at the end of the year	23592	23667	23287	22688	25624	22750	23685
Population at the end of the year (10000 people)	2115	2152	2171	2173	2171	2154	2154
Per capita urban road area (square meters/person)	6.5	6.4	6.5	6.6	6.4	6.5	6.6
Actual road area at the end of the year (10000 square meters)	13884	13834	14302	14316	13960	14098	14318

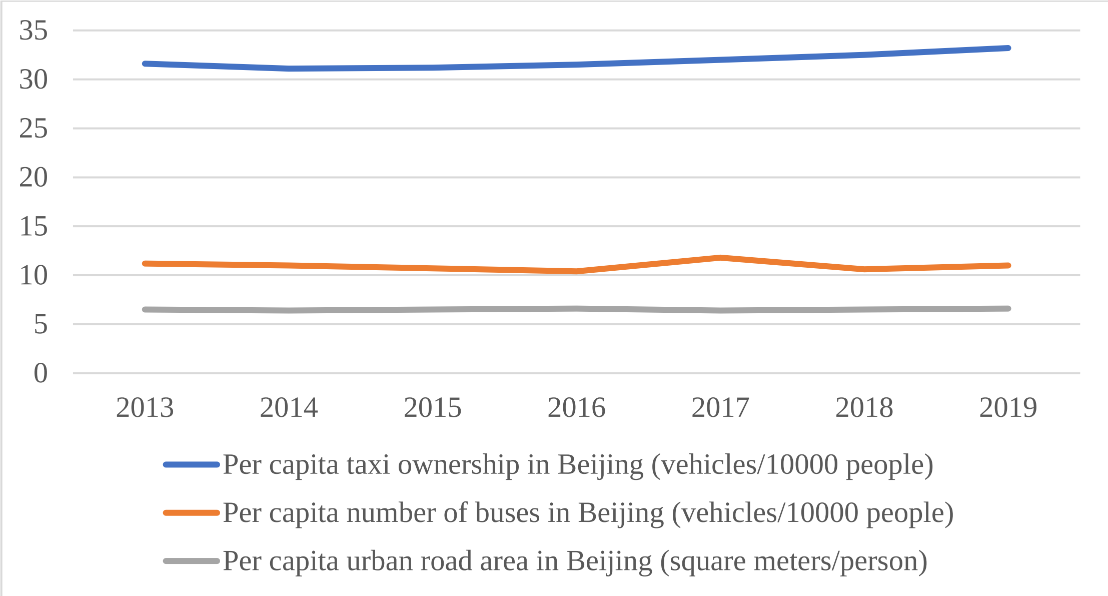

Fig. 2 Public transportation data in Beijing from 2013 to 2019 (Picture Credit: Original)

The population distribution density, the actual area of urban roads at the end of the year, and the per capita urban road area affect people's choices of travel modes. It has been presented in Table 2 and Figure 2, that although people have more buses, the number of roads that buses can travel to may decrease due to the increase in population density, leading to a greater tendency for people to choose public transportation. In addition, different modes of public transportation are mutually alternative choices for travelers.

The intensity of shared bicycles has a substitution effect with other modes of public transportation. Guangyu Cao et al. believe that the intensity of shared bicycle usage is related to its alleviating effect on traffic congestion and conducted a regression analysis of the interaction effect. They found that as the usage of shared bicycles increases by a certain extent, the concentration of PM2.5 will correspondingly decrease [5]. However, Qianbing Xiao et al. believe that the emergence of shared bicycles has not fundamentally changed the choices of people who originally traveled by motor vehicles [6] In the short term, shared bicycles themselves are short-distance transportation tools, mainly playing a connecting role between public transportation stations, and their impact is relatively small. The substitution effect of other public transportation modes is strong, and people who originally used motor vehicles as their mode of transportation find it difficult to change their choices. Therefore, the impact of shared bicycles on urban air quality governance is weak. In the long run, the increase in the number of shared bicycles themselves brings people more choices. Compared to the decrease in per capita taxi ownership and per capita bus ownership analyzed earlier, and considering the decrease in per capita road area, shared bicycles can travel on narrower roads. People will increase their use of shared bicycles. In the long run, the substitution effect of shared bicycles on other modes of public transportation has increased. However, it is difficult to estimate the usage of shared bicycles among people who already use motor vehicles as their mode of transportation. The time measurement unit and regional clustering of shared bicycles will affect the measurement of air quality control effects. Considering meteorological factors such as temperature, maximum wind speed, precipitation, and relative humidity, there is a significant seasonal difference between the deployment of platforms and the use of shared bicycles, which in turn affects the decision-making of the former. For example, the winter weather in the north is cold, with high average maximum wind speeds, and frequent cold and snow weather, as well as road icing, which affects the use of shared bicycles. Moreover, heating in autumn and winter in the north will increase overall carbon emissions and air pollutant concentrations. If measured on a monthly basis, it is more conducive to introducing more meteorological indicators to eliminate this fixed effect. In the southeastern coastal areas, the summer weather is scorching with strong sunlight, and during the same period of water and heat, the probability of the public using shared bicycles for travel will decrease.

5. Conclusion

This paper focuses on air quality governance in Beijing and explores the effects of two strategies, the tail number restriction policy and the entry of shared bicycle platforms, on urban air quality governance. It is found that policies targeting heavy industry have a more significant effect on urban air quality governance at the current stage. The effect of the tail number restriction policy is limited to a certain extent, which is related to the main objectives of policy implementation and the limited time scale of natural experiments, resulting in the inability to achieve observations in different seasons, and the absorption of meteorological factors by other interfering factors. The entry of shared bicycle platforms has to some extent reduced the concentration of relevant pollutants in the air, but in the short term, it has had no significant impact on the reduction of pollutant concentration in the air, and the overall urban environment has not had a significant governance effect due to the entry of shared bicycles. However, when shared bicycles reach a certain stage of development, they will play a certain role in environmental governance. This may be due to the differences in the secondary costs of short-term and long-term bicycle-sharing management, the welfare effects it brings to the city, the intensity of bicycle-sharing usage, and the substitution effects of other modes of transportation.

Based on the above conclusions, this paper provides the following suggestions. The focus of policy governance should be on promoting industrial structure transformation and reducing the degree of air pollution caused by heavy chemical industry. Secondly, within an appropriate range, the government should provide certain policy incentives to shared bicycle platform enterprises, assist in managing the placement of shared bicycles, and promote shared green transportation methods reasonably.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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