Research on the Impact of Environmental Protection Investment Structure on China's Industrial Waste Gas Emission Reduction

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Abstract: Environmental protection investment, as an important means to promote air pollution control, is fundamental to realize the sustainable development of economy. This paper mainly discussed the influence mechanism of environmental protection investment on pollutant emissions. Industrial exhaust is the main source of air pollution, so the industrial waste gas was selected as a research sample to study the relationship between environmental protection investment structure and industrial exhaust emissions. The results show that there is a lagging correlation between the industrial waste gas investment and total industrial waste gas emissions, and the lag time is about 4 years. From the statistical relationship, the management of industrial waste gas investment can achieve industrial waste gas emission reduction, but the impact is lagging.

1. Introduction
With the rapid development of economy, China's industrialization and urbanization process has accelerated, and the extensive economic growth mode with high energy-consumption, high material-consumption and high emissions has also emerged. The air pollution has become a serious problem. The total emissions of three major pollutants in the atmosphere were, SO₂: 1.129 million tons, NOₓ: 13.943 million tons, and dust: 10.107 million tons in 2016. Air pollution problem in China has attracted worldwide attentions, and the ecological damage has attracted the attention of government in China.

According to the experience of developed countries, Environmental protection investment, as an important means to promote air pollution control, is fundamental to realize the sustainable development of economy. Environmental issues as a typical manifestation of market mechanism failure, government environmental investment is an effective means to improve environmental quality. In recent years, the government investment in environmental protection has been increasing year by year. According to the statistics of the Environmental Protection Administration, the national environmental protection investment during the “7th Five-Year Plan”, “Eighth Five-Year Plan”, “Ninth Five-Year Plan”, “Tenth Five-Year Plan” and “11th Five-Year Plan” period were 47.7 billion, 130.6 billion, 344.752 billion, 839.94 billion and 2 trillion, and it reached 921.98 billion in 2016. With the increasing environmental protection investment, China's air pollutant emissions have decreased in recent years (as shown in Figure 4). However, air quality improved slightly, and there is still a big gap from the ideal air quality.
Although environmental investment is an important means to promote the air pollution control, there are still many problems in environmental protection investment. Studying the relationship between environmental protection investment structure and emission reduction of industrial waste gas, and studying how to optimize the environmental protection investment structure to maximize the efficiency of industrial waste gas treatment has strong theoretical and practical significance.

2. Interaction mechanism between environmental protection investment and industrial waste gas emission

Grossman studied the quality data of air pollutants (SO2, soot) in North American cities, he found that it met the inverted U-shaped relationship proposed by Kuznets in studying the relationship between income difference and economic growth in the United States, and named it Kuznets curve. The curve is called the EKC curve in the field of environmental protection [1]. The EKC curve shows that environmental quality is closely related to economic development. With the economic development, the environmental quality shows a change law of increasing first and then decreasing [2]. Many foreign scholars have explained the mechanism of EKC curves from different angles. Grossman believes that the EKC curve is the result of combination of scale effect, structural effect and technological effect. At the beginning, environmental pollution can be understood as a necessary output in the process of economic growth, and expands with economic growth. As the economy develops to a certain level, per capita income improvements, changes in industrial structure, and advances in technology and equipment will collectively lead to improved environmental quality [3]. Aghion believes that economic development has led to increased demand for living environment, forcing the government and the society, to increase investment in environmental protection and reduce pollutant emissions [4]. Lopez and Taylor believe that international trade has led to a decline in the inverted U-shaped curve, that is, developed countries have transferred their pollution-intensive industries to economically underdeveloped countries [5]. Panayotou believes that the market mechanism is the leading role. When the economy develops to the later stage, the environmental pollution discharge will be marketized. In order to reduce the emission cost, the industry will update the technology to reduce pollutant emissions [6].

The coordinated development of environment and economy is the key to sustainable development. In order to explore the theoretical possibilities of sustainable development, scholars have introduced environmental investment into the economic growth model [7-9]. Based on the framework of the endogenous growth theory, Aghion and Taylor embed the pollutant emission factor as a variable. The results show that the increase of environmental protection expenditure will reduce the pollutant emission factor, and the sustainable development is proved [4][10]. Loschel's research found that embedding technical variables in the endogenous growth model is conducive to reducing the cost of environmental protection investment, and technological advances will produce environmental spillover effects, thereby promoting pollutant emission reduction and promoting sustainable development [11]. Domestic scholars, such as Yanpeng Wang and Yinong He have embedded environmental investment into the endogenous growth model. The results show that increasing environmental protection investment and improving the efficiency of environmental protection investment are necessary conditions for sustainable economic and environmental development [12].

3. Impact of environmental protection investment on pollutants reduction

3.1 Analysis of waste gas control investment in China

The classification of environmental protection investment is mainly divided into government investment and self-raised investment by enterprises. This article mainly discusses the whereabouts of environmental protection, that is, the completion of environmental protection. According to the classification method of China Statistical Yearbook, the completion of investment in industrial pollution control is further divided into waste gas, wastewater, solid waste, and other wastes. This article mainly discusses the waste gas control investment.
Figure 1 shows the trend of industrial pollution control total investment and waste gas control investment from 2007 to 2016 in China. As seen from Figure 1, China's industrial pollution control investment in 2007 and 2008 is relatively large, but it began to decline from 2008, and fell to the bottom in 2010. In 2010, the total investment in industrial pollution control was only 39.697 billion, and the investment for waste gas treatment was only 18.819 billion. In fact, since 2001, the Chinese government has begun to pay attention to waste gas treatment, and the amount of investment for environmental protection has increased year by year, it has reached a maximum in 2007 and 2008. However, large-scale haze weather began to appear nationwide in 2011. The emergence of such foggy weather is the inevitable result of China's long-term extensive economic development. The state attached great importance to atmospheric environmental issues. Since 2011, the investment in waste gas treatment has increased rapidly year by year, reaching the highest value in 2014. The total investment in industrial pollution control was 99.765 billion, of which the investment in waste gas pollution control reached 78.939 billion, accounting for 79.13% of the total investment. Figure 2 shows the proportion of waste gas control investment in the total industrial pollution control investment. It can be seen that waste gas control is the most important part of industrial pollution control, and the proportion of waste gas control investment accounts for more than 50% per year, and the highest reached 79.13%.

Figure 2 The proportion of waste gas treatment investment in the total industrial pollution control investment

3.2. Industrial waste gas pollution in China

Figure 3 shows the trend of industrial waste gas emissions from 2011 to 2016 in China. The total amount of exhaust emissions has shown a downward trend. In particular, the total emissions of waste gas decreased from 59.01 million tons in 2011 to 35.079 million tons in 2016. Industrial waste gas is mainly divided into industrial sulfur dioxide emissions, nitrogen oxide emissions, and industrial dust emissions, as shown in Figure 4, it can be seen that sulfur dioxide and nitrogen oxide emissions show a downward trend year by year, while dust emissions first increase and then decline over the years. The dust emissions reached a maximum of 17.408 million tons in 2014 and fell to 10.107 million tons in 2016.
3.3. Relationship between environmental investment and industrial exhaust emissions

Firstly, the relationship between waste gas control investment and waste gas emission is analyzed from the overall perspective. Figure 5 shows the relationship between industrial waste gas investment and total industrial waste gas emissions. It can be seen from the figure that the investment in industrial waste gas and the emission of exhaust gas generally show a trend of decreasing first and then increasing. In 2007, investment in waste gas control began to decline. From the perspective of exhaust emissions, waste gas emission decreased in the period of 2007-2010. This is because China increased the amount of investment in industrial pollution control year by year before 2007. Then the investment began to decline in 2008, the industrial waste gas emissions began to rise in 2011, and the atmospheric environment became worse and worse. The exhaust gas emissions peaked and the atmospheric environment quality deteriorated severely in 2014. Since 2011, China began to pay attention to environmental issues and increased investment in industrial waste gas control, and the exhaust emissions began to decrease in 2015. From the preliminary statistical relationship, it can be known that there is a lagging correlation between the industrial waste gas investment and the total industrial waste gas emissions, and the lag time is about 4 years. From the statistical relationship, the management of industrial waste gas control investment can achieve industrial waste gas emission reduction, but the impact is lagging.

The total emissions of sulfur dioxide, nitrogen oxides, industrial dust all show trends of decreasing first and then increasing, reflecting the lagging effect of this environmental governance investment on the emission reduction of various pollutants. Through the above statistical analysis, it can be seen that there is a significant relationship between the investment of waste gas and industrial waste gas emissions, that is, the waste gas control investment can make the realization of industrial waste gas emission reduction, but there is a certain period of lag. It can be seen that a certain time difference
between the beginning of environmental protection investment and the improvement of environmental quality.

4. Conclusions and Analysis
The total amount of industrial exhaust emissions in China has a short-term upward process, after reaching the peak, industrial exhaust emissions decrease and environmental quality is improved. It shows that there is a lag effect in the management of industrial waste gas investment. Through theoretical analysis, it can be known that the treatment of industrial waste gas achieves pollution reduction through three effects of scale effect, technical effect and structural effect. However, there is a so-called inverted U-shaped relationship between economic scale and pollution emissions. That is to say, different stages of economic development and scale of development will affect pollutant emissions. This inverted U-shaped relationship is the so-called EKC curve. Since Grossman proposed the EKC hypothesis, scholars have conducted in-depth research, and this article does not go into details. According to the relationship between change of GDP per capita and change of industrial exhaust emissions, it is found that the EKC curve exists in the total amount of industrial waste gas and three specific industrial pollutants. The analysis found that according to the 2016 China Statistical Yearbook data, China is currently in the decline phase of the EKC curve.

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