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Smog Pollution, Environmental Uncertainty, and Operating Investment

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Abstract: Smog pollution in China has drawn worldwide attention. Using companies' data from Chinese Securities Markets and Accounting Research database (CSMAR) and air quality monitoring data from China National Environmental Monitoring Centre (CNEMC), we employ the $PM_{2.5}$ concentration as a proxy for smog pollution and examine the effect of smog pollution on company environmental uncertainty and operating investment in 74 key cities in China. The empirical results show that smog pollution causes an increase in company environmental uncertainty and a decrease in operating investment for Chinese listed companies, with environmental uncertainty as a mediating variable. Smog pollution can positively influence companies' environmental uncertainty through their employees and high pressure from the public and government. According to the real-options-based investment approach, companies choose to "wait and see" and, correspondingly, reduce operating investment under high environmental uncertainty such as that caused by smog pollution. Additionally, we find that state-owned enterprises are more significantly influenced by smog pollution in terms of environmental uncertainty and operating investment because of their close relationships with the government and their responsibility to set an example among Chinese companies in the fight against smog pollution.

Keywords: smog pollution; environmental uncertainty; operating investment



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1. Introduction

Development at the expense of the environment has occurred in many countries over the past century and has continued in many developing countries in recent years. However, a deteriorating environment can hinder sustainable economic development. Since 2011, smog pollution has appeared at a high frequency in many areas of China, and many areas in China are enveloped in toxic smog with two to four times the $PM_{2.5}$ concentration of the World Health Organization (WHO's) air quality standard. The smog events in some cities in China demonstrate the interdependence between the environment and development. Smog pollution not only endangers people's health and emotions [1–4], but also affects the economy unavoidably in various ways. For example, Levy and Yagil [5] find that air pollution affects traders' investment in the stock market and leads to reduced stock returns. In response to the increasingly serious air pollution, the Chinese government has implemented environmental policies and economic measures to control deterioration and improve air quality [6,7]. Such changes in the external environment and political processes increase political uncertainty and put additional pressure on companies [8–11]. Therefore, it is necessary to explore the real economic effects of smog pollution on companies.

Operating capital investment is a basic and important indicator reflecting a company's operating conditions and managers' operating expectations. In addition, for an organization, environmental uncertainty is manifested by the inability to determine how the environment may change and make decisions accordingly. This study examines the effect of smog pollution on the operating capital investment of Chinese companies and the mediation effect of environmental uncertainty in this process, which, to our knowledge, has not been examined yet. To this end, we employ the level of concentration of $PM_{2.5}$ (particulate matter with aerodynamic diameter less than $2.5\ \mu m$, which is about 3% of the diameter of a human hair) released by the China National Environmental Monitoring Centre as a proxy for smog severity and investigate whether smog pollution increases environmental uncertainty and, therefore, decreases operating investment for Chinese listed companies. Our sample is derived from the Chinese Securities Markets and Accounting Research database (CSMAR) and contains a total of 7092 company-year observations from 2013 to 2017. The initial year of sample selection, 2013, was the year when air quality monitoring data became first available to the public.

We conduct several regressions to examine our hypothesized and the regression results show that smog pollution significantly reduces operating investment through its increasing effect on environmental uncertainty. Furthermore, we predict that the positive and negative effects of smog pollution on environmental uncertainty and operating investment, respectively, are more significant for state-owned enterprises (SOEs), which have a closer relationship with the government and undertake more social responsibility than non-SOEs (NSOEs). We verify the robustness of our results by changing the mediation effect test, controlling for the effect of accounting for standard revisions, and excluding a competitive hypothesis involving earnings management. The results of these tests support our conclusions.

This study contributes to the literature in two ways. First, to the best of our knowledge, this study is the first to find that Chinese companies in polluted areas choose to decrease operating investment because of the high environmental uncertainty resulting from smog pollution. Shi et al. [12] state that even in the most optimistic case, it will take years to comprehensively determine the impact of smog on the economy, society, and human health. Compared with the efforts of the UK and the US over the past decades, China has just begun to address the smog problem. Extensive fundamental research is thus urgently needed to provide the necessary information about smog pollution. Our study highlights the significant effect of smog pollution on Chinese listed companies' environmental uncertainty and operating investment. In other words, it expands and deepens our understanding of the economic effects of smog pollution. Second, this study provides empirical evidence on the influence of smog pollution on companies' operating investment. We not only find the negative effect of smog on company operating investment, but also that this influence is achieved partly through the increase in environmental uncertainty resulting from smog aggravation. This finding that can be extended to other relevant studies on pollution and its economic influence.

The rest of the paper is organized as follows: Section 2 reviews the literature on smog. Section 3 develops the research hypotheses. Sections 4 and 5 describe the research design and the empirical results, respectively. Section 6 presents additional test results and the conclusions.

2. Literature Review and Hypotheses Development

2.1. The Institutional Background of Smog Pollution in China

The word "smog" was first used in 1905 by Dr. Henry Antoine Des Voeux at the Public Health Congress in London, England to describe "smoky fog" [13]. Currently, it is widely used to represent air pollution. Smog not only has the characteristics of common air pollutants, but also some particularities owing to its unique chemical composition and geographical distribution. It has left a deep imprint on human society through two notorious incidents. The first was the Great London Smog of 1952, which was reported to

have caused more than 10,000 deaths within two months and more damage in the long term. The second incident was the photochemical smog in Los Angeles in the 1960s, which was a secondary pollutant caused by vehicle and industrial emissions [14].

Since these deadly smog incidents, the US has launched the Clean Air Act and the UK has adopted economic market-based approaches to control and stop smog pollution [6,15]. After decades of effort, the smog pollution in London and Los Angeles has gradually decreased. However, smog pollution has become one of the most threatening challenges facing emerging economies in the past few years [16], which has a large population base and extensive industrial emissions [17]. Here, we review the institutional background of smog pollution in China and the literature related to the influence of smog pollution.

The severe smog pollution in China is formed mainly through chemical processes and consists of fine particulate matter, referred to as $PM_{2.5}$. Since 2011, smog pollution has appeared at a high frequency in many areas of China, affecting approximately one-quarter of the territory and more than 600,000,000 people [18]. Moreover, the three most developed and densely populated areas in China (the Beijing-Tianjin-Hebei, the Yangtze River Delta, and the Pearl River Delta regions) are enveloped in toxic smog for an average of more than 100 days each year [19], with two to four times the $PM_{2.5}$ concentration of the World Health Organization (WHO's) air quality standard [20]. Smog pollution poses a serious threat to both human health and the ecological environment [21–24].

The Chinese government has formulated a series of policies, measures, and regulations to curb smog pollution. After the extremely serious smog incident in January 2013, when the $PM_{2.5}$ levels were record-breaking and about 800 million people were affected [25], the Chinese government proposed the first action plan for the prevention and control of air pollution. The main goal of the Action Plan was to decrease $PM_{2.5}$, in the Pearl River Delta region, the Yangtze River Delta region, and the Beijing-Tianjin-Hebei region by 15 percent, 20 percent, and 25%, respectively, by 2017. Specifically, the Action Plan set a clear target of reducing the $PM_{2.5}$ level in Beijing to below $60 \mu\text{m}/\text{m}^{-3}$ [26]. In 2018, against the background of successfully completing the first Action Plan, the State Council distributed the Three-Year Action Plan for Winning the Blue Sky Defense Battle.

In addition to the environmental measures taken by the government, as identified in the Action Plans of 2013 and 2018, the Chinese Central Government conducted the first round of large-scale environmental inspections in 2016–2017 for the implementation of environmental measures by local governments across the country. According to the speech made by Liu Changgen, deputy director of China's national environmental protection supervision office, at the regular press conference of China's Ministry of environmental protection on December 28 in 2017, the environmental inspectors accepted a total of 135,000 complaints from the people, issued fines of up to 1.43 billion yuan (around 208 million US dollars), detained 1527 people, and held 18,199 local officials responsible. However, aside from the government's inspection and investigation of corporate and individual compliance with the environmental laws and regulations, the main content of the environmental inspections was to inspect environmental affairs at all government levels, regarding whether officials were performing their duties in accordance with the law and whether there were issues with lax politicians and law abidance.

Beginning in 2018, to further strengthen the effectiveness of environmental inspections, the Central Environmental Protection Inspection Team implemented inspections in 20 provinces to review and rectify the remaining problems and effectively promote the government's environmental protection. In 2019, the second round of routine environmental protection inspections was put on the agenda, to be completed in about three years. In addition, according to the latest news released on the website of the Central People's Government of China (www.gov.cn accessed on 3 September 2021), all the seven central ecological and environmental protection supervision teams in the fourth batch of the second round of routine environmental protection inspections have been stationed. Even though measures to control smog pollution and improve air quality have achieved

good initial results in China, there is still much room for improvement in air quality in many regions.

2.2. Environmental Uncertainty under the Influence of Smog Pollution

Current research on smog pollution in China, which has attracted increasing public attention [27,28], has shown that economic growth and energy intensity are the two main factors contributing to the increase in smog pollution [29]. Prior studies have investigated the specific apportionment of the sources of smog pollution [30], the formation process of urban smog pollution [31], international and interprovincial exports of smog pollution [32], and the contribution of local and outside pollutants emissions [33]. Another stream of smog pollution research has studied the influence of smog pollution on human physical and emotional health. Smog pollution is positively associated with lung cancer, cardiovascular diseases, respiratory diseases, mortality, and other adverse health effects [3,4,34–36]. Additionally, Smog pollution can lead to psychiatric symptoms and mood problems, such as depression, feelings of helplessness, tension, anxiety, and further behavioral changes, such as increased risk of suicide [37,38].

Regarding the economic impact of smog pollution, Levy and Yagil [5] use stock return data from four U.S. stock exchanges and find that smog pollution has a negative correlation with stock returns. Especially, in the Chinese context, some studies indicate that smog pollution can affect corporate accounting or financial behaviors as well as other aspects in operations. In aspect of financing, based on the data of listed companies in China and the air quality monitoring data, Li et al. [39] show evidence that smog pollution has positive impact on the demand of company debt financing, but negative impact on the availability of company debt financing. Similarly, the empirical analysis of Li et al. [40] shows that air pollution has negative impact on the total government subsidies obtained by companies. In aspect of other aspects in operation, smog can impact company from inside, and have significant influence on total factor productivity [41] and cash holdings [42]. In addition, smog can also impact company from outside, and influence the market value of firms [43,44] and the audit quality of auditors [45]. For an organization, environmental uncertainty is manifested by the inability to determine how the environment may change and make decisions accordingly. Duncan [46] believes that environmental uncertainty is the unpredictability of the changes in the trade market environment, which is reflected in the changes in environmental factors such as market demand, technology, policies, and suppliers. Environmental uncertainty brings unpredictability to the company because unexpected events can disrupt the production and operation of the company.

Smog affects people first and, then, this influence is passed on to the business operating environment through human economic activities. Therefore, we believe that the serious smog in China increases company environmental uncertainty in operating aspects through the following types of people (roles) related to the company.

2.2.1. Effect on Employees

Moods and emotions have drawn significant attention in the research related to organizational behavior [47,48] and have been shown to affect individual behaviors such as creativity and organizational citizenship behavior [49,50]. According to the affective events theory (AET) developed by Weiss and Cropanzano [51], the effectiveness of employees is significantly related to their moods or emotions. Employees experiencing depression, bad nerves, stress, and anxiety have higher absenteeism rates at work and lower productivity levels [52,53]. Hence, depression, anxiety, and other negative emotions caused by smog pollution can erode employees' work performance and creativity, leading to a decline in the company's productivity. Chang et al. [54] showed that a pollutant with $PM_{2.5}$, which can penetrate indoors, has a significantly negative effect on labor productivity, while pollutants that do not travel indoors have little effect on productivity.

In addition to the decrease in productivity resulting from emotional disorders, Zhang et al. [55], using data from Guangzhou, China, found that short-term exposure

to air pollution is associated with an increase in hospital admissions. During and after an outbreak of smog, the health problems of employees and their families may lead to more absenteeism. Employees with health concerns may even quit their jobs and move to places with higher air quality. Moreover, for some manufacturing or retail industries, the possible reduction in employees' outdoor promotion activities [19] may directly result in a decline in sales revenue. All of these results of smog—declining work efficiency, employee absenteeism and turnover, and sales decline—can lead to an increase in environmental uncertainty.

2.2.2. Pressure from the Public/Government

The Chinese government implemented strict administrative measures to control air quality. These measures, which were implemented intensively around two events, were effective in improving air quality within a short period. The two events were the Asia-Pacific Economic Cooperation (APEC) event held in Beijing in November 2014 and the Chinese Victory Day Parade in September 2015. The administrative measures adopted by the Chinese government before the two events were drastic, including forcing high-polluting industries to shut down, stopping construction, and implementing restrictions on motor vehicles on the roads [12]. The rare clean sky in Beijing during the APEC event was called “APEC blue” on the Internet, the term becoming a hot phrase in China. However, the smog returned swiftly immediately after the measures were no longer in force. Negative economic effects are unavoidable if the government tries to reduce smog pollution through administrative measures.

Changes in the political environment due to pressure from the public and the government can affect companies in several ways and increase environmental uncertainty. The first is an increase in the cost of meeting established emission standards, which requires investment in environmental protection facilities and technical upgrades [56]. The second is the additional taxes levied by the government on high-polluting companies [57]. Even though China currently has no specific “smog tax,” companies that produce atmospheric pollutants must pay an environmental protection tax. The third are fines for companies that do not meet pollutant emission standards. Despite the risk of the suspension of business licenses, some companies continue to secretly produce emissions. The fourth method is an administrative order to stop the production of large quantities of air pollutants [12]. The fifth is the decrease in external funding by companies from banks and governments resulting from air pollution. These five possible ways in which companies may be affected lead to an increase in operating and financing costs and a decrease in revenues and profits, thus, an increase in environmental uncertainty. Considering the influence mechanism of smog pollution, we divide our first hypothesis into two parts and propose the first part as follows:

Hypothesis 1a. *Smog pollution has a positive effect on the environmental uncertainty of listed companies in China.*

2.3. Operating Investment under the Influence of Smog Pollution

According to the real-options-based investment approach, an increase in environmental uncertainty (volatility) will lead to a decrease in company operating investment [58]. Many scholars in economics and finance research have demonstrated a negative relationship between volatility and investment in the real-options-based investment approach [59–61]. As Arif et al. [58] state, the intuition for the negative effect of environmental uncertainty (volatility) on operating investment is as follows: when considering investment costs, especially sunk costs that cannot be recovered, companies trade off the returns from investing today against the benefit of delaying investment until the operating conditions may improve. The benefit of postponing investment can be seen as the “option to wait.” Since high environmental uncertainty increases the value of the option, companies prefer to “wait and see” instead of investing immediately.

As previously stated, smog pollution increases the environmental uncertainty of companies through its influence on employees and pressure from the public or government. The possible influence effects—a decrease in worker efficiency, employee absenteeism, a decline in sales, and an increase in operating costs—lead to lower returns from operating investment. Under such conditions, companies will decrease operating investment in the current period to avoid the risk of huge losses, with the expectation of obtaining higher returns from the investment in the future, when conditions would have improved. Therefore, we propose the second part of the first hypothesis:

Hypothesis 1b. *Smog pollution has a negative effect on the operating investment of listed companies in China through its positive influence on environmental uncertainty.*

China's unique corporate shareholding structure provides the background for us to further study the impact of smog pollution. Chinese companies can be divided into SOEs and NSOEs, with the controlling shareholders of SOEs being the government. State-owned holding, a unique corporate governance feature in China, is also a direct expression of the relationship between the government and companies.

During the current market transition period in China, the government continues to play an important role in economic activities. The close relationship that develops due to state-owned equity provides SOEs with financial and political support from the government [62]. At the same time, the relationship between SOEs and the government strengthens the implementation of government administrative measures among SOEs [63,64], such as pollution control measures to fight smog. Increases in operating costs and tax fees and decreases in revenues and profits due to pressure from the government are more significant for SOEs.

Moreover, SOEs often undertake multiple tasks, such as maintaining social stability [65,66]. The public whose support is important to SOEs [67] usually has higher expectations that SOEs will undertake more social responsibility in the work of reducing smog. As smog becomes more serious, pressure from the public will intensify the increase in SOEs' environmental uncertainty, leading to less operating investment. By contrast, the controlling shareholders of NSOEs are usually private companies or individuals. An NSOE does not have a close relationship with the public and is not established with the expectation that it would undertake social responsibilities.

Therefore, considering the relationship with the government, the positive and negative effects of smog on environmental uncertainty and operating investment are more significant for state-owned enterprises than for non-state-owned enterprises. Therefore, we propose the following hypothesis:

Hypothesis 2. *The increase in environmental uncertainty and the decrease in operating investment resulting from smog pollution are more significant for SOEs than for NSOEs.*

3. Research Design

3.1. Model

Considering a mediation effect, the mediation variable, M , reflects the influence pathway of the independent variable X on the dependent variable Y . Therefore, the influence of X on Y can be decomposed into either direct or indirect influence, depending on whether its realization path involves the mediation variable as a criterion for differentiation. In our hypotheses, environmental uncertainty is the mediating variable in the negative influence of smog on company operating investment.

A common method of examining the mediation effect, which was proposed by Baron and Kenny [68] and called the causal steps approach, is applied to the following equations:

$$Y = \beta_2 + cX + \varepsilon_2 \quad (1)$$

$$M = \beta_1 + aX + \varepsilon_1 \quad (2)$$

$$Y = \beta_3 + c'X + bM + \varepsilon_3 \quad (3)$$

Coefficients a , b , c , and c' in the equations reflect the relations among the three variables, X , M , and Y . We can confirm the existence of the mediation effect by examining whether the coefficients satisfy the following conditions: (a) coefficient c in Equation (1) is significant, proving the linear relation between the independent variable X and dependent variable Y (direct effect); (b) coefficient a in Equation (2) is significant, proving the linear relation between the independent variable X and mediation variable M ; (c) coefficient b in Equation (3) is significant, meaning that mediation variable M helps to predict the value of dependent variable Y (indirect effect); and (d) coefficient c' in Equation (3), which reflects the direct effect of X on Y after controlling for the indirect mediation effect, is significantly smaller than coefficient c in Equation (1). Coefficient c' in Equation (3) is significantly smaller than coefficient c in Equation (1), which can also be expressed as follows: the intensity of the mediation path ($a \times b$) is greater than 0.

As the most popular method for examining the mediation effect, Baron and Kenny's [68] causal steps approach has also received a lot of questioning and criticism [69–71]. Since the weak test power of the causal steps approach (sequential test coefficients) means that the test results are likely to be insignificant when the product of the coefficients is actually significant [72,73], directly testing the significance of the coefficients' product has been proposed as a better approach to examining the mediation effect. One of the most famous direct test methods is the Sobel test [74], which has a stronger test power than the causal steps approach. It examines the mediation effect directly through the z-test proposed by Sobel [74]:

$$z = \frac{a \times b}{\sqrt{b^2 s_a^2 + a^2 s_b^2}} \quad (4)$$

where a and b are the coefficients in Equations (2) and (3) and s_a^2 and s_b^2 are their variances.

We construct the following models according to Baron and Kenny [68] to examine the effect of smog pollution on company operating investment and the mediation effect of company environmental uncertainty in this process using company features as control variables:

$$OI_{it} = \beta_2 + cPM_{2.5\ it} + \sum Controls_{it} + \varepsilon_2 \quad (5)$$

$$Un_{it} = \beta_1 + aPM_{2.5\ it} + \sum Controls_{it} + \varepsilon_1 \quad (6)$$

$$OI_{it} = \beta_3 + c'PM_{2.5\ it} + bUn_{it} + \sum Controls_{it} + \varepsilon_3 \quad (7)$$

where $PM_{2.5\ it}$ is the independent variable representing the average annual concentration value in year t of the city where company i is located. If the city has several air pollution monitoring stations, we use the average of their smog concentration data.

OI_{it} is the accruals of company i in year t in billions of yuan. It is a proxy for the scale of a company's operating investment. Accruals is defined as the difference between accounting profit and cash flow from operating activities under the implementation of the accrual accounting. It is mainly consisted of changes in the company's accounts receivable, accounts payable, total inventories and other parts. As an important part of financial reporting, accounting accruals is one of the important manifestations of the company business operations. Several prior studies suggest that accruals reflect deliberate investment choices by the company [75–78]. Specifically, OI_{it} is calculated as the amount of change between the results at the end of year t and the results at the end of year $t - 1$ of (current asset–current liabilities + taxes payable + interest payable), minus the results in year t of (net added value of cash and cash equivalents + depreciation of fixed assets, oil and gas assets, and productive production materials + amortization of intangible assets + Amortization of long-term deferred expenses). All data calculations are taken from the relevant presentation item in the financial statements of company i in years t and $t - 1$.

Un_{it} is the mediation variable representing the environmental uncertainty of company i in year t . Based on Ghosh and Olsen [79]—and supported and used by Bergh and

Lawless [80], Dess and Beard [81] and Dechow [82]—we use the coefficient of the variation in sales (CSV) to proxy for environmental uncertainty. The coefficient of variation of sales considers only companies' market characteristics and, therefore, can capture external environmental uncertainty as opposed to managements' response to that environment. It was calculated using the following model:

$$CSV(Z_i) = \frac{\sqrt{\sum_{t=1}^3 \frac{(z_i - \bar{z})^2}{3}}}{\bar{z}} \quad (8)$$

where z_i is the market uncertainty for company i in year t , calculated as the coefficient of variation in sales, and \bar{z} is the three-year mean. To mitigate industry effects, z_i is not the original value of the coefficient of the variation in sales but the normalized value, which is divided by the average environmental uncertainty in the company's industry. We choose to use the variance in the past three years to calculate the coefficient of the variation in sales, which is shorter than the five-year period used by Ghosh and Olsen [79].

In Equations (5)–(7), we include the following variables to control for the influence of variations in ownership, company size, and capital structure: the nature of company ownership (SOE_{it}), the natural logarithm of total assets ($Size_{it}$), and leverage (Lev_{it}). The book-to-market value ratio (BTM_{it}), return on assets (ROA_{it}), and rate of business revenue increase ($Growth_{it}$) are included to control for the influence of a company's development condition and performance in operating investment. We include accrual-based earnings management (DA_{it}) and type of audit opinion ($Auditty_{it}$) in Equations (5)–(7) to control for the influence of a company's upside or downside earnings management and misstatements of financial statements on accruals, which is a proxy for the operating investment in our research design. We also control the fixed effect of year, industry and location of the company in Equations (5)–(7), and the Equations are based on panel data. Table 1 presents detailed definitions of the variables.

Table 1. Variable definitions.

Variable	Meaning	Definition of Variable
Dependent variable		
<i>OI</i>	Operating investment	Accruals of company i from the financial statement in year t
Mediating variable		
<i>Un</i>	Environmental uncertainty	The coefficient of variation for sales of company i after removing industry effects in year t
Independent variable		
<i>PM_{2.5}</i>	Smog	Average annual <i>PM_{2.5}</i> concentration data at the location of company i in year t
Grouping variable		
<i>SOE</i>	State ownership	A dummy variable equal to 1 if company i is state-owned, and 0 otherwise
Control variables		
<i>Size</i>	Company scale	The log value of total assets of company i at the end of year t
<i>Lev</i>	Leverage	The debt-to-assets ratio of company i at the end of year t
<i>BTM</i>	Book-to market ratio	The ratio of equity to market value of company i at the end of year t
<i>ROA</i>	Return on assets	The result of dividing net income by total assets of company i at the end of year t
<i>Growth</i>	Sales growth	The result of dividing the difference in sales of year t minus sales of year $t - 1$ by the sales of year $t - 1$ of company i
<i>DA</i>	Earnings management	The level of accrual-based earnings management calculated using the modified Jones model [83]
<i>Auditty</i>	Audit opinion	A dummy variable equal to 1 if company i receives a modified audit opinion in year t , and 0 otherwise

To examine our second hypothesis, we first regress Equations (5)–(7) using our whole sample, then divide our sample into two sub-samples, SOEs and NSOEs, according to the nature of company ownership (SOE_{it}), and separately regress Equations (5)–(7) using the two sub-samples. Consistent with our hypotheses, in the regression results for the whole sample and the SOE subsample, we expect coefficient a in Equation 6 to be positive and significant, c and b in Equations (5) and (7) to be negative and significant, and c' in Equation (7) to be significantly smaller than the value of c in Equation (5), which indicate the separate positive and negative influence of smog on company environmental uncertainty and operating investment and the mediation effect of environmental uncertainty in the influence path. We also expect the influence of smog on environmental uncertainty and company operating investment to be lower or non-significant for the NSOE subsample.

3.2. Data

As stated above, the smog pollution in China has become severe in recent years, and the Chinese government is determined to carry out corresponding environmental governance. Therefore, China is in the initial stage of vigorous environmental governance, which provides a good research scenario for us to study how smog affects the level of company operating investment through its influence on environment uncertainty. We obtained China's smog data from the website of the China National Environmental Monitoring Centre (CNEMC), the official environmental monitoring agency in China. In January 2013, the Monitoring Center released the first monthly report on the air quality for 74 key cities and put forward the Air Quality Composite Index, which includes the data for $PM_{2.5}$. The 74 cities selected by the Monitoring Center to implement the first phase of the new air quality standards in China cover the most polluted areas: the Beijing-Tianjin-Hebei Region, the Yangtze River Delta region, the Pearl River Delta region, and other important cities, such as provincial capitals. Considering that the regional gross domestic product (GDP) of these cities accounted for 56% of the national total during 2013–2017, these samples are representative for our study. Table 2 lists the 74 cities.

Table 2. 74 cities in the air quality report.

Classification	Cities				
Beijing-Tianjin-Hebei Region	Beijing	Tianjin	Shijiazhuang	Tangshan	Qinhuangdao
	Handan	Xingtai	Baoding	Zhangjiakou	Chengde
	Cangzhou	Langfang	Hengshui		
Yangtze River Delta region	Shanghai	Nanjing	Wuxi	Xuzhou	Changzhou
	Suzhou	Nantong	Lianyungang	Huai'an	Yancheng
	Yangzhou	Zhenjiang	Taizhou	Suqian	Hangzhou
	Ningbo	Wenzhou	Jiaxing	Huzhou	Shaoxing
Pearl River Delta region	Jinhua	Quzhou	Zhoushan	Taizhou	Lishui
	Guangzhou	Shenzhen	Zhuhai	Foshan	Jiangmen
	Zhaoqing	Huizhou	Dongguan	Zhongshan	
	Taiyuan	Hohhot	Shenyang	Dalian	Changchun
	Harbin	Hefei	Fuzhou	Xiamen	Nanchang
Other provincial capital cities and important cities	Jinan	Qingdao	Zhengzhou	Wuhan	Changsha
	Nanning	Haikou	Chongqing	Chengdu	Guiyang
	Kunming	Lhasa	Xi'an	Lanzhou	Xining
	Yinchuan	Urumqi			

We obtain financial statement data for all listed companies in the Chinese Shanghai and Shenzhen stock exchanges for the period 2013–2017 from the China Stock Market and Accounting Research database (CSMAR). The sample period starts in 2013 because it is the first year that the CNEMC released monthly air quality reports.

The CSMAR database contains 15,744 company-year observations from 2013 to 2017. We excluded 535 observations of B-share companies and 831 observations in the financial industry because of their differences from A-share companies and other industries. We also deleted 4083 observations of companies from cities, not among the 74 cities, because they lack air quality monitoring data. We further excluded 3203 observations with missing data to calculate the variables. The final sample consisted of 7092 company-year observations. The sample selection procedure is shown in Table 3.

Table 3. Sample selection.

Items	Observations
Total company-year observations available in CSMAR for 2013–2017	15,744
Less: Observations of B shares	(535)
Companies in the financial industry	(831)
Observations without air-quality monitoring data	(4083)
Observations with missing data to calculate variables	(3203)
Final sample	7092

4. Empirical Results

4.1. Descriptive Statistics

Table 4 provides the results of the univariate statistics for the dependent variable, independent variable, mediation variable, and control variables in Equations (5)–(7). The mean and median of working capital accruals are -0.181 and -0.029 , respectively, which suggests a negative investment over the sample period on average. The mean and standard deviation of $PM_{2.5}$, are 56.099 and 20.818 , respectively, suggesting serious smog conditions in Chinese cities on average and the variation within cities. The mean *Lev* was 0.437 in our sample, while the mean of *growth* was 84.7% . Among the observations, 34.8% were from SOEs, and 3.3% received unqualified audit opinions over the sample period.

Table 4. Descriptive statistics.

Panel A: Descriptive Statistics for the Whole Sample						
Variables	N	Mean	Median	Std. Dev.	Min	Max
<i>OI</i>	7092	-0.181	-0.029	4.110	-109.193	190.456
<i>Un</i>	7092	0.948	0.242	3.236	0.000	79.338
$PM_{2.5}$	7092	56.099	52.960	20.818	20.083	160.070
<i>SOE</i>	7092	0.348	0	0.476	0	1
<i>Size</i>	7092	22.322	22.161	1.266	15.577	27.469
<i>Lev</i>	7092	0.437	0.428	0.236	-0.195	8.612
<i>BTM</i>	7092	0.881	0.558	0.992	0.003	12.100
<i>ROA</i>	7092	0.058	0.042	1.293	-3.960	108.366
<i>Growth</i>	7092	0.847	0.000	3.192	-0.961	22.899
<i>DA</i>	7092	0.015	0.015	0.327	-8.100	4.100
<i>Auditty</i>	7092	0.033	0	0.179	0	1

4.2. Descriptive Statistics

In the Pearson correlation coefficient of the variables shown in Table 5, the correlation coefficients of all variables are less than 0.5 (excluding autocorrelation between *BTM*, *Size* and *Lev*). What is more, from Table 5, we can also see that $PM_{2.5}$ and *OI* are significantly negatively correlated, $PM_{2.5}$ and *Un* are significantly negatively correlated, and *OI* and *Un* are significantly negatively correlated, preliminarily confirming the previous conjecture of the relationship between variables. Table 6 shows that variance inflation factors (VIF) are

all less than five, and the mean value is 1.3. There is no serious multicollinearity problem in this paper.

Table 5. Correlation matrix.

Variables	OI	Un	PM _{2.5}	SOE	Size	Lev	BTM	ROA	Growth	DA	Auditty
OI	1										
Un	−0.292 ***	1									
PM _{2.5}	−0.028 **	0.042 ***	1								
SOE	−0.043 ***	0.172 ***	0.112 ***	1							
Size	−0.099 ***	0.458 ***	0.006	0.359 ***	1						
Lev	−0.039 ***	0.193 ***	0.033 ***	0.242 ***	0.468 ***	1					
BTM	−0.048 ***	0.335 ***	0.083 ***	0.335 ***	0.645 ***	0.510 ***	1				
ROA	0.001	−0.003	0.008	−0.009	−0.063 ***	−0.018	−0.011	1			
Growth	0.033 ***	0.006	−0.008	0.004	0.030 **	0.032 ***	0.050 ***	−0.001	1		
DA	0.469 ***	−0.316 ***	0.004	−0.012	−0.119 ***	−0.021 *	−0.077 ***	−0.008	0.000	1	
Auditty	0.006	−0.003	−0.016	−0.002	−0.053 ***	0.075 ***	−0.014	0.064 ***	0.053 ***	0.008	1

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Variance inflation factors.

Variables	VIF	1/VIF
Size	2.27	0.440
BTM	2	0.500
Lev	1.45	0.690
Un	1.4	0.713
SOE	1.19	0.837
PM _{2.5}	1.18	0.850
DA	1.12	0.894
Auditty	1.03	0.973
Growth	1.02	0.979
ROA	1.01	0.989
Mean VIF	1.3	

4.3. Regression Results

Table 7 presents the regression results of Equations (5)–(7) using the entire sample and the two subsamples. After controlling for company characteristics that might affect company environmental uncertainty or operating investment, estimation coefficients a , b , c , and c' in the whole sample are 0.004 ($t = 2.26$), -0.221 ($t = -14.27$), -0.006 ($t = -2.89$), and -0.006 ($t = -2.55$), respectively, indicating that smog pollution significantly increases company environmental uncertainty and has a negative effect on company operating investment. The Sobel test result is -0.001 ($z = -2.23$), which supports our hypothesis that environmental uncertainty has a mediating effect on the influence of smog on company operating investment. Hence, our first hypotheses, H1a and H1b, are supported.

Estimation coefficients a , b , c and c' for the SOE subsample regression results are 0.009 ($t = 2.03$), -0.253 ($t = -9.44$), -0.014 ($t = -2.53$), and -0.012 ($t = -2.19$), respectively, while the coefficients are 0.001 ($t = 0.90$), -0.019 ($t = -1.00$), -0.001 ($t = -0.75$), and -0.001 ($t = -0.73$) for the NSOE subsample. The results show that the effect of smog on environmental uncertainty and operating investment is more significant for SOEs than for NSOEs. Therefore, H2, is supported.

Table 7. The effect of smog in the whole sample and subsamples.

DV	Whole Sample				SOE		NSOE		
	OI Coef.	Un Coef.	OI Coef.	OI Coef.	Un Coef.	OI Coef.	OI Coef.	Un Coef.	OI Coef.
PM _{2.5}	−0.006 *** (−2.89)	0.004 ** (2.26)	−0.006 ** (−2.55)	−0.014 ** (−2.53)	0.009 ** (2.03)	−0.012 ** (−2.19)	−0.001 (−0.75)	0.001 (0.90)	−0.001 (−0.73)
Un			−0.221 *** (−14.27)			−0.253 *** (−9.44)			−0.019 (−1.00)
SOE	−0.234 ** (−2.37)	0.047 (0.63)	−0.224 ** (−2.30)						
Size	−0.161 *** (−3.32)	1.042 *** (28.46)	0.070 (1.38)	−0.250 ** (−2.17)	1.582 *** (18.54)	0.150 (1.24)	−0.064 ** (−2.12)	0.697 *** (28.89)	−0.051 (−1.56)
Lev	−0.342 (−1.59)	−0.566 *** (−3.42)	−0.467 ** (−2.16)	0.350 (0.52)	−0.993 ** (−1.99)	0.099 (0.15)	−0.597 *** (−5.01)	0.119 (1.25)	−0.595 *** (−4.99)
BTM	0.149 ** (2.43)	0.229 *** (4.97)	0.200 *** (3.31)	0.138 (1.10)	0.144 (1.55)	0.174 (1.41)	0.108 ** (2.18)	0.014 (0.35)	0.109** (2.19)
ROA	0.000 (0.064)	0.000 * (1.30)	0.000 (0.35)	−0.250 (−0.43)	0.159 (0.37)	−0.210 (−0.36)	0.000 (0.18)	0.000 ** (2.51)	0.000 (0.22)
Growth	−0.010 (−0.73)	0.006 (0.61)	−0.009 (−0.64)	−0.025 (−0.73)	0.017 (0.69)	−0.021 (−0.61)	0.006 (0.80)	0.001 (0.10)	0.006 (0.80)
DA	5.857 *** (44.13)	−2.609 *** (−26.01)	5.280 *** (38.55)	6.286 *** (27.28)	−2.544 *** (−14.93)	5.642 *** (23.86)	3.785 *** (25.77)	−2.115 *** (−18.13)	3.746 *** (24.64)
Auditty	−0.026 (−0.11)	0.453 ** (2.46)	0.075 (0.31)	−0.021 (−0.03)	0.932 * (1.95)	0.214 (0.34)	0.073 (0.52)	0.121 (1.10)	0.074 (0.54)
Control year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control location	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7092	7092	7092	2469	2469	2469	4623	4623	4623
F	172.79	237.91	179.73	74.64	91.31	78.29	64.31	179.54	59.03
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R ²	0.2252	0.2862	0.2468	0.2471	0.2870	0.2732	0.1309	0.2982	0.1309
Sobel test	−0.001 ** (z = −2.23)				−0.002 ** (z = −1.99)		−0.000 (z = −0.67)		
a	0.004 ** (z = 2.26)				0.009 ** (z = 2.03)		0.001 (z = 0.90)		
b	−0.221 *** (z = −14.27)				−0.253 *** (z = −9.44)		−0.019 (z = −1.00)		
Indirect effect	−0.001 ** (z = −2.23)				−0.002 ** (z = −1.99)		−0.000 (z = −0.67)		
Direct effect	−0.006 ** (z = −2.55)				−0.012 ** (z = −2.19)		−0.001 (z = −0.73)		
Total effect	−0.006 ** (z = −2.89)				−0.014 ** (z = 2.53)		−0.001 (z = −0.75)		

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

5. Discussion

5.1. Bootstrap Test

To strengthen the test power of the causal steps approach, we used the recommended Sobel test in our research design and achieved test results that confirm the mediation effect of environmental uncertainty. However, the Sobel test has limitations because of the presumption that the coefficients and their products all have a normal distribution, which is not usually the case in reality, and thus the results may be inaccurate [84,85].

We use a bootstrap approach, which is a method of repeated sampling from the samples, to replace the Sobel test and directly examine the product of the coefficients to test the robustness of our results. We use two bootstrap methods in our test: percentile bootstrap and bias-corrected bootstrap. Both have stronger test power than the Sobel test, but the test power of the bias-corrected bootstrap method is better [86,87]. If the percentile or bias-corrected confidence intervals achieved from the sampling results do not contain 0, the product of the coefficients is significant and the median effect is significant [88].

Table 8 reports the bootstrap test results for the whole sample and the two subsamples. We report only the bootstrap test results in the table because the specific regression coefficients and the significance of the independent variable, median variable, and control variables are the same as those in Table 7. Table 8 shows that, in the whole sample, neither the percentile confidence interval nor the bias-corrected confidence interval contain 0, which means that the mediation effect of environmental uncertainty is significant. In the subsamples, the percentile confidence intervals contain 0, while the bias-corrected confidence intervals, which have a higher test power, do not. Therefore, we can still conclude that the mediation effect of environmental uncertainty is significant under the bootstrap test, even for the non-state-owned subsample, which the Sobel test showed to be non-significant in Table 8. As the regression coefficients are the same as those of

Table 8. The effect of smog in the whole sample and subsamples using the bootstrap test.

(P) Percentile Confidence Interval
(BC) Bias-Corrected Confidence Interval

To adapt to the development of China's economy and improve the quality and transparency of accounting information in Chinese companies, the Ministry of Finance of the People's Republic of China revised five accounting standards and issued three new accounting standards at the beginning of 2014. To exclude the influence of accounting standard revisions and test the robustness of our empirical results, we use panel data from 2014 to 2017 to regress Equations (5)–(7) and conduct the Sobel test. Table 9 reports the regression results for the entire sample and the subsamples.

Table 9. The effect of smog during 2014–2017.

[illegible]

Table 9. Cont.

DV	Whole Sample				SOE		NSOE		
	OI	Un	OI	OI	Un	OI	OI	Un	OI
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
N	5789	5789	5789	1968	1968	1968	3821	3821	3821
F	142.33	194.92	150.20	59.65	71.31	63.72	57.90	156.29	53.21
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R ²	0.2266	0.2868	0.2510	0.2470	0.2822	0.2767	0.1408	0.3090	0.1409
Sobel test	−0.001 ** (z = −2.31)				−0.003 * (z = −1.85)		−0.000 (z = −0.84)		
a	0.005 ** (z = 2.35)				0.010 ** (z = 1.89)		0.001 (z = 1.14)		
b	−0.244 *** (z = −13.75)				−0.278 *** (z = −9.02)		−0.026 (z = −1.24)		
Indirect effect	−0.001 ** (z = −2.31)				−0.003 * (z = −1.84)		−0.000 (z = −0.84)		
Direct effect	−0.005 * (z = −1.90)				−0.013 * (z = −1.82)		0.000 (z = 0.09)		
Total effect	−0.006 ** (z = −2.29)				−0.016 ** (z = 2.16)		0.000 (z = 0.07)		

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

The results show that smog pollution has a significant positive effect on environmental uncertainty and a negative effect on company operating investment through the mediation effect of environmental uncertainty. Moreover, the effect of smog pollution on environmental uncertainty and operating investment is more significant in the SOE subsample, as companies that have a close relationship with the government and undertake more social responsibility. The results support our hypotheses and underscore the robustness of our previous empirical results.

5.3. The Mediation Effect Test of Earnings Management

Since we employ company accruals as a proxy for the operating investment scale, it is possible that the decrease in operating investment is not caused by smog pollution but by the manipulation of accruals for other purposes. To exclude this possibility, we control for the level of accrual-based earnings management in our regression models and obtain empirical results that support our hypotheses. However, a competing hypothesis is that earnings management might also have a mediation effect on the influence of smog on operating investment, which may be even larger than the mediation effect of environmental uncertainty but be mistakenly attributed to environmental uncertainty in the research design.

Due to the high pressure from the public and the government, companies in cities with heavy smog pollution may choose to conduct downward accrual-based earnings management to pretend to be weak, which can give rise to sympathy from the public rather than attract blame for not undertaking enough social responsibility to improve air quality. Therefore, to exclude this competitive hypothesis, we test the mediation effect of earnings management in Equations (5)–(7), with the level of accrual-based earnings management (DA_{it}) as the mediation variable. Table 10 reports the regression results with the new mediation variable for the whole sample and the two subsamples. The Sobel test shows that, although earnings management has a significant influence on accruals (5.854, $t = 44.14$), it does not have a mediation effect on the influence of smog pollution on operating investment in any of the samples, which supports the robustness of our research design and results.

Table 10. The mediation effect of earnings management.

DV	Whole Sample				SOE			NSOE	
	OI	DA	OI	OI	DA	OI	OI	DA	OI
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
<i>PM</i> _{2.5}	−0.005 *	0.000	−0.006 ***	−0.013 *	0.000	−0.014 **	−0.000	0.000	−0.001
DA	(−1.95)	(1.25)	(−2.85)	(−1.93)	(0.59)	(−2.53)	(−0.35)	(0.73)	(−0.65)
SOE			5.854 ***			6.281 ***			3.819 ***
			(44.14)			(27.26)			(26.18)
Size	−0.093	0.023 ***	−0.229 **						
	(−0.84)	(2.63)	(−2.32)						
Lev	−0.381 ***	−0.037 ***	−0.163 ***	−0.757 ***	−0.080 ***	−0.254 **	−0.086 ***	−0.006 *	−0.065 **
	(−7.00)	(−8.62)	(−3.37)	(−5.83)	(−8.04)	(−2.21)	(−2.67)	(−1.84)	(−2.15)
BTM	0.020	0.063 ***	−0.350	0.711	0.062	0.323	−0.480 ***	0.030 **	−0.593 ***
	(0.08)	(3.22)	(−1.60)	(0.92)	(1.04)	(0.48)	(−3.78)	(2.49)	(−5.01)
ROA	0.105	−0.006	0.143 **	0.219	0.013	0.140	0.038	−0.015 ***	0.095 *
	(1.53)	(−1.17)	(2.33)	(1.53)	(1.14)	(1.11)	(0.72)	(−2.99)	(1.93)
Growth	−0.000	−0.000	0.000	0.402	0.104 **	−0.249	−0.000	−0.000	0.000
	(−0.60)	(−1.41)	(0.06)	(0.60)	(2.02)	(−0.42)	(−0.39)	(−1.59)	(0.19)
Auditty	0.003 ***	0.000	0.003 ***	0.001	0.000	0.000	0.004 ***	−0.000 *	0.005 ***
	(2.77)	(0.27)	(2.99)	(0.53)	(0.69)	(0.22)	(6.93)	(−1.76)	(8.10)
Control year	−0.100	−0.004	−0.076	−0.148	−0.016	−0.045	0.087	0.005	0.070
	(−0.36)	(−0.19)	(−0.31)	(−0.20)	(−0.29)	(−0.07)	(0.59)	(0.33)	(0.51)
Control industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control location	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	7092	7092	7092	2469	2469	2469	4623	4623	4623
F	9.66	13.02	173.69	5.95	10.90	74.58	8.44	3.31	71.12
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Adj. R ²	0.0133	0.0183	0.2262	0.0197	0.0386	0.2470	0.0158	0.0050	0.1430
Sobel test	0.001 (z = 1.25)				0.002 (z = 0.59)			0.000 (z = 0.73)	
a	0.000 (z = 1.25)				0.000 (z = 0.59)			0.000 (z = 0.73)	
b	5.854 *** (z = 44.14)				6.281 *** (z = 27.26)			3.819 *** (z = 26.18)	
Indirect effect	0.001 (z = 1.25)				0.002 (z = 0.59)			0.000 (z = 0.73)	
Direct effect	−0.006 *** (z = −2.85)				−0.014 ** (z = −2.53)			−0.001 (z = −0.65)	
Total effect	−0.005 * (z = −1.95)				−0.013 * (z = −1.93)			−0.000 (z = −0.35)	

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

6. Discussion and Conclusions

6.1. Research Conclusions

Using financial statement data from CSMAR and air quality monitoring data from CNEMC, we employ the *PM*_{2.5} concentration as a proxy for smog pollution and investigate the effect of smog pollution on company environmental uncertainty and operating investment in 74 cities in China. We anticipate that companies in China have experienced a significant increase in environmental uncertainty and a decrease in operating investment related to smog pollution. The positive influence of smog pollution on environmental uncertainty is given by its impact on employees, the public, and government. Employees living in area with health-threatening smog pollution may suffer from physical and mental illnesses, which can result in low productivity and even relocation because of health concerns. The public's attention to smog pollution and its pressure on the government may increase the potential environmental costs for companies and even result in direct losses through compulsory shutdowns. Additionally, according to the real option-based approach, the increase in environmental uncertainty will discourage operating investment in the current period and prompt companies to choose to “wait and see,” which results in a decrease in operating investment under serious smog pollution.

We also find that the increase in environmental uncertainty and the decrease in operating investment caused by smog pollution are more significant for SOEs than NSOEs. We suggest that a possible reason for this effect is the close relationship between SOEs and the government, which increases the intensity of government smog-control measures. Another reason is that, from their establishment, SOEs are expected to maintain steady economic growth and undertake social responsibilities, which increases the public pressure on them to set an example to fight against smog pollution, which further increases their environmental uncertainty.

The results of our research are consistent with related studies which show evidence of negative impact of smog on companies. We find that the smog has decreasing effect on corporate operating investment, through its increasing effect on the environmental uncertainty. Previous studies have concluded that smog has negative impact on the debt financing and government subsidies obtained by companies [39,40], and also the total factor productivity of companies [41]. All of these findings could be the results of the increased environment uncertainty of the company, and correspondingly the causes of the reduction in corporate operating investment, which is consistent with our influence mechanism and empirical results.

This study deepens the understanding of the economic aspects of smog pollution by providing evidence of its effect on company environmental uncertainty and operating investment. Our empirical results confirm that the serious smog pollution in China not only damages the physical and mental health of citizens but also deteriorates the operating environment of companies. Worsening smog pollution has led to a significant increase in environmental uncertainty and, consequently, a decrease in company operating investment. Furthermore, this study enriches the literature related to company operations by providing evidence that smog can indeed significantly affect a company's operating environment and should be considered in company processes for making important operational decisions.

6.2. Research Implications

This study reveals the importance of preventing and controlling smog pollution from the perspective of company operating investment, which provides empirical evidence for companies to arrange their operating investment and for governments to further implement environmental policies. The implications drawn from this study are as follows. First, we prove that the external natural environment has a significant impact on the operation activities of companies. Therefore, companies should carefully analyze related risks and expenses caused by the external natural environment in their investment or operation decisions. Companies should adjust their operating investment level based comprehensive understanding of the unique natural and economic environment they face.

Second, companies, as the main subject of environmental governance and the microeconomic entity affected by smog pollution, should take the responsibility for environmental governance and strengthen their sense of social responsibility. Third, considering the decrease of company operating investment contributed to smog pollution and increase of environmental uncertainty, the government needs to further strengthen environmental governance, and also use economic means to increase the confidence of companies in their operations. Only through this method can the country achieve the realization of simultaneous progress in the environment and economy.

6.3. Research Deficiencies and Prospects

There are still some limitations in this paper: First, this paper use air quality monitoring data at the city level from the China National Environmental Monitoring Centre. The time span and level of the study may have a certain impact on the results. With the improvement of corporate-level disclosure of environmental information in the future, subsequent studies can use both city-level and corporate-level data to obtain comprehensive results. Second, the external natural environment of the enterprise involves many contents that could also have influence on the environmental uncertainty of companies. In addition to smog pollution, it also includes factors such as weather changes and characteristics of the geographical environment. Whether these factors have similar effects on the operating investment needs further examination. This could be the direction and focus of future studies.

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