

Article

Air Quality Uncertainty and Earnings Management

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Abstract: We empirically examine the influence of rising political costs from the air quality uncertainty caused by regional air quality fluctuations on firms' earnings management. The results indicate that when air quality uncertainty increases, firms tend to increase their degree of earnings management and are more willing to carry out downward earnings management. We also find that the relationship is more obvious in the bottom-ten cities according to air quality ranking. Further evidence shows that the effect is most pronounced for less market-oriented regions, northern regions, manufacturing industries and firms with high asset-liability ratio and high media attention. In addition, we find that air quality uncertainty affects earnings management through the intermediary effect of government environmental investment. We explore the influence of the external environmental uncertainty on earnings management decisions, and the results have significant reference value for improving firms' earnings quality level.

Keywords: air quality uncertainty; air quality ranking; earnings management; political cost

1. Introduction

Previous studies have explored the relationship between air quality and the stock market, worker productivity, analyst forecasting, and executive compensation [1–4]. In these studies, air quality is directly measured with the absolute value of the AQI (Air quality index, AQI is a dimensionless index that quantitatively describes the air quality. It is an air quality evaluation standard issued by the state starting in March 2012. There are six pollutants monitored: sulfur dioxide, PM₁₀, PM_{2.5}, carbon monoxide, and ozone. The higher the AQI is, the higher the level and the more serious the air pollution.) and PM_{2.5} (Particulate Matter 2.5 refers to the atmospheric particulate matter with a diameter less than or equal to 2.5 micrometers, and it is the main cause of haze weather.). However, the uncertainty of the air quality change has a more profound impact on firms' behavior than the absolute value. Chinese State Council announced the Air Pollution Prevention and Control Action Plan (Action Plan) on 13 September 2013, which shows tremendous determination to improve air quality in China and adds the air quality into the comprehensive assessment of the leadership team and leading cadres. Because one of the Action Plan's assessment objectives is the reduced ratio of the inhalable particulate matter concentration (according to the Air Pollution Prevention and Control Action Plan, by 2017 the concentration of inhalable particulate matter in prefecture-level and higher cities nationwide is required to drop by more than 10% compared with 2012), the local governments pay close attention to and are very sensitive to changes in air quality. Large fluctuations of a region's air quality index mean that local governments are exposed to large environmental and political risks. Especially after the Ministry of Ecology and Environment began to publish real-time regional air quality rankings monthly in 2013, huge external pressure has been transmitted from local governments to the firms within their jurisdiction. Some studies have documented the impact of external air quality changes on firms' micro-decision behavior. For instance, Liu and Liu studied the effect of the PM_{2.5}

explosion incident on earnings management and found that high-polluting firms carried out significant downward earnings management to avoid political costs [5]. However, the existing literature does not address the impact of air quality uncertainty on earnings management. Following Ghosh and Olsen [6], regional air quality uncertainty is calculated with the $PM_{2.5}$ index. We selected the listed companies in Shenzhen and Shanghai in 2014–2017 as the sample and examined the relation between air quality uncertainty and earnings management. The results indicate that when the air quality uncertainty grows, firms, especially those in the bottom-ten cities in terms of their air quality ranking, tend to increase their degree of earnings management and carry out downward earnings management. Further evidences show that the air quality uncertainty affects earnings management through government environmental investment which reveals the influence mechanism of air quality uncertainty on earnings management. In China, the government is a main body of environmental governance. For instance, the annual growth rate of environmental investment from the government is over 14% from 2011 to 2013. See <http://news.sina.com.cn/o/2014-03-08/160429657503.shtml>. More importantly, government environmental investment can significantly arouse environmental investment from other bodies, including firms, banks, and social groups. Furthermore, the amount of government environmental investment can transmit a signal that governments increase regulatory efforts to firms.

We contribute to two strands of literature. We contribute to the literature on policy effect of air pollution regulation. Existing literature focuses on the effect of air quality index's absolute value and study the effect of air quality index on stock market, worker productivity, and analyst forecasts. However, according to the Action Plan, the change of pollutant concentration is a key point of assessment by the central government, so local governments pay more attention to the change value of air pollution than the absolute value. Large frequency changes of air pollution index mean great political risks that local governments do not pass the mid-term and final assessment. Existing literature have ignored the requirement of air protection rules, including the Action Plan. To fill this gap, from the perspective of regional air quality fluctuations, we explore the influence of air quality uncertainty on earnings management decisions and obtain the decision-making behavior pattern of firms' managers in the face of external environmental risks.

We also contribute to the literature on influencing factors of earning management. Existing literature show that incentives for managing earnings include equity financing, meeting the expectations of financial analysts, bonus plans, and debt costs. Some studies have concerned the smog's effect (delegated as the $PM_{2.5}$ burst incident) on earning management via political costs [5]. However, this study does not explore the air quality effect on earning management directly. Therefore, we selected the Action Plan as the institutional background and studied the relation between air quality uncertainty and earning management. In order to relieve the endogeneity problem, we also used the air quality ranking as an exogenous event to effectively solve the endogenous problem and gain reliable conclusions. Our results confirm the effect chain of air quality uncertainty, environmental regulation, political cost, and earning management and show a new factor that affects managers' decision of earning management.

The remainder of the paper is organized as follows. We propose the hypothesis in Section 2. Section 3 describes the data and sample selection, and Section 4 reports the empirical findings. Section 5 concludes the paper.

2. Institutional Background, Literature, and Hypothesis Development

2.1. Institutional Background

2.1.1. Air Quality Regulation in China

With the rapid development of China's economy, the central government has begun to pay increasingly more attention to air quality. Environmental data have achieved a leap from being non-existent to covering all prefecture-level cities with real-time releases. In 2013, triggered by the $PM_{2.5}$ crisis, the Air Pollution Prevention and Control Action Plan was implemented by the Chinese

government as the first national strategy on air pollution control. This Action Plan has defined specific quantitative targets and clear time nodes, and provided ten key actions and 35 concrete measures, including the upgrading of industrial structure, adjustment of energy structure, point and nonpoint source pollution control, and reward and punishment mechanisms for local governments. Feng et al. reveal that the Action Plan has provided an effective way to alleviate air pollution in China, with the annual average concentrations of PM_{2.5}, PM₁₀, and SO₂ decreasing significantly, by 12.13% (from 2015), and by 17.45% and 47.73% (from 2013), respectively [7]. Among the measures of the Action Plan, two measures are of importance for local officials. One measure is the air quality ranking of prefecture-level cities. An air quality ranking was formed for the first batch of cities using the new air quality standards (74 pilot cities including the Beijing-Tianjin-Hebei region, the Yangtze River Delta, the Pearl River Delta and other key regions; municipalities directly under the central government; provincial capitals and cities specifically designated in the state plan). The top ten and bottom ten cities were announced to the country every month. In January 2015, monitoring data from all prefecture-level cities in China started to be published online every hour in real time. Another measure is the reward and punishment mechanisms for officials of local governments. The Action Plan required that a mid-term assessment would be conducted in 2015, and a final assessment of the implementation of the action plan would be conducted in 2017. The results of the mid-term and final assessment are an important basis for comprehensive assessment of local leading groups and cadres. For local governments that fail the annual assessment, the environmental protection department, in conjunction with the organization department, supervisory authority, and other departments, will interview the relevant persons in charge of local governments and their relevant departments, put forward rectification opinions, and supervise them.

After the Action Plan, Chinese central government issued some rules to improve the air quality. On July 3, 2018, the State Council issued The Three-Year Plan on Defending the Blue Sky to expand the air quality ranking range. Air quality information is gradually becoming open and transparent, ensuring air quality is a political task that local governments and firms need to pay attention to at all times. If the regional air quality index always remains high or low, it exerts certain pressures on local governments and firms, but these pressures are not the biggest. The biggest environmental pressure comes from the large change of the air quality index after removing the seasonal impact. When a region's air quality index fluctuates greatly, it means that there are great environmental and political risks. In order to adapt to the hard constraints of the energy conservation and emission reduction goals and responsibilities from the central government, local governments must intervene in the decision-making behavior of the firms within their jurisdiction. In terms of firms, they try to do something including conducting earnings management in order to avoid becoming intervened objects.

2.1.2. The Relationship between Government and Firms in China

Since 1999, a Modern Enterprise System is required to be established in The Third Plenary Session of the 14th CPC (the Communist Party of China) Central Committee. A Modern Enterprise System requires the separation of government functions from enterprise management. However, because local governments have a substantial amount of scarce resources, including land, bank loans, government contracts, and initial public offerings, which greatly affects the incentives and behaviors of various players in the region [8], both state-owned firms and non-state-owned firms tend to establish a good relationship with local governments via the equity and political connections to obtain the scarce resources. At the same time, local governments also require firms to help achieve local government goals, such as economic development, employment, and air quality. Facing the huge pressure of air pollution, local governments want firms to contribute to improving air quality. For firms, realizing local governments' objectives means a loss of revenue or increased costs, which are called political costs. In order to avoid or reduce political costs, firms are prone to make their performance not so good to be selected by local governments to contribute to air quality.

2.2. Literature Review

Earnings management occurs when managers use accounting methods or arrange transactions to change financial reports to mislead some stakeholders' about the underlying economic performance of the company or to influence contracts based on reported earnings [9]. According to Healy and Wahlen [9], motivations behind higher absolute levels of earnings management include meeting capital markets expectations, contracting incentives, and avoiding political costs.

Meeting capital markets expectations is the first factor that motivates the earning management. There is a positive correlation between corporate accounting earnings and stock prices, and higher reported earnings can lead to relatively higher stock prices [10,11]. Equity financing is an important motivation for corporate earnings management [12,13]. In the process of an initial public offering, additional issues, and rights issues, the managers have a strong incentive to increase earnings and convey false information to investors and other users of financial information [14–16]. Some studies have found that when the frequency of slight declines and losses in earnings is abnormally low while the frequency of slight gains and gains in earnings is abnormally high, it proves that managers will also conduct earnings management for the purpose of avoiding a decline in earnings and avoiding losses under the transaction cost theory and prospect theory [17,18]. Other evidences suggest that when the firms fail to meet the analyst's target, the market value of the firm will be lost, and the manager will experience a reduced salary or even be terminated. When the firms cannot cater to investor sentiment, investors may sell stocks to cause the firms' stock price to fall. For those reasons, managers try to meet the expectations of the outside by overstating earnings [19,20].

The second factor that causes the earning management is contracting incentive. When accounting data is used to monitor contracts between listed firms and related stakeholders, contract motivations are generated, which mainly include management compensation contracts and debt contracts. Based on the principal–agent relationship, managers will manipulate accounting earnings to maximize their compensation and bonus for their own benefit [21,22]. Managers will also carry out earnings management for increasing job security. Before the change of executives, senior executives who were temporarily dismissed tended to manipulate profits and increase reported earnings to maintain personal interests or reputation; after the change of executives, succession executives often reduce profits through negative earnings management and attribute the responsibility to their predecessors so that their performance can be improved [23–25]. Meanwhile, earnings overstatement is greater in the early than in the later years of a CEO's service [26]. In addition, those companies that violate or are likely to violate the debt contract will make accounting choices to increase revenue to reduce or evade the restrictions of the debt contract [27].

The third factor that leads to earning management is political cost. Political costs are the potential wealth transfer that firms face because of industry regulation, tax barriers, and other political activities. Existing literature shows that firms will manage earnings to reduce the net cost of potential regulatory outcomes under the uncertainty of changing regulation and external environment. Cahan et al. took the new environmental regulations issued by the U.S. Congress as a research event, and found that firms in a relevant industry would reduce the level of earnings management [28]. Based on the policy of Australian government to levy income tax on the gold mining industry, Monem found that firms in the gold mining industry would reduce earnings in the period of government policy formulation and review to avoid being imposed more income tax [29]. Ramanna and Roychowdhury examined the discretionary accrual choices of outsourcing firms with links to U.S. congressional candidates during the 2004 elections through the political cost hypothesis [30]. Godsell et al. examined earnings management by E.U. firms that initiated an antidumping investigation, revealing that earnings management increases when accounting data directly affect the magnitude of the tariffs imposed in the trade investigation [31]. An increase in policy risk implies an increase in the opaqueness of the information environment and in the expected volatility of future operating profitability [32]. Yung and Root used the Baker, Bloom, and Davis index (BBD) to investigate the association between policy

uncertainty and earnings management; the results show that firms will manage reporting earnings when policy uncertainty is high [33].

In general, earnings management is not only a common financial means for managers to achieve financial goals, but also an effective plan for firms to cope with adverse situations [34]. In the framework of earnings management motivation, scholars have studied the impact of corporate-level governance factors on earnings management, such as equity structure, equity incentives, personal characteristics of executives, board of directors, board of supervisors, external auditing, institutional investor shareholding, corporate reputation, and other corporate governance factors. At the same time, it also pays attention to the impact of the external governance environment such as macroeconomic fluctuations, accounting system reform, investor protection level, legal governance level, tax policy, government intervention, media supervision, and other factors. However, factors causing changes in the political costs do not include air quality uncertainty. Environmental uncertainty refers to the fluctuation and unpredictability caused by factors such as consumers, suppliers, competitors, and regulators [35]. Environmental uncertainty increases the volatility of a company's earnings. In other words, greater environmental uncertainty is associated with a higher degree of earnings management [6]. Since the air quality is becoming increasingly more important, the air quality uncertainty has been a factor affecting the environmental uncertainty. According to the concept of environmental uncertainty, we define fluctuations in the external air quality as air quality uncertainty. Some studies have concerned the smog's effect (delegated as the PM2.5 burst incident) on earning management via political costs [5]. However, this study does not explore the air quality effect on earning management directly and does not include air quality uncertainty. We select the Action Plan as the institutional background and study the relation between air quality uncertainty and earning management.

2.3. Hypothesis Development

The air quality uncertainty, as a macro change of the external environment, affects firms' activities through political costs. Political costs are the potential wealth transfer that firms face because of industry regulation, tax barriers, and other political activities. It makes firms subject to strict government supervision, which is significantly related to accounting data. When the air quality uncertainty increases to reduce or avoid political costs, firms may implement earnings management using accounting procedures or accounting options to reduce the expected value of the wealth transfer. On the one hand, if the regional air quality uncertainty is increasing and the overall trend is decreasing, local governments will use various resources to improve the environmental quality under the pressure of the superior environmental target responsibility system. Local governments tend to adopt stricter environmental regulations for the firms within its jurisdiction, such as strengthening law enforcement and supervision and increasing environmental regulation or environmental protection investment. The source of these funds is firms. Local governments transfer resources using related party transactions [36] and raising taxes [37]. To respond to the strict regulation, firms' managers tend to hide their true performance and reduce their attractiveness with earnings management. By lowering firms' profits, firms show a worse image to increase sympathy from local governments. Some firms may even get subsidies from the government with those measures [38]. On the other hand, if the regional air quality uncertainty is increasing and the overall trend is also increasing, local governments tend to balance environmental performance and economic development. Firms tend to choose downward earnings management to keep a low profit level if the government pursues stable regional air quality and strictly regulates firms. If the government tends to pursue GDP (gross domestic product) growth, managers would engage in performance-oriented earnings management and managers might overestimate profits in response to government and market incentives. In summary, we propose that firms tend to improve their degree of earnings management when the regional air quality uncertainty increases. Therefore, we propose the following hypothesis:

There is a positive relationship between the regional air quality uncertainty and the degree of firms' earnings management.

3. Research Design

3.1. Sample Selection and Data Sources

Our sample covers all publicly listed firms on China's two stock exchanges (Shanghai Stock Exchange and Shenzhen Stock Exchange) over the period from 2014 to 2017. In order to reduce the influence of registration place, we excluded 33 firms whose registration place changed during the sample period. In detail, 10 firms changed their registration places in 2014, 4 firms in 2015, 7 firms in 2016, and 12 firms in 2017. The main explanatory variable is the lagged air quality uncertainty in the city where a firm is registered. The $PM_{2.5}$ data, which are used to calculate the air quality uncertainty, are from the center for Socioeconomic Data and Applications at Columbia University based on the aerosol optical depth (AOD) measured by NASA satellite remote sensing. The data on accounting information are obtained from the China Stock Market and Accounting Research (CSMAR) database and the macro data are from the Urban Statistical Yearbook of China. We excluded the observations of financial firms, firms with missing data, bankrupt firms and firms that had listing times less than one year. Therefore, we obtained 9461 final observations. All variables are winsorized at the 1% and 99% levels.

3.2. Model Design and Variable Definition

To verify the relation between earnings management and air quality uncertainty, we established the regression model (1) as follows.

$$|DA_t| = \alpha_0 + \alpha_1 AQU_{t-1} + \alpha_2 Controls_t + \sum Year + \sum Industry + \sum Province + \varepsilon_t \quad (1)$$

We used models (2) to (4) to estimate the accrued earnings management by industry and year based on the cross-section Modified Jones Model [39]. To ensure the statistical characteristics of the regression, industries with less than 10 observations were excluded from the sample. The higher the absolute value of the discretionary accruals (DA) are, the bigger the degree of earnings management. In models (2) to (4), $TA_{i,t}$ is the total accruals, $NDA_{i,t}$ is the non-discretionary accruals, $A_{i,t-1}$ is the total assets at the beginning of the period, $\Delta REV_{i,t}$ is the change in operating income, $\Delta REC_{i,t}$ is the change in accounts receivable, and $PPE_{i,t}$ is fixed assets.

$$\frac{TA_{i,t}}{A_{i,t-1}} = \beta_1 \frac{1}{A_{i,t-1}} + \beta_2 \frac{\Delta REV_{i,t}}{A_{i,t-1}} + \beta_3 \frac{PPE_{i,t}}{A_{i,t-1}} + \varepsilon_{i,t} \quad (2)$$

$$NDA_{i,t} = \beta_1 \frac{1}{A_{i,t-1}} + \beta_2 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{A_{i,t-1}} + \beta_3 \frac{PPE_{i,t}}{A_{i,t-1}} \quad (3)$$

$$DA_{i,t} = \frac{TA_{i,t}}{A_{i,t-1}} - NDA_{i,t} \quad (4)$$

Ghosh and Olsen [6] use the standard deviation of the industry-adjusted sales revenue using the average over the past five years to measure the environmental uncertainty faced by firms. Following Ghosh and Olsen [6], we calculated the standard deviation of the $PM_{2.5}$ concentration in each prefecture-level city in the preceding three years scaled by its mean value to measure the air quality uncertainty (AQU), and the calculation process is shown in models (5)–(7). Considering the lagged effect of air quality on firm behavior, AQU is lagged by one period.

$$Sd(PM_{2.5}) = \sqrt{\frac{1}{3} \sum_{k=t-2}^t (PM_{2.5k} - \overline{PM_{2.5}})^2} \quad (5)$$

$$\overline{PM_{2.5}} = \frac{1}{3} \sum_{k=t-2}^t PM_{2.5k} \quad (6)$$

$$AQU_t = Sd(PM_{2.5}) / \overline{PM_{2.5}} \quad (7)$$

Following Fan and Wong [40], Njah and Jarbouï [41], and Liu and Stephen [42], the control variables in this article are as follows: (1) common financial indicators of the firms such as *Size* (firm size), *Lev* (the ratio of liabilities to assets), *Shr* (the shareholding ratio of the largest shareholder), *Growth* (the ratio of the increase in operating income to the operating income in the previous period), *Capx* (cash paid to purchase fixed assets, intangible assets, and other long-term assets divided by total assets at the end of the period), *SOE* (a firm is a state-owned (SOE) firm if its ultimate controlling shareholder is a state government, and it is a non-SOE otherwise); (2) *Loss* (a dummy variable that equals one if the net profits are less than zero in the current year, and zero otherwise) and *Avloss* (A dummy variable that equals one if the ROE is greater than or equal to zero and less than 1%, and zero otherwise); (3) *Instshr* (the shareholding ratio of institutional investors) and *Opinion* (a dummy variable that equals one if the audit opinion of the firm is a standard unqualified opinion, and zero otherwise); (4) local economic development such as *GDP* (GDP growth rate) and *Marketization* (the marketization index of China's provinces); (5) other regional environmental characteristics such as *Solid* (comprehensive utilization rate of industrial solid wastes), and *Refuse* (decontamination rate of urban refuse); (6) managers' choice of negative earnings management or positive earnings management based on different motivations such as *Direc_DA* (a dummy variable that equals one if the accrued earnings management is less than zero, and zero otherwise) in the main regression. The Appendix A provides the definitions of all variables.

We focused on the coefficient α_1 of *AQU* in model (1). If $\alpha_1 < 0$, then firms reduce their earnings management when facing air quality uncertainty. If $\alpha_1 > 0$, then firms increase their earnings management when facing air quality uncertainty.

4. Empirical Analysis

4.1. Descriptive Statistics

Table 1 reports the descriptive statistics of the variables. The average value of accrued earnings management (*DA*) was 0.059 and the standard deviation was 0.062. The mean value of air quality uncertainty (*AQU*) was 0.094, and the standard deviation was 0.048, indicating that the air quality fluctuation was quite different between regions.

Table 1. Descriptive statistics.

Variable	N	Mean	Q1	Median	Q3	Std. Dev
DA	9461	0.059	0.018	0.040	0.077	0.062
AQU	9461	0.094	0.056	0.088	0.125	0.048
Size	9461	22.270	21.390	22.11	22.99	1.257
Lev	9461	0.428	0.263	0.418	0.581	0.205
Shr	9461	0.341	0.225	0.321	0.438	0.147
Growth	9461	0.220	−0.024	0.111	0.293	0.553
Capx	9461	0.043	0.013	0.030	0.060	0.041
Instshr	9461	0.402	0.216	0.412	0.576	0.227
SOE	9461	0.361	0	0	1	0.480
Opinion	9461	0.975	1	1	1	0.157
Loss	9461	0.085	0	0	0	0.279
Avloss	9461	0.137	0	0	0	0.344
GDP	9461	0.080	0.070	0.080	0.089	0.015
Marketization	9461	8.588	7.300	9.350	9.77	1.780
Solid	9461	0.869	0.833	0.924	0.967	0.152
Refuse	9461	0.977	0.990	1	1	0.063
Direc_DA	9461	0.467	0	0	0	0.499
EI	9461	1.257	0.810	1.100	1.490	0.682
AQU_Mean	9461	0.093	0.062	0.095	0.115	0.038
Sub_city	9461	0.076	0	0	0	0.265

4.2. Baseline Regressions

We run a multiple regression using model (1) to test the relation between air quality uncertainty and earnings management, and Table 2 reports the regression results. The results show that the coefficients (α_1) on *AQU* are positive and significant (0.025, $T = 1.799$ in Column (1); 0.026, $T = 1.836$ in Column (2); 0.074, $T = 2.339$ in Column (3); and 0.030, $T = 1.7$ in Column (4)) for the different control variables and the year, industry, and province fixed effects. The regression results support our hypothesis, suggesting that firms increase their degree of earnings management in order to avoid or reduce the political costs as much as possible when the air quality uncertainty increases. We also find that firms with more assets (*Size*) and a standard unqualified opinion (*Opinion*) have less earnings management. The firms with more debt (*Lev*) and operating income growth (*Growth*) tend to increase earnings management.

Table 2. Regression results of air quality uncertainty on earnings management.

Dep. DA	(1)	(2)	(3)	(4)
<i>AQU</i>	0.025 * (1.799)	0.026 * (1.836)	0.074 ** (2.339)	0.030 * (1.700)
<i>Size</i>		−0.006 *** (−7.479)	−0.010 *** (−3.832)	−0.007 *** (−8.612)
<i>Lev</i>		0.043 *** (8.961)	0.039 ** (2.049)	0.036 *** (7.324)
<i>Shr</i>		0.005 (1.143)	−0.010 (−0.992)	0.002 (0.517)
<i>Growth</i>		0.027 *** (14.125)	0.089 *** (2.843)	0.026 *** (13.772)
<i>Capx</i>		−0.122 *** (−7.041)	−0.186 *** (−3.588)	−0.076 *** (−4.395)
<i>Instshr</i>		0.003 (0.725)	−0.009 (−0.763)	−0.001 (−0.192)
<i>SOE</i>		−0.002 (−1.380)	−0.003 (−1.108)	−0.004 ** (−2.335)
<i>Opinion</i>		−0.023 *** (−4.461)	−0.025 ** (−2.210)	−0.023 *** (−4.360)
<i>Loss</i>		0.019 *** (5.586)	0.028 *** (3.131)	0.020 *** (5.793)
<i>Avloss</i>		−0.005 ** (−2.125)	−0.000 (−0.058)	−0.004 * (−1.730)
<i>GDP</i>		0.021 (0.419)	0.389 (1.004)	0.009 (0.140)
<i>Marketization</i>		0.001 * (1.717)	−0.001 (−0.806)	0.001 (0.239)
<i>Solid</i>		0.004 (0.824)	0.001 (0.076)	−0.004 (−0.855)
<i>Refuse</i>		−0.004 (−0.435)	−0.018 (−0.579)	0.008 (0.795)
<i>Dirac_DA</i>		−0.010 *** (−8.168)	−0.017 *** (−3.802)	−0.011 *** (−8.409)
<i>Cons</i>	0.057 *** (40.593)	0.185 *** (9.153)	0.280 *** (4.486)	0.212 *** (6.393)
<i>Year fixed effect</i>	No	No	Yes	Yes
<i>Industry fixed effect</i>	No	No	Yes	Yes
<i>Province fixed effect</i>	No	No	No	Yes
<i>N</i>	9461	9461	9461	9461
<i>Adj.R²</i>	0.0002	0.099	0.048	0.137

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.3. Cross-Sectional Analysis

The relation between earnings management and regional air quality uncertainty varied with the characteristics of the regions and firms.

4.3.1. Firm Characteristics

Firm characteristics include the nature of the industry, capital structure, and media attention. The increasing energy consumption is one of the main reasons for China's environmental degradation. In the process of China's economic development, carbon emission, and energy consumption, the manufacturing industry plays an important role, and it will inevitably become the key target of the adjustment of the energy structure in the Action Plan. The Manufacturing industry is under more pressure from the local government and the public than firms in a non-manufacturing industry. They tend to carry out more earnings management to avoid excessive political costs. Panel A of Table 3 shows that in the manufacturing industries group, the positive effect on *AQU* is significant at the 10% level, indicating that the firms in a manufacturing industry can increase managers' earning management behaviors when facing external air quality uncertainty.

Table 3. Cross-sectional analysis.

<i>Panel A: Manufacturing Industry</i>		
Dep. DA	(1)	(2)
	Manufacturing industry	Non-manufacturing industry
<i>AQU</i>	0.037 * (1.832)	0.021 (0.645)
<i>Controls</i>	Yes	Yes
<i>Fixed effect</i>	Yes	Yes
<i>N</i>	5933	3528
<i>Adj.R²</i>	0.083	0.152
<i>Panel B: Asset-Liability Ratio</i>		
Dep. DA	(1)	(2)
	High ratio	Low ratio
<i>AQU</i>	0.045 * (1.923)	0.016 (0.643)
<i>Controls</i>	Yes	Yes
<i>Fixed effect</i>	Yes	Yes
<i>N</i>	4729	4732
<i>Adj.R²</i>	0.123	0.146
<i>Panel C: Media Attention</i>		
Dep. DA	(1)	(2)
	High attention	Low attention
<i>AQU</i>	0.046 ** (2.001)	0.016 (0.571)
<i>Controls</i>	Yes	Yes
<i>Fixed effect</i>	Yes	Yes
<i>N</i>	4824	4637
<i>Adj.R²</i>	0.121	0.142
<i>Panel D: Degree of Marketization</i>		
Dep. DA	(1)	(2)
	High marketization	Low marketization
<i>AQU</i>	0.014 (0.471)	0.047 ** (2.165)
<i>Controls</i>	Yes	Yes
<i>Fixed effect</i>	Yes	Yes
<i>N</i>	4941	4520
<i>Adj.R²</i>	0.127	0.149

Table 3. Cont.

<i>Panel E: North and South</i>		
	(1)	(2)
Dep. DA	Northern region	Southern region
<i>AQU</i>	0.063 * (1.906)	0.006 (0.235)
<i>Controls</i>	Yes	Yes
<i>Fixed effect</i>	Yes	Yes
<i>N</i>	3191	6270
<i>Adj. R²</i>	0.135	0.132

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

The capital structure is usually expressed by the asset-liability ratio. The firms with a high asset-liability ratio have a higher risk of debt default, so they will conduct earnings management to avoid debt default [43]. According to the median of the proportion of asset-liability ratio, we partition the sample into two groups, high ratio (above the median) and ratio (below the median). The results in Panel B of Table 3 show that for firms with a high asset-liability ratio, the positive effect on *AQU* is significant (0.045 with $T = 1.923$).

Media attention is an effective supplement to the corporate governance mechanism. The market pressure hypothesis believes that the media affects the information environment of the capital market through functions such as information dissemination and information manufacturing and puts tremendous pressure on managers so they will take earnings management behavior to meet the market's expectations for their own benefit. Following Fang and Press [44], we use the "Baidu News Search Engine" (Baidu News Search Engine: <http://news.baidu.com>) to search for the number of news articles with the abbreviation of listed firms in the title each year and define it as media attention. We divide the sample into high media attention and low media attention groups. Panel C of Table 3 reports the regression results of model (1) based on the media attention. The results show that in the high media attention group, the positive effect of air quality uncertainty is pronounced (0.046 with $T = 2.001$), suggesting that firms are worried that they will become the focus of government attention when media attention is high and will adjust earnings for political cost considerations.

4.3.2. Regional Characteristics

Regarding regional aspects, there are many factors that can influence earnings management, such as the degree of marketization and the difference between the north and south. Under the special institutional environment of China, the market imbalance in the regional development process is one of the main features. If a region has a low degree of marketization, the local government's intervention is more severe, and businesses face greater external constraints in their decision-making. We measure the degree of marketization in the provinces according to the Marketization Index of China's Provinces. We divide the sample into high marketization and low marketization groups. Panel D of Table 3 reports the regression results of model (1) based on the degree of marketization. The results show that in the high marketization group, the positive effect of air quality uncertainty is not pronounced (0.014 with $T = 0.471$), suggesting that local governments have less interference with firms in areas with high marketization, so firms lack the motivation to conduct earnings management.

The difference between north and south affects future air quality changes, and firms located in the north face greater political costs and are more likely to carry out earnings management. We divide the country into the southern region and the northern region with the Qinling Mountains-Huaihe River Line as the boundary. Panel E of Table 3 reports the regression results of model (1) based on the north and south regions. The results show that for firms located in the north region, the coefficient (α_1) for *AQU* is significant at the 10% level, indicating that the local governments and firms in the northern

region may pay more attention to the impact of external air quality uncertainty in the context of central heating policies than in southern region.

4.4. Further Analysis

We conjecture that the environmental pressure caused by the air quality uncertainty is transmitted to firms through the local government, and this affects the earnings management strategy of managers. Therefore, when the air quality uncertainty increases, local governments increase their investments in environmental protection, and then firms implement earnings management. To test this transmission path, we measure the governments' environmental protection investment (*EI*) using the ratio of the total investment in the treatment of industrial pollution to the GDP of each province, and set models (8)–(10) following Wen and Ye [45].

$$|DA_t| = \alpha_0 + \alpha_1 AQU_{t-1} + \alpha_2 Controls + \varepsilon \quad (8)$$

$$EI_t = \beta_0 + \beta_1 AQU_{t-1} + \beta_2 Controls + \varepsilon \quad (9)$$

$$|DA_t| = \gamma_0 + \gamma_1 AQU_{t-1} + \gamma_2 EI_t + \gamma_3 Controls + \varepsilon \quad (10)$$

If the regression coefficients α_1 , β_1 , and γ_2 are all significant and the significance level or value of γ_1 decreases compared to α_1 , it indicates that there is a mediating effect. The results in column (2) of Table 4 show that the air quality uncertainty increased the governments' environmental protection investment (0.428 with $T = 6.214$). The results of column (3) show that the regression coefficient of the effect of government environmental protection investment on earnings management is significantly positive, while the regression coefficient of the effect of air quality uncertainty on earnings management is not pronounced and lower than that of column (2). The results show that the intermediary effect of government environmental protection investment is significant, and so our expected impact path is supported.

Table 4. Path analysis results of the effect of air quality uncertainty on earnings management.

	(1)	(2)	(3)
	DA	EI	DA
<i>AQU</i>	0.031 * (1.762)	0.428 *** (6.214)	0.029 (1.632)
<i>EI</i>			0.005 ** (2.262)
<i>Size</i>	−0.006 *** (−8.293)	−0.000 (−0.243)	−0.006 *** (−8.292)
<i>Lev</i>	0.035 *** (7.032)	0.007 (0.815)	0.035 *** (7.026)
<i>Shr</i>	0.002 (0.404)	0.023 (1.415)	0.002 (0.378)
<i>Growth</i>	0.026 *** (13.621)	−0.003 (−0.863)	0.026 *** (13.641)
<i>Capx</i>	−0.081 *** (−4.675)	−0.009 (−0.216)	−0.081 *** (−4.673)
<i>Instshr</i>	−0.002 (−0.573)	−0.004 (−0.586)	−0.002 (−0.567)
<i>SOE</i>	−0.004 ** (−2.431)	−0.001 (−0.249)	−0.004 ** (−2.428)
<i>Opinion</i>	−0.021 *** (−4.123)	0.000 (0.006)	−0.021 *** (−4.120)
<i>Loss</i>	0.017 *** (5.199)	−0.004 (−0.345)	0.017 *** (5.204)

Table 4. Cont.

	(1)	(2)	(3)
	DA	EI	DA
<i>Avloss</i>	−0.005 * (−1.868)	0.001 (0.079)	−0.005 * (−1.868)
<i>GDP</i>	0.013 (0.188)	2.373 *** (8.265)	0.000 (0.005)
<i>Marketization</i>	0.001 (0.278)	0.082 *** (7.932)	0.000 (0.107)
<i>Solid</i>	−0.004 (−0.835)	−0.137 *** (−8.836)	−0.004 (−0.693)
<i>Refuse</i>	0.008 (0.828)	−0.071 ** (−2.037)	0.009 (0.864)
<i>Cons</i>	0.201 *** (6.044)	0.139 (1.247)	0.200 *** (6.023)
<i>Year fixed effect</i>	Yes	Yes	Yes
<i>Industry fixed effect</i>	Yes	Yes	Yes
<i>Province fixed effect</i>	Yes	Yes	Yes
<i>N</i>	9461	9461	9461
<i>Adj.R²</i>	0.131	0.886	0.131

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.5. Robustness Check

4.5.1. Redefinition of the Independent Variable

According to the principle of $(X_i - X_{\min}) / (X_{\max} - X_{\min})$, we standardized AQU as AQU' to the range of 0 to 1. Then, we replace AQU with AQU' in model (1) to conduct a robustness check. The results show that the coefficient of AQU' is significantly positive at the 10% level in column (1) of Table 5, which is consistent with the original regression conclusion. According to the positive and negative values of discretionary accruals, we also divide the whole sample into the positive management group and negative management group. The results show that in the sub-sample test with $DA < 0$, the regression coefficient is positive and significant (0.011 with $T = 1.717$), illustrating that the impact of air quality uncertainty on earnings management exists in firms with lower profit requirements. The sample with $DA > 0$ failed the significance test, which means that the air quality uncertainty has no effect on upward earnings management. In summary, when the air quality uncertainty increases, firms tend to increase their degree of earnings management, and they are more willing to carry out downward earnings management than upward earnings management.

Table 5. The regression results of replacing the independent variable.

Dep. DA	(1)	(2)	(3)
	Full Sample	Sub-Sample: $DA > 0$	Sub-Sample: $DA < 0$
<i>AQU'</i>	0.009 * (1.753)	0.006 (0.809)	0.011 * (1.717)
<i>Controls</i>	Yes	Yes	Yes
<i>Year fixed effect</i>	Yes	Yes	Yes
<i>Industry fixed effect</i>	Yes	Yes	Yes
<i>Province fixed effect</i>	Yes	Yes	Yes
<i>N</i>	9461	5038	4423
<i>Adj.R²</i>	0.131	0.141	0.165

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.5.2. Redefinition of the Dependent Variable

Following Roychowhury [46], we constructed a comprehensive real earnings management measurement index (*REM*) using three individual indicators: abnormal cash flow from operations (*ACFO*), abnormal production costs (*APROD*), and abnormal discretionary expenses (*ADISEXP*, which includes R & D expenses, advertising expenses, sales expenses, etc. We calculate the actual discretionary expense data using the sum of sales expenses and management expenses in the income statement). Then, we examine whether the firms' real earnings management changes with the air quality uncertainty. Meanwhile, $REM = -ACFO + APROD - ADISEXP$. We take their absolute values just like in model (1). Table 6 shows that the coefficients of *AQU* are positive and significant (0.034, $T = 1.909$ in Column (1); 0.065, $T = 2.467$ in Column (2); 0.058, $T = 3.34$ in Column (3); and 0.145, $T = 2.995$ in Column (4)), which indicate that the air quality uncertainty is enhanced and firms have more motivation to conduct real earnings management. The results further verify the main conclusion of our studies.

Table 6. The regression results of replacing the dependent variable.

	(1)	(2)	(3)	(4)
	ACFO	APROD	ADISEXP	REM
<i>AQU</i>	0.034 * (1.909)	0.065 ** (2.467)	0.058 *** (3.400)	0.145 *** (2.995)
<i>Controls</i>	Yes	Yes	Yes	Yes
<i>Year fixed effect</i>	Yes	Yes	Yes	Yes
<i>Industry fixed effect</i>	Yes	Yes	Yes	Yes
<i>Province fixed effect</i>	Yes	Yes	Yes	Yes
<i>N</i>	9029	9029	9029	9029
<i>Adj.R²</i>	0.096	0.158	0.137	0.137

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.5.3. Eliminate the Effect of Sample Clustering Phenomenon

The research samples in this paper are clustered to some extent, and there will be some confusion as to whether the difference in earnings management is caused by regional air quality uncertainty or by sample distribution. We exclude the sample observed with the largest number of listed firms in Beijing, Shanghai and Shenzhen to re-regress (there are 910 companies in Beijing, 754 in Shanghai, and 766 in Shenzhen). Table 7 shows that the empirical results have not changed.

Table 7. The regression results excluding firms located in Beijing, Shanghai and Shenzhen.

Dep. DA	(1)	(2)	(3)	(4)
<i>AQU</i>	0.030 * (1.742)	0.033 ** (2.089)	0.045 *** (2.872)	0.032 * (1.661)
<i>Controls</i>	No	Yes	Yes	Yes
<i>Year fixed effect</i>	No	No	Yes	Yes
<i>Industry fixed effect</i>	No	No	Yes	Yes
<i>Province fixed effect</i>	No	No	No	Yes
<i>N</i>	7031	7031	7031	7031
<i>Adj.R²</i>	0.000	0.088	0.124	0.126

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.5.4. Group Regression of Air Quality with the Top Ten and the Bottom Ten Cities

We examine the general relationship between the regional air quality uncertainty and the degree of earnings management of listed companies. There are certain endogenous problems between the two

variables. In order to mitigate the endogenous problems effectively, we need to use an exogenous shock event. The fact that the Ministry of Ecology and Environment has released real-time monthly air quality rankings in the top ten and last ten cities since 2013 provided us with a good research opportunity. First, air quality is a good exogenous event that not controlled by regions and firms. Second, firms in the low air quality-ranking cities have greater incentives to avoid potential political costs than those in the high air quality-ranking cities. The air quality ranking is a reputation mechanism. The central government puts pressure on cities with poor environmental quality by making a “public appearance,” and it forces them to improve their environmental performance. Meanwhile, the reputation incentive has an impact on the choice of a government’s environmental strategy. The public and media maintain or enhance their social identity through external response behaviors, such as in-depth reports on the regions with the lowest air quality and extensive discussions in the media. For regional governments, keeping out of the bottom 10 is their primary goal, but it is difficult to achieve when there is great air quality uncertainty. Therefore, in order to overcome these difficulties and achieve the goal of improving their air quality ranking, the regional government inevitably strengthens the environmental regulation for the firms in its jurisdiction. Generally, it is reflected in the improvement of corporate environmental regulations and the collection of environmental improvement fees from firms for air quality improvements. Compared with other firms, the firms in the bottom ten cities face greater political costs and have a stronger incentive to avoid the political costs through earnings management. Therefore, we conduct a group regression. Table 8 shows that the firms in the bottom ten cities carry out more significant earning management than other cities.

Table 8. Group regression of the air quality in the top ten and the bottom ten cities.

Dep. DA	(1)	(2)
	Top Ten Cities	Bottom Ten Cities
<i>AQU</i>	−0.011 (−0.106)	0.651 * (1.681)
<i>Controls</i>	Yes	Yes
<i>Year fixed effect</i>	Yes	Yes
<i>Industry fixed effect</i>	Yes	Yes
<i>Province fixed effect</i>	Yes	Yes
<i>N</i>	940	323
<i>Adj.R²</i>	0.154	0.268

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.5.5. Endogenous Test

In order to avoid possible missing variables, we use the mean value of *AQU* in the same province (*AQU_Mean*) as the instrumental variable of *AQU* to perform two-stage regression analysis. On the one hand, the air quality uncertainty of a city is closely related to the air quality uncertainty of other cities in the same province, which implies the correlation of the instrumental variables. On the other hand, the air quality uncertainty in other cities does not directly affect the earnings management behavior of local firms. Considering the regional dispersion of parent-subsidiary companies, we collect the registration places of subsidiaries of listed firms and use *Sub_city* (a dummy variable that equals one if the listed firm has no subsidiaries in other prefecture-level cities and zero otherwise) as another instrumental variable. Table 9 shows that the air quality uncertainty and earnings management are still significantly positively correlated at the 10% level when using *AQU_Mean* and *Sub_city* as instrumental variables. When the Wald F statistic is greater than 10, it passes the weak instrumental variable test. Therefore, the endogenous problems in the model that may be caused by missing variables have no effect on the empirical conclusions.

Table 9. Two-stage regression results based on the instrumental variable method.

	<i>First Stage</i>	<i>Second Stage</i>
	<i>AQU</i>	<i> DA </i>
<i>AQU_Mean</i>	1.018 *** (77.453)	
<i>Sub_city</i>	0.001 (1.009)	
<i>AQU</i>		0.046 * (1.949)
<i>Size</i>	−0.000 (−0.431)	−0.006 *** (−9.466)
<i>Lev</i>	−0.001 (−0.317)	0.035 *** (8.155)
<i>Shr</i>	−0.002 (−1.115)	0.002 (0.428)
<i>Growth</i>	−0.000 (−0.541)	0.026 *** (14.163)
<i>Capx</i>	0.011 (1.507)	−0.082 *** (−5.238)
<i>Instshr</i>	0.001 (0.696)	−0.002 (−0.638)
<i>SOE</i>	0.001 * (1.701)	−0.004 *** (−2.852)
<i>Opinion</i>	0.002 (0.875)	−0.021 *** (−4.099)
<i>Loss</i>	−0.002 (−1.605)	0.017 *** (5.304)
<i>Avloss</i>	0.002 * (1.753)	−0.005 * (−1.883)
<i>GDP</i>	0.008 (0.202)	0.007 (0.104)
<i>Marketization</i>	−0.002 ** (−2.151)	0.000 (0.151)
<i>Solid</i>	−0.001 (−0.228)	−0.004 (−0.812)
<i>Refuse</i>	0.006 (0.807)	0.008 (0.787)
<i>Cons</i>	0.013 (0.882)	0.203 *** (6.206)
<i>Year fixed effect</i>	Yes	Yes
<i>Industry fixed effect</i>	Yes	Yes
<i>Province fixed effect</i>	Yes	Yes
<i>N</i>	9461	9461
<i>Adj.R²</i>	0.749	0.130
<i>Wald F statistic</i>	5620.165	

The t-statistics based on standard errors clustered at the firm level are reported in parentheses. The symbols ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

5. Conclusions and Discussion

We empirically examine the influence of the rising political costs caused by regional air quality fluctuations on firms' earnings management. The results indicate that when the air quality uncertainty grows, firms have a tendency to increase their degree of earnings management and are more willing to carry out downward earnings management. We also find that the relation is more obvious in the bottom ten cities of the air quality ranking. Further evidences show that the relation between air quality uncertainty and earnings management varies with macro and micro factors. The effect is more pronounced in less market-oriented regions, northern regions, manufacturing industries and firms with

high asset-liability ratio and high media attention. In addition, we find that the air quality uncertainty affects earnings management through the intermediary of government environmental investment. Our study advances the literature of policy effect of air pollution regulation and earning management. Consistent with the Action Plan, we use the air quality uncertainty as a proxy of the potential political risk in a region and explore the policy effect on the decision-making of managers. Comparing the absolute measure of air quality index in existing literature, the fluctuation measure indicates more political risks. Furthermore, we study the effect of political cost from environmental policy on firms' earning management. Our results find that the air quality uncertainty is an important influencing factor of earning management in the countries where strict air regulation laws are implemented.

According to our empirical results, two measures can be taken by the central government. First, our results prove the importance of strengthening air quality supervision from the perspective of earnings management, and we provide empirical evidence for the government to make environmental policies. Due to the huge differences in economic development and the natural environment, the central government should not only focus on the current air quality status, but should also pay more attention to the air quality changes. The "anti-driving" effect of the air quality ranking should also be fully used. The central government should incorporate environmental performance into the assessment of governance mechanisms and force the regions with lower air quality rankings and large changes to attach great importance to solidly promote comprehensive environmental governance. Second, the accounting information quality of firms decreases when facing the external environmental uncertainty. Central and local governments should pay full attention to the effect of air quality uncertainty on firms' accounting information and strengthen the regulations on firms in regions that have big air quality uncertainty.

There are some limitations in our study. First, consistent to Staszkievicz and Szelągowska [47], the cross-sectional method has the implicit assumption that model parameters are stable across firms and over time. Though we have controlled for the year, industry, and province fixed effect in our regressions and resolved this problem to a certain extent, this problem still exists. Second, compared to Chen et al. [48], our measure of air quality flattens the real effect of air quality. However, this problem does not affect our results, which show that air quality has a bigger effect on earning management than the current results. More accurate measurements can be used in future studies. Furthermore, an appropriate exogenous event is needed to study the effect of air quality uncertainty on earning management to get more reliable results on the air quality ranks in cities.

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Appendix A. Variable Definitions

<i>Variables</i>	<i>Definition</i>
$ DA $	The absolute value of the discretionary accruals, estimated by the Jones model and calculated from model (2) to model (4).
AQU	The air quality uncertainty lagged by one period, calculated using model (5) to model (7).
$Size$	Firm size as the natural logarithm of the firm's total assets measured at the end of the year.
Lev	The ratio of liabilities to assets.
Shr	The shareholding ratio of the largest shareholder.
$Growth$	The ratio of the increase in operating income to the operating income in the previous period.

<i>Capx</i>	Cash paid to purchase fixed assets, intangible assets and other long-term assets divided by total assets at the end of the period.
<i>Instshr</i>	The shareholding ratio of institutional investors
<i>SOE</i>	A firm is classified as an <i>SOE</i> (state-owned enterprise) if its ultimate controlling shareholder is a state government, and it is a non- <i>SOE</i> otherwise.
<i>Opinion</i>	A dummy variable that equals one if the audit opinion of the firm is a standard unqualified opinion, and zero otherwise
<i>Loss</i>	A dummy variable that equals one if the net profits are less than zero in the current year, and zero otherwise.
<i>Avloss</i>	A dummy variable that equals one if the ROE is greater than or equal to zero and less than 1%, and zero otherwise.
<i>GDP</i>	The <i>GDP</i> growth rate of the region.
<i>Marketization</i>	The marketization index of China's provinces.
<i>Solid</i>	Comprehensive utilization rate of industrial solid wastes.
<i>Refuse</i>	Decontamination rate of urban refuse
<i>Direc_DA</i>	A dummy variable that equals one if the accrued earnings management are less than zero, and zero otherwise.
<i>EI</i>	Government investment in environmental protection; the ratio of the total investment in industrial pollution control to the <i>GDP</i> of each province.
<i>AQU_Mean</i>	The instrumental variable of <i>AQU</i> , calculated by the mean <i>AQU</i> in the same province.
<i>Sub_city</i>	A dummy variable that equals one if the listed firm has no subsidiaries in other prefecture-level cities and zero otherwise

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