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**Article**

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## Does air pollution affect executive pay?

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### ABSTRACT

Senior talents are the source and driving force of sustained economic growth, so attracting and retaining senior talents is crucial to local economic development. From the perspective of senior talents – executives, using a sample of publicly traded A-share listed companies during 2005–2018 in China, we examine the impact of air pollution on executive compensation. We find that air pollution level is significantly and positively correlated with executive compensation. This effect is more prominent for firms have less bargaining power, firms where executives have more bargaining power and executives are younger. Further studies show that air pollution inhibits the accumulation of local executive talent. Finally, adjusting executive compensation according to air pollution levels can improve future firm performance. All in all, from the perspective of listed firms' decision makers, this paper enriches and expands the literature about economic outcomes of air pollution and further reveals the micro mechanism of air pollution negatively influencing macro economic development, providing the empirical evidence for local government policy making of talent introduction, improving the environmental governance capacity and finally promoting high quality economic development.

### KEYWORDS

Air pollution; executive compensation; human capital; executive incentive

## 1. Introduction

Over the past 40 years of reform and opening-up, China's economic development has made remarkable achievements. However, the extensive economic growth model in the past has led to increasingly serious environmental problems, which seriously restricts the healthy and sustainable development of China's economy. In this context, it is very important to seek harmony between economic development and environmental protection. Studies have shown that air pollution can have negative effects, such as reducing individual decision-making efficiency (Dong et al., 2019; Song & song, 2018), curbing corporate research and development investment (Luo, Xu et al., 2019) and innovation output (Luo, Yang et al., 2019), and reducing business productivity (Fu et al., 2017; Li & Zhang, 2019), inhibiting regional economic development (Chen & Chen, 2018; Hanlon, 2016). Although there are lots of research on the economic consequences of air pollution, less literature studies the economic consequences of air pollution from the perspective of

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micro-business decision makers. As the overall strategy of the framer and implementer, the importance of executives to the development of the enterprise is self-evident. Meanwhile, executives belong to the senior talents in the society, and senior talents are the driving force for sustained economic growth. Therefore, studying the impact of air pollution on firm executives will not only help us to understand more deeply how air pollution affects micro-enterprise decision-making, but also help us to identify the mechanisms through which air pollution affects macroeconomics.

Effective compensation contract is an effective way to motivate managers to work hard and achieve the harmony between managers and shareholders' interests (Holmstrom, 1979; Mirrlees, 1976). Therefore, given the importance of compensation arrangements to firms and executives, this paper examines whether and how air pollution affects executive pay. Economics considers living environment, prestige and social status to be important non-monetary gains for managers (Jensen & Murphy, 1990), and ignoring the effects of non-monetary gains can seriously distort our understanding of executive compensation contracts (Mathios, 1989), which in turn affects the design of effective compensation contracts. The air in the natural environment is closely related to people's life, and its quality largely determines people's satisfaction with their living environment, so air quality is also an important non-monetary benefit, which will also affects executive pay. When poor air harms executives' physical and mental health, executives have an incentive to demand higher pay from companies, and companies have an incentive to pay higher salaries to retain and motivate executives.

Based on the perspective of micro-enterprise decision makers, this paper examines how local air pollution affects executive pay, taking 2005–2018 as a research sample for China's A-share listed companies. We find that air quality is an important non-monetary gain for executives, and that it is a substitute for executive monetary compensation. Specifically, companies pay significantly higher salaries to executives working in areas with higher air pollution than executives working in areas with lower air pollution, indicating that the company pays executives a premium for air pollution. Furthermore, this conclusion is more pronounced in firms with less bargaining power, firms where executives are more bargaining power, and firms where senior executives are junior. Further research shows that air pollution reduces the attractiveness of senior talent and inhibits the accumulation of local senior talent (as shown by the lower probability of foreign executives and overseas executives working in local companies), but increased executive pay can mitigate the negative impact of air pollution on the accumulation of senior talent. Finally, adjusting executive pay to changes in air pollution is conducive to improving the company's performance.

The main contribution of this paper are as follows. First, from the perspective of senior talents, it enriches the study of the economic consequences of air pollution. Prior literature focuses on how air pollution affects regional economic growth (Chen & Chen, 2018; Hanlon, 2016; Li & Zhang, 2019), labour mobility (Sun et al., 2019; Xue et al., 2019), enterprise innovation (Luo, Xu et al., 2019; Luo, Yang et al., 2019), less attention is paid to examine how air pollution affects executives. This paper not only pays attention to the possible influence of air pollution on executive compensation, but also analyzes its mechanism from the perspective of enterprise characteristics and executive characteristics, which provides empirical evidence for people to better understand how air pollution affects micro-individuals. Second, from the perspective of external natural

environment factor, it provides a new perspective and empirical evidence for the study on the factors of executive compensation. Based on the principal-agent theory, the existing literature mainly focuses on how the financial characteristics of the company (Firth et al., 2006; X. Wang & He, 2012), corporate governance (Ang et al., 2000; Zheng et al., 2012), executive features (Hill & Phan, 1991; S. Li et al., 2015) and other factors affect executive compensation. This paper examines how air pollution affects executive pay, expanding the relevant literature on the factors of executive compensation. Third, this paper has a certain policy reference significance. The conclusion of this paper shows that air pollution not only increases the labour cost of local enterprises, but also inhibits the accumulation of local human capital. This paper reveals an important mechanism through which air pollution affects negatively economic development from the micro-enterprise level, and provides empirical evidence for our government to further improve their environmental management capacity so as to achieve high-quality economic development. The enlightenment of this paper is that, in addition to implementing the talent introduction policy, local governments can also promote local economic development by improving local air quality and creating a good living environment to attract senior talents.

## 2. Literature review and hypothesis development

### 2.1. Literature review

Early studies have focused on the effects of air pollution on human health, for example, medical studies have shown that air pollution increases the prevalence of respiratory diseases, central nervous system diseases, and cancer (Y. Lu et al., 2015; Seaton et al., 1995), which may even increase regional mortality and shorten life expectancy (Y. Chen et al., 2013). Moreover, exposure to polluted air reduces people's subjective well-being and mental health, leading to mental illness (Chen et al., 2018; Heyes et al., 2016; Vert et al., 2017; Zhang et al., 2017), making people anxious and depressed and develops idle behaviour (Fehr et al., 2017; J. G. Lu et al., 2018).

Following the above studies, more and more literature began to pay attention to the economic consequences of air pollution. At the macro level, air pollution inhibits local job growth (Hanlon, 2016), slows urbanisation and undermines the accumulation of human capital (Chen & Chen, 2018), thereby curbing local economic growth.

At the micro level, based on the theory that air pollution will harm the physical and mental health of micro-individuals, the existing literature mainly studies the effects of air pollution on labour supply, enterprise productivity and individual decision-making. On the labour supply side, based on the reduction in sulphur dioxide emissions due to the closure of Mexican refineries, Hanna and Oliva (2015) found that improved air quality can increase workers' working hours. In terms of corporate productivity, the study found that air pollution reduces productivity because air pollution harms workers' physical and mental health and thus reduces their productivity (Fu et al., 2017), reduces labour supply (Li & Zhang, 2019), reduces corporate R&D (Luo, Xu et al., 2019) and inventors' innovative output (Luo, Yang et al., 2019).

Other literature focuses on how air pollution affects individual decision-making. For example, air pollution affects the auditor's cognitive abilities and mood, which in turn reduces audit quality (Song & Song, 2018). Air pollution can also negatively affect analyst behaviour, such as reducing analyst optimism (Dong et al., 2019) and the timeliness and accuracy of analyst earnings forecast revisions (Li et al., 2020). In addition, air pollution can also lower investor returns on stocks through investor sentiment (Heyes et al., 2016; Wu et al., 2018). The damage caused by air pollution can also increase turnover among executives and highly qualified employees (Levine et al., 2018; Wang et al., 2020; Xue et al., 2019), increase the labour cost of enterprises (Shen et al., 2019), and reduce corporate performance (Xue et al., 2019).

## 2.2. Hypothesis development

Executive compensation contract is a compensation system arrangement made by shareholders to motivate and restrain executives. Effective compensation contract can alleviate conflicts of interest between shareholders and executives, finally improving the company's operating performance (Core et al., 1999; Jackson et al., 2008; Murphy, 1985). In real life, however, a contract that is valid under any circumstances does not exist, and its effectiveness is affected by incentive issues (Holmstrom, 1979; Ittner et al., 1997; K. Wang & Xiao, 2011). Therefore, effective compensation contracts need to be constantly adjusted according to the actual situation. Air is one of the necessary natural conditions for human survival, and its quality will affect the cost-benefit of executives, which will affect the effective incentive of the original salary level to the executives. The impact of air pollution on executive pay has two aspects.

From executives' point of view, senior managers are more motivated and able to demand higher pay from companies than general employees in the face of air pollution. First, in terms of motivation, executives are more concerned about non-monetary gains such as living conditions. Therefore, they are more motivated to demand a pay premium. Economics considers living environment, prestige and social status to be important non-monetary gains for managers (Jensen & Murphy, 1990). Executives typically earn more than general employees, and executives tend to care more about quality of life after they meet basic living needs. Studies have shown that air pollution increases the prevalence of respiratory diseases, central nervous system diseases, and diseases such as cancer (Y. Lu et al., 2015; Seaton et al., 1995), and even shortens life expectancy in the long run (Y. Chen et al., 2013). At the same time, exposure to contaminated air can affect negatively mood and induce mental illness (S. Chen et al., 2018; Heyes et al., 2016; Vert et al., 2017), and reduce people's subjective well-being and mental health (Levinson, 2012; Zhang et al., 2017). As a result, air pollution can make life worse, which in turn reduces executive non-monetary returns. According to rational people's assumptions, the different proportions of the combination of air quality and monetary compensation constitutes a non-difference curve tilted to the bottom right. Executives seek a balance between non-monetary gains such as air quality and monetary compensation to maximise their utility. When executives' non-monetary earnings fall, they need to increase monetary compensation to maintain their current utility levels. As a result, when air quality drops, executives demand higher

monetary pay. Second, in terms of ability, senior managers own more bargaining power in the labour market and thus are able to claim higher pay. Senior managers are senior talents, often with highly educated, highly skilled and competent characteristics. They have more job opportunities in the labour market, and therefore more bargaining power in the process of salary contract formulation. Moreover, executives have higher positions in the company than general employees and are better able to use their power to influence their pay. Thus, from executives' point of view, when air pollution increases, executives are not only more motivated to demand a pay premium, but also better able to achieve their goals.

From a corporate perspective, companies also have incentives to offer executives a pay premium for air pollution. Senior managers are responsible for the formulation and implementation of the company's strategy, which is very important to the survival and development of the enterprise. Whether the executive can be effectively motivated is related to the realisation of the goal of maximising shareholder value. Therefore, it is necessary for companies to incorporate non-monetary gains such as air quality into executive compensation contracts. The reasons are as follows. First, air pollution reduces non-monetary returns of executives and discourages them from working hard. Increased air pollution can harm executives' physical and mental health. When other conditions such as monetary compensation remain unchanged, executives' enthusiasm for hard work decreases, resulting in a decline in work efficiency. For example, Fu et al. (2017) found that air pollution reduced worker productivity. In order to motivate executives to continue their efforts, companies must pay higher salaries to compensate for the loss of non-monetary gains caused by air pollution. Second, air pollution may lead to the loss of existing executive talent. Studies have shown that air pollution can cause highly skilled people such as inventors to flow out (Luo, Yang et al., 2019). Given the increased emphasis on non-monetary benefits such as quality of life and greater job-choice skills, executives are likely to find another job if they fail to make up for the damage caused by air pollution timely. Executive turnover may affect the development of the original business activities of the enterprise, and even cause the loss of corporate customers and business performance decline. Therefore, in order to retain highly skilled personnel, it is necessary for enterprises to pay a pay premium to senior executives. Third, air pollution reduces the supply of local executive talent and reduces the bargaining power of companies in the managers' market. Sun et al. (2019) found that air pollution will harm the health of workers, and have significantly negative impact on labour employment location. According to Maslow's hierarchy of demand theories, higher-income executives are more concerned with physical health and less willing to work in areas with high levels of air pollution, reducing the supply of highly skilled people. In the case of the demand for executive talent unchanged, the bargaining power of enterprises in the manager's market becomes weaker. In order to recruit and retain good senior managers, companies need to offer higher levels of compensation. As a result, from a corporate perspective, air pollution can also lead companies to pay executives more. Based on the above analysis, our first hypothesis is as follows:

**Hypothesis 1. *Caeteris paribus*, firms in areas with poor air quality pay higher salaries to executives.**

### 3. Research design

#### 3.1. Empirical model

In order to examine how air pollution affects executive compensation, we construct model (1) for multiple regression analysis.

$$\begin{aligned} CEOpay_{i,t+1} = & \beta_0 + \beta_1AQI_{i,t} + \beta_2Size_{i,t} + \beta_3Lev_{i,t} + \beta_4Growth_{i,t,t} + \beta_5Roa_{i,t} \\ & + \beta_6Age_{i,t} + \beta_7Soe_{i,t} + \beta_8Top1_{i,t} + \beta_9Board_{i,t} + \beta_{10}Indep_{i,t} \\ & + \beta_{11}Insshare_{i,t} + \beta_{12}CEOage_{i,t} + \sum Firm + \sum Year + \varepsilon_{i,t+1} \end{aligned} \quad (1)$$

Following Yang et al. (2014), Cu and Li (2015), executive compensation(CEOpay) equals to the natural logarithm of the CEO's total annual compensation, including annual salary and allowance.

Following Li and Zheng (2016), air pollution(AQI) is the main explanation of variable, which equals the natural value of the city air quality index. Air pollution levels can be divided into six levels according to the air quality index: excellent (0–50), good (50–100), mild pollution (100–150), moderate pollution (150–200), severe pollution (200–300) and heavy pollution (300 or more). The higher AQI value means more serious air pollution in the area.

Following existing research (Jiang et al., 2014; Xin et al., 2007), we also control a number of other variables that affect executive compensation in the model, including firm size, financial leverage, sales growth, profitability. In addition, we also include firm and year fixed effects to control for any omitted firm- and time-invariant factors that affect executive compensation. We expect  $\beta_1$  to be significantly positive, that is, air pollution will make firms pay higher salaries to executives. The definition of specific variables is detailed in Table 1.

#### 3.2. Data and sample

Considering that data on executive characteristics and property right of listed companies has only been disclosed in detail since 2004, our sample period is from 2005 to 2018. We obtain air quality index data from the National Urban Air Quality Daily, and executive compensation and other financial data of listed companies from the CSMAR database. We

**Table 1.** Variable definitions.

Variables	Definition
<i>CEOpay</i>	The natural logarithm of the CEO's total annual compensation, including annual salary and allowance.
<i>AQI</i>	The natural logarithm of the urban air quality index, and higher AQI value means more serious air pollution in the area.
<i>Size</i>	The natural logarithm of the market value of the company.
<i>Lev</i>	Total liabilities divided by total assets.
<i>Growth</i>	One-year percentage growth in sales.
<i>Roa</i>	Net profit divided by total assets.
<i>Age</i>	The natural logarithm of the company's year of listing.
<i>Soe</i>	A dummy variable that equals one if a firm is state-owned, and 0 otherwise.
<i>Top1</i>	The proportion of the largest shareholder' shareholding.
<i>Board</i>	Number of board members at the end of the year.
<i>Indep</i>	The number of independent directors divided by the total number of directors.
<i>Insshare</i>	The number of shares held by institutional investors divided by the number of common shares.
<i>CEOage</i>	The natural logarithm of CEO age.

**Table 2.** Descriptive statistics.

VARIABLES	N	MEAN	SD	MIN	P25	P50	P75	MAX
<i>CEOpay</i>	20,213	13.133	0.824	10.800	12.700	13.100	13.600	15.300
<i>AQI</i>	20,213	4.335	0.295	3.710	4.150	4.320	4.500	5.130
<i>Size</i>	20,213	22.567	1.140	20.300	21.800	22.500	23.200	26.000
<i>Lev</i>	20,213	0.445	0.207	0.051	0.281	0.446	0.605	0.883
<i>Growth</i>	20,213	0.226	0.542	-0.564	-0.006	0.129	0.305	3.870
<i>Roa</i>	20,213	0.044	0.053	-0.142	0.015	0.038	0.070	0.211
<i>Age</i>	20,213	2.188	0.687	0.660	1.700	2.300	2.770	3.210
<i>Soe</i>	20,213	0.459	0.498	0.000	0.000	0.000	1.000	1.000
<i>Top1</i>	20,213	0.359	0.152	0.090	0.238	0.339	0.468	0.749
<i>Board</i>	20,213	8.861	1.797	5.000	8.000	9.000	9.000	19.000
<i>Indep</i>	20,213	0.369	0.052	0.286	0.333	0.333	0.400	0.571
<i>Insshare</i>	20,213	0.193	0.199	0.000	0.034	0.120	0.302	0.777
<i>CEOage</i>	20,213	3.869	0.133	3.497	3.784	3.871	3.970	4.159

further screen our sample using the following criteria: i) excluding financial insurance industry companies; ii) deleting ST, PT company samples; iii) deleting samples with asset liability ratio greater than 1 and with missing financial data; iv) firms that do not pay CEO compensation were excluded. In order to overcome the influence of extreme values, all continuous variables in the model are winsorised at 1th and 99th percentiles.

### 3.3. Descriptive statistics

Table 2 shows the descriptive statistics for the main variables in model (1). As can be seen from the table, the mean and median of CEOpay (natural logarithm of executive compensation) are 13.133 and 13.100, respectively, and the standard deviation is 0.824, indicating that the distribution of executive compensation is basically in line with the normal distribution. The mean and median of AQI is 4.335 (i.e. air quality index is 79.865) and 4.320 (i.e. air quality index is 74.922), respectively, reaching the secondary standard of the national daily air quality. The standard deviation of AQI is 0.295, which is relatively reasonable. The descriptive statistics of AQI is consistent with Li and Zheng (2016), Luo, Yang et al. (2019).

### 3.4. Correlation analysis

Table 3 presents the correlations among the variables in model (1). Most of the correlation coefficients between the control variables are below 0.4, indicating that there is no serious multi-collinearity problem in model (1). Although air pollution(AQI) is negatively correlated with executive compensation(CEOpay), the factors such as the company's inherent characteristics, regional environment and time trends have not yet been considered in the model, pending further multiple regression analysis below.

## 4. Empirical results

### 4.1. The impact of air pollution on executive pay

In order to examine how local air pollution affects executive pay of local listed companies, we estimate the model (1), in which the explanatory variable is executive compensation(CEOpay) and the explanatory variable is air pollution(AQI). The empirical results are



Table 3. Correlation coefficient matrix.

VARIABLES	CEOpay	AQI	Size	Lev	Growth	Roa	Age	Soe	Top1	Board	Indep	Insshare	CEOAge
CEOpay	1.000												
AQI	-0.067*	1.000											
Size	0.445***	0.060***	1.000										
Lev	0.010	0.026***	0.336***	1.000									
Growth	0.043***	-0.029***	0.048***	0.057***	1.000								
Roa	0.246***	-0.030***	0.103***	-0.370***	0.186***	1.000							
Age	0.091***	0.024***	0.350***	0.370***	-0.011	-0.201***	1.000						
Soe	-0.080***	0.060***	0.201***	0.290***	-0.056***	-0.147***	0.385***	1.000					
Top1	-0.041***	0.039***	0.148***	0.073***	0.019***	0.077***	-0.081***	0.241***	1.000				
Board	0.026***	0.022***	0.173***	0.167***	-0.024***	-0.019***	0.096***	0.280***	0.032***	1.000			
Indep	0.035***	-0.022***	0.065***	-0.033***	0.009	-0.006	-0.040***	-0.101***	0.026***	-0.433***	1.000		
Insshare	0.235***	-0.037***	0.305***	-0.017**	0.032***	0.120***	0.104***	0.019***	0.072***	0.008	0.016**	1.000	
CEOAge	0.134***	0.028***	0.166***	-0.003	-0.042***	0.015**	0.068***	0.081***	0.023***	0.026***	0.040***	0.112***	1.000

注：\*、\*\*和\*\*\*分别表示10%、5%和1%显著性水平

shown in Table 4. Specifically, in order to examine the direct impact of air pollution on executive compensation, in Column (1) we only control the firm-year fixed effect. As can be seen from Column (1), the estimated coefficient on AQI is significant and positive (0.089,  $t = 2.70$ ), indicating that listed companies in cities with higher levels of air pollution pay their executives more than listed companies with lower levels of air pollution. To further verify the reliability of the conclusion, we added a number of control variables affecting executive compensation in Column (2), and found that the estimated coefficient on AQI is still significant and positive (0.095,  $t = 2.97$ ). The economic implication is that when air pollution level increases by 1%, executive pay will increase by 0.095%. In this sample, 1th and 99th percentiles of air quality index are 40 and 169, respectively. Thus, *caeteris paribus*, an increase of 322% in areas with extremely poor air quality (indices 169) than in areas with extremely good air quality (index 40) will result in a 30.59% increase in executive pay ( $322 \times 0.095\%$ ). During the sample period, the average executive compensation of listed companies was 4.96 million yuan, and air pollution will increase the

**Table 4.** The impact of air pollution on executive pay.

VARIABLES	(1)	(2)	(3)
	CEOpay	CEOpay	CEOpay
<i>AQI</i>	0.089*** (2.70)	0.095*** (2.97)	
<i>AQI50_100</i>			0.041** (2.08)
<i>AQI100_150</i>			0.071*** (2.78)
<i>AQI150_</i>			0.079** (2.19)
<i>Size</i>		0.221*** (21.93)	0.220*** (21.88)
<i>Lev</i>		-0.096** (-2.55)	-0.097** (-2.55)
<i>Growth</i>		0.029*** (4.12)	0.029*** (4.16)
<i>Roa</i>		1.325*** (13.27)	1.326*** (13.28)
<i>Age</i>		-0.115*** (-5.23)	-0.115*** (-5.26)
<i>Soe</i>		-0.185*** (-7.32)	-0.187*** (-7.39)
<i>Top1</i>		0.083 (1.44)	0.085 (1.47)
<i>Board</i>		0.012*** (2.92)	0.012*** (2.90)
<i>Indep</i>		0.153 (1.31)	0.146 (1.25)
<i>Insshare</i>		0.007 (0.28)	0.008 (0.32)
<i>CEOage</i>		-0.000 (-0.01)	0.000 (0.00)
<i>Constant</i>	13.154 (93.52)	8.176*** (26.56)	8.556*** (31.29)
<i>Firm</i>	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes
<i>N</i>	20213	20,213	20,213
<i>Adj. R<sup>2</sup></i>	0.18	0.22	0.22

The numbers in parentheses are the t-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

average executive pay of listed companies by 1.52 ( $4.96 \times 30.59\%$ ) million yuan. By the end of 2018, there were 3,587 A-share listed companies, and it is roughly estimated that extreme changes in air quality may result in changes in executive compensation of listed companies totalling 5.45 ( $3587 \times 1.52/1000$ ) billion yuan.

We also examine the impact of air pollution in different levels on executive pay. We divide the air pollution level into four categories: excellent (0–50), good (50–100), mild pollution (100–150), moderate pollution and above (150 or more), and set up 3 dummy variables AQI50\_100, AQI100\_150, AQI150\_. For variable AQI50\_100, when the air quality index is between 50–100, the value is 1, otherwise 0, and the other three variables are defined in the same way. In Column (3) of Table 4, we replace the continuous variable AQI in model (1) with three dummy variables AQI50\_100, AQI100\_150, AQI150, and we find that the coefficients of the three variables are significant and positive, and gradually increase with air pollution level. The results further confirm that local listed companies pay more to executives as air pollution levels increase. Table 4 supports hypothesis 1 of this paper: *caeteris paribus*, serious air pollution makes listed firms offer higher executive compensation.

## 4.2. Robustness test

### 4.2.1. Endogenous problem

In view of the fact that it is difficult for listed companies to affect the local ecological environment, local air pollution is largely exogenous to local company itself. Moreover, the air is fluid and local air pollution may not be local, so local air pollution may not be related to the local economic development (Shen et al., 2019). Therefore, the conclusion of this paper is less disturbed by endogeneity problem. However, in order to alleviate the omitted problems, we solve them by constructing instrumental variable using two-stage estimation method. Following existing studies (Chen & Chen, 2018; Sun et al., 2019), we use the ventilation coefficients as a instrumental variable for air pollution. The instrumental variable depends on the city's wind speed and the height of the planetary boundary layer, both of which are determined by meteorological conditions and geographic conditions, and are not directly related to executive compensation in the region. Therefore, ventilation coefficients can satisfy the exogenous assumptions of the instrumental variable. Higher ventilation coefficient means stronger air flow, and then local air pollution can be alleviated, thus making ventilation coefficients meet the correlation hypothesis of instrumental variable.

Specifically, the natural logarithm of ventilation coefficients (VC) is used as the instrumental variable for air pollution in this paper. Column (1)–(2) of Table 5 reports the regression results. We can find that the instrumental variable VC is significantly and negatively correlated with AQI in the first stage in Column (1). In the second stage in Column (2), the coefficient on AQI is still significantly positive, that is, air pollution is positively correlated with executive pay, which indicates that the conclusions of this paper are sound even when the effects of endogenous problems are taken into account<sup>1</sup>

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<sup>1</sup>This article also uses the scenario of executive change for further analysis and finds that executive pay increases significantly when executives work in areas with poorer air quality, further supporting the conclusions of this article.

**Table 5.** The impact of air pollution on executive pay: robustness test.

VARIABLES	(1)	(2)	(3)	(4)
	first stage	second stage	<i>Tpay</i>	<i>Pay1</i>
VC	-0.125*** (-64.79)			
AQI		0.089*** (3.89)	0.113** (2.26)	0.078*** (3.52)
Size	0.008*** (3.94)	0.217*** (21.17)	0.234*** (14.80)	0.246*** (35.22)
Lev	-0.000 (-0.00)	-0.102*** (-2.65)	-0.080 (-1.34)	-0.114*** (-4.31)
Growth	-0.009*** (-2.94)	0.027*** (3.78)	0.059*** (5.34)	0.026*** (5.39)
Roa	0.017 (0.45)	1.301*** (12.74)	1.958*** (12.46)	1.162*** (16.73)
Age	-0.005* (-1.74)	-0.098*** (-4.44)	-0.576*** (-16.69)	-0.135*** (-8.89)
Soe	0.042*** (10.52)	-0.182*** (-7.07)	-0.258*** (-6.49)	-0.116*** (-6.61)
Top1	0.028** (2.49)	0.096 (1.62)	0.199** (2.18)	0.009 (0.22)
Board	-0.002** (-2.29)	0.013*** (3.10)	0.011 (1.62)	0.008*** (2.86)
Indep	-0.212*** (-6.13)	0.154 (1.30)	0.458** (2.50)	0.056 (0.69)
Insshare	-0.022** (-2.30)	0.016 (0.60)	0.544*** (13.10)	-0.053*** (-2.90)
CEOage	0.040*** (3.21)	-0.005 (-0.12)	0.147** (2.31)	0.060** (2.15)
Constant	4.903*** (80.26)	8.001*** (29.38)	7.922*** (16.35)	8.692 (40.59)
Firm	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Weak instrumental variable test	F = 5170.68	-	-	-
N	19424	19,424	20,213	20,213
Adj. R <sup>2</sup>	0.45	0.23	0.10	0.50

The numbers in parentheses are the t-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

#### 4.2.2. Other robustness tests

In order to enhance the robustness of the conclusions of this paper, we also use other ways to measure executive compensation. Following Lin and Su (2011), we calculate the total CEO compensation to measure executive compensation according to formula (2):

$$Tpay = Cpay + Spay = Cpay + 0.01 \times Price \times Share \quad (2)$$

Where *Tpay* represents CEO's total compensation; *Cpay* represents CEO's annual monetary compensation; *Spay* represents the equity compensation. Price is the closing price of the company's stock at the end of the year and Share is the number of shares held by the CEO at the end of the year. We replace *CEOpay* with the natural logarithm of *Tpay* in model (1), and the regression results are shown in Column (3) of Table 5. We can find that the coefficient on AQI is significant and positive, indicating that even when equity compensation is taken into account, air pollution is still significantly positively correlated with executive compensation consistent with the previous conclusions.

Following Xin et al. (2007) and Fang (2011), we also measure executive compensation by the natural logarithm of the total compensation of the top three highest-paid executives (Pay1) disclosed by the company and the results are shown in Column (4) of Table 5. The results show that the coefficient on AQI is also significant and positive, consistent with the previous conclusions. The results in Column (3)-(4) of Table 5 show that the positive correlation between air pollution and executive compensation is robust and less affected by how executive compensation is measured.

### 4.3. Heterogeneity analysis

#### 4.3.1. Company's bargaining power

The previous conclusions suggest that companies tend to pay higher salaries to retain and motivate existing executives in order to compensate for the negative impact of air pollution on executives' physical and mental health. However, the motivation and ability of listed companies to pay this compensation premium is affected by their bargaining power. When enterprises are in a more competitive industry, the demand for senior talents is bigger and thus talent is scarce. Then the company bargaining power is weaker and its motivation to pay a pay premium due to air pollution will be stronger. We examine how the bargaining power of a company affects the relationship between air pollution and executive compensation from the perspective of product market competition. We expect that when a company operates in a more competitive industry, its bargaining power is weaker and at this time it is more motivated to pay a pay premium to attract and retain senior talent.

We use the Herfindahl Index (HHI) of the company's industry to measure the degree of product market competition, and then divide the sample into two subsamples based on the median value of HHI and estimate model (1) separately for both subsamples. The results are shown in Table 6. As can be found from Table 6, the coefficient on AQI is not significant in the 'High' subsample (0.040,  $t = 0.97$ ), but significant and positive in the 'Low' subsample (0.160,  $t = 3.03$ ). The results of Table 6 show that when companies operate in a more competitive industry, they rely more on senior talent, have less bargaining power and pay more for air pollution.

#### 4.3.2. Executive bargaining power

From the executive's point of view, we continue to examine how executive characteristics affect the relationship between air pollution and executive compensation. Highly skilled talents have more job opportunities in the labour market and are therefore more bargaining power than low-skilled talents. As a result, highly skilled talents have the ability to make companies pay higher salary premiums in the face of air pollution. Following Du and Peng (2017), we use executive education background (Edu) to measure executive bargaining power. We divide executive education background into five categories: high school education, associate degree, bachelor degree, master degree and doctor degree, and Edu equals to 1, 2, 3, 4, 5, respectively. According to the median value of Edu, our sample is divided into two subsamples. We re-estimate model (1) separately for both subsamples and results can be found in Table 7. It can be found that the coefficient on AQI is significant and positive in the 'High' subsample (0.143,  $t = 3.14$ ), indicating that executive bargaining power reinforces the positive correlation between air pollution and executive pay.

**Table 6.** Heterogeneity analysis: the effect of company's bargaining power.

VARIABLES	(1)	(2)
	High	Low
	<i>CEOpay</i>	<i>CEOpay</i>
<i>AQI</i>	0.040 (0.97)	0.160*** (3.03)
<i>Size</i>	0.229*** (16.68)	0.165*** (9.50)
<i>Lev</i>	-0.050 (-0.96)	-0.142** (-2.33)
<i>Growth</i>	0.042*** (4.87)	0.013 (1.04)
<i>Roa</i>	0.914*** (6.61)	1.481*** (9.77)
<i>Age</i>	-0.176*** (-6.01)	-0.059 (-1.49)
<i>Soe</i>	-0.172*** (-4.68)	-0.186*** (-4.53)
<i>Top1</i>	0.281*** (3.37)	-0.106 (-1.11)
<i>Board</i>	0.011* (1.92)	0.019*** (2.79)
<i>Indep</i>	0.170 (1.09)	0.328* (1.72)
<i>Insshare</i>	-0.034 (-0.98)	0.053 (1.22)
<i>CEOage</i>	-0.109** (-2.01)	0.024 (0.35)
<i>Constant</i>	8.723*** (21.05)	8.891*** (16.99)
<i>Firm</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>N</i>	11574	8639
<i>Adj. R<sup>2</sup></i>	0.11	0.16

The numbers in parentheses are the t-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

#### 4.3.3. Executive qualifications

Air pollution not only causes real harm to people's health (Y. Chen et al., 2013), but also lowers people's living satisfaction (Zhang et al., 2017) and the quality of life. As a result, executives have a trade-off between the non-monetary losses caused by air pollution and the material benefits of monetary compensation. Executives with higher qualifications are already able to earn higher pay, and monetary compensation is less attractive for them. Thus, we expect that air pollution has a greater impact on the compensation of executives with lower qualifications.

In general, when an executive is older, he has accumulated more work experience and social relationships, and his or her qualifications are deeper. We employ CEO age to measure executive qualifications and divide the sample into two subsamples based on the median value of CEO age. We report results in Table 8. We find that the coefficient on AQI is significant and positive in the subsample with young CEO

**Table 7.** Heterogeneity analysis: the effect of executive bargaining power.

VARIABLES	(1)	(2)
	High	Low
	<i>CEOpay</i>	<i>CEOpay</i>
<i>AQI</i>	0.143*** (3.14)	0.050 (1.09)
<i>Size</i>	0.215*** (15.19)	0.211*** (13.66)
<i>Lev</i>	-0.034 (-0.62)	-0.119** (-2.10)
<i>Growth</i>	0.026** (2.54)	0.021** (2.20)
<i>Roa</i>	1.409*** (9.97)	1.158*** (7.93)
<i>Age</i>	-0.132*** (-4.18)	-0.160*** (-4.92)
<i>Soe</i>	-0.160*** (-4.18)	-0.171*** (-4.52)
<i>Top1</i>	-0.083 (-0.97)	0.159* (1.81)
<i>Board</i>	0.021*** (3.51)	0.008 (1.27)
<i>Indep</i>	0.051 (0.32)	0.388** (2.20)
<i>Insshare</i>	0.047 (1.27)	-0.035 (-0.89)
<i>CEOage</i>	0.053 (0.80)	-0.037 (-0.62)
<i>Constant</i>	7.904*** (17.59)	8.750*** (18.75)
<i>Firm</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>N</i>	10681	9532
<i>Adj. R<sup>2</sup></i>	0.16	0.13

The numbers in parentheses are the t-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

(0.141,  $t = 2.94$ ), but insignificant in the subsample with old CEO. The results suggest that the relationship between air pollution and executive pay is influenced by the attractiveness of monetary pay to executives.

#### 4.4. Further analysis

##### 4.4.1. The impact of air pollution on the accumulation of executive talent

We argue that air pollution can restrain the accumulation of senior talents by reducing living attractiveness to senior talents. With the supply of local senior talents reducing, companies have to pay more to retain or attract executives. In order to better understand the mechanism through which air pollution affects executive compensation, we further investigate the impact of air pollution on the accumulation of executive talents. Following Xue et al. (2019), we measure executive talent accumulation by whether executives were from other provinces (*Exprov\_ceo*) or had overseas background (*Oversea\_ceo*).

**Table 8.** Heterogeneity analysis: the effect of executive qualifications.

	(1) old CEO	(2) young CEO
	<i>CEOpay</i>	<i>CEOpay</i>
<i>AQI</i>	0.023 (0.49)	0.141*** (2.94)
<i>Size</i>	0.206*** (12.39)	0.205*** (14.03)
<i>Lev</i>	-0.085 (-1.38)	-0.019 (-0.35)
<i>Growth</i>	0.031*** (2.85)	0.025*** (2.61)
<i>Roa</i>	1.257*** (8.04)	1.307*** (9.25)
<i>Age</i>	-0.107*** (-3.02)	-0.146*** (-4.45)
<i>Soe</i>	-0.253*** (-5.96)	-0.120*** (-3.42)
<i>Top1</i>	0.260*** (2.66)	0.015 (0.17)
<i>Board</i>	-0.002 (-0.30)	0.026*** (4.25)
<i>Indep</i>	-0.131 (-0.72)	0.350** (2.05)
<i>Insshare</i>	0.020 (0.52)	-0.000 (-0.00)
<i>Constant</i>	8.984*** (20.91)	8.217*** (20.57)
<i>Firm</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>N</i>	10028	10,185
<i>Adj. R<sup>2</sup></i>	0.01	0.18

The numbers in parentheses are the t-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

Specifically, when a CEO's birthplace or native place is in a province different from province where the company is registered, *Exprov\_ceo* is set to 1, and 0 otherwise. When a CEO has overseas learning or work experience, *Oversea\_ceo* is set to 1, and 0 otherwise. We estimate a logit model with *Exprov\_ceo* and *Oversea\_ceo* as the dependent variables, respectively, in Column (1)-(2) of Table 9. We find that the coefficient on *AQI* is significant and negative, that is, air pollution reduces the probability of outside executives and executives with overseas background to work in local companies, which shows that air pollution inhibits the accumulation of local senior talent, increases the difficulty of recruiting senior talent, and makes companies have to pay higher salaries.

Can higher pay mitigate the negative impact of air pollution on executive talent accumulation? We further examine how executive compensation affects the relationship between air pollution and the accumulation of executive talent, and the results are shown in Column (3)-(4) of Table 9. It can be found that the interaction coefficients on *AQI*×*CEOpay* are significant and positive, indicating that higher compensation can mitigate the negative impact of air pollution on the accumulation of executive talent,

**Table 9.** The impact of air pollution on the accumulation of executive talent.

VARIABLES	(1)	(2)	(3)	(4)
	<i>Exprov_ceo</i>	<i>Oversea_ceo</i>	<i>Exprov_ceo</i>	<i>Oversea_ceo</i>
<i>AQI</i>	-0.622*** (-8.36)	-0.236** (-1.98)	-0.679*** (-7.37)	-0.185 (-0.58)
<i>AQI</i> × <i>CEOpay</i>			0.277** (2.21)	0.356* (1.67)
<i>CEOpay</i>			0.201*** (4.32)	0.364*** (4.98)
<i>Size</i>	0.216*** (9.31)	0.289*** (6.90)	0.281*** (8.79)	0.246*** (5.54)
<i>Lev</i>	-0.174 (-1.37)	-0.914*** (-4.45)	-0.767*** (-2.71)	-1.173*** (-5.64)
<i>Growth</i>	0.076** (1.97)	0.024 (0.43)	0.221*** (7.58)	0.050 (0.85)
<i>Roa</i>	-1.823*** (-4.27)	-1.431** (-2.08)	-3.597*** (-5.87)	-1.701** (-2.30)
<i>Age</i>	0.202*** (5.73)	-0.364*** (-6.54)	0.089*** (2.62)	-0.351*** (-6.28)
<i>Soe</i>	0.053 (1.08)	-0.719*** (-7.48)	0.179*** (5.17)	-0.877*** (-8.77)
<i>Top1</i>	-0.186 (-1.39)	-0.190 (-0.79)	0.756*** (7.50)	-0.054 (-0.23)
<i>Board</i>	0.016 (1.29)	-0.048** (-2.05)	-0.033** (-2.12)	-0.061** (-2.52)
<i>Indep</i>	1.669*** (4.19)	1.501** (2.34)	1.283*** (3.98)	1.080 (1.57)
<i>Insshare</i>	-0.046 (-0.43)	0.407** (2.30)	-0.001 (-0.01)	0.419** (2.29)
<i>CEOage</i>	-0.241* (-1.71)	-1.328*** (-4.90)	-0.184 (-1.29)	-1.475*** (-5.41)
<i>Constant</i>	-2.273*** (-2.88)	-1.518 (-1.07)	-7.032*** (-8.78)	0.783 (0.49)
<i>Indcd</i>	Yes	Yes	Yes	Yes
<i>Year</i>	Yes	Yes	Yes	Yes
<i>N</i>	12677	17,437	12,677	17,437
<i>Pseudo. R<sup>2</sup></i>	0.05	0.07	0.06	0.10

The numbers in parentheses are the t(z)-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

increasing the probability of senior talent to work locally. The empirical results in [Table 9](#) show that companies need to pay higher salaries to motivate existing executives or attract external executives.

#### 4.4.2. An analysis of economic consequences

The above analysis suggests that companies will adjust executive pay according to the change of air pollution to compensate for the loss of non-monetary gains caused by air pollution and motivate executives to work hard. We further whether increasing executive pay will help alleviate the lack of incentives for executives and improve the company's future performance. We generate the dummy variable (*Match*) and *Match* is set to 1 if air pollution and the executive pay increases or decreases at the same time, otherwise 0. We report results in [Table 10](#). The dependent variables are the company's future performance measured by the return on total assets (*F\_roa*) in year  $t + 1$  and the return on net assets (*F\_roe*) in year  $t + 1$ , respectively. The main variable of interest is *AQI*×*Match* and we find

**Table 10.** An analysis of economic consequences.

VARIABLES	(1)	(2)
	<i>F_roe</i>	<i>F_ebit</i>
<i>AQI</i>	-0.004 (-0.57)	-0.015 (-0.35)
<i>AQI</i> × <i>Match</i>	0.010** (2.03)	0.066** (2.00)
<i>Match</i>	-0.003** (-2.09)	-0.025** (-2.37)
<i>Size</i>	0.008*** (3.73)	0.771 (53.63)
<i>Lev</i>	0.031*** (4.02)	0.365*** (6.95)
<i>Growth</i>	0.021*** (13.56)	0.185*** (17.70)
<i>Age</i>	-0.023*** (-5.08)	-0.322*** (-10.54)
<i>Soe</i>	-0.007 (-1.30)	-0.083** (-2.14)
<i>Top1</i>	0.039*** (3.10)	0.678*** (7.93)
<i>Board</i>	-0.002* (-1.77)	-0.005 (-0.86)
<i>Indep</i>	0.007 (0.30)	-0.248 (-1.52)
<i>Insshare</i>	0.043*** (7.72)	0.097*** (2.62)
<i>CEOage</i>	-0.013 (-1.48)	0.088 (1.54)
<i>Constant</i>	-0.030 (-0.52)	2.000*** (5.10)
<i>Firm</i>	Yes	Yes
<i>Year</i>	Yes	Yes
<i>N</i>	16529	15,017
<i>Adj. R<sup>2</sup></i>	0.05	0.45

The numbers in parentheses are the t-statistics. \*, \*\*, and \*\*\* represent significance at the 0.1, 0.05, and 0.01 levels, respectively.

that the interaction coefficients on *AQI*×*Match* were significant and positive, indicating that when air pollution increases, increasing executive compensation can help mitigate the negative impact of air pollution on executive, thereby improving company performance.

## 5. Conclusions

Air is one of the conditions on which human beings depend, and its quality will affect human health and life. With the continuous improvement of people's demand for quality of living environment, the environmental quality represented by air quality has gradually become an important factor affecting the flow of high-skilled talents, and the accumulation of senior talents is related to the high-quality development of regional economy. Based on this situation, we examine how city air pollution affects compensation of senior talents – executives.

Overall, we find companies pay significantly higher salaries to executives working in areas with low air pollution than executives working in areas with low air pollution, indicating that companies pay executives a pay premium because of air pollution. Furthermore, this conclusion is more pronounced when firms have less bargaining power,

when executives have more bargaining power, and when executives have less qualifications (younger CEO). Further research shows that air pollution inhibits the accumulation of local executive talent (executives from other provinces and executives with overseas experience are less likely to work in local companies), but increasing executive compensation can mitigate the negative impact of air pollution on executive talent accumulation. Finally, adjusting executive compensation according to the change of air pollution is conducive to improving the company's performance. In a word, from the perspective of micro-enterprise decision maker, we find that air pollution increases the cost of human capital and inhibits the accumulation of senior talents, which further reveals the micro-effect mechanism of air pollution negatively affecting macroeconomic development.

The implications of this paper are as follows. First, for policymakers, national and local institutions should develop more effective measures to fundamentally improve air pollution and thus promote high-quality economic development. It has become a consensus that air pollution has a negative impact on macroeconomic growth. Macroeconomic is composed of micro enterprises. Therefore, macroeconomic growth is inseparable from the development of micro enterprises. The company's executives are the leaders in the formulation and implementation of the company's strategy and play an important role in the company's operation and management. The conclusion of this paper shows that air pollution inhibits the accumulation of senior talents in the region, which is not conducive to the economic development of enterprises and regions. Therefore, policy makers should pay attention to the negative impact of air pollution on senior talents, and seek ways and means to fundamentally improve environmental pollution.

Second, from the point of view of talent introduction, local governments should formulate measures to improve local air quality and create a good living environment to attract the influx of senior talents. The key to regional economic development depends on the local ability to attract and retain talent. With the increase of people's income level, people pay more attention to physical health and local living environment, especially high-skilled people. Therefore, in addition to implementing the higher cost of talent introduction policy, local governments can also improve air quality to create a comfortable living environment to attract talent, and the influx of talent will promote the growth of the local economy which can make up for the economic costs of environmental protection, and ultimately achieve the harmonious unity of economic growth and environmental protection.

Third, for enterprises, enterprises should improve the working environment of employees, and pay more salary to employees suffering from worse air pollution. Poor air quality not only harms employees' physical and mental health, but also reduces their motivation to work and ultimately lowers firm value. The conclusion of this paper shows that adjusting executive compensation according to air pollution is beneficial to improving the performance of enterprises. Therefore, companies should realise that higher air quality is a non-monetary benefit to employees, and should pay higher wages for employees suffering from worse air pollution to motivate them to work hard. At the same time, we also find that air pollution will inhibit the incentive of local senior talent, and thus increase the cost of enterprise talent recruitment. Therefore, enterprises should realise that they can not pursue their own economic benefits at the expense of external environmental quality, because environmental pollution in turn will negatively affect the production and operation of enterprises, which is not conducive to the sustainable

development of enterprises. Enterprises should strengthen technological innovation and eliminate high pollution production methods. Only in this way can enterprises achieve their own sustainable development.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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