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Is a Regional Coordination Approach to Air Pollution Management Helpful? Evidence from China

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Abstract: In February 2017 China began to require the regional coordination of four ministries and 28 cities surrounding Beijing to manage air pollution. The Coordination attempts to unify air pollution standards and implements various new methods to monitor air pollution. Leveraging the natural experiment and using a difference-in-differences research design, we note that firms located in the treatment cities invest more in the environment than those in the control cities. In addition, we find that non-state-owned firms (non-SOEs) respond more strongly than SOEs. The findings remain qualitatively the same after accounting for selection bias in the cities included in the Coordination. Most importantly, air quality improves for treatment cities after the implementation of the Coordination. Our findings offer lessons to other emerging markets for implementing their air pollution management programs. Specifically, we sharpen our knowledge of the administrative management needed to improve coordination among government agencies and local officials in the management of air pollution and suggest that the government can play an active role in enhancing air pollution management.

Keywords: environmental regulation; air pollution; regional coordination

1. Introduction

China has seen spectacular economic growth since its 1978 reform. According to World Bank statistics published in 2019, despite the economic slowdown in recent years, the average GDP growth rate of China was approximately 9.5% from 1978 to 2018. (The yearly GDP growth rates are presented in Appendix A). In the process of pursuing fast economic growth, however, China has emitted a problematic amount of pollution. In response, the Chinese government has attempted to regulate pollution, but the effectiveness of these policies has been limited (Hao et al. [1]; Zhu et al. [2]; Xie et al. [3]). Studies on the effectiveness of environmental regulations have primarily focused on the content of regulations (Faure and Svatikova [4]; Faure and Zhang [5]) or firms' responses to different types of regulations (Gao et al. [6]; El-Bassiouny and Letmathe, [7]; and Zhou and Shen [8]). The impact of coordination among administrative and local government agencies on environmental performance is underexplored. Specifically, it is unclear whether a holistic approach to the coordination of various government agencies and local officials contributes to better firm-level and city-level environmental performance.

Based on the Chinese government's recent (February 2017) coordination approach to air pollution regulatory reform (hereafter called the "Coordination"), which required four ministries and 28 major

cities around Beijing (the two autonomous cities of Beijing and Tianjin, and 26 other cities in the four surrounding provinces) to unify their air quality standards to regulate air pollution, we examine the effectiveness of the Coordination in terms of firm-level environmental investment and city-level air quality. Our findings provide novel insights into a new administrative approach to environmental enforcement and offer valuable lessons for other emerging markets.

Using a difference-in-differences (DID) research design, we find that firms located in treatment cities (those subject to the Coordination) engage in more environmental investment than those located in the control cities in the same provinces (those not involved in the Coordination). The findings are robust after accounting for selection bias. Moreover, we find that non-state-owned firms (non-SOEs) respond more strongly than SOEs in making environmental investment. Most importantly, the air quality indeed improved in treatment cities after the Coordination, as measured by major air quality indicators such as sulfur dioxide, nitrogen dioxide, and other emissions. Additional analysis suggests that the increase in pollution inspection by local government officials partially contributes to the increase in environmental investment.

Our paper contributes to the literature in several ways. First, we confirm that a holistic approach of coordinating governmental agencies and local officials is helpful to managing air pollution. Our findings offer evidence to suggest that the ineffectiveness of some environmental regulations may be due to the silo approach of regulatory implementation. Second, we advance the literature on the effectiveness of environmental regulations. Our results complement the literature by noting that more than just the context of environmental regulations matters: a coordinated plan among administrative and local government officials contributes to their success. Collectively, our findings offer insights for other emerging markets engaged in environmental efforts and suggest that the government should strengthen its role in air pollution management.

2. Background, Literature Review, and Hypothesis Development

Background and Literature Review

Due to the emphasis on economic development, less developed countries, such as China, primarily evaluate the performance of government officials in terms of economic performance under their jurisdiction. To empower local government officials, the central Chinese government gives significant authority to local government officials in setting their economic policies. For instance, city officials can give subsidies or tax relief to firms that boost local economic performance (Wu et al. [9]). Consequently, local government officials can enhance their careers by outperforming their peers in economic development (Maskin et al. [10]; Li and Zhou [11]). Interestingly, the focus on economic performance, sometimes at a cost to the environment, is not limited to China. Cutlip and Fath [12] evaluated carbon emissions over a 200-year period and suggested that carbon dioxide emissions generally rise with economic activities, suggesting that countries accept an increase in air pollution when advancing their economies. Similarly, Wen et al. [13] found that left- or right-wing governments in 85 countries chose economic over environmental performance when facing a possible trade-off between the two. Botetzagias et al. [14] studied the impact of economic recession and government rescue packages in a sample of European Union countries during 2000-2015. The authors reported that when a country is in a recession and receives a rescue package, it is more likely to experience poor environmental performance, suggesting that a country may choose economic over environmental welfare in bad economic times.

Another side effect of the emphasis on economic development is the short-sightedness of government officials. This is because government officials, whether elected or appointed, typically have a short tenure, while environmental improvement takes a long time. For instance, Chinese government officials have a tenure of four years, while it takes 20-30 years to see a significant improvement in air pollution rates (<https://bbs.pinggu.org/thread-3951744-1-1.html> (accessed December 17, 2019)). Thus,

government officials, in general, focus their attention and resources on other short-term government initiatives such as those related to economies instead of environmental management.

Collectively, the emphasis on economic performance drives local government officials to set aside environmental concerns. (Maskin et al. [10]; Ran [15]). Ran [15] points out a big gap in the environmental policies of the central government and execution of them by local government. Essentially, local officials do not prioritize environmental goals (Chen et al. [16]; Ghanem et al. [17]) due to central government pressure to advance local economies. In some cases, officials sacrifice environmental standards to attract high-polluting local and foreign direct investments to create jobs and grow local economies. Most importantly, government agencies and localities do not coordinate their environmental efforts. The silo approach of government officials casts doubt on the ability of environmental regulations to be effective. Ran [15] and Kostka and Mol [18] have attributed the differences between regulation and reality to the failure of the central government to take significant measures to address the incentive structure by executing environmental policies with an eye on the big picture. Kostka and Nahm [19] concluded that the role of governments has been under-researched in the context of environmental policy effectiveness, despite studies suggesting that government officials tend to react to citizens' environmental petitions. For instance, Zhang et al. [20] reported that local officials heighten their environmental efforts after an increase in related proposals from members of the Chinese People's Political Consultative Conference, but the effect of direct letters from citizens is minimal. These studies imply that it is potentially more effective to use a "top-down" approach for implementing environmental regulations. Without the central government's proactive approach, the success of environment regulations is doubtful.

In February 2017, the Chinese government began to implement a holistic approach to air quality management. Using Beijing as the focus, it asked four ministries (Ecology and Environment, the National Economic Development Committee, Finance, and Energy) to coordinate with two autonomous cities (Beijing and Tianjin) and 26 major cities in four surrounding provinces (Hubei, Shanxi, Shandong, and Henan) to create an air quality plan to manage air pollution. The three major provision of the Coordination are: (1) to develop air quality standards and apply them to these 28 major cities, (2) to publicly disclose the relative city rankings of air quality each month and evaluate government officials quarterly on the basis of those relative rankings, and (3) to audit air quality in these 28 major cities by using environmental inspectors. These inspectors have the authority to close polluting businesses and reprimand or dismiss city officials.

The Coordination was the first step taken by the Chinese government to improve its administrative environmental management and apply it air pollution management. Essentially, the Coordination is a holistic approach that mandates the cooperation of related government agencies and administrative environmental personnel (city officials) to carry out environmental regulations. In an early study in the city of Chongqing, Li and Chan [21] report that within-city coordination reduces air pollution in cities. In a qualitative study, Klinsrisuk et al. [22] examined the effect of the coordination of government agencies on energy and transportation policies in Thailand and concluded that such coordination effectively reduces CO₂ emissions.

We examine air pollution because it impacts human health and is different from other forms of pollution (Song et al. [23]; Kubatko and Kubatko [24]). In addition, air pollution has a strong externality. An air quality improvement in a city may be offset by poor air quality in adjacent cities. Thus, some city-level government officials do not have incentives to engage in air quality improvement until a strong top-down directive asks them to do so. For instance, Máca et al. [25] studied six Eastern European countries' air pollution from electricity plants and noted that the market-based economic approach to air quality regulation (e.g., pollution license) is not effective. The authors called for a more active government role in regulating air pollution.

According to official environmental statistics from the Report on the State of the Environment in China in 2016 (<http://www.mee.gov.cn/hjzl/zghjzkqb/lnzghjzkqb/201706/P020170605833655914077.pdf> (accessed 12 November 2019)), only 84 of the 338 Chinese cities (approximately 25%) met the air

quality standards in China. In a global context, the World Bank reported that, as of 2016, air quality contributed to an economic loss of USD 5 trillion per year. The International Energy Agency stated that air pollution is one of four major threats to human health and leads to 6.5 million deaths per year.

Air pollution is mobile; the identification of polluting entities is difficult, and its impact spreads to other regions. Decreasing pollution would increase the costs of the polluting entities; thus, they prefer not to make those adjustments. In addition, air pollution has a strong free-rider effect: when polluting entities decrease their emissions, other entities benefit without paying the costs. Therefore, we expect that regional coordination among government officials and neighboring cities is essential to managing air pollution. For example, on 1 July 2014, the city of Tianjian raised the pollution fees on firms 5- to 10-fold for sulfur dioxide and other emissions. Subsequently, these firms in Tianjian relocated to the adjacent Hebei province to continue production, and Tianjian's air quality did not improve. The Coordination should help to address this type of problem.

We maintain that the Coordination is a novel idea in environmental regulation execution due to its holistic approach and the requirement for regional coordination. The Coordination seeks to manage air quality by using uniform air quality standards and holding local officials accountable. Most importantly, local officials are subject to public scrutiny and government oversight. With local government officials' careers at stake, we expect them to step up the monitoring of polluting firms within their jurisdiction, and focus on the enforcement of regulations. Accordingly, these polluting firms will make more environmental investment after the Coordination relative to periods before the Coordination and relative to firms in the control cities. The testable hypothesis is as follows.

Hypothesis 1 (H1). *Firms located in the 28 cities in the Coordination make more environmental investment than firms in cities not in the Coordination, or do so more often than they did before the Coordination.*

Environmental policies are influenced by the institutional characteristics of the firms (Hillman et al. [26]; Wang et al. [27]). Different executives respond to environmental regulations differently. In China (and other emerging economies), state ownership is significant. We argue that state ownership has two possible impacts on environmental responses. First, SOEs have fewer market-oriented incentives but respond better to government policies (Shleifer and Vishny [28]; Leiter et al. [29]). That is, SOEs actively engage in environmental investment better than non-SOEs. Second, due to CEOs' political connections, SOE executives may be able to negotiate preferential treatment from local environmental officials, even in cases of bad air pollution (Wang and Wheeler [30]). Thus, SOEs engage in less environmental investment. A research question that arises is whether SOEs make more or less environmental investment after the Coordination than non-SOEs. We state the second testable hypothesis as one side of the argument:

Hypothesis 2 (H2). *Relative to SOEs, non-SOEs engage in more environmental investment than SOEs if they are located in cities covered in the Coordination.*

3. Data and Research Design

3.1. Data

We considered the 28 regionally coordinated cities around Beijing as of February 2017 as the treatment cities. For comparison, we used cities of a similar size in the same four provinces as control cities. The cities in both the treatment and control groups are presented in Table 1. We used the 2014–2017 data to compare the three years before and one year after the Coordination.

Table 1. Treatment and control cities in the Coordination.

| Cities in the Regional Coordination of Air Pollution and the Selected Control Cities. | |
|---|--|
| Treatment cities (required air pollution control coordination) | Control cities (no coordination) |
| <ul style="list-style-type: none"> • Beijing and Tianjin (autonomous cities) • Shijiazhuang, Tangshan, Baoding, Langfang, Cangzhou, Hengshui, Handan, and Xingtai (Hebei Province) • Taiyuan, Yangquan, Changzhi, and Jincheng (Shanxi Province); • Jinan City, Zibo, Liaocheng, Dezhou, Binzhou, Jining, and Heze (Shandong Province) • Zhengzhou, Xinxiang, Hebi, Anyang, Jiaozuo, Puyang, and Kaifeng (in Henan Province) | <ul style="list-style-type: none"> • Qinhuangdao, Zhangjiakou, and Chengde (Hebei Province) • Datong, Shuozhou, Jinzhong, Yuncheng, Xinzhou, Linfen, and Luliang (Shanxi Province) • Qingdao, Zaozhuang, Dongying, Yantai, Weifang, Tai'an, Weihai, Rizhao, Laiwu, and Linyi (Shandong Province) • Luoyang, Xuchang, Pingdingshan, Luohe, Nanyang, Sanmenxia, Zhumadian, Shangqiu, Xinyang, and Zhoukou (Henan Province) |

We included all the publicly traded A-share firms in the polluting industries and hand-collected the environmental investment data through annual reports. The 16 industries are thermal power, steel, cement, electrolytic aluminum, coal, metallurgy, chemicals, petrochemicals, building materials, papermaking, brewing, pharmaceuticals, fermentation, textiles, tanning, and mining.

Environmental investment includes all preventive expenses related to the environment such as equipment that purifies air and fees paid to the government for emission permits. We obtained firm-level environmental inspection frequencies and city air quality data from the Ministry of Ecology and Environment. Baidu searches provided us with government officials' characteristics. We collected data for various pollutant levels for cities from the City Statistics Almanac. Firm-level characteristics are from the China Stock Market and Accounting Research database. We Winsorized the continuous variables at the 1% and 99% levels. The final data have 793 firm years for firm-level environmental investment.

3.2. Research Methods

3.2.1. Baseline Results

We used the following multiple regression model to examine H1:

$$INVEST_{i,t} = \alpha_0 + \alpha_1 JOINT_{i,t} + CONTROL + YEAR + FIRM + \varepsilon_{i,t}, \quad (1)$$

where *INVEST* is the ratio of environmental investment to total assets times 100 and *JOINT* is a (1, 0) indicator variable with a value of 1 if a firm is located in a treatment city after it became part of the Coordination, and 0 otherwise. Firms located in the control cities always have a value of 0 for *JOINT*. Equation (1) is a DID research design to capture the natural experiment of implementation of the Coordination. If H1 is valid, α_1 is positive. For H2 to be valid, we expect α_1 for the non-SOE subsample to be larger than that of the SOE subsample.

There are three sets of control variables. The first set is firm characteristics: return on equity (*ROE*), financial leverage (*LEV*), firm size (*SIZE*), and shareholding ratio of the largest shareholder (*LARGEST*). The second set is government official characteristics in terms of city Communist Party secretary tenure (*TENURE*), age (*AGE*), and whether there is a change of Communist Party secretary (*CHANGE*). The third set is the environmental quality characteristics in a city in which a firm located. Specifically, we used the *AQI100*, *AQI150*, *AQI200*, and *AQI300* variables to measure air quality in terms of the number of days with an air quality index between 100 and 150, between 150 and 200, between 200 and 300 (*AQI200*), and above 300, respectively. These control variables account for the

impact of firm, government official, and air quality contributing factors that drive a firm's decision to make environmental investment.

We include year and firm fixed effects in Equation (1). Table 2 presents detailed definitions of the data. Equation (1) is a DID model for the impact of the air quality coordination plan on a firm's environmental investment. Due to the strong presence of SOEs in China, we expect that the incentives to respond to government environmental policies differ between SOEs and non-SOEs. Therefore, we examine Equation (1) by using a full sample and subsample of SOEs and non-SOEs.

Table 2. Variable definitions.

| | Variables | Definitions |
|---|-------------------|--|
| Dependent variable | <i>INVEST</i> | (environmental investment/total assets) *100 |
| Explanatory variable | <i>JOINT</i> | Takes a value of 1 for firms located in cities that participated in the air quality coordination and value of 0 before the coordination. It takes the value of 0 for control firms |
| Firm-level control variables | <i>ROE</i> | Net income/shareholder equity |
| | <i>LEV</i> | Total liabilities/total assets |
| | <i>SIZE</i> | Natural logarithm of total assets at year-end |
| | <i>LARGEST</i> | Shareholding ratio of the largest shareholder |
| Government official control variables | <i>TENURE</i> | Number of years on the job for the city communist party secretary |
| | <i>AGE</i> | Age of the city communist party secretary |
| | <i>CHANGE</i> | Takes a value of 1 if the city communist party secretary changes and 0 otherwise |
| Environmental quality control variables | <i>AQI100</i> | Number of days of light pollution (Air Quality Index between 100 and 150) |
| | <i>AQI150</i> | Number of days of moderate pollution (Air Quality Index between 150 and 200) |
| | <i>AQI200</i> | Number of days of heavy pollution (Air Quality Index between 200 and 300) |
| | <i>AQI300</i> | Number of days of serious pollution (Air Quality above 300) |
| Environmental regulation variable | <i>REGULATION</i> | Natural logarithm of 1 plus the firm-level environmental visits in a year |

The DID research design in Equation (1) compares the pre- and post-policy change periods (i.e., the natural experiment) on treatment (those affected by the Coordination) and control (those not affected by the Coordination) firms. Several environmental studies use the same research design (Hsueh [31] and Yang et al. [32]). For instance, using a DID research design, Yang et al. [32] compare air pollution in cities before and after high-speed rail (HSR) and conclude that HSR reduces air pollution. In the authors' setting, the construction of HSR represents a policy change, while the treatment and control cities are those with pre- and post-HSR periods. The advantage of a DID research design is that it singles out the impact of a policy change by comparing the same set of treatment and control samples.

3.2.2. Propensity Score Matching (PSM)

The cities subject to the air quality coordination plan represent a natural experiment of environmental policy. However, the Ministry of Ecology and Environment may select specific cities to join the Coordination. Such a bias may yield misleading results (Heckman [33]). To avoid possible selection bias, we follow Zhai et al. [34] to conduct a PSM approach to match treatment and control firms with city air quality (*AQI*), *TENURE*, *AGE*, *CHANGE*, *ROE*, *LEV*, and *SIZE*. By doing

so, we account for the impact of other factors that may impact the selection process. Thus, the PSM samples have characteristics similar to the control variables to allow us to single out the impact of the Coordination on environmental investment. Then, we examine Equation (1) by using the PSM samples.

3.2.3. Heckman Two-Stage Analysis

For robustness, we also used the Heckman [33] two-stage analysis to mitigate selection bias. In the first stage, we used a Probit model to estimate an identification equation to predict the probability of a city being included in the Coordination in 2017. Specifically, we used the sulfur dioxide level (*SO2-D*), dust discharge level (*DUST-D*), the weight of a city's secondary industries (*SECOND*), and the city GDP in natural logarithm (*LNGDP*) as the drivers to identify a city's chance of being included by the Ministry of Ecology and Environment in the Coordination. Next, we recovered the inverse Mill's ratio (*IMR*) and used it to augment Equation (1) in the second stage of analysis. Similar to PSM, the Heckman approach is widely used to mitigate selection bias (Zhai et al. [34]).

4. Results and Discussion

4.1. Summary Statistics

We present summary statistics of the sample in Table 3. The mean and median of firm-level environmental investment are 0.718% and zero of total assets, respectively. The small mean and zero median suggest that typical firms make little or no environmental investment, which is consistent with firm executives' low prioritization of environmental issues. The low firm-level environmental investment also implies that local government officials do not enforce environmental regulations, which allows firm executives to ignore environmental investment. Hence, we are not surprised that the environmental performance of China is far from satisfactory. The mean of *JOINT* is 0.18, indicating that approximately 18% of the sample firms are located in cities with an air quality coordination plan. In terms of profitability, the mean of return on equity (*ROE*) is approximately 3.83% and has a standard deviation of 13.5%, indicating that, on average, firms make good profits, with some variation. Hence, it is not for lack of funds that firms do not make environmental investment. The air pollution variables show that environmental pollution is a serious problem in China. For instance, the mean of *AQI100* (the lightest air pollution) is approximately 70 days in a year in a typical city.

Table 3. Summary statistics.

| Variable | N | Mean | Std | Min | Median | 75th | Max |
|----------------|-----|--------|-------|--------|--------|--------|-------|
| <i>INVEST</i> | 793 | 0.718 | 1.928 | 0 | 0 | 0.0555 | 22.37 |
| <i>JOINT</i> | 793 | 0.180 | 0.385 | 0 | 0 | 0 | 1 |
| <i>ROE</i> | 793 | 0.0383 | 0.135 | −0.798 | 0.0468 | 0.0888 | 0.436 |
| <i>LEV</i> | 793 | 0.403 | 0.234 | 0.0035 | 0.401 | 0.591 | 1.056 |
| <i>SIZE</i> | 793 | 22.53 | 1.462 | 19.47 | 22.33 | 23.47 | 25.96 |
| <i>LARGEST</i> | 793 | 37.03 | 14.00 | 6.410 | 35 | 45.38 | 89.09 |
| <i>TENURE</i> | 793 | 2.544 | 1.345 | 0 | 2 | 4 | 8 |
| <i>AGE</i> | 793 | 57.71 | 6.311 | 45 | 57 | 62 | 69 |
| <i>CHANGE</i> | 793 | 0.349 | 0.477 | 0 | 0 | 1 | 1 |
| <i>AQI100</i> | 793 | 69.90 | 51.39 | 0 | 78 | 110 | 161 |
| <i>AQI150</i> | 793 | 30.88 | 23.59 | 0 | 38 | 51 | 72 |
| <i>AQI200</i> | 793 | 19.11 | 16.30 | 0 | 20 | 29 | 76 |
| <i>AQI300</i> | 793 | 6.276 | 8.251 | 0 | 3 | 12 | 41 |

4.2. Baseline Findings

We present our baseline findings in Table 4. The coefficients of *JOINT* are positive and significant at the 1% or 5% levels in columns (1) to (3), suggesting that when a firm is located in a treatment city post-Coordination, it makes more environmental investment than a firm located in a control city

or before Coordination. The impact of an air quality coordinator on environmental investment is economically significant. Using column (1), the coefficient of *JOINT* is 1.302, indicating that a firm in a treatment city has 1.302 per cent points more environmental investment than a firm in a control city. Given the mean firm-level of environmental investment is 0.718%, a 1.302 percent point reduction represents 181% of a typical firm. Thus, the regional coordination of 28 cities to decrease air pollution significantly encourages firms located in these cities to make substantially more environmental investment. The findings support H1. We interpret the findings to mean the Coordination has some initial positive results in terms of encouraging firms to make more environmental investment.

Table 4. Impact of regional coordination on firm-level environmental investment.

| Variables | (1) | (2) | (3) |
|---|-----------------------|-----------------------|---------------------------|
| | <i>INVEST</i> Full | <i>INVEST</i> SOEs | <i>INVEST</i> Non-SOEs |
| <i>JOINT</i> | 1.302 *** (3.57) | 0.811 ** (2.30) | 2.244 *** (3.55) |
| <i>ROE</i> | −0.173 (−0.27) | −0.364 (−0.72) | 0.225 (0.16) |
| <i>LEV</i> | −1.302 * (−1.91) | −0.510 (−0.80) | −2.283 * (−1.84) |
| <i>SIZE</i> | −0.022 (−0.09) | −0.543 * (−1.93) | −0.088 (−0.20) |
| <i>LARGEST</i> | 0.005 (0.52) | 0.008 (0.95) | −0.034 * (−1.84) |
| <i>TENURE</i> | −0.040 (−0.30) | −0.160 (−1.23) | −0.043 (−0.19) |
| <i>AGE</i> | −0.040 (−0.86) | 0.117 ** (2.12) | −0.091 (−1.26) |
| <i>CHANGE</i> | −0.035 (−0.13) | 0.001 (0.00) | −0.150 (−0.31) |
| <i>AQI100</i> | −0.009 * (−1.88) | −0.001 (−0.12) | −0.015 * (−1.76) |
| <i>AQI150</i> | −0.036 *** (−2.70) | −0.014 (−1.18) | −0.067 *** (−2.70) |
| <i>AQI200</i> | 0.041 ** (2.32) | 0.029 * (1.89) | 0.050 (1.47) |
| <i>AQI300</i> | 0.033 (1.38) | 0.041 * (1.95) | 0.002 (1.03) |
| Year | yes | yes | yes |
| Firm | yes | yes | yes |
| Constant | 6.685 (1.03) | 9.426 (1.32) | 8.813 (0.85) |
| χ^2 for equal coefficients of <i>JOINT</i> | | | 3.143 * |
| N | 793 | 414 | 379 |
| Adj. R ² | 0.224 | 0.376 | 0.222 |
| F | 2.051 | 3.057 | 1.943 |

Table 4 presents the results for the impact of regional coordination on firm-level environmental investment. *T*-statistics are reported in parentheses. Definitions of variables are presented in Table 2. ***, **, and * indicate 1%, 5%, and 10% significance.

In addition, the χ^2 for equal coefficients of *JOINT* from columns (2) and (3) is significant at the 10% level, indicating that the impact of the Coordination is much stronger for the non-SOEs than SOEs. The results are consistent with two potential explanations. First, SOEs, due to their government backing, already had more environmental investment before the Coordination than non-SOEs. Therefore, the marginal impact of the Coordination for SOEs, although significant, is not as strong as that of non-SOEs. In the alternative, SOEs, due to their networking with local government officials, are able to withstand environmental enforcement better than non-SOEs. Overall, the results support H2.

Interestingly, with the exception of some air quality pollution variables, most of the control variables are not significant, suggesting that a firm's environmental investment depends more on government regulation, enforcement or air quality, not necessarily driven by firm characteristics, such as profitability, financial leverage, firm size, shareholding ratio of the largest shareholder, or other government official characteristics, such as tenure and newly on the job of the government officials. In addition, for air pollution variables, *AQI100* and *AQI200* have negative and significant coefficients in columns (1) and (3), while *AQI200* and *AQI300* have positive and significant coefficients. That is, an average firm makes less (more) environmental investment when the air quality in its city is good (bad). This is not a surprise finding as if government officials and executives perceive bad (good) air quality, they step up (lower) their efforts at fighting air pollution.

4.3. Robustness Checks

4.3.1. Propensity Score Matching

We plotted the profiles of treatment and control firms before and after PSM in Figure 1 and used the city air quality (*AQI*), *TENURE*, *AGE*, *CHANGE*, *ROE*, *LEV*, and *SIZE* variables as the PSM criteria. From the graphical analysis, the propensity score is very different for the treatment and control firms before the PSM. However, after PSM, the propensity score of the treatment and control firms is much closer. Hence, examining Equation (1) using PSM firms can mitigate some selection bias.

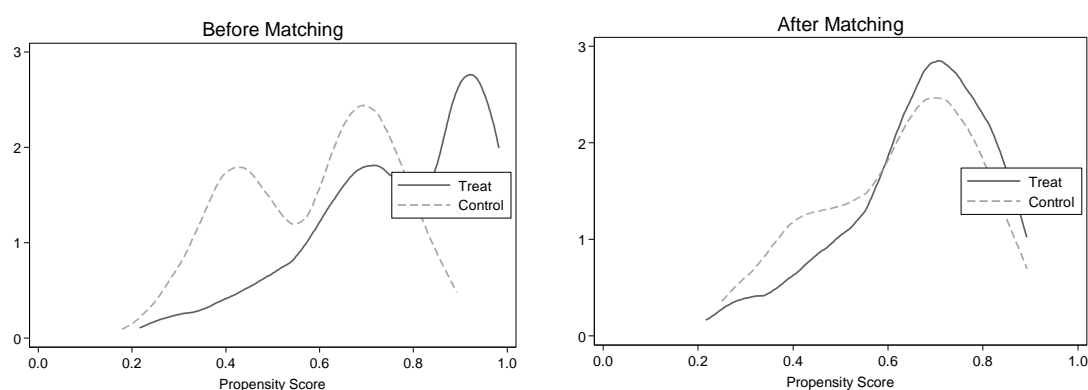


Figure 1. Propensity scores of treatment and control firms before and after matching.

The results using the PSM sample are presented in Table 5. Similar to those in Table 4, the coefficients of *JOINT* are positive and significant at the 1% or 5% level, and the coefficient of *JOINT* in column (3) is significantly larger than that of column (2) in Table 5. In addition, most of the coefficients of control variables are not significant. Overall, the magnitudes of the coefficients in Tables 4 and 5 are similar, indicating that the selection bias, if any, is not severe.

Table 5. Robustness checks: Propensity score matching sample.

| Variables | (1) | (2) | (3) |
|--------------|------------------------------|-----------------------|---------------------------|
| | <i>INVEST</i> Full Sample | <i>INVEST</i> SOEs | <i>INVEST</i> Non-SOEs |
| <i>JOINT</i> | 1.238 *** (2.89) | 0.864 * (1.90) | 2.042 *** (2.91) |
| <i>ROE</i> | −0.371 (−0.47) | −0.650 (−0.89) | −0.071 (−0.05) |
| <i>LEV</i> | −2.006 ** (−2.03) | −0.885 (−0.85) | −2.868 * (−1.78) |
| <i>SIZE</i> | −0.252 (−0.75) | −0.777 * (−1.86) | −0.354 (−0.70) |

Table 5. Cont.

| Variables | (1) | (2) | (3) |
|---|-----------------------|-------------------|---------------------|
| | INVEST Full Sample | INVEST SOEs | INVEST Non-SOEs |
| LARGEST | 0.002 (0.17) | 0.012 (0.94) | −0.034 * (−1.65) |
| TENURE | 0.059 (0.39) | −0.127 (−0.75) | 0.076 (0.32) |
| AGE | −0.035 (−0.67) | 0.120 * (1.71) | −0.074 (−0.96) |
| CHANGE | 0.264 (0.80) | 0.145 (0.42) | 0.310 (0.57) |
| AQI100 | −0.005 (−0.80) | 0.001 (0.17) | −0.011 (−1.06) |
| AQI150 | −0.017 (−0.98) | −0.013 (−0.72) | −0.038 (−1.33) |
| AQI200 | 0.029 (1.31) | 0.029 (1.33) | 0.033 (0.86) |
| AQI300 | 0.021 (0.77) | 0.041 (1.48) | 0.017 (0.36) |
| Year | yes | yes | yes |
| Firm | yes | yes | yes |
| Constant | 11.887 (1.43) | 14.401 (1.38) | 14.210 (1.17) |
| χ^2 for equal coefficients of <i>JOINT</i> | | | 3.218 * |
| N | 586 | 273 | 313 |
| Adj. R ² | 0.289 | 0.360 | 0.306 |
| F | 2.422 | 2.799 | 2.403 |

Table 5 presents the results for the impact of regional coordination on firm-level environmental investment using the PSM sample. *T*-statistics are reported in parentheses. Definitions of variables are presented in Table 2. ***, **, and * indicate 1%, 5%, and 10% significance.

4.3.2. Heckman Two-Stage Analysis

We present the results of the Heckman first-stage analysis in column (1) of Table 6. We found that the coefficient of *LNGDP* is positive and significant at the 1% level, suggesting that the Chinese central government primarily uses economic activities as the selection criteria for a city to be included in the Coordination. Next, we recovered the inverse Mill's ratio (*IMR*) from column (1) and used it to augment Equation (1).

In the second stage, the coefficients of *JOINT* in columns (2) to (4) continue to be positive and significant at the 1% or 5% level, and the one for non-SOEs is significantly larger than that of the SOEs in Table 6. Most importantly, the coefficients of *IMR* are not significant, indicating that the selection bias, if any, is not severe, which echoes the findings in Table 5. Hence, the baseline findings in Table 4 are not due to selection bias, and the level of such bias, if any, is minimal.

Table 6. Robustness checks: Heckman two-stage analysis.

| First Stage | | Second Stage | | | |
|---------------|------------------------|--|------------------------|------------------------|------------------------|
| (1) | | (2) | (3) | (4) | |
| City Level | | Firm Level | | | |
| Variables | Full Sample | Variables | INVEST | INVEST | INVEST |
| | | | Full Sample | SOEs | Non-SOEs |
| <i>SECOND</i> | −0.006 (−0.69) | <i>IMR</i> | −0.007 (−0.02) | −0.344 (−0.35) | −0.046 (−0.12) |
| <i>LNGDP</i> | 0.640 *** (3.97) | <i>JOINT</i> | 1.313 *** (3.57) | 0.815 ** (2.25) | 2.254 *** (3.54) |
| <i>SO2-D</i> | 42.262 (1.02) | <i>ROE</i> | −0.180 (−0.28) | −0.374 (−0.74) | 0.258 (0.18) |
| <i>DUST-D</i> | −23.778 (−0.74) | <i>LEV</i> | −1.311 * (−1.92) | −0.504 (−0.78) | −2.294 * (−1.84) |
| | | <i>SIZE</i> | −0.019 (−0.07) | −0.545 * (−1.93) | −0.080 (−0.18) |
| | | <i>LARGEST</i> | 0.004 (0.48) | 0.007 (0.88) | −0.034 * (−1.84) |
| | | <i>TENURE</i> | −0.043 (−0.32) | −0.167 (−1.28) | −0.051 (−0.22) |
| | | <i>AGE</i> | −0.041 (−0.87) | 0.114 ** (2.06) | −0.092 (−1.26) |
| | | <i>CHANGE</i> | −0.040 (−0.15) | −0.015 (−0.06) | −0.165 (−0.33) |
| | | <i>AQI100</i> | −0.009 * (−1.84) | −0.001 (−0.13) | −0.016 * (−1.76) |
| | | <i>AQI150</i> | −0.036 *** (−2.67) | −0.015 (−1.20) | −0.067 *** (−2.68) |
| | | <i>AQI200</i> | 0.042 ** (2.32) | 0.030 * (1.94) | 0.050 (1.47) |
| | | <i>AQI300</i> | 0.033 (1.38) | 0.041 * (1.89) | 0.002 (1.04) |
| Year | yes | Year | yes | yes | yes |
| Constant | −11.202 *** (−3.80) | Firm Constant | yes 6.682 (1.03) | yes 9.855 (1.37) | yes 8.727 (0.84) |
| N | 230 | χ^2 for equal coefficients of <i>JOINT</i> | | | 3.019 * |
| | | N | 791 | 413 | 378 |
| | | Adj. R ² | 0.222 | 0.374 | 0.218 |
| | | F | 2.030 | 3.017 | 1.912 |

Table 6 presents the results for the impact of regional coordination on firm-level environmental investment using the Heckman [28] two-stage analysis. *T*-statistics are reported in parentheses. Definitions of variables are presented in Table 2. ***, **, and * indicate 1%, 5%, and 10% significance.

4.4. Transmission Mechanism

What is the transmission mechanism for the positive impact of the Coordination on firm-level environmental investment of the 28 treatment cities? We argue that the Coordination puts political pressure on city government officials to step up their regulatory efforts, leading to an increase in environmental investment by firms located in the treatment cities. Our argument is similar to the logic in Shleifer and Vishny [23]. To examine the validity of our conjecture, we used the mediating procedure outlined in Baron and Kenny [35] as follows:

$$REGULATION_{i,t} = \beta_0 + \beta_1 * JOINT_{i,t} + CONTROL + YEAR + FIRM + \pi_{i,t} \quad (2)$$

$$INVEST_{i,t} = \delta_0 + \delta_1 JOINT_{i,t} + \delta_2 REGULATION_{i,t} + CONTROL + YEAR + FIRM + \lambda_{i,t}, \quad (3)$$

where *REGULATION* is the number of environmental inspections at a firm in a year, which we used to capture the intensity of environmental enforcement. According to Baron and Kenny [35], if β_1

is significant and both δ_1 and δ_2 are significant (only δ_2 is significant), *REGULATION* is a partial (complete) mediator. The reasoning is that, if environmental enforcement is a mediating factor, the Coordination pushes for more enforcement (in Equation (1)), which leads to more firm-level investment (in Equation (2)).

We present the findings in Table 7. Across columns (1), (3), and (5), the coefficients of *JOINT* are positive and significant at the 1%, 5%, or 10% level and fulfill the condition that β_1 is significant. In columns (2), (4), and (6), the coefficients of *JOINT* and *REGULATION* are both positive and significant at the 1% and 10% levels. Hence, when a city steps up its regulatory effort by enforcing regulations, firms respond by making greater environmental investment. Collectively, the Chinese government's coordination plan encourages the 28 cities' officials to increase regulatory efforts. In response, firms located in these 28 cities engage in higher environmental investment. Interestingly, in column (3), we notice that the coefficients of *ROE*, *SIZE*, and *CHANGE* are significant at the 1%, 5%, or 10% level with the expected signs for explaining *REGULATION* for the SOE subsample. The same coefficients are not significant for the non-SOE subsample in column (5). When an SOE is more profitable or bigger, it is inspected less frequently. In addition, when a city is serious polluted, whether it is SOE or non-SOEs located in the city has more environmental inspection. Similarly, when a city has a new leader, an SOE located in the city is inspected more frequently. Hence, environmental inspection for SOEs is more sensitive to certain factors than for non-SOEs.

Table 7. Transmission mechanism.

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---------------------|----------------------------------|------------------------------|---------------------------|-----------------------|-------------------------------|---------------------------|
| | <i>REGULATION</i> Full Sample | <i>INVEST</i> Full sample | <i>REGULATION</i> SOEs | <i>INVEST</i> SOEs | <i>REGULATION</i> Non-SOEs | <i>INVEST</i> Non-SOEs |
| <i>JOINT</i> | 0.444 *** (3.91) | 1.435 *** (3.13) | 3.083 *** (3.21) | 0.855 ** (2.01) | 0.303 ** (2.12) | 2.353 *** (3.05) |
| <i>REGULATION</i> | | 0.260 * (1.93) | | 0.044 * (1.88) | | 0.359 * (1.84) |
| <i>ROE</i> | -0.385 ** (-1.97) | -0.271 (-0.43) | -3.783 *** (-2.78) | -0.388 (-0.76) | 0.037 (0.12) | 0.238 (0.17) |
| <i>LEV</i> | 0.111 (0.53) | -1.270 * (-1.87) | -0.071 (-0.04) | -0.497 (-0.78) | 0.123 (0.43) | -2.239 * (-1.81) |
| <i>SIZE</i> | -0.109 (-1.36) | -0.052 (-0.20) | -1.846 ** (-2.42) | -0.552 * (-1.95) | -0.015 (-0.15) | -0.094 (-0.22) |
| <i>LARGEST</i> | -0.000 (-0.10) | 0.005 (0.51) | -0.005 (-0.20) | 0.008 (0.95) | 0.003 (0.61) | -0.033 * (-1.79) |
| <i>TENURE</i> | -0.011 (-0.28) | -0.045 (-0.34) | -0.189 (-0.54) | -0.165 (-1.27) | 0.030 (0.57) | -0.032 (-0.14) |
| <i>AGE</i> | -0.006 (-0.43) | -0.041 (-0.89) | 0.203 (1.37) | 0.118 ** (2.14) | -0.022 (-1.31) | -0.099 (-1.37) |
| <i>CHANGE</i> | 0.064 (0.76) | -0.020 (-0.07) | 0.862 (1.28) | 0.001 (0.00) | 0.087 (0.77) | -0.119 (-0.24) |
| <i>AQI100</i> | -0.007 *** (-4.49) | -0.010 ** (-2.17) | -0.073 *** (-6.33) | -0.001 (-0.19) | -0.000 (-0.20) | -0.016 * (-1.77) |
| <i>AQI150</i> | -0.011 *** (-2.63) | -0.040 *** (-2.92) | -0.162 *** (-4.92) | -0.016 (-1.27) | 0.001 (0.14) | -0.067 *** (-2.69) |
| <i>AQI200</i> | -0.003 (-0.56) | 0.041 ** (2.29) | -0.021 (-0.51) | 0.029 * (1.87) | 0.007 (0.94) | 0.053 (1.55) |
| <i>AQI300</i> | 0.009 *** (3.18) | 0.031 (1.30) | 0.160 ** (2.11) | 0.041 * (1.89) | 0.015 ** (2.48) | 0.004 (1.09) |
| Year | yes | yes | yes | yes | yes | yes |
| Firm | yes | yes | yes | yes | yes | yes |
| Constant | 2.859 (1.43) | 7.411 (1.15) | 33.196 * (1.72) | 9.509 (1.32) | 1.707 (0.72) | 9.425 (0.91) |
| N | 793 | 793 | 414 | 414 | 379 | 379 |
| Adj. R ² | 0.302 | 0.230 | 0.365 | 0.375 | 0.0913 | 0.226 |
| F | 2.582 | 2.084 | 2.968 | 3.041 | 1.335 | 1.964 |

Table 7 presents the results for the transmission mechanism for the impact of regional coordination on firm-level environmental investment. *T*-statistics are reported in parentheses. Definitions of variables are presented in Table 2. ***, **, and * indicate 1%, 5%, and 10% significance.

4.5. Does Air Quality Improve?

The success of the Coordination can be alternatively measured by the air quality in treatment cities vis-à-vis control cities. We conducted a DID analysis on the period between July 2016 and December 2017 by measuring the daily air quality in treatment and control cities. Because the Coordination began in February 2017, we defined a new dummy variable, *JOINT_AIR*, with a value of 1 for March to December 2017, and 0 otherwise. We modified Equation (1) to be

$$QUALITY_{i,t+1} = \phi_0 + \phi_1 JOINT_AIR_{i,t} + CONTROL + YEAR + MONTH + CITY + \theta_{i,t}, \quad (4)$$

where *QUALITY* is the daily air quality in a city. We use the air quality index (*AQI*), PM25 particles in the air (*PM25*), PM10 particles in the air (*PM10*), and sulfur dioxide (*SO2*), nitrogen dioxide (*NO2*), and carbon monoxide (*CO*) levels to gauge air quality in a city on a specific day. The set of control variables includes average wind speed (*SPEED*), highest temperature in a month (*TEMP_HIGH*), lowest temperature in a month (*TEMP_LOW*), rain or snow (*RAIN_SNOW*), consecutive labor off days (*DOUBLE*), and public holidays (*HOLIDAYS*). All these weather conditions and work-day scenarios affect air quality. We controlled for year, month, and city fixed effects in Equation (4).

We present the findings of Equation (4) in Table 8. Consistently across all six columns, the coefficients of *JOINT_AIR* are negative and significant at the 1% level, suggesting that treatment cities exhibit better air quality after the implementation of the Coordination. Control variables, if significant, carry the expected signs. For instance, the coefficients of *SPEED* are negative and significant at the 1% level. Thus, if the wind speed is high, the air quality improves.

Table 8. Impact of air quality coordination effort on air quality.

| Variables | (1) AQI | (2) PM25 | (3) PM10 | (4) SO2 | (5) NO2 | (6) CO |
|---------------------|-------------------------|-------------------------|------------------------|------------------------|------------------------|------------------------|
| <i>JOINT_AIR</i> | -13.421 *** (-11.52) | -11.895 *** (-11.66) | -13.554 *** (-8.83) | -5.530 *** (-9.71) | -3.584 *** (-10.75) | -0.276 *** (-18.13) |
| <i>SPEED</i> | -4.853 *** (-9.22) | -6.984 *** (-15.16) | -4.459 *** (-6.44) | -4.460 *** (-17.34) | -5.500 *** (-36.52) | -0.133 *** (-19.39) |
| <i>TEMP_HIGH</i> | 2.218 *** (18.66) | 1.208 *** (11.62) | 3.308 *** (21.14) | 1.377 *** (23.71) | 1.045 *** (30.72) | 0.010 *** (6.51) |
| <i>TEMP_LOW</i> | 0.970 *** (7.11) | 1.340 *** (11.21) | 0.381 ** (2.12) | -1.144 *** (-17.13) | -0.378 *** (-9.68) | 0.015 *** (8.65) |
| <i>RAIN_SNOW</i> | 0.799 (1.05) | 3.792 *** (5.70) | 0.111 (0.11) | -1.488 *** (-4.00) | -0.173 (-0.80) | 0.048 *** (4.80) |
| <i>DOUBLE</i> | 2.420 *** (3.79) | 1.561 *** (2.79) | 3.961 *** (4.71) | 1.241 *** (3.97) | 0.211 (1.15) | 0.003 (0.34) |
| <i>HOLIDAYS</i> | -11.422 *** (-7.58) | -9.104 *** (-6.90) | -15.434 *** (-7.77) | -0.732 (-0.99) | -8.106 *** (-18.79) | -0.128 *** (-6.52) |
| Year | yes | yes | yes | yes | yes | yes |
| Month | yes | yes | yes | yes | yes | yes |
| City | yes | yes | yes | yes | yes | yes |
| Constant | 162.163 *** (52.01) | 138.715 *** (50.83) | 173.508 *** (42.26) | 56.961 *** (37.37) | 59.346 *** (66.51) | 2.527 *** (62.14) |
| N | 25,252 | 25,252 | 25,252 | 25,252 | 25,252 | 25,252 |
| Adj. R ² | 0.354 | 0.389 | 0.352 | 0.508 | 0.566 | 0.456 |
| F | 190.7 | 221.3 | 189.2 | 357.8 | 452.6 | 291.2 |

Table 8 presents the results for the impact of regional coordination on city-level air quality. We report the *t* statistics in parentheses. Definitions of variables are presented in Table 2. ***, **, and * indicate 1%, 5%, and 10% significance.

5. Summary

China's rapid and insufficiently regulated economic growth has caused environmental problems that impact human health. Studies have suggested that a regulatory approach to environmental management is only moderately helpful (Hao et al. [1]; Zhu et al. [2]; Xie et al. [3]). A plan to improve the environmental management of air pollution by coordinating various government and local agencies emerged in early 2017. To mitigate the mobile nature of air pollution, the Coordination attempted

to unify pollution standards and implement various new methods to monitor air pollution through a regional coordination effort. The Chinese air pollution control coordination involved four ministries and 28 cities surrounding Beijing. Using this natural experiment, we examine the impact of government agencies and local government officials' coordination on firm-level environmental investment in China.

Using a DID research design, we found that firms in the treatment cities engage in more environmental investment than firms in control cities. In addition, we discovered that non-SOEs respond more strongly than SOEs. The findings remain qualitatively the same after accounting for selection bias in the inclusion of cities chosen to participate in the Coordination. Most importantly, air quality improves for treatment cities after the implementation of the Coordination. Therefore, our findings offer solutions to the ineffectiveness of environmental regulations alone, as expressed in Hao et al. [1], Zhu et al. [2], and Xie et al. [3]. Given that other emerging markets may share situations similar to China's, the positive outcomes of the Coordination provide a roadmap for other countries to implement their environmental regulations. In addition, the different magnitudes of responses by SOEs versus non-SOEs suggest that the success of any government program on environmental implementation may depend on the nature of firm ownership.

Our findings have two major implications. First, by confirming that government-led regional coordination is helpful, we advance the literature on how to effectively enforce environmental regulations. Coordination among administrative and local government agencies holds local officials accountable and, most importantly, improves environmental management. Hence, if executed properly, a government's proactive approach to environmental management can be effective. The critical element is holding government officials accountable. Thus, our findings echo and complement those related to specific elements in environmental regulations (Faure and Svatikova [4]; Faure and Zhang [5]) or different types of regulations (Gao et al. [6]; El-Bassiouny and Letmathe, [7]; and Zhou and Shen [8]). We show that it is not just the regulations themselves but the implementation of the regulations that encourages success.

Second, in terms of practice, we show that because the mitigation of air pollution benefits free-riders, a holistic approach of regional coordination among government officials is useful and perhaps essential. Such an approach mandates that the involved government agencies and officials cooperate to strengthen enforcement and enhance the outcomes of environmental management. We note that the Coordination does not establish new environmental regulations but instead adopts a new administrative approach to implementing existing regulations. Thus, our findings imply that, in some cases, the ineffectiveness of government policies is not because of inadequate regulations but rather due to poor coordination among the government agencies and officials who execute the regulations. Hence, our findings echo Li and Chan's [21] findings that a coordinated effort in the city of Chongqing improved environmental performance. Our study shows that a government can sharpen its implementation of environmental regulations through a "top-down" approach, and accordingly recognizes that government officials should play a more prominent role than the general public in the fight to improve air quality.

Overall, we find that the holistic approach to environmental management in China has been successful in four ways. First, firms were encouraged to and actually made more environmental investment. Second, government officials realized that the central government is serious about improving the environment. Third, air pollution improved in the treatment cities. Fourth, given the strong externality nature of air pollution, our findings suggest that a top-down mandatory regional coordination is effective to internalize all involved parties in executing environmental regulation. We argue that the coordination approach may also be effective for other types of pollution (e.g., water pollution). When environmental management is not effective, a government can take a leadership role by sharpening its administrative procedures to make officials in different departments and levels work together to "own" the environmental management process.

Our findings offer lessons for other emerging markets when designing their air pollution management programs. Specifically, for environmental regulations to be effective, it is critical that government officials are held accountable and that they coordinate with one another.

Our paper has three limitations. First, China's regional coordination approach to managing air pollution is a trial and thus limited data are available. In the future, researchers can revisit the topics covered in this study when more data become available in China or other emerging markets. Second, we focus our analysis on high-pollution public firms. It would be interesting to examine the responses to the Coordination of small businesses and other nonpolluting firms. Third, although the Coordination is a notable breakthrough, we do not know the correlation between the administrative environmental management approach and the opinions and technical and financial capabilities of Chinese citizens. Hence, our findings do not reflect the views of the citizens affected by air pollution, so a key factor to investigate in the future would be how citizens respond to the Coordination. We contend that Chinese citizens likely agree with the directions of the proposed changes but their opportunities to participate in air pollution management are limited. Given the nature of air pollution and the fact that firms often do not participate in air pollution clean-up, it is unavoidable that air pollution management requires a "top-down" policy. Our study shows that coordination between various parts of government improves the implementation of environmental regulations.

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Appendix A. GDP Growth Rate in China (1978–2018)

Appendix A presents the annual GDP growth rate in China. The source is the World Bank (<https://data.worldbank.org/country/china> [accessed November 12, 2019]).

| Year | GDP Growth Rate (%) | Year | GDP Growth Rate (%) |
|------------------|---------------------|------|---------------------|
| 1978 | 11.13 | 1999 | 7.67 |
| 1979 | 7.60 | 2000 | 8.49 |
| 1980 | 7.81 | 2001 | 8.34 |
| 1981 | 5.17 | 2002 | 9.13 |
| 1982 | 8.93 | 2003 | 10.04 |
| 1983 | 10.84 | 2004 | 10.11 |
| 1984 | 15.14 | 2005 | 11.40 |
| 1985 | 13.44 | 2006 | 12.72 |
| 1986 | 8.94 | 2007 | 14.23 |
| 1987 | 11.69 | 2008 | 9.65 |
| 1988 | 11.23 | 2009 | 9.40 |
| 1989 | 4.19 | 2010 | 10.64 |
| 1990 | 3.91 | 2011 | 9.55 |
| 1991 | 9.29 | 2012 | 7.86 |
| 1992 | 14.22 | 2013 | 7.77 |
| 1993 | 13.87 | 2014 | 7.30 |
| 1994 | 13.05 | 2015 | 6.91 |
| 1995 | 10.95 | 2016 | 6.74 |
| 1996 | 9.93 | 2017 | 6.76 |
| 1997 | 9.23 | 2018 | 6.60 |
| 1998 | 7.84 | | |
| All-year average | 9.5 | | |

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