5

The Case of Fine Particulate Matter Control

The sources of $PM_{2.5}$ are so various that it takes real determination and sometimes drastic measures to control it consistently. Where do those incentives come from? Cadre evaluation.

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As shown in the previous chapter, local leaders' political incentives often translate into implementation patterns that augment their promotion prospects, as evidenced by SO_2 industrial pollution control. Those patterns are observable as political regulation waves. In this chapter, I will apply the theory of the political regulation wave to explain patterns in the *efforts to control* $PM_{2.5}$, which has more diverse sources spanning a wider range of sectors than SO_2, and, by extension, is more challenging to control. I will show that while *actual efforts* may have corresponded to what political environmental protection waves require, the *actual levels* of annual average $PM_{2.5}$ concentration exhibited continued pollution waves even when the incentives to promote environmental protection waves were built into the evaluation system.

Understanding $PM_{2.5}$ and its sources is still ongoing, creating nontrivial regulatory ambiguity and challenges. $PM_{2.5}$ is formed as a result of fuel burning and chemical reactions; its sources span a wide range of sectors. Researchers and practitioners are gradually gaining new knowledge about contributors to $PM_{2.5}$. For instance, a recent study finds that water vapor from combustion can enhance the formation of secondary aerosols (Xing et al. 2020). At a State Council meeting led by Premier Li Keqiang in September 2020, experts also identified the overuse of ammonia in treating NO_x emissions as a cause for haze. Without sufficient information about these sources and their emissions patterns both spatially and temporally, which differ from locality to locality, $PM_{2.5}$ reduction is often difficult and drastic efforts can prove counterproductive. Such complexities may explain the haze that has blanketed northeastern skies in China in early 2021 despite significantly reduced traffic and industrial operations amid COVID-19.

According to satellite-derived statistics, political pollution waves, which were observed during 2000–10, continued into the 2013–17 period in prefectures treated

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and untreated for $PM_{2.5}$ reduction policies alike, though officially reported statistics would suggest much-dampened political pollution waves in treated cities. During both 2000–10 and 2013–17, regulatory forbearance appeared to be the most likely explanation for the political pollution waves. Qualitative evidence suggests that the continuation of the political pollution wave into the latter period when binding reduction targets were introduced is more a reflection of the amount of ambiguity involved for local regulators to effectively manage $PM_{2.5}$, rather than localities willfully disregarding the preferences of the central government. During both periods, political pollution waves were fostered in prefectures whose top leaders were politically unconnected with their direct superiors.

The chapter is organized as follows. I will first outline the various policy directives and measures introduced by the central government in an effort to contain $PM_{2.5}$ pollution. I will then present data and measurements for $PM_{2.5}$ and economic development, followed by empirical evidence. I discuss potential alternative mechanisms to regulation before concluding the chapter.

5.1 MAKE THE SKY BLUE AGAIN

The 18th Party Congress in November 2012 was a watershed moment for environmental protection in China. It affirmed the "construction of ecological civilization" as a top goal of the Communist Party and integrated it into the party constitution. In September 2013, the State Council promulgated the Clean Air Action Plan (in full, the Air Pollution Prevention and Control Action Plan), which, for the first time, detailed specific targets for PM concentration reduction by 2017, using the PM levels in 2013 as the baseline (State Council 2013a). Article 27 of the plan stipulates that reduction in PM would become a binding target in the target responsibility system used to evaluate the performance of officials. Specifically, four regional clusters received binding targets to reduce $PM_{2.5}$. They are Jing-Jin-Ji and surrounding areas (i.e., Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, and Shandong), Yangtze River delta (i.e., Shanghai, southern Jiangsu, and northern Zhejiang), Pearl River delta (i.e., some prefectures in Guangdong that include Guangzhou, Shenzhen, Zhuhai, Foshan, Jiangmen, Zhaoqing, Huizhou, Dongguan, and Zhongshan), and Chongqing. One notable feature of the action plan is that, for the first time, a policy to control an air pollutant is spearheaded and promoted directly by the State Council; the previous TCZ SO_2 control policy, in contrast, was proposed by the SEPA and later approved by the State Council. At the annual meeting of the NPC in March 2014, Premier Li Keqiang officially declared "war against pollution" and denounced smog as "nature's red-light warning against the model of inefficient and blind development" (Xinhua 2014).

In the spirit of changing priorities in favor of ecology and the environment, several policy measures have been rolled out and implemented gradually to clamp down on air pollution. By the end of 2017, China had been winning its "war against pollution" in an unprecedented way. It has been estimated that between 2013 and 2017, annual average concentrations of $PM_{2.5}$ dropped by about 33 percent, PM_{10} by about 28 percent, SO_2 concentration by 54 percent, and CO concentration by 28 percent in the seventy-four key cities (Huang et al. 2018). In comparison, it took the United States more than a decade and two major recessions to achieve comparable levels of pollution reduction under the 1963 Clean Air Act and later amendments.

Below, I will discuss six major policy measures that signal new intent at the center, align new interests between the center and the local, and improve monitoring of the locality: (1) the phaseout of coal and the promotion of renewable energy, (2) clean production and industrial pollution reduction, (3) environmental impact assessment of projects, (4) clean transportation and the promotion of the new energy vehicle (NEV) industry, (5) the curbing of overcapacity, and (6) strengthened monitoring and transparency.

5.1.1 *Coal Phaseout and Renewable Energy*

I begin with arguably the most significant contributor to $PM_{2.5}$ pollution – coal burning. Coal is the most carbon-intensive fossil fuel, and arguably the dirtiest; phasing it out is a crucial step toward achieving emissions reduction and pollution control. Article 1 of the Air Pollution Action Plan lays out policy measures to cut back on the burning of coal for heating and electricity. For instance, the government aims to accelerate central heating, promote coal-to-gas and coal-to-electricity projects, build high-efficiency and energy-conserving coal-fired boilers, and gradually get rid of decentralized coal-fired boilers. Areas where air pollution had been particularly rampant (e.g., Jing-Jin-Ji, Yangtze River delta, Pearl River delta) were slated to finish the construction or renovation of pollution treatment facilities for coal-fired power plants and boilers by the end of 2015. The promotion of clean energy in the residential sector has targeted rural households, which had historically burnt coal in large amounts for winter heating. By the end of 2017, 6 million households – 4.8 million of which were in Jing-Jin-Ji and the surrounding region – switched from the use of coal to natural gas for electricity.

As coal has been undergoing a phaseout, renewable energy has been on the rise. The country is now the world's leading producer of renewable energy and the leading investor in clean energy research and development (R&D) (Shen, Cain, and Hui 2019). Policy measures to boost the growth of renewables include massive subsidies, tax cuts, funds for renewable R&D, among others. The amendment to the Renewable Energy Law of the People's Republic of China (中华人民共和国可再生能源法 [修正本]), which came into effect on April 1, 2010, proposed the launch of a "protective full-amount acquisition system" (Standing Committee of the NPC, 2009). Under this system, state power-grid enterprises are required to purchase the full amount of electricity generated from renewable resources that satisfies the technical standards for grid synchronization. Working toward that goal, the State Council is to work with

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the state power regulatory authority to determine the proportion of the overall generating capacity to come from renewable resources during a planned period of time. The central government has also been pushing for mandatory integration of renewable energy in electricity generation (Reuters 2016; Shen 2021a).

5.1.2 *Clean Production and Industrial Pollution Reduction*

Clean production has been a policy goal since the late 1990s. In June 2002, the NPC approved the Clean Production Promotion Law of the People's Republic of China (中华人民共和国清洁生产促进法), which laid out the foundation of this centrally led endeavor (Standing Committee of the NPC 2002a). Since 2010, more governing documents were issued to promote cleaner production and industrial pollution reduction further. For instance, in April 2010, the MEP issued the Notice to Further Promote Clean Production in Key Industries (关于深入推进重点企业清洁生产的通知), which required annual plans for the assessment and auditing of clean production among key industries such as heavy metal (MEP 2010). In 2012, a presidential decree on the Decision to Revise the Clean Production Promotion Law of the People's Republic of China (关于修改《中华人民共和国清洁生产促进法》的决定) was promulgated and implemented. It made law the annual planning of clean production and made clean production auditing mandatory for enterprises that pollute beyond national or regional standards, exceed the energy consumption per unit of output standard, or use nocuous or harmful raw materials in the production process (Standing Committee of the NPC 2012).

A series of new policies were targeted at reducing emissions from thermal power plants. In July 2011, the Emission Standard of Air Pollution for Thermal Power Plants (火电厂大气污染物排放标准, aka GB 13223-2011) was revised for the third time, with more stringent emissions limits (MEP and AQSIQ 2011). The limits set for newly built coal-fired power-generating units were 100, 100, and 30 mg/m^3 for SO_2, NO_x, and PM emissions, respectively. It was an ambitious policy, especially in comparison with similar policies in the United States (184, 135, and 20 mg/m^3 for SO_2, NO_x, and PM, respectively) and the European Union (200, 200, and 30 mg/m^3 for SO_2, NO_x, and PM, respectively). In 2014, China introduced ultralow emissions standards for coal-fired power-generating units to limit further their SO_2, NO_x, and PM emissions to 35, 50, and 10 mg/m^3, respectively. These ultralow emissions standards covered all existing and future coal-fired power units. Existing units with at least 580 kW installed capacity were required to meet the ultralow emissions standards by 2020. It is estimated that between 2014 and 2017, the annual emissions of SO_2, NO_x, and PM from thermal power plants reduced by 65 percent, 60 percent, and 72 percent, respectively (Tang et al. 2019).

Closely related to clean production is the circular economy initiative (循环经济), which seeks to close the loops by turning the outputs from one production process into inputs for another. It emphasizes reducing, reusing, and recycling and was

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legislated as a national endeavor at the 16th NPC in 2002. An entire chapter of the 11th FYP (2006–10) was devoted to the discussion of the circular economy. The Circular Economy Promotion Law of the People's Republic of China (中华人民共和国循环经济促进法) was passed by the NPC in 2008 and took effect the following year. The law required local governments to consider circular economy when designing investment and development strategies and enacted targets for the coal, steel, electronics, and chemical and petrochemical industries (Standing Committee of the NPC 2008). More recently, the 12th FYP (2011–15) outlined the national policy shift from resource efficiency to resource recycling, especially for heavy industrial resources, making circular development a national development strategy. The plan proposed a 10-100-1,000 strategy: 10 major programs to recycle industrial waste, convert industrial parks, remanufacture, and develop waste collection and recycling systems; 100 demonstration cities; 1,000 demonstration enterprises or industrial parks. In 2012, the National Development and Reform Commission (NDRC) and the Ministry of Finance called for a complete circular economy transition by 2015 in half of the national industrial parks and 30 percent of the provincial ones, with the goal of achieving close-to-zero pollution discharge in these areas. In January 2013, the State Council promulgated the Circular Economy Development Strategies and Short-Term Action Plan (循环经济发展战略及近期行动计划), a national strategy to achieve a circular economy – and the first of its kind in the world (State Council 2013b). Additional targets for 2015 included increasing energy productivity, measured by GDP per unit of energy by 18.5 percent relative to the 2010 level; improving water productivity by 43 percent; and increasing the output of the recycling industry to RMB 1.8 trillion (about USD 276 billion) from the 2010 level of RMB 1 trillion. Other policy measures included reusing at least 75 percent of coal gangue from mining or 70 percent of pulverized fuel ash from coal combustion during electricity generation. Some of the targets extended into the 13th FYP.

5.1.3 *Environmental Impact Assessment of Projects*

Environmental impact assessment (EIA) is nothing new in China's environmental governance, but it was not enforced adequately or taken seriously. The concept of EIA was first introduced in 1973 at the First Conference for National Environmental Protection in Beijing. The first official EIA was conducted in 1979 for a copper mine. In 1981, the State Planning Commission, the State Construction Commission, and the State Economic and Trade Commission jointly issued the Management for Environmental Protection of Capital Construction Projects to provide detailed guidance on how EIAs should be conducted. In 1986, the EIA licensing system was introduced to allow the National Environmental Protection Agency (NEPA) and the EPBs to review assessment standards and revoke licenses if the practitioners, which were mostly research institutes, failed to perform their jobs. However, it was

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not until around the early 2000s that this system was used with some serious intent (Wang, Morgan, and Cashmore 2003). After more than two decades of experience with EIA, a revised Environmental Assessment Impact Law of the People's Republic of China (中华人民共和国环境影响评价法) took effect in 2003. However, it left the then existing project-level EIA system largely intact (Standing Committee of the NPC 2002b).

One prominent reason why EIAs had been implemented poorly is that they were perceived by localities to be impediments to economic progress. The discretion credited to local officials as a result of decentralization reforms, which is documented in detail in Chapter 3, gave room for relaxing the standards of the EIA and approving polluting projects that could contribute to the local economy. Enterprises in receipt of foreign investment and township and village enterprises were, for quite some time, approved without EIAs due to lack of legal provision (Wang, Morgan, and Cashmore 2003). The situation did not improve much in the 2000s and early 2010s. According to then vice minister of the environment, Pan Yue, in a statement released in February 2016, "Projects unhindered by EIA have become the main cause of pollution, environmental emergencies, chaotic distribution, overcapacity, and disorderly development" (Xinhua 2016).

Actions have been taken in recent years to bring more teeth to the implementation of the EIA Law. As of 2016, an assessment campaign was underway in the Jing-Jin-Ji region, Shanghai, and the Pearl River delta region (Xinhua 2016). In 2016, a newly revised Environmental Assessment Impact Law was passed by the General Assembly of the NPC, which imposes far greater fines for the construction of unapproved or not-yet-approved projects (Standing Committee of the NPC 2016).

5.1.4 *Clean Transportation and the Promotion of New Energy Vehicles*

Emissions from transportation are one of the three most significant contributors to $PM_{2.5}$ pollution. At the heart of the effort to promote clean transportation is the development of NEVs. Supporting the NEV sector is seen by the central government as a critical pathway to realizing four goals: becoming a global leader in the NEV industry, thereby creating jobs and boosting exports; achieving energy security by reducing the country's oil dependence on the Middle East; reducing urban air pollution from mobile sources; and cutting back on carbon emissions (Howell, Lee, and Heal 2014). The central government has made aggressive efforts to leapfrog the auto industries of other countries by promoting the domestic NEV industry, including electric vehicles (EVs), hybrid electric vehicles (HEVs), battery electric vehicles, and fuel cell vehicles. In 2012, the State Council announced a target of total sales of five million EVs and HEVs by 2020 (State Council 2012). On May 23, 2014, President Xi declared that developing NEVs is the only way for China to transform from a vast automobile country to a powerful automobile country. In 2015, the State

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Council promoted the plan of Made in China 2025 (中国制造2025), an initiative to comprehensively upgrade China's industry; the NEV industry was one of ten key industrial sectors to be promoted (State Council 2015a).

To promote the deployment of NEVs, the Chinese government has enacted numerous policies, such as subsidies and tax benefits. In 2014, the State Council issued instructions on accelerating the deployment of NEVs, which stated that EVs and HEVs would be exempt from vehicle purchase taxes between September 1, 2014, and December 31, 2017, and that subsidies to cities and enterprises would be matched by the scale of NEV deployment (State Council 2014). Later that year, the Notice on Financial Support Policies for the Promotion and Deployment of NEVs during 2016–2020 (关于2016-2020年新能源汽车推广应用财政支持政策的通知), jointly issued by the Ministry of Finance, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, and the NDRC, was circulated for public comment (Ministry of Finance et al. 2014). It includes subsidy information to cities for establishing NEV charging stations.

5.1.5 *The Curbing of Overcapacity*

Overcapacity in the steel, aluminum, and cement industries, which had been a long-standing problem in China, produced enormous amounts of $PM_{2.5}$ pollution without putting the overproduction to good use. According to a European Chamber report, steel production was so untethered from the real market demand that it was more than double the combined production of the next four leading producers – Japan, India, the United States, and Russia. Sixty percent of China's aluminum production capacity had negative cash flow. In 2011 and 2012 alone, China produced as much cement as the United States did during the entire twenty-first century (European Chamber 2016, 1). The state's stimulus package in response to the 2007–9 global financial crisis, accompanied by the ease with which producers were able to secure loans from the government, further fostered industrial overcapacity between 2008 and 2014. Such exacerbation was particularly extraordinary in the steel, aluminum, cement, refining, flat glass, and paper industries (European Chamber 2016, 3).

The central government recognized the perils of overcapacity, and a series of policy measures were rolled out to rein it in. To boost demand, the government began promoting urbanization domestically and exports internationally, including through the Belt and Road Initiative. To restrain supply, the government began to impose stricter control on loans and credit as well as higher standards for market entry and project approval; strengthen supervision and enforcement of practices to curb overcapacity; standardize the energy pricing system and curb subsidies in sectors such as aluminum production; accelerate the elimination of industry with backward capacity (European Chamber 2016, 6).

Specifically, as early as August 2009, the State Council revised its policy targets to reduce the negative consequences from overcapacity, such as factory closures, unemployment, and mounting bad loans (State Council 2009). In 2012, the NDRC initiated a progressive electricity pricing system for producers of aluminum. In advance of the 3rd Plenum of the 18th Party Congress in 2013, the State Council put forth water and electricity price reforms, which called for the removal of all local price subsidies and introduced tiered pricing for significant users of water and electricity in sectors defined by overcapacity (State Council 2013c). Existing projects would potentially be reevaluated, and proposed projects would be killed in priority sectors, which included steel, cement, electrolytic aluminum, flat glass, and shipbuilding. These policy initiatives have the potential of reducing $PM_{2.5}$ pollution and dampening the political pollution waves.

5.1.6 *Strengthened Monitoring and Transparency*

Since 2012, a series of new measures and standards have been rolled out to strengthen monitoring and transparency at both the city and the firm levels and to encourage and enable public participation in monitoring environmental performance.

New Standards

New rules would not yield desirable results without improved monitoring. The Ministry of the Environment and the General Administration of Quality Supervision, Inspection and Quarantine jointly issued the new National Ambient Air Quality Standards (NAAQS) in February 2012. This new NAAQS adds new eight-hour concentration standards for $PM_{2.5}$ and O_3; tightens the concentration limits for PM_{10} and NO_2; and establishes a two-level system for ambient air quality.[30] The AQI replaced the API. (SEPA started collecting API data for major cities in 2000, efforts that extended to more cities over time. However, SEPA did not control the monitoring stations; the local EPBs gathered and reported pollution statistics.) The NAAQS imposed a stricter standard on PM_{10} and the calculation of the AQI factors in additional pollutants, including $PM_{2.5}$, O_3, and CO.

Monitoring Cities

Following the promulgation of the new NAAQS, the MEP rolled out a three-stage implementation plan for air quality monitoring that spanned the years 2012–14 and involved the installation of more than 1,600 EPA-grade monitoring stations that would track real-time concentrations for six criteria pollutants. During the first stage, 496 stations in 74 cities – which included (1) cities in the Jing-Jin-Ji, Yangtze River

30 Level I regions include nature reserves and tourist sites as well as other areas that require special protection. Level II regions refer to residential areas, commercial and residential areas, cultural districts, industrial districts, and the countryside.

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delta, and Pearl River delta areas, (2) municipalities directly under the central government, provincial capitals, and (3) other listed cities – were required to establish, test, and implement monitoring stations to measure and publicize pollutant concentrations as per the new NAAQS requirements by January 1, 2013. During the second stage, the above measures were expanded to an additional 116 cities with 449 monitoring stations, to be implemented by January 1, 2014. During the third stage, all remaining 177 cities became subject to air pollution monitoring and air quality disclosure with 552 monitoring stations by November 2014. Pollutant concentration information was required to be publicized via various official websites for environmental monitoring as well as via cell phone, Weibo, television, and radio in easy-to-understand format and language.

Monitoring Factories

In 2013, China launched the CEMS program, under which initiative automatic pollutant monitors were installed at more than twenty-five thousand plants across the country. Each plant's hourly emissions data had to be posted to provincial government websites in real time. The MEP publicized the full list of CEMS firms on its website. That was not the first time that an automatic monitoring system was set up at factories. Back in 2004, SEPA launched a nationwide automated monitoring system for key polluting firms. A flow meter was installed on the site to monitor pollutant discharges and each local EPB had a monitoring center that collected data for all key pollutants from each installed meter in real time. However, while data was being collected, it was only shared with the government and the monitored firms, but not externally. Since 2013, the real-time, hourly CEMS data has been released to the public.

Measures were taken to prevent tampering with the CEMS monitoring equipment. The MEP imposed strict protocols for third-party installation of CEMS equipment. CCTVs were installed close to the monitoring equipment and turned on 24/7 to deter potential interference. Furthermore, the MEP employed algorithms to detect irregularities in the CEMS data and hosted monthly supervisory sessions with local EPBs to discuss such anomalies.

Increased frequency of central and local inspections at factories, or enhanced police patrol, was another mechanism used to strengthen monitoring from 2013 when the State Council announced a new target in the Clean Air Action Plan to cut emissions for heavily polluting industries by 30 percent by 2017. The inspectors often went into factories for surprise inspections, and such inspections often happened at least once a month. Violators of the CEMS proper functioning or of the pollution emissions standard – especially factories that smelted aluminum and burnt coal – were required to temporarily or permanently shut down (Clark 2017). Sometimes entire industrial regions were shut down temporarily. In 2016, the MEP sent inspectors to thirty provinces, where more than eighty thousand factories had their officials reprimanded, fined, or charged with environmental criminal offenses (Schmitz 2017).

Public Participation

The public has been encouraged to participate in environmental governance since the 11th FYP. In 2006, SEPA issued the Interim Measures for Public Participation in Environmental Impact Assessment (环境影响评价公众参与暂行办法), which specified the legal rights of the public to participate in the making and implementation of environmental policies (SEPA 2006). In the same year, SEPA set up the 12369 environmental appeals platform, which provided a hotline phone service and a website for citizens to report potential violations of pollution standards. Furthermore, SEPA established local offices in each prefecture's EPB. Whenever a complaint is made via the 12369 platform, it is directed to the responsible local office for further investigation. A group of inspectors may examine the alleged violation. For confirmed violations, penalties such as fines are issued.

The MEP released, in 2014, Guiding Opinions on Promoting Public Participation in Environmental Protection (关于推进环境保护公众参与的指导意见) and, in 2015, Measures for Public Participation in Environmental Protection (环境保护公众参与办法), which both lay out important channels for the public to participate in enforcing environmental policies (MEP 2014 and 2015). These documents affirm the central government's support for public engagement in environmental governance and specify the various channels of reporting for suspected malfeasance, including letters, fax, email, the 12369 hotline, government websites, and environmental protection agencies.

5.2 DATA AND MEASURES

Having laid out the policy directives and specific policies that could impact $PM_{2.5}$ pollution, I now turn to the data and measures for $PM_{2.5}$ and economic growth I use for empirical analysis. Specifically, I refer to both satellite-based (2000–17) and officially reported (2014–17 or 2015–17) concentration figures for $PM_{2.5}$. For economic growth, I refer to officially reported GDP statistics, officially reported cargo volumes, and satellite-derived nighttime luminosity.[31]

As with the SO_2 case study, I examine trends in both official and satellite-derived statistics on economic development and $PM_{2.5}$ concentration and compare them to reveal interesting aspects about local governance in China. Official statistics reflect what subordinates want their superiors to know, while satellite-derived data are more objective and representative of reality.

5.2.1 *Measuring $PM_{2.5}$*

$PM_{2.5}$ refers to all aerosol particles whose diameter is smaller than 2.5 μm. The most dangerous type of air pollution, $PM_{2.5}$ decreases lung function, contributes to

[31] The data source used in this book for nighttime luminosity is that of the National Oceanic and Atmospheric Administration (NOAA 2015).

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cancer, and kills by triggering heart attacks and strokes (Seaton et al. 1995; Dominici et al. 2006). In China, $PM_{2.5}$ is mainly generated by the types of economic activities that are most rewarded by cadre evaluation, namely, industrial production, infrastructure projects, and transportation.

For satellite-derived measures, I use annual, ground-level $PM_{2.5}$ concentration statistics derived from three NASA satellite sensors and a GEOS-Chem chemical transport model (van Donkelaar et al. 2015; van Donkelaar et al. 2019). Unlike SO_2, the small size of $PM_{2.5}$ allows it to travel long distances, making it challenging to assign the source prefecture of $PM_{2.5}$. In other words, the measured level of concentration may not reflect the level of emissions in that prefecture. For this project, the quantity of immediate interest is the *trend* in pollutant emission levels. If the level of concentration deviates from the emission level by equal proportions across years, the measured tenure effect's statistical significance remains intact. I will explain why that is the case with $PM_{2.5}$ transport matrices and a box model. More explanation of $PM_{2.5}$ pollution measurement can be found in Appendix C. By the time of this writing, satellite-based $PM_{2.5}$ concentration levels are available from 2000 to 2017.

For official measures, I refer to local monitor-based monthly $PM_{2.5}$ concentration readings. The data are downloaded from www.aqistudy.cn/historydata/. I then aggregate the monthly statistics to the annual level. Some prefectures started measuring and publicizing such readings as early as December 2013, while others did not begin until December 2014, so the yearly figures could span 2014–17 or 2015–17.

5.2.2 *Measuring Economic Development*

GDP growth rates have been documented to link powerfully to political promotion prospects (Bo 2002; Chen, Li, and Zhou 2005; Li and Zhou 2005; Wu et al. 2013). GDP data, covering 2000 to 2017, comes from prefectural statistical yearbooks. Official GDP statistics are believed to be exaggerated. According to the former party secretary of Liaoning Province and the current premier, the volume of rail cargo reflects the state of economic development more objectively. It should be quite accurate because fees are charged based on freight weight (WikiLeaks 2007). Hence cargo volumes are plausibly more reflective of actual economic growth.

In addition, I use satellite-derived nighttime luminosity to proxy the level of economic activity. Nighttime luminosity is a delicate, aggregate measure that captures well the sources of $PM_{2.5}$: consumption of electricity generated from the burning of fossil fuels, the nighttime operation of industries, and road lights for nighttime cargo transportation. It has been documented to correlate well with economic activity (Chen and Nordhaus 2011; Henderson, Storeygard, and Weil 2012). Nighttime luminosity data come from the Global Defense Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) nighttime lights series. Thanks to the high spatial resolution of the luminosity data at 2.7 km x 2.7 km, researchers can create measures for a region as small as a township. These data are available annually from 1992 to 2013.

5.3 EMPIRICAL EVIDENCE

To examine the first hypothesis on the political pollution wave and the second hypothesis on the political environmental protection wave outlined in Chapter 2, I run OLS regressions based on Eqs. (5.1) and (5.2) for 2000–10 and 2014–17 (under the first phase of the Clean Air Action Plan when official $PM_{2.5}$ data were available). τ represents the environmental or economic outcome of interest. δ, ζ, and η represent the prefecture, year, and leader fixed effects, respectively. The industrial structure and geography of a locality inherently influence air quality, so applying prefecture fixed effects is necessary. National macroeconomic shocks also affect the scale of local economic activities and, by extension, air pollution levels. Thus, applying year fixed effects is needed. Leader characteristics, such as educational attainment, also can affect the outcome of interest, so I include leader fixed effects in regression analyses. Including such fixed effects can also allow the intercepts of trends for different tenures to vary. Standard errors are clustered at the prefectural level.

$$\tau_{i,t} = \beta YearInOffice_{i,t} + \gamma\delta_i + \delta\zeta_t + \phi\eta + \epsilon_{i,t} \tag{5.1}$$

$$\tau_{i,t} = \beta_1 YearInOffice_{i,t} + \beta_2 YearInOffice_{i,t}{}^2 + \gamma\delta_i + \delta\zeta_t + \phi\eta + \epsilon_{i,t} \tag{5.2}$$

The unit of analysis is prefecture-year. Economic, energy consumption, and pollution patterns exhibit seasonal variation, and such variation may exceed inter-annual variation, so using average annual data allows for relevant comparisons between observations. Also, satellite-derived estimates are subject to meteorological effects; using average yearly data can partially mitigate the impact of meteorological events that may push values away from the typical conditions.

5.3.1 *Before $PM_{2.5}$ Control Became Part of Cadre Evaluation*

Before $PM_{2.5}$ became a criteria air pollutant in prefectures, temporal changes in $PM_{2.5}$ suggest that on average, spending one more year in office was associated with a 0.87 μg/m^3 increase in annual $PM_{2.5}$ concentration (3.90 percent of the standard deviation in $PM_{2.5}$ level) – statistically significant at the 0.001 level (Table 5.1). The WHO air quality guideline for $PM_{2.5}$ is no more than 10 μg/m^3 annually, which means the annual increment is nearly 9 percent of that threshold. Further, confirming theoretical intuition derived from an official emphasis on “steady” and “gradual” implementation, the pattern during a given tenure approximates a linear trend.

TABLE 5.1 *Relationship between political tenure and satellite-derived $PM_{2.5}$ concentration, 2000–10*

	$PM_{2.5}$ (satellite)	
Year in office	0.87***	0.85***
	(0.15)	(0.23)
(Year in office)^2		0.00
		(0.03)
Controls	Y	Y
Observations	2,358	2,358

Sources: Prefectural Yearbooks; van Donkelaar et al. 2015; van Donkelaar et al. 2019.
Note: Clustered standard errors appear in parentheses.
* indicates significance at the 10% level.
** indicates significance at the 5% level.
*** indicates significance at the 1% level.

Given the diverse sources of $PM_{2.5}$, creating an aggregated measure of regulatory stringency in all related sectors is a formidable challenge. It is made even more so due to the often big discrepancies between what is written on paper (e.g., official pollution levy rates) and what happens on the ground (e.g., actual pollution levy applied) in China. However, pollution is generated and mediated via two main pathways: economy and regulation (Ringquist 1993). Is the gradual increase in pollution the result of economic growth and/or regulatory relaxation?

To determine the plausibility of the first pathway, I examine the relationship between economic outputs and pollution. I regress year in office on economic outcomes, measured by official GDP and cargo volume statistics and satellite-derived nighttime luminosity. I find a significant and steady ascension in reported GDP statistics, but opposite trends for cargo volumes and nighttime luminosity. Since the latter two measures are plausibly more objective and reflective of actual economic output, the results suggest that GDP statistics are inflated gradually across time in office to cater to the upper levels' preference – which is discussed in detail in Chapter 3. These results suggest that the economy may not actually have been booming across leaders' tenures, which serves to discredit economic growth as a possible mechanism in explaining the political pollution wave. This leaves regulatory forbearance as a more plausible explanation. As such, I assess the (lack of) effects of economic development and environmental regulation on pollution in the last year compared to the previous years using causal mediation analysis in Appendix D; the results suggest that the significantly positive effect of the final year in tenure, compared to all previous years in office, on $PM_{2.5}$ level is entirely the result of regulatory relaxation, which is consistent with results from Table 5.2.

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TABLE 5.2 *Relationship between political tenure and economic outputs, 2000–10*

	Log (GDP) (official)		Log (Cargo volumes) (official)		Nighttime luminosity (satellite)	
Year in office	0.04***	0.04***	−0.03***	−0.03***	−0.97***	−1.07***
	(0.01)	(0.01)	(0.00)	(0.00)	(0.05)	(0.08)
(Year in office)^2		0.00		0.00		0.02
		(0.00)		(0.00)		(0.01)
Controls	Y	Y	Y	Y	Y	Y
Observations	2,061	2,061	2,309	2,309	2,358	2,358

Sources: Prefectural Yearbooks; City Statistical Yearbooks; NOAA 2015.
Note: Clustered standard errors appear in parentheses.
* indicates significance at the 10% level.
** indicates significance at the 5% level.
*** indicates significance at the 1% level.

Consistent with the qualitative evidence presented earlier in the book, applying laxer regulation could be accomplished as quickly as a phone call (Interview 0715CD03). The lack of inspection by "Tom" could give "Jerry" – a polluting factory – the opportunity to burn cheaper and dirtier coal or not operate their pollution treatment facilities (Wang 2013).

How might political connection influence the strength of the political pollution wave? Intuitively, having connections could dilute the importance of performance in advancement if there is a substitution effect. In that case, the political pollution wave could be dampened. To quantitatively assess the relationship, I ran regressions using the interaction term between year in office and connection as the explanatory variable on the whole sample and using year in office as the explanatory variable, based on Eq. (5.1), on subsamples of the data. A political connection is conceptualized as being from the same prefecture, having gone to the same college, or having worked at the same work unit at the same time. Details on the criteria and coding procedure for political connection can be found in Appendix A. The results suggest that those without political connections were more incentivized than those who were connected to augment their performance in ways that led to stronger political pollution waves. The results in Table 5.3 suggest that for politically unconnected prefectural party secretaries, each additional year in office was associated with an average of 0.92 $\mu g/m^3$ increase in $PM_{2.5}$ concentration (4.14 percent of the standard deviation in $PM_{2.5}$ level) compared to those who were connected.

5.3.2 *After $PM_{2.5}$ Control Became Part of Cadre Evaluation*

After incentives to reduce $PM_{2.5}$ were instituted in 2013, how did the patterns in pollution change? On the one hand, the officially monitored and the satellite-derived

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TABLE 5.3 *Relationship between political connection and the strength of the political pollution wave, 2000–10*

		$PM_{2.5}$ (satellite)	
	Connected	Not connected	Full
Year in office	0.21	0.92***	
	(0.61)	(0.20)	
Year in office × connection			0.07
			(0.18)
Controls	Y	Y	Y
Observations	364	1,907	2,271

Sources: Prefectural Yearbooks; www.people.com.cn; www.xinhuanet.com; van Donkelaar et al. (2015); van Donkelaar et al. (2019).
Note: Clustered standard errors appear in parentheses.
* indicates significance at the 10% level.
** indicates significance at the 5% level.
*** indicates significance at the 1% level.

TABLE 5.4 *Relationship between political tenure and $PM_{2.5}$ concentration, 2013–17*

	$PM_{2.5}$ (official)	$PM_{2.5}$ (satellite)	
Year in office	4.72***	1.39**	1.61***
	(0.85)	(0.52)	(0.28)
Year in office × treatment group	−2.48*	−0.35	−0.18
	(1.25)	(0.72)	(0.49)
Controls	Y	Y	Y
Observations	737	737	1038
Duration	2014–17	2014–17	2013–17

Sources: Prefectural Yearbooks; Clean Air Action Plan; van Donkelaar et al. 2015; van Donkelaar et al. 2019; www.aqistudy.cn/historydata/.
Note: Clustered standard errors appear in parentheses.
* indicates significance at the 10% level.
** indicates significance at the 5% level.
*** indicates significance at the 1% level.

statistics suggest similar trends in prefectures that were not treated for $PM_{2.5}$ reduction: the old political pollution waves continued. As shown in Table 5.4, on average, every additional year the prefectural party secretary spent in office was associated with a 4.72 $\mu g/m^3$ increase in officially reported $PM_{2.5}$ concentration (26.68 percent of the standard deviation in monitor-based $PM_{2.5}$ readings). The magnitude is smaller

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TABLE 5.5 *Relationship between political tenure and officially reported GDP and industrial regulatory stringency, 2013–17*

	Log (GDP)	Industrial SO_2 removal ratio	Industrial dust removal ratio
Year in office	−0.00	0.14***	−0.01
	(0.01)	(0.01)	(0.01)
Year in office × treatment group	−0.00	−0.02	0.04
	(0.02)	(0.04)	(0.04)
Controls	Y	Y	Y
Observations	811	420	425
Duration	2013–17	2013–17	2013–17

Sources: Prefectural Yearbooks; Clean Air Action Plan; City Statistical Yearbooks.
Note: Clustered standard errors appear in parentheses.
* indicates significance at the 10% level.
** indicates significance at the 5% level.
*** indicates significance at the 1% level.

based on satellite-derived $PM_{2.5}$ levels, at 1.39 $\mu g/m^3$ (8.04 percent of the standard deviation in satellite-derived $PM_{2.5}$ concentrations).

On the other hand, statistical analysis reveals a tale of two trends for prefectures treated for $PM_{2.5}$ reduction. The satellite-based trend suggests that the temporal trend is not statistically different from that for untreated prefectures. However, official monitor-based data reveal a much-dampened political pollution wave – an average of 2.24 $\mu g/m^3$ increase in $PM_{2.5}$ concentration for each additional year spent in the office, which is more than half the magnitude for untreated prefectures. The discrepancy between officially reported and satellite-derived data may suggest that some local leaders had incentives to manipulate official measurements to appear more compliant.

Is the continued political pollution wave the result of gradual regulatory relaxation or economic growth? I find the effect of year in office on reported GDP statistics to be consistent across a given tenure, so official statistics would make economic growth an unlikely mechanism to explain the continued political pollution wave.[32] As shown in Table 5.5, there is reportedly a gradual scale-up for the industrial regulation of SO_2, but not for dust, which is a source of PM pollution. The lack of a scale-up in economic growth and industrial regulation of dust suggests that regulatory forbearance likely remains the mechanism for the continued political pollution waves.

[32] The yearbooks' data offerings changed, such as excluding rail cargo volumes for 2015 and onwards. In addition, the DMSP-OLS stable nighttime lights series data ended in 2013. While another similar data source – the Suomi National Polar-Orbiting Partnership Visible Infrared Imaging Radiometer Suite (NPP-VIIRS) composite data – became available after 2012, the two datasets differ in their spatial and radiometric properties, making it challenging to conduct a consistent temporal analysis using both datasets. Some attempts have been made at intercalibrating these two sources, with varying degrees of success. Future research analyzing just the post-2012 period can utilize the NPP-VIIRS dataset.

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TABLE 5.6 *Relationship between political connection and the strength of the political regulation wave, 2014–17*

	$PM_{2.5}$(official)		$PM_{2.5}$(satellite)	
	Connected	Not connected	Connected	Not connected
Year in office	−3.87	5.37***	0.90	1.81*
	(2.09)	(0.95)	(1.28)	(0.73)
Year in office × treatment group	−3.52	−3.49*	1.72	−0.82
	(3.17)	(1.56)	(2.10)	(0.98)
Controls	Y	Y	Y	Y
Observations	124	470	124	470

Sources: Prefectural Yearbooks; Clean Air Action Plan; www.people.com.cn; www.xinhuanet.com; van Donkelaar et al. 2015; van Donkelaar et al. 2019; www.aqistudy.cn/historydata/.
Note: clustered standard errors appear in parentheses.
* indicates significance at the 10% level.
** indicates significance at the 5% level.
*** indicates significance at the 1% level.

Similar to trends in the earlier period, prefectural party secretaries without political connections with their direct superiors induced significant political pollution waves, with an annual average increment that could range between 1.81–5.37 $\mu g/m^3$ (Table 5.6). In prefectures whose party secretaries were not politically connected with their direct superiors, monitor-based statistics suggest that such magnitudes could be 3.49 $\mu g/m^3$ lower. However, satellite-derived data reveal that the difference between treated and untreated prefectures is insignificant. This may suggest that the unconnected leaders in treated cities were incentivized to manipulate $PM_{2.5}$ data to look more compliant with the preference of superiors.

For those who were politically connected, the lack of statistical significance suggests that environmental regulation was consistently applied across a prefectural party secretary's tenure, regardless of whether the prefecture was treated for a $PM_{2.5}$ reduction policy. In other words, the results suggest that politically connected local leaders put up an environmental performance to cater to their superiors' preferences, which is different from the 2000–10 period. The reversal in the incentives to pander to superiors may suggest that performance and connections were more complementary during 2013–17 than 2000–10.

5.4 ALTERNATIVE MECHANISMS

In this section, I discuss two alternative mechanisms to regulatory forbearance – bureaucratic capture and rent-seeking – that may also plausibly explain the political pollution waves for $PM_{2.5}$. I argue that bureaucratic capture is unlikely the dominant

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mechanism. Still, rent-seeking cannot be ruled out, given how closely related strategic planning and rent-seeking are in Chinese politics.

5.4.1 *Bureaucratic Capture*

Those who had worked in prefectures where they became party secretaries could be more poised to capture bureaucracies via their superior local knowledge and personal connections. Suppose bureaucratic capture is the dominant mechanism for the political pollution wave. In that case, a testable implication is that individuals who had worked longer in the prefectures before becoming party secretaries would induce stronger political pollution waves.

Placing party secretaries into different bins based on the length of their prior experience working in the prefecture, I find that those with such previous experience and, by extension, a higher capability to capture the environmental bureaucracy are not statistically different from those without prior work experience in the prefecture (Figure 5.1). These results weaken the possibility of bureaucratic capture as the mechanism to explain the political pollution wave.

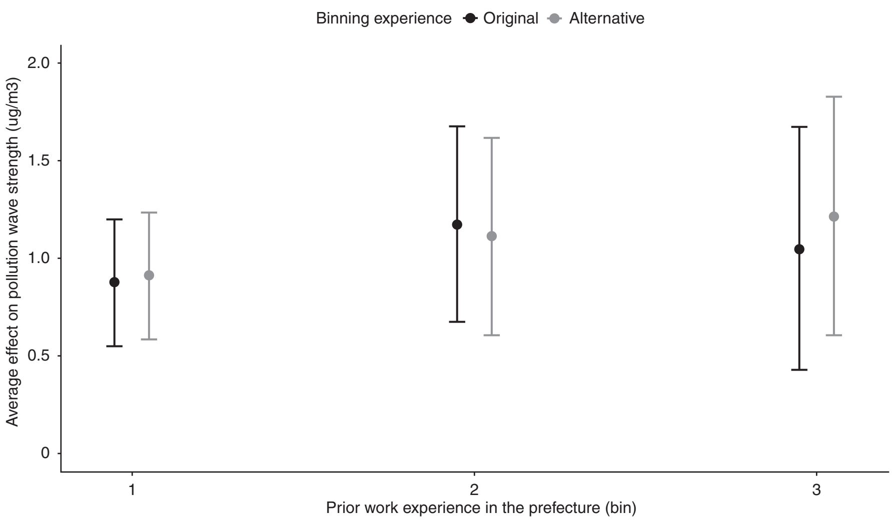

FIGURE 5.1 Relationship between having previously worked in the prefecture and the average annual increase in $PM_{2.5}$ (original bins: no experience = "0"; 1–3 years' experience = "1"; 4 or more years' experience = "2"; alternative bins: no experience = "0"; 1–4 years' experience = "1"; 5 or more years' experience = "2"). Prefectural Yearbooks; www.people.com.cn; www.xinhuanet.com; van Donkelaar et al. 2015; van Donkelaar et al. 2019.

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5.4.2 *Rent-Seeking*

Some may argue that an additional, alternative hypothesis is rent-seeking. According to Gordon Tullock, who originated the idea, rent-seeking refers to individuals obtaining benefits for themselves at the cost of someone or something else through the political arena (Tullock 1967). Krueger (1974), Posner (1975), Buchanan (1980), and so on, have further developed the idea. In the case of a political pollution wave, rent-seeking can be understood as local political leaders turning a blind eye to, or even promoting, polluting activities, thus undermining the central government's environmental goals as well as public health in exchange for personal gains like political promotion.

There are ways for local political leaders to promote social stability and economic development while potentially getting away with the additional pollution. First of all, localities can juke the stats and feed upper levels with misinformation. Sometimes, instead of submitting blatantly doctored data, local environmental authorities and governments may tamper with measurement methodology, such as the number and location of pollution monitors (Interview 03BJ0715). Furthermore, although the public is often encouraged to supervise local compliance, polluting industries and businesses have developed strategies to cope with it. To preempt potential public dissent over air pollution, managers of some enterprises allow operation at night to take advantage of lower electricity costs and to ensure smoke evades the public eye (South China Morning Post 2017). When the sun rises, nocturnal temperature inversion ends, and the warming of the air near the ground will rise, taking the pollutants with it to the upper troposphere.

In China's context, strategic behavior (e.g., extending regulatory forbearance, misreporting statistics to cater to the preferences of superiors) and rent-seeking are interlinked and inseparable. As discussed in Chapter 3, political rank and wealth are strongly and positively correlated in China. Strategic behavior to gain promotion is often accompanied by rent-seeking. Here I do not and cannot exclude the possibility of rent-seeking, but argue for a career incentive-based theory of pollution regulation.

5.5 CONCLUSION

This chapter has laid out the new policy directives and measures post-2010 aimed to curb PM pollution and extends the political regulation wave framework to the empirical case of $PM_{2.5}$ pollution, both before and after it became a criteria pollutant with binding reduction targets. Compared to SO_2, $PM_{2.5}$ is a more vicious pollutant whose control involves a much higher level of difficulty and ambiguity. Therefore, it does not satisfy the third scope condition of the theory, which requires the policy issue to be high conflict and low ambiguity. However, according to the theoretically derived predictions in Chapter 2, political pollution waves and

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the regulatory forbearance mechanism are still likely to hold, but political environmental protection waves are unlikely.

Empirical evidence is in line with those predictions. Before $PM_{2.5}$ control entered into cadre evaluation criteria (2000–10), satellite-derived statistics suggest that top prefectural leaders were incentivized to gradually order laxer regulation of polluters during their tenure to maintain social stability. Regulatory relaxation resulted in political pollution waves and reported economic booms (which may not have actually happened, based on economic measures that are considered more objective than official GDP statistics). After $PM_{2.5}$ control was built into cadre evaluation in select prefectures (2013–17), strong political pollution waves continued, though officially reported local monitor readings seemed to suggest much-attenuated pollution waves. That may reflect the desire of local leaders in prefectures with binding targets to make their superiors believe that they were doing some effective work to make $PM_{2.5}$ regulation more consistent over time. Regulatory forbearance stands out as the most plausible mechanism to account for the political pollution wave during both periods. The incentive to take actions that would lead to political pollution waves was more potent when the top prefectural leaders were not connected to their direct superiors at the provincial level during both periods.

Unlike what the official at a national research institute under the MEP had predicted (quoted at the opening of this chapter), changing the incentive structure provided by the cadre evaluation system was not enough. Given the expressed local determination and the well-documented drastic measures to fight air pollution, the lack of regulatory effectiveness, rather than outright negligence, likely explains the continued political pollution waves. I will explain potential policy solutions to reduce the level of regulatory ambiguity in the last chapter. The next chapter will turn to examine the difficult tradeoffs of political regulation waves.