

Appendix A: Descriptive Statistics

Table A1: Summary statistics

	Observations	Mean	SD
Panel A. Core variables			
PM _{2.5} (μg/m ³ , logged)	13,882,880	3.8590	0.4525
PM _{2.5} (μg/m ³)	13,895,138	51.8314	20.8029
Post Centralization (dummy, 1=yes)	13,895,138	0.0846	0.2782
Panel B. Regional characteristics			
GDP per capita (RMB/person, logged)	13,895,138	9.9637	0.8818
Output of secondary industry (100 million RMB, logged)	13,895,138	8.5603	1.1226
Output of tertiary industry (100 million RMB, logged)	13,895,138	8.4319	1.1331
Coal consumption (10,000 metric tons, logged)	13,868,520	9.3228	0.7918
Panel C. Weather conditions			
Sunshine duration (hours)	13,825,640	1,976.0829	489.4954
Average wind speed (m/s)	13,825,640	2.1171	0.5971
Precipitation (mm)	13,825,640	941.0095	488.9664
Average temperature (°C)	13,825,640	14.2412	4.4071
Average pressure (hPa)	13,825,640	966.4194	61.2051
Average relative humidity (%)	13,825,640	68.6721	8.9983

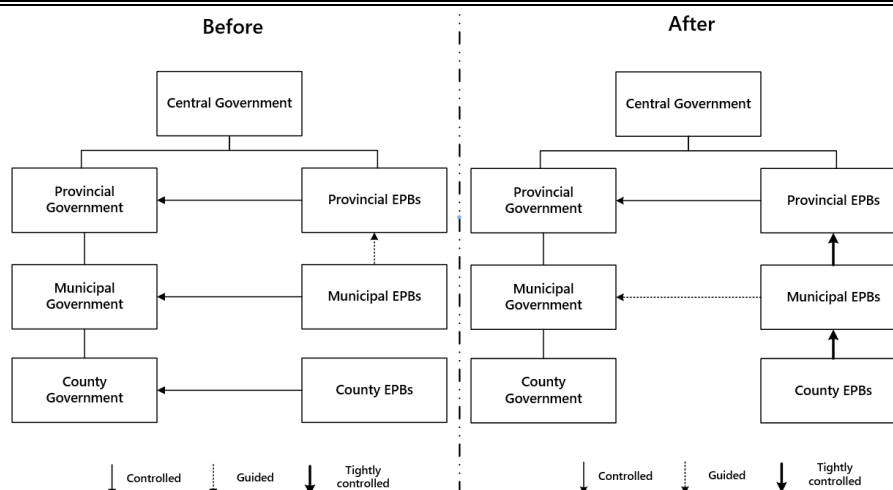


Figure A1: Changes in power structure before and after environmental centralization reform (EPBs: environmental protection bureaus)

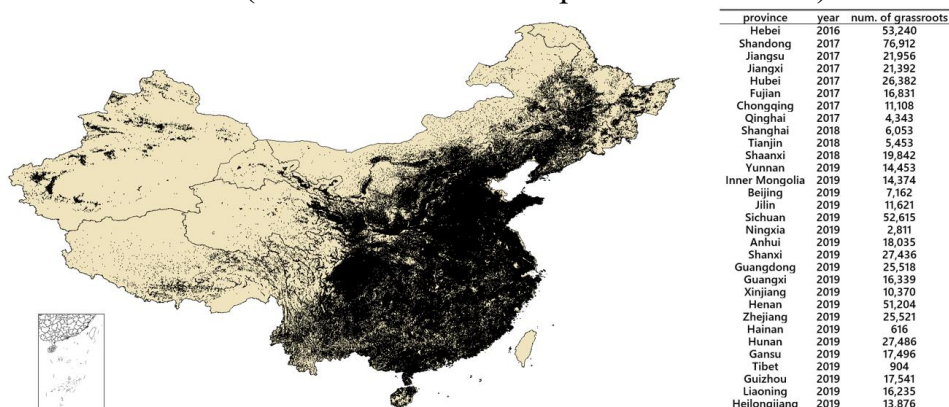


Figure A2: Temporal and spatial distribution of grassroots units and centralization reforms

Appendix B: Institutional Context

China's government operates within a hierarchical structure, with authority distributed across multiple levels, from the central government down to provincial, municipal, county, and other levels. Local officials are evaluated through a promotion tournament system, where their career advancement depends heavily on their ability to achieve key performance indicators, primarily focused on economic growth (Whiting, 2000, Xu, 2011, Bo, 1996). This system creates a significant tension between the goals of economic development and environmental protection. Local governments, driven by the imperative to boost gross domestic product (GDP), investment, and fiscal revenues, prioritize short-term economic gains over long-term environmental sustainability. This trade-off has historically posed challenges for effective environmental governance, as local officials may be incentivized to overlook environmental regulations in favor of economic achievements (Kahn et al., 2015).

For many years, the country's environmental governance has struggled with the challenges posed by the decentralization of environmental monitoring, supervision, and enforcement powers. The vertical division of these responsibilities has led to misaligned incentives and externalities (Ma et al., 2023). On the one hand, the principle of incentive compatibility has been undermined by the conflict between local governments' economic and environmental objectives. Strengthening environmental control is perceived as detrimental to local economic performance, which has traditionally hindered effective environmental management at the local level. On the other hand, the fragmentation of environmental governance has compromised the principle of internalizing externalities. Cross-regional environmental issues, such as air pollution, create mismatches between the costs and benefits

of environmental protection for local governments, leading to ineffective cooperation between neighboring regions (Ostrom et al., 1999). This situation has resulted in “free-rider” behaviors, where local authorities neglect their environmental responsibilities, assuming that the burden will be borne by others.

In response to the challenges of fragmented systems, the State Council issued the *Guiding Opinions on the Pilot Work for the Reform of Vertical Management Systems for Environmental Monitoring, Supervision, and Law Enforcement Below the Provincial Level* in 2016, which introduced a centralized structure. A key aspect of this reform was the introduction of a semi-vertical management system between the provincial and municipal levels, and a fully vertical management system from the municipal to the county level. Under this new structure, municipal environmental protection bureaus (EPBs) became subject to dual management: while they remain a part of the municipal government, their operations and leadership are now primarily directed by the provincial environmental protection department. This shift significantly reduces the influence of local municipal governments over environmental matters. Furthermore, county-level EPBs were transformed into branch offices directly managed by the municipal EPBs, effectively removing them as independent entities within the county government. This restructuring centralized decision-making power, with provincial-level authorities now playing a pivotal role in appointing the leadership of municipal EPBs, while municipal EPBs handle the appointments at the county level.

Another critical change introduced by the reform was the complete centralization of environmental monitoring responsibilities to the provincial level. Environmental monitoring, which includes the assessment and evaluation of ecological quality, was previously managed

by city and county governments. Post-reform, all such activities are now under the exclusive purview of the provincial environmental departments. This centralization aims to standardize environmental assessments and reduce the risk of data manipulation that was prevalent when local governments controlled monitoring efforts (Ghanem and Zhang, 2014). The restructuring also included the transfer of environmental supervision functions from city and county levels to the provincial level. By consolidating these functions, the reform seeks to enhance oversight and ensure more consistent enforcement of environmental regulations across regions. Environmental enforcement responsibilities, which were previously managed by county governments, were elevated to the municipal level, with the municipal EPBs now directly overseeing and commanding county-level enforcement efforts. This reorganization ensures that environmental enforcement aligns more closely with provincial directives, with some aspects of enforcement coming directly under the supervision of the provincial environmental departments.

Appendix C: Original Policy Documents



Guidelines on Pilot Work for Vertical Management System Reform of Environmental Protection Agencies Below the Provincial Level

Issued by the General Office of the CPC Central Committee and the General Office of the State Council

September 22, 2016, 17:52

Source: Xinhua News Agency

BEIJING, September 22 (Xinhua) — The General Office of the Communist Party of China Central Committee and the General Office of the State Council recently issued the "Guidelines on Pilot Work for Vertical Management System Reform of Environmental Protection Agencies Below the Provincial Level" and distributed a notice requiring all regions and departments to implement the guidelines earnestly in combination with local conditions.

The full text of the Guidelines is as follows:

I. General Requirements

(1) Guiding Principles

The reform shall comprehensively implement the spirit of the 18th CPC National Congress and the Third, Fourth, and Fifth Plenary Sessions of the 18th CPC Central Committee, thoroughly study and implement the spirit of General Secretary Xi Jinping's series of important speeches, closely focus on coordinating and promoting the five-sphere integrated plan and the four-pronged comprehensive strategy, firmly establish new development concepts, conscientiously implement the decisions and arrangements of the CPC Central Committee and the State Council, reform the basic systems of environmental governance, establish and improve a local environmental protection management system that combines vertical and horizontal coordination with clear division of responsibilities and authorities that is well-supported, authoritative and efficient, effectively implement supervision responsibilities over local governments and their relevant departments, enhance the independence, uniformity, authority and effectiveness of environmental monitoring, inspection and law enforcement, adapt to new requirements for coordinated resolution of cross-regional and cross-watershed environmental problems, standardize and strengthen the construction of local environmental protection agency teams, and provide strong institutional guarantees for building a beautiful China with blue skies, green land and clean water.

(2) Basic Principles

Adhere to a problem-oriented approach. The reform pilot should be conducive to promoting the resolution of prominent problems in the local environmental protection management system, conducive to clarifying, breaking down and implementing environmental protection

responsibility objectives and tasks, conducive to mobilizing the enthusiasm of local Party committees, governments and their relevant departments, and conducive to a smooth transition from the old to the new environmental protection management system.

Strengthen performance of duties and responsibilities. Local Party committees and governments shall bear overall responsibility for the ecological environment in their respective regions. A clear and reasonably divided environmental protection responsibility system shall be established and improved, supervision and inspection shall be strengthened, and implementation of environmental protection responsibilities shared by both Party and government officials, with dual responsibilities for a single position, shall be promoted. Those who fail to perform their duties or neglect their responsibilities shall be held strictly accountable.

Ensure smooth and efficient operations. The system and mechanisms shall be reformed and improved, provincial-level environmental protection departments' management of environmental monitoring and inspection at municipal and county levels shall be strengthened, the relationship between unified supervision and management by environmental protection departments, territorial primary responsibilities, and division of responsibilities among relevant departments shall be properly coordinated, and ecological environmental governance capabilities shall be enhanced.

Properly coordinate and integrate. Top-level design shall be well executed, coordination with various tasks of ecological civilization system reform shall be maintained, linkage with the improvement of ecological and environmental protection systems shall be established, connection with the classified reform of public institutions, administrative examination and approval system reform, and comprehensive administrative law enforcement reform shall be achieved, and the comprehensive effectiveness of reform shall be enhanced.

II. Strengthening Environmental Protection Responsibilities of Local Party Committees, Governments and Their Relevant Departments

(3) Implementing the Requirement that Local Party Committees and Governments Bear Overall Responsibility for the Ecological Environment

Pilot provinces shall further strengthen the primary environmental protection responsibilities of Party committees and governments at all local levels and the primary responsibilities of principal leading members of Party committees and governments, improve the target responsibility assessment system for leading cadres, and make the state of ecological environmental quality an important element in the assessment and evaluation of Party and government leadership teams. A responsibility investigation system shall be established and implemented for leading cadres who illegally or improperly interfere with environmental monitoring and law enforcement activities or meddle in the investigation and handling of specific environmental protection cases, supporting environmental protection departments in performing their duties according to law and regulations.

(4) Strengthening the Responsibilities of Local Environmental Protection Departments

Provincial-level environmental protection departments shall implement unified supervision and management of environmental protection work throughout the province (autonomous region, municipality directly under the Central Government), uniformly plan and construct environmental monitoring networks throughout the province (autonomous region, municipality directly under the Central Government), conduct law enforcement on provincial-level environmental protection licensing matters and other issues, provide guidance to municipal and county-level environmental law enforcement agencies, and investigate and handle cross-municipal disputes and major cases. Municipal-level environmental protection departments shall implement unified supervision and management of environmental protection work within the entire municipal area, be responsible for territorial environmental law enforcement, and strengthen comprehensive coordination. County-level environmental protection departments shall strengthen on-site environmental law enforcement, transfer existing environmental protection licensing and other functions to municipal-level environmental protection departments, and undertake some specific environmental protection licensing work within the scope authorized by municipal-level environmental protection departments.

(5) Clarifying Environmental Protection Responsibilities of Relevant Departments

Pilot provinces shall formulate lists of environmental protection responsibilities for relevant departments with ecological and environmental supervision duties, clarifying the environmental protection responsibilities of various relevant departments in industrial pollution prevention and control, agricultural pollution prevention and control, urban and rural sewage and waste treatment, environmental protection in land and resources development, motor vehicle and vessel pollution prevention and control, natural ecological protection and other areas, and conducting supervision and management according to their respective responsibilities. Those who manage development must manage environmental protection, and those who manage production must manage environmental protection, forming a work pattern of joint efforts and achieving the internal unity and mutual promotion of development and environmental protection. Party committees and governments at all local levels shall incorporate the performance of environmental protection duties by relevant departments into annual departmental performance assessments.

III. Adjusting the Local Environmental Protection Management System

(6) Adjusting the Management System of Municipal and County Environmental Protection Agencies

Municipal-level environmental protection bureaus shall implement dual management with provincial-level environmental protection departments (bureaus) taking the leading role, while remaining working departments of municipal governments. The Party group of the provincial-level environmental protection department (bureau) shall be responsible for nominating the director and deputy directors of municipal-level environmental protection bureaus, conducting inspections in conjunction with municipal Party committee organization departments, soliciting opinions from municipal Party committees, and then submitting to municipal Party committees and governments for handling according to relevant prescribed procedures, with the director being subject to appointment and removal by the municipal

people's congress. The Party group secretary, deputy secretaries, and members of municipal-level environmental protection bureaus shall be approved and appointed or removed by the Party group of the provincial-level environmental protection department (bureau) after soliciting opinions from municipal Party committees. Environmental protection bureaus of districts and counties under municipalities directly under the Central Government and counties (cities, districts) directly under provincial administration shall implement reforms with reference to municipal-level environmental protection bureaus. Environmental protection bureaus of cities specifically designated in the state plan and sub-provincial cities shall implement dual management with provincial-level environmental protection departments (bureaus) taking the leading role; for matters involving the appointment and removal of department-level cadres, management shall be conducted according to the corresponding cadre management authority.

County-level environmental protection bureaus shall be adjusted to become branch bureaus dispatched by municipal-level environmental protection bureaus, directly managed by municipal-level environmental protection bureaus, with leadership team members appointed and removed by municipal-level environmental protection bureaus. Reform plans for the environmental protection management systems of development zones (high-tech zones) and other areas shall be determined by pilot provinces.

After adjustment of the local environmental protection management system, attention should be paid to coordinating the exchange and deployment of environmental protection cadres.

(7) Strengthening Environmental Inspection Work

Pilot provinces shall elevate the environmental inspection functions of municipal and county-level environmental protection departments to the provincial level, to be exercised uniformly by provincial-level environmental protection departments, implementing environmental inspection through forms such as dispatch to municipalities or cross-municipal and county regions. Upon authorization by provincial governments, provincial-level environmental protection departments shall supervise and inspect the implementation of environmental protection laws, regulations, standards, policies and plans by governments and relevant departments at municipal and county levels within their administrative regions, the implementation of dual responsibilities for a single position, and the implementation of environmental quality responsibilities, reporting to provincial Party committees and governments in a timely manner.

(8) Adjusting the Environmental Monitoring Management System

Ecological environmental quality monitoring, investigation, evaluation and assessment work for the province (autonomous region, municipality directly under the Central Government) and its municipalities and counties shall be uniformly undertaken by provincial-level environmental protection departments, implementing provincial-level monitoring and assessment of ecological environmental quality. Existing municipal-level environmental monitoring agencies shall be adjusted to become environmental monitoring agencies dispatched by provincial-level environmental protection departments to municipalities, directly managed by provincial-level environmental protection departments, with personnel

and operating expenses borne by the provincial level. Leadership team members shall be appointed and removed by provincial-level environmental protection departments (bureaus). Principal officers shall serve as members of the Party group of municipal-level environmental protection bureaus, and opinions from municipal-level environmental protection bureaus should be solicited in advance. Provincial-level and municipal-dispatched environmental monitoring agencies shall primarily be responsible for ecological environmental quality monitoring work. Reform plans for environmental monitoring agencies of districts and counties under municipalities directly under the Central Government shall be determined by the environmental protection bureaus of municipalities directly under the Central Government in combination with actual conditions.

The primary functions of existing county-level environmental monitoring agencies shall be adjusted to law enforcement monitoring, elevated together with county-level environmental protection bureaus to the municipal level, with personnel and operating expenses borne by the municipal level. Specific work shall be under the leadership of county-level environmental protection branch bureaus, supporting and cooperating with territorial environmental law enforcement, forming effective linkage and rapid response between environmental monitoring and environmental law enforcement, while also performing ecological environmental quality monitoring-related work as required.

(9) Strengthening Municipal and County Environmental Law Enforcement Work

The focus of environmental law enforcement shall shift downward to municipalities and counties, grassroots law enforcement teams shall be strengthened, and territorial environmental law enforcement shall be reinforced. Municipal-level environmental protection bureaus shall uniformly manage and command county-level environmental law enforcement forces within their administrative regions, with personnel and operating expenses borne by the municipal level. Environmental law enforcement agencies shall be legally granted the conditions and means to implement on-site inspections, administrative penalties, and administrative compulsion. Environmental law enforcement agencies shall be included in the sequence of government administrative law enforcement departments, equipped with investigation and evidence collection, mobile law enforcement and other equipment, unified environmental law enforcement personnel uniforms shall be provided, and frontline environmental law enforcement vehicles shall be guaranteed.

IV. Standardizing and Strengthening the Construction of Local Environmental Protection Agencies and Teams

(10) Strengthening Standardized Construction of Environmental Protection Agencies

Pilot provinces shall, without exceeding the existing agency quotas and total staff allocations of localities, comprehensively resolve issues concerning environmental protection agency staffing and personnel status involved in system reform, ensuring that environmental protection departments have the resources needed to perform their duties. Municipal and county-level environmental protection bureaus that are currently still public institutions using public institution staffing shall, in combination with system reform and the classified reform

of public institutions, gradually transition to administrative agencies using administrative staffing.

Environmental inspection functions shall be strengthened, an environmental inspection system shall be established and improved, and organizational leadership for environmental inspection work shall be strengthened. Full-time leaders responsible for environmental inspection at provincial-level environmental protection departments (bureaus) shall be assigned, internal environmental inspection agencies shall be strengthened in combination with work needs, and exploration of establishing an environmental inspection commissioner system shall be undertaken.

The construction of environmental monitoring agencies shall be standardized and strengthened, and the management of social monitoring agencies and operation and maintenance agencies by environmental protection departments shall be reinforced. Pilot provinces shall, in combination with the classified reform of public institutions and comprehensive administrative law enforcement reform, standardize the establishment of environmental law enforcement agencies. An enforcement responsibility system shall be improved, and environmental supervision and law enforcement conduct shall be strictly standardized and constrained. Personnel and staffing streamlined from municipal and county-level environmental protection agencies shall focus on reinforcing frontline environmental law enforcement forces.

Townships (sub-districts) shall implement environmental protection responsibilities, clarify the agencies and personnel responsible for environmental protection, ensuring that there are people responsible for duties and people to perform tasks. Relevant localities shall establish and improve rural environmental governance systems and mechanisms, raising the level of rural environmental protection public services.

(11) Strengthening Environmental Protection Capacity Building

Normative documents on environmental protection monitoring, inspection, law enforcement and other aspects shall be issued as soon as possible, standardized capacity building for environmental protection monitoring, inspection and law enforcement shall be comprehensively promoted, personnel training shall be strengthened, and the professional level of teams shall be enhanced. Capacity building of county-level environmental monitoring agencies shall be strengthened, and monitoring qualification issues in monitoring agency reform shall be properly resolved. An administrative law enforcement personnel certification and qualification management system shall be implemented. Nuclear and radiation safety monitoring and law enforcement capacity building shall continue to be strengthened.

(12) Strengthening Party Organization Construction

The Party building work responsibility system shall be conscientiously implemented, and comprehensive strict Party governance shall be put into practice. According to regulations, Party groups shall be established in qualified municipal-level environmental protection bureaus, accepting the leadership of the municipal Party committees that approved their establishment, and reporting and requesting instructions on Party work to the Party group of

the provincial-level environmental protection department (bureau). After approval by the municipal Party committee organization department, the Party group of the municipal-level environmental protection bureau may establish branch Party groups in county-level environmental protection branch bureaus. According to the principle of territorial management, Party grassroots organizations shall be established and improved, and Party grassroots organizations of municipal and county-level environmental protection departments shall accept the leadership of the local working committee of the Party's government agencies and the guidance of the Party group of the environmental protection bureau (branch bureau) at the corresponding level. The establishment of discipline inspection agencies of environmental protection departments below the provincial level shall be determined by the provincial-level environmental protection department (bureau) in consultation with provincial-level discipline inspection authorities and reported for approval according to procedures.

V. Establishing and Improving Efficient and Coordinated Operating Mechanisms

(13) Strengthening Cross-Regional and Cross-Watershed Environmental Management

Pilot provinces shall actively explore the establishment of environmental supervision and administrative law enforcement agencies according to watersheds, cross-regional environmental protection agencies, and orderly integrate supervision forces from different fields, different departments and different levels. Provincial-level environmental protection departments (bureaus) may select municipal-dispatched environmental monitoring agencies with relatively strong comprehensive capabilities to undertake cross-regional and cross-watershed ecological environmental quality monitoring functions.

Provincial environmental protection departments (bureaus) of pilot provinces shall take the lead in establishing and improving regional cooperation mechanisms, promoting cross-regional and cross-watershed environmental pollution joint prevention and control, and strengthening joint monitoring, joint law enforcement and cross law enforcement.

Municipal Party committees and governments are encouraged to implement unified management within the entire municipal area according to the integrity of the ecological and environmental system, with unified planning, unified standards, unified environmental impact assessment, unified monitoring and unified law enforcement, and consolidating and establishing cross-municipal district environmental law enforcement and environmental monitoring agencies.

(14) Establishing and Improving Environmental Protection Deliberation and Coordination Mechanisms

Governments at and above the county level in pilot provinces shall establish and improve environmental protection deliberation and coordination mechanisms, study and resolve major environmental protection problems in their respective regions, strengthen comprehensive decision-making, and form work synergy. Daily work shall be undertaken by environmental protection departments at the corresponding level.

(15) Strengthening Cooperation Between Environmental Protection Departments and Relevant Departments

Environmental protection departments at all local levels shall provide support for territorial Party committees and governments in performing their environmental protection responsibilities and provide monitoring support for emergency response to environmental incidents. Municipal-level environmental protection departments shall assist in the overall planning and scientific decision-making of county-level ecological and environmental protection work. Provincial-level environmental protection department municipal-dispatched environmental monitoring agencies shall proactively strengthen coordination and linkage with territorial environmental protection departments, participate in their relevant meetings, and provide support for municipal and county environmental management and law enforcement. For counties that currently do not have environmental monitoring agencies, their environmental monitoring tasks shall be undertaken by municipal-level environmental protection departments consolidating existing county-level environmental monitoring agencies, or assisted by municipal-dispatched environmental monitoring agencies. Joint law enforcement and emergency response between environmental protection departments at all local levels and relevant departments and units shall be strengthened, and environmental protection work shall be advanced collaboratively.

(16) Implementing Environmental Monitoring and Law Enforcement Information Sharing

Provincial environmental protection departments (bureaus) of pilot provinces shall establish and improve ecological environmental monitoring and environmental law enforcement information sharing mechanisms, take the lead in establishing and operating ecological environmental monitoring information transmission networks and big data platforms, achieving interconnection, real-time sharing and shared results with municipal governments and their environmental protection departments, county governments and county-level environmental protection branch bureaus. Environmental protection departments shall promptly communicate environmental monitoring, inspection, law enforcement and other situations to territorial Party committees, governments and their relevant departments.

VI. Implementing Reform-Related Policy Measures

(17) Steadily Conducting Personnel Transfers

Pilot provinces shall, according to relevant regulations and in combination with adjustments to agency affiliation relationships, correspondingly transfer staffing and personnel, optimize the allocation of agencies and staffing of environmental protection departments within their administrative regions, make reasonable adjustments, and achieve consistency between personnel and positions. Pilot provinces shall, based on local realities, study and determine the quantity, conditions and procedures for personnel transfers, and conduct transfer work in an open, fair and impartial manner. Governments at all local levels shall study and issue policy measures to resolve issues such as personnel transfer, job transfer and placement, ensuring the stability of environmental protection teams. After reform, county-level environmental protection departments shall continue to implement the parallel system of civil servant positions and ranks according to national regulations.

(18) Properly Handling Assets and Liabilities

Asset inventories shall be conducted according to relevant regulations, accounting clearance and asset verification shall be performed well, ensuring consistency between accounts and actual assets, and strictly preventing the loss of state-owned assets. For state-owned asset gains and losses discovered during inventory, handling shall be conducted according to relevant regulations after verification by finance departments at the corresponding level and approval by governments at the corresponding level. According to the principle that assets follow agencies, asset transfer and handover shall be completed properly according to the procedures and requirements stipulated in relevant state-owned asset management systems. According to the principle that claims and liabilities follow assets (agencies), responsible persons for claims and liabilities shall be clarified, and claims and liabilities transfer and handover shall be completed properly. For debt issues that local governments have committed to resolve through subsequent fiscal year appropriations or other funding arrangements, transfers shall be conducted after proper handling.

(19) Adjusting Funding Support Channels

During the pilot period, basic expenditures and corresponding operating expenses required for environmental protection departments to conduct normal work shall in principle be resolved through original channels, and transferred along with agency adjustments after verification of transfer base amounts. Local finances shall fully consider expenses for personnel transfer and placement, and ensure funding support for reform work. According to the principle of matching powers and expenditure responsibilities, environmental protection departments shall be incorporated into the fiscal budget systems of corresponding levels for support. Personnel treatment shall be handled according to the principle of territorialization. Environmental protection department funding support standards shall be determined by localities according to law within the existing institutional framework in combination with actual conditions.

VII. Strengthening Organizational Implementation

(20) Strengthening Organizational Leadership

Party committees and governments of pilot provinces shall bear overall responsibility for pilot work on environmental protection vertical management system reform and establish relevant work leading groups. Party committees of pilot provinces shall grasp the direction of reform and study and resolve major problems in reform. Governments of pilot provinces shall formulate reform implementation plans, clarify responsibilities, and implement reform pilots actively and steadily. Environmental protection, agency staffing, organization, development and reform, finance, human resources and social security, legal affairs and other departments of pilot provinces shall cooperate closely and work together to advance reform. Party committees and governments at municipal and county levels shall effectively resolve problems arising during the reform process, ensuring smooth development of reform work and orderly advancement of environmental protection work.

The Ministry of Environmental Protection and the Central Commission for Institutional Reform shall strengthen classified guidance and tracking analysis of pilot work, provide good

model guidance and exchange training, strengthen overall coordination and supervision and inspection, study and issue relevant policy measures, and promptly report major matters to the CPC Central Committee and the State Council. For matters involving amendments to laws and regulations, legal procedures shall be followed.

(21) Strictly Enforcing Work Discipline

During the pilot period, political discipline, organizational discipline, fiscal and economic discipline and other disciplines shall be strictly enforced, solid work shall be done in publicity and public opinion guidance, and ideological stability work for cadres and staff shall be conducted conscientiously.

(22) Advancing Reform in an Orderly Manner

All provinces (autonomous regions, municipalities directly under the Central Government) are encouraged to apply for pilot work and actively prepare in advance. The Ministry of Environmental Protection and the Central Commission for Institutional Reform shall, based on the characteristics of economic and social development and types of environmental problems in different regions, combined with local reform foundations, study reform implementation plans of provinces applying for pilot status, and comprehensively determine pilot provinces. Reform implementation plans of pilot provinces must be organized and implemented only after filing and approval by the Ministry of Environmental Protection and the Central Commission for Institutional Reform.

Pilot provinces shall, according to the requirements of these guidelines and their reform implementation plans, innovate methods and approaches according to local conditions, refine measures, implement policies, conduct pilot tests first, and strive to complete pilot work by the end of June 2017, forming self-assessment reports. The Ministry of Environmental Protection and the Central Commission for Institutional Reform shall conduct summary evaluations of pilot work, propose supporting policies and work arrangement recommendations, and comprehensively roll out reform work after approval by the CPC Central Committee and the State Council.

Provinces not included in the pilot shall actively conduct preliminary work such as surveys and policy research, organize the formulation of reform implementation plans, organize implementation and develop work in an orderly manner after filing and approval by the Ministry of Environmental Protection and the Central Commission for Institutional Reform, striving to complete adjustment of environmental protection management systems below the provincial level by the end of June 2018. On this basis, all provinces (autonomous regions, municipalities directly under the Central Government) shall further improve supporting measures and mechanisms, ensuring comprehensive completion of the environmental protection agency monitoring, inspection and law enforcement vertical management system reform tasks during the "13th Five-Year Plan" period, and achieving efficient operation of environmental protection departments below the provincial level nationwide according to the new system by 2020.

Appendix D: Results for Alternative Mechanisms

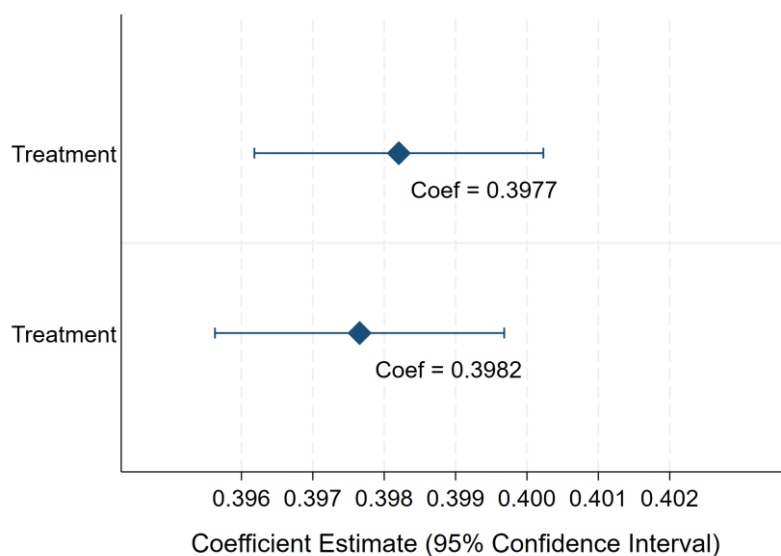


Figure D1: Testing the incentive bias and data manipulation mechanism

Note: This figure demonstrates the incentive bias and data manipulation mechanism of the environmental centralization reform. The key explanatory variable is the post-reform environmental centralization implementation indicator. The dependent variable is the logarithm of the deviation between NASA satellite-estimated PM_{2.5} concentrations and the annual reported concentrations from grassroots units. The control strategy remains consistent with the baseline estimation, incorporating pre-reform regional characteristics interacted with year fixed effects, pre-reform weather characteristics interacted with year fixed effects, and grassroots unit fixed effects. Both the first and second models employ robust standard errors clustered at the grassroots level and report 95% confidence intervals. The distinction between the two models lies in whether weather conditions are controlled.

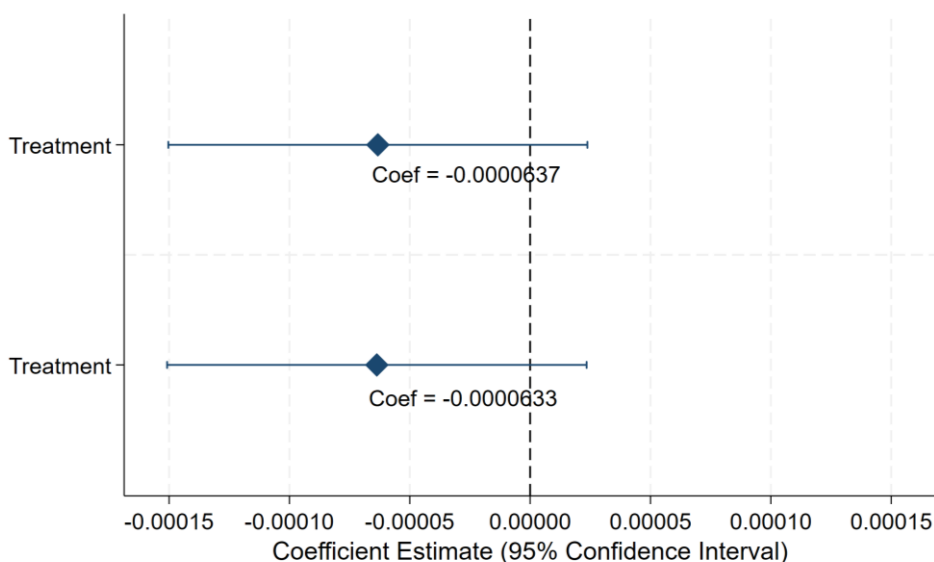


Figure D2: Placebo test for the externality comparison mechanism

Note: This figure demonstrates the externality comparison mechanism of the environmental centralization reform. The key explanatory variable is the post-reform environmental centralization implementation indicator. The dependent variable is the logarithm of noise pollution levels, measured in equivalent sound level dB(A) units. The control strategy remains consistent with the baseline estimation, incorporating pre-reform regional characteristics

interacted with year fixed effects, pre-reform weather characteristics interacted with year fixed effects, and grassroots unit fixed effects. Both the first and second models employ robust standard errors clustered at the grassroots level and report 95% confidence intervals. The distinction between the two models lies in whether weather conditions are controlled.

Appendix E: Robustness Tests and Heterogeneity Analysis

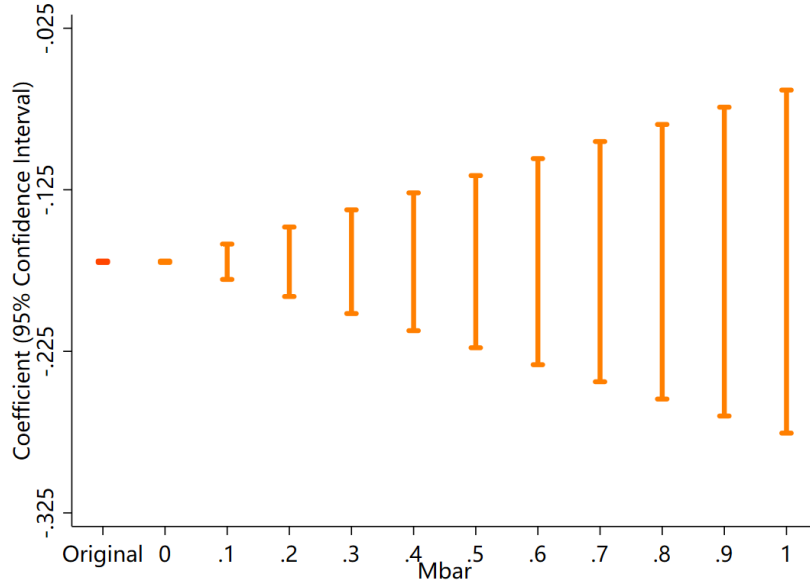


Figure E1: Honest DiD estimates

Note: This figure presents the results from the honest DiD robustness test. The specification includes controls for pre-reform regional characteristics interacted with year fixed effects, pre-reform weather characteristics interacted with year fixed effects, and grassroots-level unit fixed effects. The figure reports 95% confidence intervals around the point estimates. The parameter Mbar represents the maximum magnitude of potential bias from violations of parallel trends.

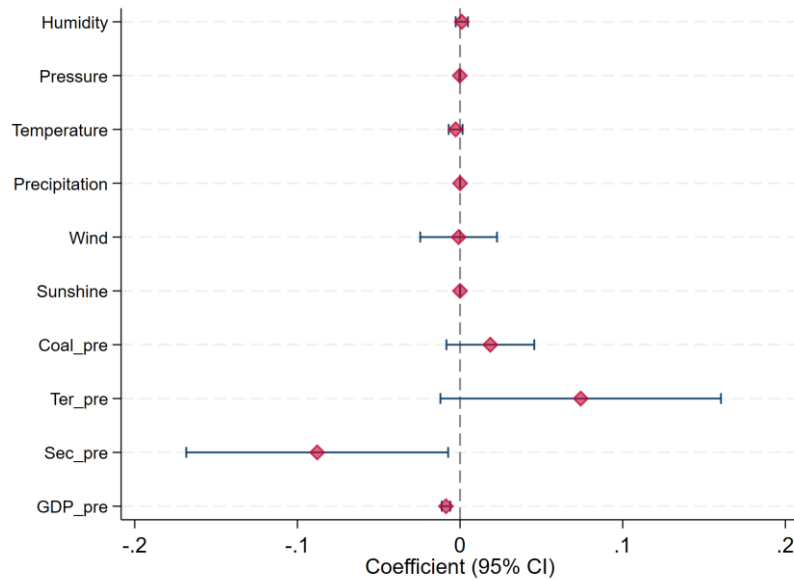


Figure E2: Testing the effects of pre-reform socioeconomic characteristics and weather conditions on the treatment indicator

Note: The dependent variable is a dummy variable indicating the implementation of the centralization reform (=1 if yes). The key explanatory variables are pre-reform socioeconomic characteristics and weather conditions. All specifications control for grassroots-level unit fixed effects.

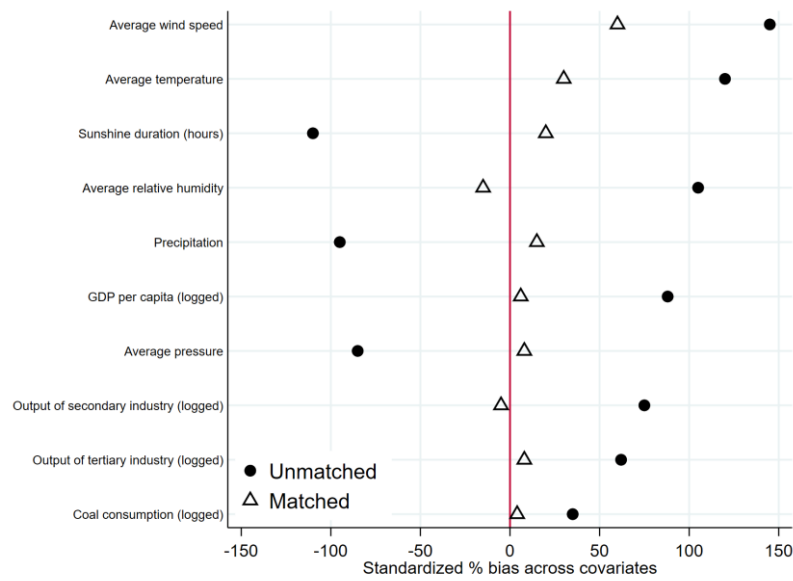


Figure E3: Bias variation before and after propensity score matching estimation

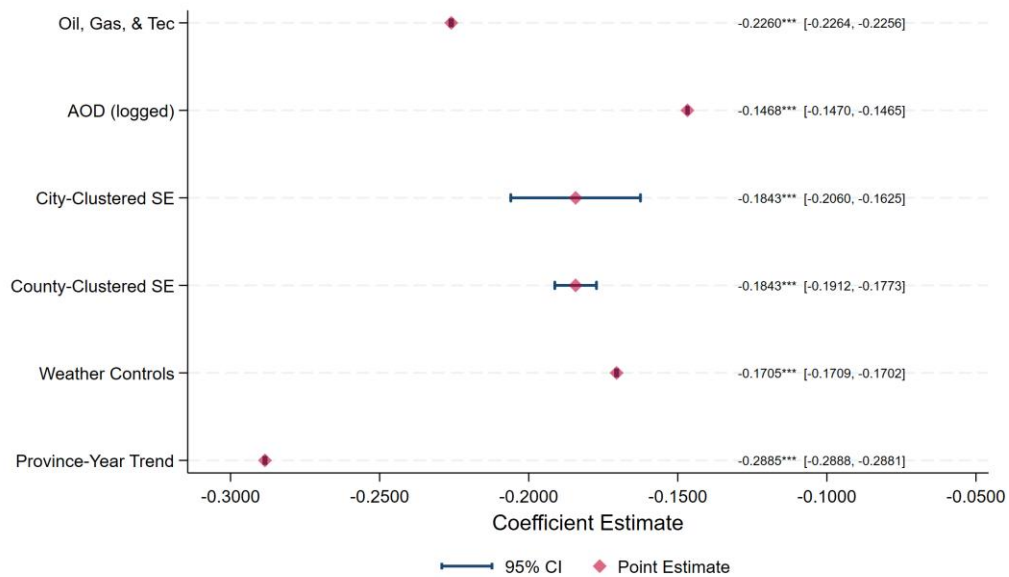


Figure E4: Additional robustness tests (Part 1)

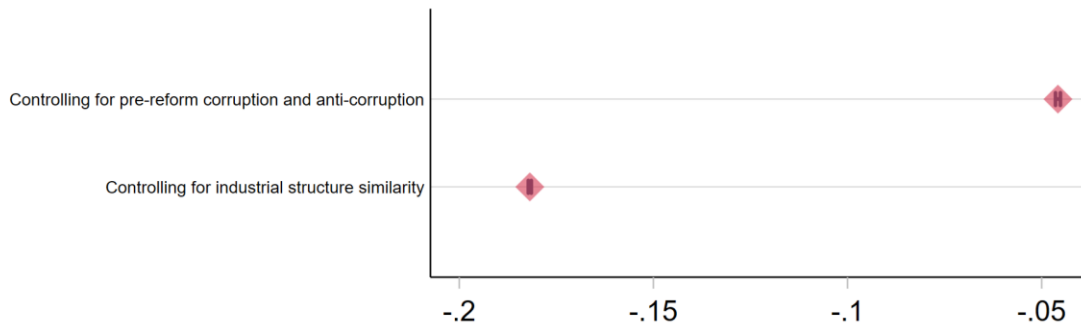


Figure E5: Additional robustness tests (Part 2)

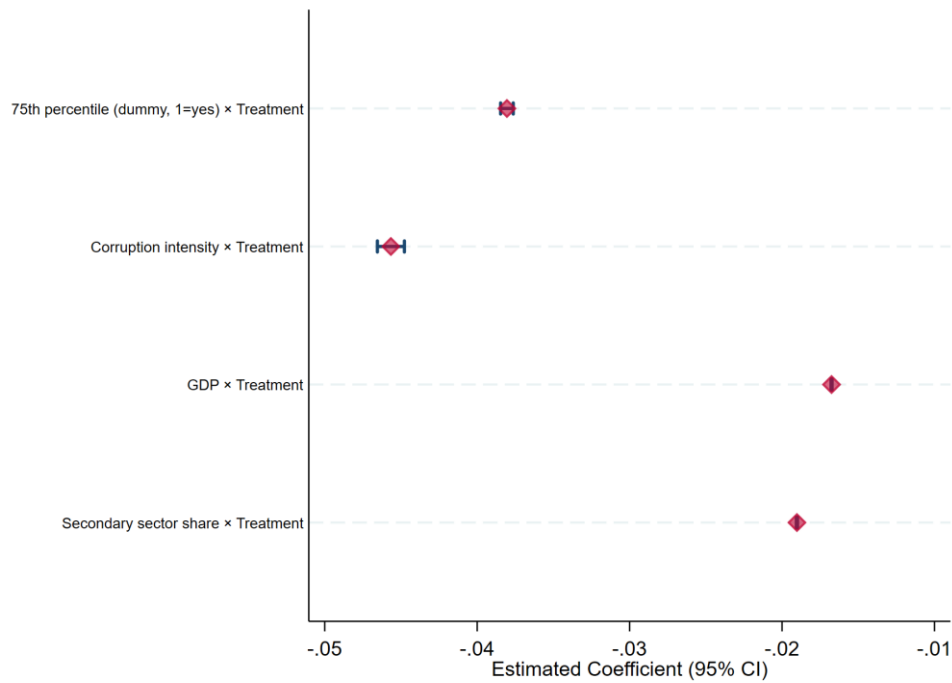


Figure E6: Heterogeneity analysis

Note: The heterogeneity analysis interacts the treatment variable with city-level characteristics. "75th percentile (dummy, =1 if yes)" indicates whether the PM_{2.5} concentration exceeds the 75th percentile; "corruption intensity" measures the number of corrupt officials; "GDP" denotes GDP per capita; and "secondary sector share" represents the share of the secondary sector in the industrial structure. The control strategy is consistent with the baseline specification, including pre-reform regional characteristics interacted with year fixed effects, pre-reform weather characteristics interacted with year fixed effects, and grassroots-level unit fixed effects. The figure reports 95% confidence intervals around the point estimates.

Table E1: Controlling for the impact of confounding policies

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1606*** (0.0002)	-0.1600*** (0.0002)
Other policies	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	630,135	626,976
Observations	13,856,262	13,786,764
Adjusted R-squared	0.8505	0.8519

Note: Other policies include information disclosure policies (Barwick et al., 2024), air pollution control measures (Ministry of Environmental Protection, 2013), emissions trading systems (State Council, 2014), green fiscal policies (Kong and Zhu, 2022), and green finance pilot projects (Bai et al., 2022). Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E2: Testing for spillover effects under SUTVA

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1894*** (0.0002)	-0.1889*** (0.0002)
SUTVA	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	630,135	626,976
Observations	13,251,001	13,181,638
Adjusted R-squared	0.8334	0.8341

Note: The SUTVA test excludes grassroots units adjacent to the treatment group following the implementation of centralization reform, using remaining grassroots units as the control group. Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E3: Testing with alternative standard error clustering levels

	Dependent variable: PM _{2.5} (logged)		
	(1)	(2)	(3)
Treatment	-0.1843*** (0.0321)	-0.1843*** (0.0002)	-0.1843*** (0.0263)
Alternative clustering	YES	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES	YES
Pre-reform weather characteristics × year fixed effects	YES	YES	YES
Grassroots-level unit fixed effects	YES	YES	YES
Number of grassroots unit fixed effects	626,976	626,976	626,976
Observations	13,786,764	13,786,764	13,786,764
Adjusted R-squared	0.8353	0.8353	0.8353
Number of clusters	626,976(30)	13,786,742	656

Note: Columns (1) through (3) cluster standard errors at the grassroots-province two-way level (presented in

parentheses), grassroots-year level, and province-year level, respectively. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E4: Testing with municipalities excluded

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1771*** (0.0002)	-0.1768*** (0.0002)
Excluding directly administered municipalities	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	600,504	597,345
Observations	13,204,380	13,134,882
Adjusted R-squared	0.8381	0.8387

Note: Municipalities include Beijing, Tianjin, Shanghai, and Chongqing. Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E5: Testing with population controls

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1847*** (0.0002)	-0.1844*** (0.0002)
Population	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	592,502	589,478
Observations	13,028,313	12,961,785
Adjusted R-squared	0.7889	0.7900

Note: Population is measured as the logarithm of registered population at the city-year level and matched to the grassroots-year level. Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E6: Propensity score matching test

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1605*** (0.0002)	-0.1602*** (0.0002)
After propensity score matching	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	564,802	561,643
Observations	10,724,527	10,664,506
Adjusted R-squared	0.8387	0.8396

Note: Propensity score matching employs kernel matching estimation. Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

and 10% levels, respectively.

Table E7: Testing with centralization reform implementation lagged by one year

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1875*** (0.0002)	-0.1870*** (0.0002)
Lagged by one year	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	630,135	626,976
Observations	13,226,105	13,159,766
Adjusted R-squared	0.8340	0.8347

Note: Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E8: Testing with centralization reform implementation lagged by two years

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1565*** (0.0002)	-0.1558*** (0.0002)
Lagged by two years	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	630,135	626,976
Observations	12,595,970	12,532,790
Adjusted R-squared	0.8536	0.8542

Note: Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E9: Testing with centralization reform implementation lagged by three years

	Dependent variable: PM _{2.5} (logged)	
	(1)	(2)
Treatment	-0.1561*** (0.0003)	-0.1539*** (0.0003)
Lagged by three years	YES	YES
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	630,135	626,976
Observations	11,965,835	11,905,814
Adjusted R-squared	0.8773	0.8778

Note: Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table E10: Estimates with alternative dependent variable (PM_{2.5})

	Dependent variable: PM _{2.5}	
	(1)	(2)
Treatment	-9.5781*** (0.0090)	-9.5408*** (0.0091)
Pre-reform regional characteristics × year fixed effects	YES	YES
Pre-reform weather characteristics × year fixed effects	NO	YES
Grassroots-level unit fixed effects	YES	YES
Number of grassroots unit fixed effects	634,221	631,062
Observations	13,868,520	13,799,022
Adjusted R-squared	0.7592	0.7609

Note: Values in parentheses report clustering robust standard errors at the grassroots-level unit. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

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