RESEARCH ARTICLE

Environmental vertical management reform and data manipulation in the public sector: evidence from China

Huange Xu[1], Guangchen Li[2] and Bo Chen[3]

[1]School of Public Administration, Southwest Jiaotong University, Chengdu, China, [2]School of Economics, Beijing Wuzi University, Beijing, China and [3]School of Economics, Jinan University, Guangzhou, China
Corresponding author: Bo Chen; Email: chenbo2019@email.szu.edu.cn

Abstract

Based on monthly panel data from 2014 to 2020 and employing the staggered difference-in-differences (staggered DID) method, we examine the impact of environmental vertical management reform on data manipulation in the public sector. We reveal that environmental vertical management reform significantly reduces data manipulation in the public sector. Moderating effect analysis shows that economic growth targets weaken the inhibitory impact of this reform. Conversely, public environmental concerns could enhance the inhibitory impact of this reform on data manipulation. Mechanism analysis reveals that environmental vertical management reform works through strengthening grassroots environmental law enforcement. The increased independence of law-enforcing departments has reduced the tendency of local governments to engage in data manipulation.

Keywords: Data manipulation; environmental vertical management reform; public sector; staggered DID

Introduction

Decentralization reforms have been widely recognized in public administration practices around the world and are considered a panacea for enhancing governance efficiency and promoting sustainable development (Li et al. 2023). In recent years, many countries have adopted various forms and degrees of decentralization. However, the results of decentralization have been mixed, provoking extensive debate in academia. On the one hand, decentralization brings decision-making and implementation closer to grassroots needs (Besley and Case 1995), fostering healthy competition among governments in the provision of public services and enhancing government responsiveness and service quality (Pollitt 2015). However, decentralization can also have adverse effects. Local officials gain greater control over

regulatory bodies, making them more susceptible to capture or interference by special interest parties and using this influence to maximize their political interests (Cao et al. 2023; Liu et al. 2022).

Given the controversy surrounding the pros and cons of decentralization, some countries that are dissatisfied with decentralization have begun to choose recentralization (Dickovick 2011; Kostka and Nahm 2017). Taking the United States as an example, since the *Clean Air Act*, the responsibility for pollution monitoring has been transferred from state and local governments to the Federal Environmental Protection Agency, resulting in a significant decline in pollutant emissions (Boffa et al. 2016). Similarly, Mertha (2005) observed a phenomenon termed "soft centralization" in China's environmental governance, where decision-making is gradually "semi-centralized" from local governments to provincial counterparts (Zhu et al. 2024). This adjustment in power configuration may have profound implications for China's environmental governance practices.

In the past, China's environmental governance followed fragmented authoritarianism. Hence, local governments lacked the motivation to provide high-quality environmental information disclosure and were insufficiently motivated to implement central policies (Xu 2022). This primarily stems from local governments' autonomy in information collection and work reporting. By leveraging their clerical expertise and information advantages, they can selectively transmit information that aligns with their interests to higher-level governments or even deliberately manipulate environmental data to protect their interests from adverse changes (Jimenez 2017). Environmental data manipulation, as a long-standing form of information distortion, poses a serious challenge to the effective supervision of subordinate behavior by higher-level governments, further complicating the principal-agent problem between governmental layers (Tang et al. 2022). Broadly speaking, data manipulation refers to strategies that alter paper-based data without generating real output improvements (Chen 2024). The existing literature explains the reasons for the data manipulation of local governments from multiple perspectives (Bevan and Hood 2006; Ghanem and Zhang 2014; Kroll and Vogel 2021; Zhang et al. 2020). Regrettably, these studies have not proposed effective strategies to reduce data manipulation, especially from the perspective of centralization.

Therefore, we focus on the recentralization of local environmental governance in China and its impact on data manipulation. In recent years, China's air pollution has become increasingly prominent. The environmental data manipulation of local governments has been shown to be closely associated with this process (Ghanem et al. 2020; Ghanem and Zhang 2014). By comparing the change rates of official PM2.5 data with those of satellite PM2.5 data since February 2014, we find obvious discrepancies between the two. As shown in Figure 1, the improvement in air quality indicated by official data is much greater than that indicated by satellite data, supporting the possibility of environmental data manipulation by local governments.

Faced with distorted environmental data, the central government has taken a series of important measures in recent years, striving to recentralize environmental governance. Since 2016, China has carried out pilot projects for environmental vertical management reform in 12 provinces or municipalities. The core of this
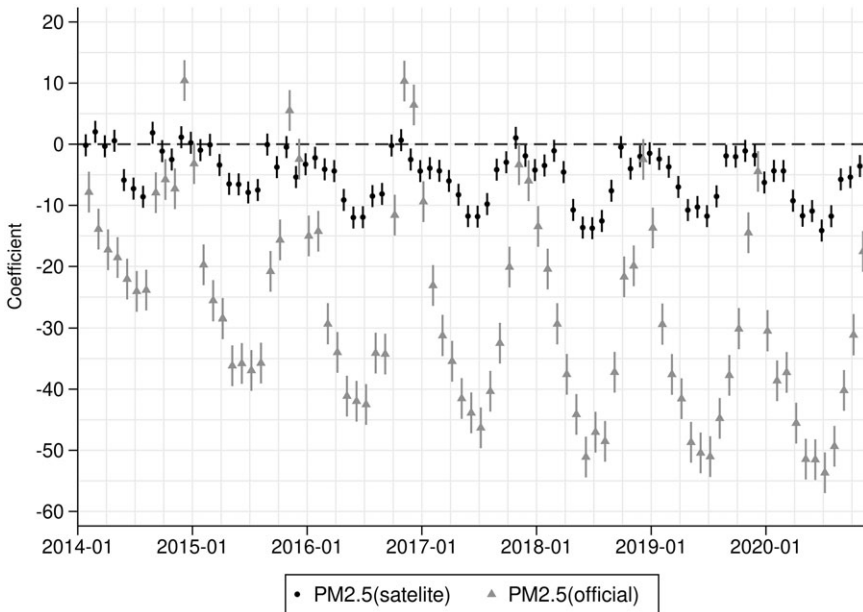
Figure 1. Divergence between the change rates of official and satellite PM2.5 data.

reform is to concentrate key functions, such as environmental monitoring, supervision, and personnel management at the provincial level, while granting more environmental enforcement power to local governments, aiming to improve the effectiveness of environmental governance by streamlining administrative powers and clarifying environmental responsibilities. Theoretically, the recentralization of environmental governance has multiple positive impacts. First, centralization improves the efficiency of environmental information collection and data processing while reducing the cost of information acquisition (Garicano 2000). More importantly, moving decision-making to a level closer to the source of information objectively increases the difficulty for local governments to tamper with environmental data. This institutional design also sets new obstacles for those who attempt to evade environmental responsibilities (Kostka and Nahm 2017). Based on the above changes, we take this as the research background and focus on examining the impact of environmental vertical management reform on reducing environmental data manipulation.

The contributions of this paper are mainly threefold. First, based on the theory of power allocation proposed by Aghion and Tirole (1997), we analyze the impact of recentralization on environmental data manipulation in the public sector from the perspective of formal and real authorities. This research not only responds to the debate on the governance effects of centralization and decentralization but also demonstrates the positive effects of recentralization on environmental governance. As a study focusing on one of the world's most representative economies, this paper could provide empirical evidence for developing countries to implement centralized environmental regulation. Second, this paper extends the literature that takes data

manipulation in the public sector as the research object and provides theoretical and empirical evidence on how to reduce data manipulation. Environmental data manipulation has a long history, but the existing literature mostly focuses on exploring this phenomenon itself and its causes while lacking necessary attention to how to reduce it. This is mainly due to the lack of suitable data and identification methods. Taking advantage of China's environmental vertical management reform as a quasi-natural experiment, this paper examines how China can change the current situation of environmental data manipulation by readjusting environmental governance. Third, this paper clarifies the mechanisms by which environmental vertical management reform affects data manipulation and identifies potential confounding factors. This paper not only explores how environmental vertical management reform affects data manipulation in the public sector but also analyzes the impacts of economic growth targets and public environmental concerns on the relationship between environmental vertical management reform and data manipulation. To a certain extent, these studies help to clarify the scenarios and conditions under which environmental vertical management reform reduces data manipulation, providing important practical insights for improving the environmental governance system.

The remainder of this paper is organized as follows: Section 2 provides a literature review; Section 3 presents the background and hypotheses; Section 4 describes the research design; Section 5 presents the baseline results and robustness tests; Section 6 analyzes the mechanisms; and Section 7 concludes this paper and provides some discussions.

Literature review

Data manipulation is a behavior in which the public sector strategically adjusts work performance or business output to achieve the goal of embellishing performance. What drives data manipulation in the public sector? Researchers have analyzed this issue from two main perspectives: formal and informal institutions (Cai 2000; Chen 2023; Gao 2009; Tang et al. 2022; Zhang et al. 2020). From the perspective of formal institutions, the current performance appraisal methods, the diversity of appraisal targets, and the motivation to avoid responsibility have stimulated data manipulation among appraised entities. Cai (2000) noted that the higher-level government's performance assessment of lower-level governments mostly focuses on indicator numbers and written materials, making it easy for appraised entities to cope with the assessment through text compilation and numerical adjustments. Taking China's town governments as an example, Gao (2009) argued that grassroots governments undertake numerous tasks, which are difficult to assess most of the time. Hence, higher-level governments often use loose periodic inspections and written reports to assess town governments' work, which creates conditions for data manipulation. In addition, Chen (2023) noted that to avoid taking responsibility, prudent public sectors strategically choose whether to manipulate data when facing different types of performance feedback, especially when facing negative performance feedback, to reduce or avoid blame for unsatisfactory performance. Furthermore, the fiscal system is also an important factor influencing data

manipulation. Zhang et al. (2020) found that after the implementation of the fiscal revenue-sharing system in China in 1994, the central government controlled most of the fiscal revenue. This led local governments to manipulate data by exaggerating grain output and other means to obtain more subsidies from the central government.

Recently, scholars have also expanded their focus on the impact of informal institutions on data manipulation. Research suggests that informal sponsorship networks and prosocial values reinforce the tendency of local officials to manipulate data. For example, Tang et al. (2022) found that in sponsorship networks characterized by personal and emotional interactions, more favored officials also have a stronger tendency to manipulate data. Moreover, the more political resources that individual officials possess and the stronger their sponsorship networks are, the greater their motivation to manipulate data. Using the list experiment method and 1,000 public management department employees, Kroll and Vogel (2021) revealed that if individuals realize the prosocial impact of their work, they may direct the organization's attention and resources toward service recipients based on falsified data.

Furthermore, scholars have focused on the negative consequences of data manipulation. Zhang et al. (2020) reported that exaggerating and manipulating grain output may overestimate the grain self-sufficiency rate, thereby threatening food security and distorting China's agricultural policy. Ghanem and Zhang (2014) argued that data manipulation hinders citizens from effectively engaging in economic activities and damages public interests and government reputation.

Despite the extensive discussion of data manipulation and its impact in the existing literature, research on how to reduce data manipulation, especially environmental data manipulation, remains very limited. The issue of environmental data manipulation should not be ignored because even slight underreporting, if occurring frequently, could increase the risk of citizens being exposed to higher levels of air pollution, thereby endangering public health (Ghanem and Zhang 2014). Therefore, it is urgently necessary to expand the scope of academic exploration to understand how to address data manipulation. The important literature on how to reduce environmental pollution provides a perspective for answering this question, broadly revealing how environmental governance practices oscillate between decentralization and centralization. On the one hand, decentralization theory suggests that local governments have better environmental information and local knowledge and are closer to ordinary people. Devolving environmental governance authority can make environmental policies more adaptable to local needs (Kostka and Hobbs 2012; Oates 1972; Shin 2017; Sigman 2014), thereby achieving positive governance results. However, environmental decentralization is not always effective, especially when faced with multiple choices between economic development and environmental protection. Local governments not only regulate with double standards but also collaborate with enterprises to jointly manipulate environmental data (Ghanem et al. 2020; Greenstone et al. 2021; He et al. 2020). In addition, Lipscomb and Mobarak (2017) found that decentralization exacerbated the externality of border water pollution.

Given the controversial results of decentralized environmental protection systems, researchers advocate changing environmental governance through

recentralization (Kostka and Nahm 2017). Currently, evidence of the positive outcomes brought about by recentralization is showing a growing trend. For example, Han and Tian (2022) found that China's environmental vertical management reform reduced enterprises' sulfur dioxide emissions by 10% and coal-fired boiler installations by 9.6%, with more prominent reform effects in areas near county borders. A recent study revealed that the centralization of environmental personnel authority reduced incentive distortions and increased the intensity of environmental regulation (Kong and Liu 2024). In addition, the literature from non-environmental fields also confirms the positive effects of recentralization in other areas, such as promoting public service provision (Malesky et al. 2014), reducing corruption (Luu et al. 2024), and attracting FDI (Luu et al. 2022). These studies provide positive evidence demonstrating that recentralization reduces environmental data manipulation. The next section will focus on the theoretical analysis of this issue.

Background and hypotheses

Background

The Chinese government began to implement environmental protection in 1973, but it was not until the beginning of this century that it began to strictly control environmental pollution, mainly due to rapid economic growth (Kong and Liu 2024). Since 1978, the central government has fully decentralized administrative and fiscal powers to local governments, strengthening their autonomy and influence in economic decision-making while also objectively promoting a political tournament based on economic growth. In other words, regions with faster economic development are more likely to have cadres promoted to central departments (Maskin et al. 2000). In this context, economic development is often more important than environmental protection at the local level, and the implementation of environmental protection policies is often disrupted and undermined.

More importantly, for a long time, China implemented a localized management system for environmental protection. The Ministry of Ecology and Environment is China's highest-level environmental protection department, with approximately 3,000 environmental protection bureaus at different levels under its jurisdiction that are responsible for local environmental supervision activities (Zhang et al. 2018). Local environmental protection departments accept not only the leadership of higher-level departments but also the management of local governments, especially in terms of personnel allocation, financial resources, and personnel management.

Due to their reliance on local governments for financial resources and career advancement, local environmental protection departments are often under the control of local governments. Hence, local governments can exert pressure on environmental protection departments, forcing them to relax environmental enforcement standards for polluting enterprises while manipulating environmental data to respond to assessments by higher-level governments. As officials from China's environmental protection departments have publicly acknowledged, to reduce assessment pressure and achieve environmental goals, some local departments have instructed monitoring stations to fabricate and tamper with monitoring

data, which frequently and seriously damages the credibility of environmental protection departments.[1]

Recognizing these challenges, the Chinese government has begun to take measures in recent years to reverse decentralized environmental governance. In September 2016, the General Office of the CPC Central Committee and the General Office of the State Council issued the *Guiding Opinions on the Pilot Reform of the Vertical Management System for Environmental Protection Agencies below the Provincial Level* (hereinafter referred to as the *Guiding Opinions*). The purpose of the *Guiding Opinions* is to recentralize regulatory agencies from the local to the provincial level to curb local protectionism, strengthen local environmental law enforcement, and improve the quality of environmental data. In this reform, departments that were originally under localized management were separated from local governments and directly managed by the government or competent department at the next highest level, with their personnel and financial authority correspondingly transferred upward.

Specifically, there are three main aspects of environmental vertical management reform. First, in terms of management institutions, the municipal-level environmental monitoring center becomes a provincial-level dispatched agency directly under the leadership of the provincial-level environmental protection department to ensure the authenticity and effectiveness of environmental data. Second, in terms of finance and personnel, the provincial-level environmental protection departments are responsible for the personnel and financial management of their municipal-level counterparts, while the municipal-level environmental protection departments are responsible for the personnel and financial management of their next lower-level counterparts. Finally, in terms of cadre management, the leadership members of county-level and municipal-level environmental protection departments are appointed and dismissed by municipal-level and provincial-level governments, respectively. These measures help higher-level governments centralize the management of environmental protection and cut off the influence of local governments on local environmental protection agencies. Changes in financial support and cadre appointments reduce local protectionism and enable county-level and municipal-level environmental departments to exercise environmental law enforcement powers more independently. This approach is conducive to the effective implementation of environmental protection policies and minimizes the possibility of data manipulation.

Hypotheses

Organizational theory suggests that power allocation is one of the core choices in organizational design (Bandiera et al. 2021; Simon 1951). In bureaucracies, power allocation not only affects the overall performance of organizations but also influences the effectiveness of policy implementation (Zhu and Zhang 2019). We adopt the distinction between formal and real authorities over decisions proposed by Aghion and Tirole (1997) in power allocation theory. Formal authority refers to the right to decide, while real authority refers to effective control over decisions. We

---

[1]Details can be seen at: http://www.xinhuanet.com/politics/2015-04/01/c_1114836968.htm.

argue that as a form of "soft centralization," China's environmental vertical management reform, which recentralizes environmental management authority to provincial governments, has achieved the effective unification of formal and real authority to some extent, thereby reducing local governments' motivation and ability to manipulate environmental data.

Organizational hierarchy shapes the structure of information transmission and communication among participants (Dessein 2002; Radner 1992), and the informational distance between formal and real authority is an important organizational design variable (Aghion and Tirole 1997; Rantakari 2012). Under China's environmental management system, the central government usually has the formal authority to initiate environmental governance, while local governments, as supervisors of environmental policies, have the power to assess the overall effectiveness of environmental governance, thus becoming the party with real authority over environmental decisions (Aghion and Tirole 1997; Dong et al. 2024). Decentralization theory suggests that local governments have an environmental information advantage under a decentralized model, which helps them accurately and quickly address environmental issues and implement environmental decisions. However, due to the long span of delegation between central and local governments in environmental governance, the resulting informational distance limits the possibility for formal authorities to observe the operation of real authority (Dobrajska et al. 2015; Holmstrom 1979). In other words, this authorization distance reduces the connection between the central and local governments, giving local governments the opportunity to manipulate environmental information and act in a self-interested manner. In general, local governments have true environmental information about their regions (Han and Tian 2022; Tang et al. 2022), while the central government, as the principal, relies mainly on the data reported by local governments for its information source (Ghanem and Zhang 2014). Therefore, large polluting enterprises that create numerous employment and tax opportunities often influence environmental regulations through interpersonal relationships and favors, resulting in exemptions from sanctions for environmental pollution violations (Jia and Nie 2017; Zhang et al. 2018). Local governments, as regulators, and enterprises, as regulated entities, are usually in collusion with each other (Dong et al. 2024) and manipulating environmental monitoring data (Ghanem et al. 2020), thereby exacerbating the gap between expected regulatory targets and actual environmental governance.

To address the above environmental governance dilemma, the central government began implementing environmental vertical management reform, recentralizing environmental monitoring, personnel appointment, and inspection rights previously devolved from local governments to the provincial government. These changes are usually referred to as recentralization (Kostka and Nahm 2017; Luu et al. 2022; Malesky et al. 2014). Recentralization may change the enforcement efforts of local regulatory agencies and help reduce environmental data manipulation. Specifically, by centralizing environmental monitoring and inspection rights, asymmetric information between the central government and local governments can be reduced. In particular, provincial government departments can supervise environmental violations by local governments and enterprises at any time by centrally exercising environmental inspection rights. Moreover, before

implementing this reform, due to the devolution of personnel appointment rights, the environmental enforcement of local environmental protection bureaus was actually controlled by local governments (Kong and Liu 2024). After this reform, the director of the local environmental protection bureau can be directly nominated, approved, and appointed by the counterpart of the provincial environmental protection bureau, and all financial resources are provided by the provincial governments. This strengthens the independence of environmental protection departments' enforcement and reduces the possibility of local departments interfering with environmental data. In summary, environmental vertical management reform has enabled the central government to reclaim real authority, transforming local governments from supervisors to those being supervised, thereby forcing them to adjust their environmental strategies to align with the central government's policy priorities. Therefore, we propose the following hypothesis:

Hypothesis 1:. Environmental vertical management reform reduces data manipulation in the public sector.

Hypothesis 2:. Environmental vertical management reform reduces data manipulation in the public sector mainly by enhancing grassroots environmental law enforcement.

Under vertical management, a formal, independent, and standardized environmental regulatory system can be established. However, in the process of top-down implementation, formal environmental regulation often faces the challenges of government proactivity and enterprise passivity, as well as limitations in sustainability and scope (Pang et al. 2022). In cases where formal regulation is absent or weak, informal regulation provides a bottom-up channel for governments and enterprises to focus on pollution control, which is considered a powerful supplement to formal environmental regulation (Greenstone and Hanna 2014; Xie et al. 2023).

Furthermore, public environmental concern is becoming an important informal environmental regulatory force (Li et al. 2018), which is defined as the degree to which people are aware of environmental problems and support efforts to solve them or indicate a willingness to contribute personally to their solution (Dunlap and Michelson 2002). The Chinese public is very concerned about environmental performance, and this trend is likely to continue (Harris 2008). Therefore, public environmental concern and environmental vertical management reform may have interactive and complementary effects, which in turn influence the quality of environmental data in China.

On the one hand, public environmental concern helps reduce information asymmetry and compensate for the lack of regulatory resources. Although environmental vertical management reform has reshaped environmental inspection and monitoring systems, provincial governments may still face dilemmas in terms of regulatory distance and regulatory resources, making it impossible to comprehensively obtain information on the environmental pollution situation in all regions, leaving some room for local governments to manipulate environmental data. Research has shown that the public's average perception of pollution hazards is

accurate and very similar to that of monitoring data, and this perception is conducive to supervising enterprises' responsibilities in emission reduction (Chen et al. 2017). In other words, through public environmental concern, regulatory entities obtain more information about local pollution, which helps improve the efficiency of their regulatory intervention and reduce data manipulation.

On the other hand, public environmental concerns help promote regulatory interactions between the government and the public in terms of environmental protection. The public can impose regulatory pressure on local governments through public letters and visits, complaints, and other means (Chu et al. 2022), prompting local governments to better implement environmental policies and reduce the probability of data manipulation. Therefore, we propose the following hypothesis:

Hypothesis 3:. Public environmental concern can strengthen the negative relationship between environmental vertical management reform and data manipulation in the public sector.

Environmental regulation increases production costs for enterprises, leading to reduced output and rising prices and ultimately lowering income growth and new investment (Feiock and Stream 2001). Therefore, local governments often face conflicting choices when pursuing economic growth and achieving environmental protection and need to rank these two goals (Nielsen 2014). Based on the difference between central commitment and local performance, Lieberthal (1997) noted that China's environmental offices are usually under the authority of officials who prioritize short-term economic growth over long-term sustainability. Fundamentally, the above phenomenon stems from China's top-down promotion tournament with economic growth as the main assessment indicator, which provides an incentive mechanism for governments at all levels below the national level to be less diligent in implementing environmental policies (Ghanem and Zhang 2014).

Although environmental compliance has been incorporated into contracts between the central government and local governments, economic growth is still considered the top priority in China (Zhang and Wang 2011). At the beginning of each year, local governments usually set their annual economic growth targets in their government work reports. Under the dual incentives of economic returns and political prospects, local officials have unparalleled enthusiasm for economic growth (Ghanem and Zhang 2014). To achieve these goals, local governments tend to weaken environmental regulations and lower environmental standards to attract more capital and other forms of mobile funds. As a result, the race to the bottom in environmental regulations has attracted more energy-intensive and highly polluting enterprises to locate in the area, forming a pollution haven.

To reverse the above situation, the Chinese government has begun to attempt to promote sustainable development by modifying the target responsibility system (Zhang 2021). Environmental targets have also become explicit indicators that local officials must adhere to, as their career prospects are closely related to whether they can achieve the targets set by higher-level departments (Ghanem and Zhang 2014). However, due to the difficulty of assessing environmental governance, the ease of

manipulating environmental data, and the imperfection of existing assessment indicators, local governments still prefer economic development and lack motivation for environmental governance. Organizations or individuals who lack the ability to meet environmental assessment targets will choose to deceive their superiors or actively manipulate data through various means to obtain special benefits or nominal performance (Ghanem and Zhang 2014; Kräkel 2007). Therefore, we can confirm that the greater the economic growth target set by local governments is, the more the inhibitory impact of environmental vertical management reform on reducing data manipulation in the public sector will be weakened. Therefore, we propose the following hypothesis:

Hypothesis 4:. Economic growth targets can weaken the negative relationship between environmental vertical management reform and data manipulation in the public sector.

The theoretical framework of this study is shown in Figure 2.

Research design

Sample and data sources

This study mainly uses China's urban air quality data as the sample. Considering that Chinese cities only began to release urban air quality data at the end of 2013, the dataset in this paper covers the time span from January 2014 to December 2020. The data sources include three parts: air quality, environmental vertical management reform, and macro and climate characteristic data at the city level.

The air quality data include two parts: official and satellite air quality data. The official data come from real-time data released by the ecological protection departments of various regions and are processed to form monthly data. The satellite data come from the NASA (National Aeronautics and Space Administration) database. The original data are in netCDF format with a resolution of 0.625° × 0.5°. We used the bilinear interpolation method to interpolate the original data to a resolution of 0.01° × 0.01° and generated monthly panel data for more than 200 cities from 1980 to 2022.

The data on environmental vertical management reform in the public sector are obtained based on the policy documents of environmental vertical management reform below the provincial level issued by various regions. The promulgation date of the provincial-level reform implementation plan is used as the starting point for the implementation of this reform.

The macro- and climate-characteristic data at the city level are obtained from various sources. The macro data, such as per capita regional gross domestic product and industrial structure, are mainly obtained from the China City Statistical Yearbook. On the other hand, climate characteristic data, including precipitation, temperature, humidity, and wind force, are sourced from the China National Environmental Monitoring Centre.[2]

---

[2]Data source: http://www.cnemc.cn/.

By integrating the above data, we construct city-level monthly panel data that include variables such as air quality, environmental vertical management reform, macroeconomic indicators, and climate characteristics.

Variable definitions

(1) Dependent variables

Measuring data manipulation has always been a challenging issue (Chen 2023). Comparing official data with those from other sources is the simplest and most commonly used method for measuring data manipulation (Ghanem and Zhang 2014; Zhang et al. 2020). For example, Tang et al. (2022) proposed using the ratio of official data to satellite data to measure data manipulation; the smaller the ratio is, the greater the degree of data manipulation. In contrast, Chen (2023) used the differences in growth rates between officially reported air quality data and satellite-observed data to represent data manipulation. Similarly, Wallace (2016) used the difference between the provincial economic growth rate and the electricity growth rate to measure data manipulation. In this paper, when measuring environmental data manipulation, we primarily focus on PM2.5. Compared to other pollutants such as SO2, PM2.5 has received more attention from governments, especially since 2014, when the Chinese government listed the reduction ratio of PM2.5 as an important indicator for assessing the performance of local officials, which may have motivated local governments to manipulate data to some extent. Based on this and with reference to Tang et al. (2022), Chen (2023), and Wallace (2016), we use the differences in growth rates between officially reported PM2.5 and satellite-observed PM2.5 to calculate environmental data manipulation. The specific method is as follows:

$$official\_rate_t = \frac{-official\_PM_{2.5,t} - official\_PM_{2.5,t-1}}{official\_PM_{2.5,t-1}} \tag{1}$$

$$satelite\_rate_t = \frac{-satelite\_PM_{2.5,t} - satelite\_PM_{2.5,t-1}}{satelite\_PM_{2.5,t-1}} \tag{2}$$

$$manipulate_t = official\_rate_t - satelite\_rate_t \tag{3}$$

(2) Explanatory variables

To capture the impact of environmental vertical management reform on data manipulation in the public sector, we construct a dummy variable (*Vertical*). Based on the staggered DID model and the implementation of this reform in each region, this dummy variable takes the value of 1 if environmental vertical reform management is implemented in a given city and 0 otherwise.

(3) Moderating and mechanism variables

This paper introduces two moderating variables: regional economic growth target (*Target*) and public environmental concern (*Baidu_haze*). The data on economic growth targets come from local government work reports. According to these reports, local governments could set economic growth targets as a work commitment to the central government and local people. Considering that the COVID-19 pandemic may affect the setting of regional economic growth targets,

this paper only collects economic growth targets from government work reports during 2014–2019 to form panel data.

We use the public's attention to PM2.5 at the city level as a proxy variable to measure public environmental concern (Jin and Deng 2024; Wu et al. 2022). The data for this variable are obtained by using Python to crawl the search index of China's largest search engine (Baidu) with "PM2.5" or "haze" as keywords, forming a monthly panel dataset from 2014 to 2020. Considering that the variable construction of environmental data manipulation uses PM2.5 data, we consider only the above two keywords.

The mechanism variable in this paper is environmental law enforcement intensity, which uses the number of environmental penalty cases (Penalty) and the number of environmental protection employees in the region (Employee) as proxy variables. The number of environmental penalty cases is obtained from the Peking University Law Database (www.pkulaw.net). We crawled approximately 500,000 environmental penalty cases from various regions during 2014–2020 and counted the number of cases by municipal departments according to the units that imposed the penalties. This is used to characterize whether environmental law enforcement by grassroots governments will increase after environmental vertical management reform. In addition, this paper also uses the number of environmental protection employees in municipal governments during 2014–2020 to represent environmental law enforcement intensity. The data on environmental protection employees are obtained from the China City Statistical Yearbook.

(4) Control variables

The control variables in this paper include two parts: socio-economic conditions and meteorological conditions of cities. First, the socio-economic conditions of a city, such as per capita regional GDP and industrial structure, have been widely found to have a significant impact on the city's air quality. Following the previous literature, we use a set of variables to control for the impact of urban socio-economic conditions on air quality, including regional gross domestic product (*Lngdp*), per capita regional gross domestic product (*Lnpergdp*), industrial structure (*Industry*), and fiscal strength (*Fiscal*). Second, meteorological conditions, such as wind force and humidity, can affect the concentration of PM2.5. Studies have shown that air currents can transport pollutants over long distances (Bergin et al. 2005). Therefore, this study controls for wind (*Wind*), humidity (*Humidity*), temperature (*Temper*), and precipitation (*Lnprecip*) to minimize the interference of external factors on the results. The descriptive statistics of the variables are shown in Table 1. The dependent, explanatory, and climate variables are monthly data, while the urban socio-economic characteristic variables are annual data.

Estimation strategy

DID is a commonly used method for policy evaluation. Its core idea is to estimate the impact of policy on target objects based on the differences between the treatment and control groups across individuals and time. As the timing of environmental vertical management reform varies across provinces, using the standard DID approach may lead to estimation bias. Therefore, we employ the staggered DID approach to mitigate concerns about contemporaneous trends possibly influencing

Table 1. Descriptive statistics

Variables	Obs	Mean	Sd	Min	Max
Manipulate	23489	−0.02	0.30	−1.00	0.83
Vertical	23489	0.33	0.47	0.00	1.00
Wind	23489	2.19	0.59	0.80	6.74
Humidity	23489	70.16	13.17	18.51	94.48
Temper	23489	14.92	10.31	−25.53	31.78
Lnprecip	23489	3.84	1.38	0.00	6.77
Penalty	1981	150.17	423.92	0.00	6186.00
Employee	1838	8.72	0.82	3.97	11.73
Target	1684	8.36	1.71	1.00	18.00
Haze_baidu	1981	0.27	0.43	0.00	10.26
Lngdp	1981	18.01	3.41	13.96	28.98
Lnpergdp	1981	10.80	0.53	9.23	12.28
Industry	1981	0.44	0.10	0.11	0.76
Fiscal	1981	0.07	0.04	0.00	0.18

the treatment effect (Baker et al. 2022). Our model setting is very similar to that of Beck et al. (2010). During the sample period, all 29 provinces eventually implemented this reform, becoming the treatment group. However, there are significant differences in the specific timing of when each province was affected by this reform, forming a pattern of staggered adoption. The staggered implementation provides important conditions for us to employ the staggered DID method to identify the causal effects of this reform.

In the context of the staggered implementation of this reform, the division of the treatment and control groups is dynamic and relative. Specifically, for any given point, the provinces that have already implemented this reform belong to the treatment group, while the other provinces can be considered the control group. The provinces in the control group provide a counterfactual for the treated provinces, allowing us to identify the net effect of this reform. As time progressed, the control group provinces gradually entered the treatment group until all provinces had completed the reform by the end of the study period. During this process, we identify the impact of this reform across different periods and regions through multiple period-group comparisons based on continuous comparisons between the treatment and control groups.

Starting in December 2016, Hebei Province and Chongqing municipality were the first in China to implement this reform. Fujian, Shandong, and other provinces began implementing this reform in 2017, and other provinces followed suit. By 2020, this reform had been fully implemented nationwide. We determine the specific time when each province began implementing the reform by searching governmental websites for policy documents related to environmental vertical management reform. To more accurately estimate the impact of this reform, we specify the implementation time of this reform down to the month. The order in which different regions began implementing this reform is shown in Figure 3. In the figure, the left side represents the period before the reform, while the right side represents the period after the reform.

Drawing on Beck et al. (2010), this paper employs the staggered DID model to estimate the impact of environmental vertical management reform on data
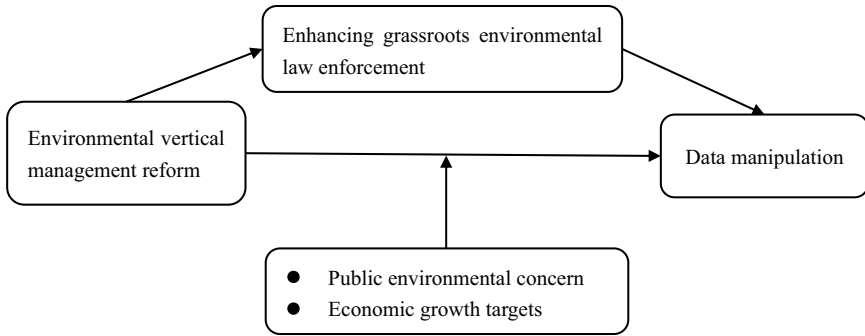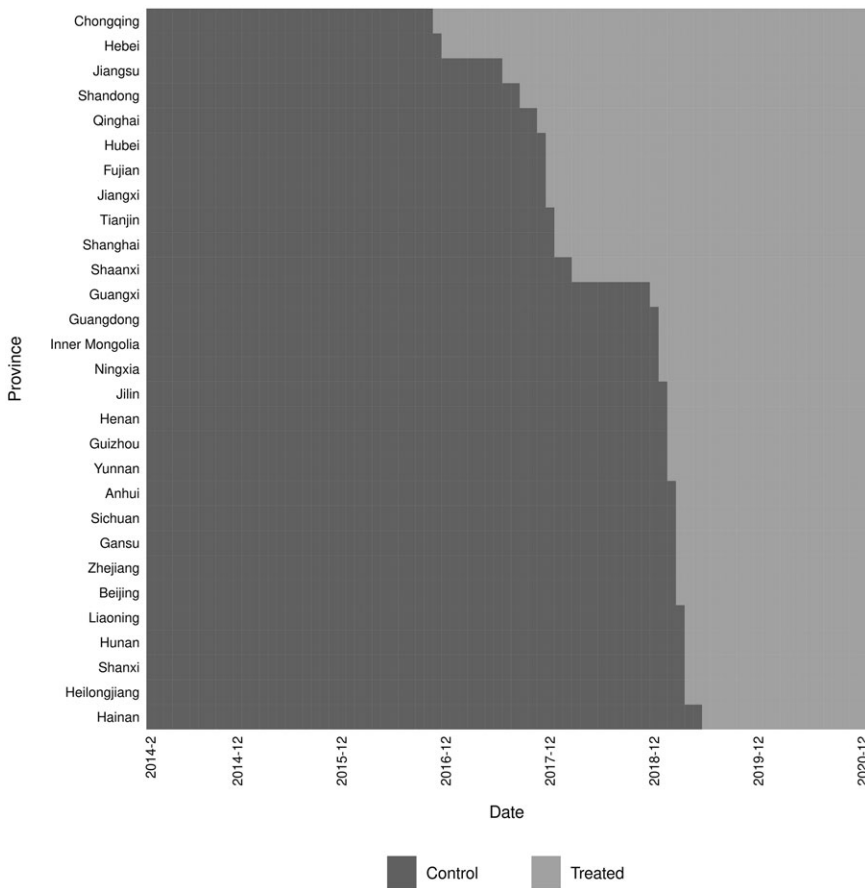
Figure 2. Theoretical framework.

Figure 3. The time distribution of environmental vertical management reform.

manipulation of local governments. The specific model is set up as follows:

$$Manipulate_{c,i,t} = \alpha + \beta Vertical_{c,,it} + \gamma Controls_{c,i,t} + Month_t + City_c + \varepsilon_{c,i,t} \quad (4)$$

where c, i, and t represent the province, city, and time, respectively. $Manipulate_{c,i,t}$ represents the data manipulation. $Vertical_{c,i,t}$ represents the environmental vertical management reform. $Controls_{c,i,t}$ is a series of control variables, including socio-economic variables (such as per capita gross regional product) and climatic characteristic variables (such as temperature). $City_c$ represents city fixed effect, which is used to control for time-invariant characteristics at the city level. $Month_t$ represents the year-month fixed effect, which is used to control for time trends and seasonal factors. $\varepsilon_{c,i,t}$ represents the random error term.

Stylized fact

Before conducting the analysis, we first compare the distribution of satellite and official data before and after environmental vertical management reform to intuitively observe its impact on environmental data manipulation. Figure 4 (a) shows the distribution of air pollution data before policy implementation (in 2014 and 2015). Both satellite and official data show that air pollution in 2015 was lower than that in 2014, but the reduction in official data was much greater than that in satellite data. Figure 4 (b) presents the distribution of air pollution from the two different data sources after policy implementation (in 2018 and 2019). The reduction in air pollution shown by official data is now quite close to that of satellite data. This comparison provides evidence that after this reform, the manipulation of air pollution data in China indeed significantly decreased.

Empirical results

Baseline results

Table 2 presents the baseline results. Column (1) shows the net effect without any control variables or fixed effects. Columns (2)-(4) incorporate control variables and city-fixed and year-month fixed effects step by step. The coefficient of *Vertical* is consistently negative and significant across all specifications. This indicates that after controlling for other factors, environmental vertical management reform significantly reduces environmental data manipulation of local governments.

Comparing the results across the four columns in Table 2, it can be found that the coefficients of *Vertical* do not change significantly with the addition of control variables and fixed effects, indicating that the bias caused by omitted variables in the baseline regression is small (Altonji Joseph et al., 2005). The findings of this study are comparable to those of Chen (2023). Specifically, Chen (2023) found that data manipulation tends to increase in cities receiving negative performance feedback, while data manipulation tends to decrease in cities receiving positive feedback. In contrast, this paper finds that the impact of environmental vertical management reform is consistent across different cities. This suggests that by establishing an environmental vertical management mechanism, the over-incentive problem under the tournament mechanism can be effectively reduced, making the goals of the
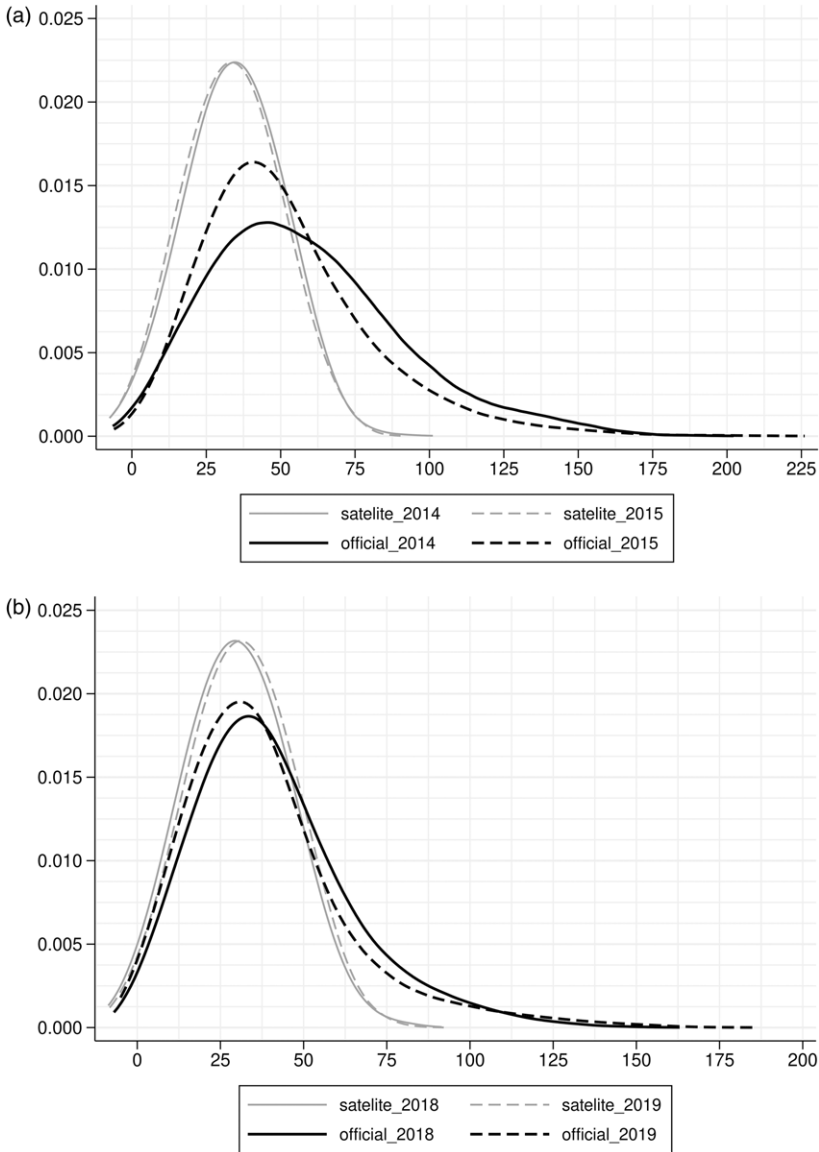
Figure 4. Kernel density of PM2.5.

central government and local governments more aligned in terms of environmental governance and achieving incentive compatibility among different participants.

Heterogeneity analysis

The promotion tournament centered on economic performance is considered an important mechanism driving China's long-term economic growth (Li and Zhou

Table 2. Baseline results

Variables	(1) Manipulate	(2) Manipulate	(3) Manipulate	(4) Manipulate
Vertical	−0.0229***	−0.0171***	−0.0226***	−0.0181***
	(0.0020)	(0.0042)	(0.0049)	(0.0054)
Wind		0.0649***	0.1850***	0.1185***
		(0.0056)	(0.0144)	(0.0126)
Humidity		−0.0058***	−0.0054***	−0.0005
		(0.0004)	(0.0006)	(0.0006)
Temper		−0.0002	−0.0011***	0.0097***
		(0.0003)	(0.0004)	(0.0009)
Lnprecip		0.0764***	0.0778***	0.0379***
		(0.0043)	(0.0050)	(0.0043)
Lngdp		0.0002	−0.0008	0.0316***
		(0.0007)	(0.0009)	(0.0096)
Lnpergdp		−0.0171***	0.0139	−0.0093
		(0.0050)	(0.0092)	(0.0107)
Second		0.0317	0.1363***	0.0676**
		(0.0271)	(0.0310)	(0.0312)
Fiscal		−0.0722	−0.1806*	0.0080
		(0.0756)	(0.1017)	(0.0780)
_Cons	−0.0101***	0.1307***	−0.5004***	−1.0271***
	(0.0014)	(0.0495)	(0.1138)	(0.1348)
Month FE	No	No	No	Yes
City FE	No	No	Yes	Yes
N	23489	23489	23489	23489
R^2_within	0.0013	0.0830	0.1174	0.3121

Note: Standard errors are presented in parentheses. ***, ** and * represent significance at the 1%, 5% and 10% levels, respectively. *City FE* and *Month FE* represent city and month fixed effects, respectively. The same applies below.

2005). Under this mechanism, the central government determines the promotion of local officials based on their economic performance. Moreover, local officials, to emerge victorious in competition, often set economic growth targets higher than those of the central government (Li et al. 2019). However, excessively high pressure for economic growth can also lead to a series of problems, a typical manifestation of which is data manipulation by local governments to exaggerate their economic performance (Chen et al. 2021). To analyze the interaction effect of economic growth targets and environmental vertical management reform, we add an interaction term between the two variables to the model. Column (3) of Table 3 shows that economic growth targets significantly weaken the inhibiting effect of environmental vertical management reform on air pollution data manipulation. Figure 5 (a) further illustrates the marginal effect of environmental vertical management reform on data manipulation at different levels of economic growth targets. As the economic growth target increases, the effect of this reform gradually weakens. When economic growth targets reach a certain high level, the positive effects of environmental vertical management reform may even be completely offset. This indicates that there is a substitutional relationship between economic growth targets and environmental vertical management reform.

The reason for this phenomenon may be that when the incentives for economic growth faced by local governments are greater than those for environmental

Table 3. Moderating effects

Variables	(1) Manipulate	(2) Manipulate	(3) Manipulate	(4) Manipulate
Vertical	−0.0576**	−0.0963***	0.0058	−0.0059
	(0.0241)	(0.0330)	(0.0071)	(0.0070)
Vertical#Target	0.0059**	0.0099**		
	(0.0028)	(0.0040)		
Vertical#Haze_baidu			−0.0761***	−0.0546***
			(0.0215)	(0.0197)
Target	0.0003	−0.0007		
	(0.0013)	(0.0017)		
Haze_baidu			−0.0462**	-0.0388*
			(0.0194)	(0.0203)
_Cons	−0.0155	−0.3669**	−0.0088***	−1.0523***
	(0.0116)	(0.1496)	(0.0033)	(0.1340)
Controls	No	Yes	No	Yes
City FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
N	19928	19928	23489	23489
R^2_within	0.2746	0.3021	0.2837	0.3130

governance, local officials allocate more attention and resources to economic growth while neglecting environmental protection, leading to an insufficient or distorted supply of environmental public services. As Zhang et al. (2018) noted, even if the environmental monitoring authority is centralized in the central government, if the central government still places economic growth targets above environmental targets, then the impact of environmental vertical management reform may be weakened.

Recent literature has shown that the improvement in air pollution in China is closely related to the increase in public environmental concern (Greenstone et al. 2021; Jin and Deng 2024). Based on 307 environmental decision-making cases, Jager et al. (2020) confirmed that public participation can significantly enhance the effectiveness of environmental governance and the implementation of environmental policies. Therefore, we use the Baidu search index as a proxy variable to measure public environmental concern and examine its impact on the effect of environmental vertical management reform. Column (4) of Table 4 shows that the greater the level of public environmental concern is, the stronger the inhibitory effect of environmental vertical management reform on the environmental data manipulation of local governments. Figure 5 (b) further plots the marginal effect of environmental vertical management reform on data manipulation at different levels of public environmental concern. As the intensity of public environmental concern increases, the effect of the reform also gradually strengthens.

Robustness checks
(1) Parallel trends and dynamic effects
In the baseline regression, we estimate the average treatment effect of environmental vertical management reform on the data manipulation. To further
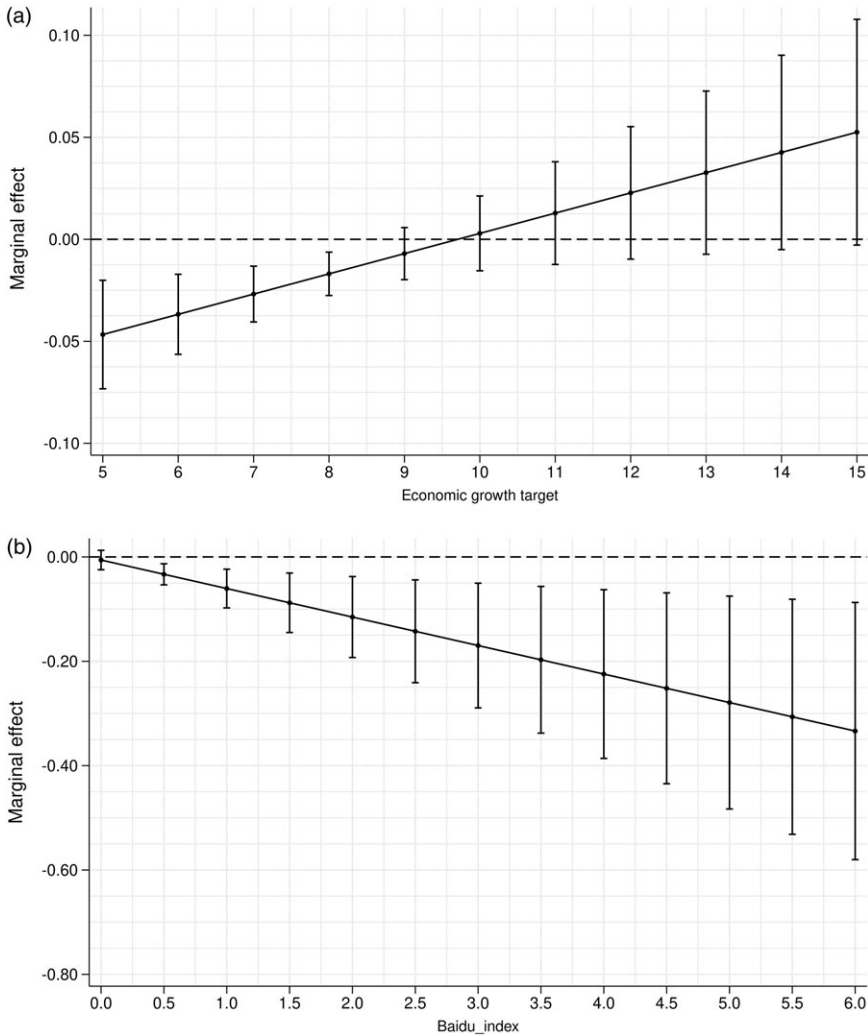
(a)

(b)

Figure 5. Moderating effects.

test the parallel trend assumption and observe the dynamic effects of this reform, we follow Beck et al. (2010) and use the event study approach to plot the regression coefficients for each period before and after the reform, as shown in Figure 6. Specifically, we set the period before this reform as the base period and examine the trend of data manipulation in each period before and after this reform. Figure 6 shows that in the periods before this reform, there was no significant difference in data manipulation between the treatment and control groups, with the coefficients fluctuating around zero and not statistically significant. This indicates that the trends of environmental data manipulation between the two groups were basically parallel before this reform, satisfying the key assumption of the DID method. After the implementation of this reform, the coefficients show a clear negative trend and

Table 4. Replacing the independent variable

Variables	(1) *Manipulate*	(2) *Manipulate*	(3) *Manipulate*	(4) *Manipulate*
Reform	−0.0344***	−0.0443***	−0.0392***	−0.0510***
	(0.0024)	(0.0053)	(0.0069)	(0.0056)
Controls	No	Yes	Yes	Yes
City FE	No	No	Yes	Yes
Month FE	No	No	No	Yes
N	23489	23489	23489	23489
R^2_within	0.0021	0.0847	0.1181	0.1220
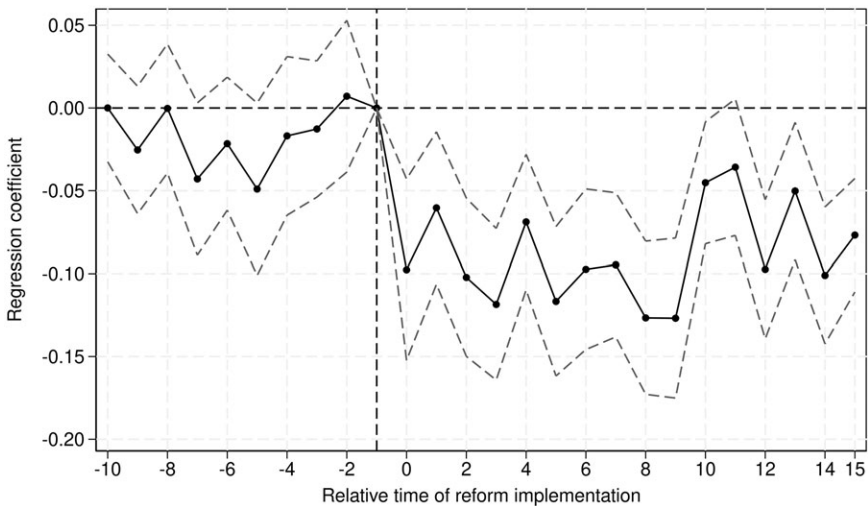
Figure 6. Parallel trends and dynamic effects.

remain stable over time, indicating that the impact of this reform is not short-term but rather persistent.

(2) Placebo test

Although the baseline results show that environmental vertical management reform can effectively reduce data manipulation, we still need to be vigilant that some unobservable factors may influence the results. Hence, referring to Li et al. (2016), we perform a placebo test to further test the robustness of the results. Specifically, we generate a set of virtual treatment groups through random sampling and then substitute them into Eq. (4) for estimation. Since these virtual treatment groups are randomly generated, they should not theoretically have any impact on the dependent variable. Hence, we expect the estimated coefficients of the independent variable to be insignificant. To enhance the reliability of the results, we repeat the random sampling and regression estimation 1000 times, obtaining 1000 virtual estimated coefficients. Figure 7 shows the distribution of these coefficients, and it can be seen from the figure that the vast majority of the estimated coefficients
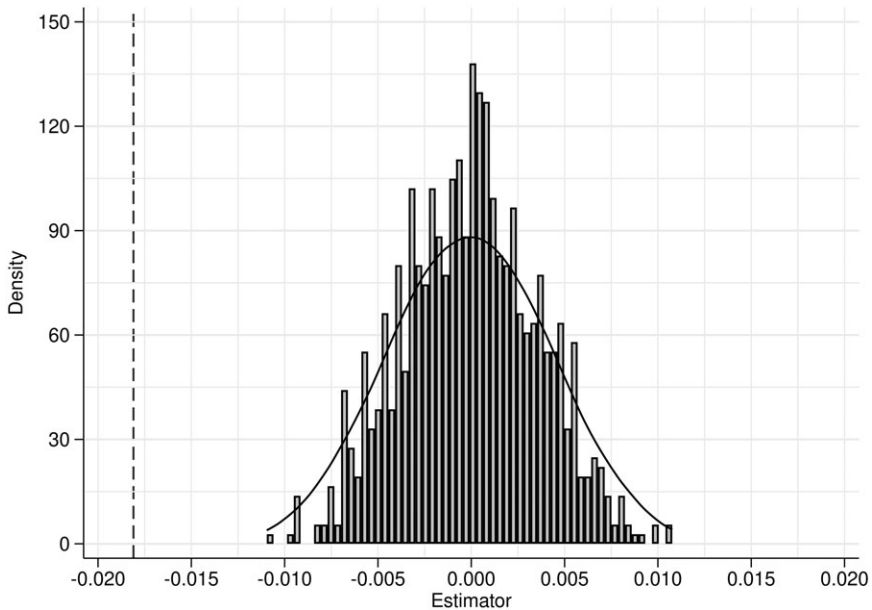
Figure 7. Placebo test.

are concentrated at approximately 0, indicating that the randomly generated treatment group does not have a significant impact on the data manipulation, which is consistent with our expectations.

(3) Replacing the independent variable

There may be an implementation time lag of this reform between provincial and municipal governments. Hence, using the time when the provincial plan was issued as the starting point of this reform may overestimate its effect. Given that the transfer of environmental monitoring authority to the provincial level is one of the key components of this reform, we use the establishment of the provincial environmental monitoring center in each city (*Reform*) as an indicator of whether the municipal departments have completed environmental vertical management reform to more accurately define the implementation time. To obtain the specific time for each prefecture-level city, we manually collect data from the governmental websites of each prefecture-level city and finally determine the implementation time of this reform for more than 200 cities. Based on these data, we re-estimate the impact of this reform on the data manipulation, and the main results are shown in Table 4. The results are still significantly negative, indicating that the role of this reform in reducing data manipulation is robust. This also suggests that even considering the time differences between provincial plans and municipal reforms, the conclusions are still reliable.

(4) Other robustness tests

To verify the robustness of our conclusions, we also conduct the following robustness tests. (1) Changing the measurement of the dependent variable. We replace the air pollution indicator from PM2.5 with sulfur dioxide (SO2) and

Table 5. Other robustness tests

Variables	(1) Manipulate_so2	(2) Manipulate	(3) Manipulate	(4) Manipulate	(5) Manipulate
Vertical	−0.0358***	−0.0584***	−0.0610***	−0.0574***	−0.0564***
	(0.0062)	(0.0076)	(0.0076)	(0.0077)	(0.0071)
Inspection					−0.1273***
					(0.0069)
_Cons	−0.6254***	−1.0742***	−0.7016**	−1.0916***	−0.9861***
	(0.1599)	(0.2871)	(0.2748)	(0.3925)	(0.2569)
Controls	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
N	23489	23157	20093	23489	23489
R^2_within	0.0429	0.1147	0.1072	0.1159	0.1232

recalculate the degree of data manipulation. (2) The samples of municipalities directly under the central government are removed. Considering that the administrative levels of Beijing, Tianjin, Shanghai, and Chongqing are higher than those of other prefecture-level cities, we remove these four cities from the sample. (3) Excluding the years affected by the COVID-19 pandemic. The COVID-19 pandemic in 2020 had a widespread impact on China's economy. Le et al. (2020) reported that China's air quality significantly improved during the pandemic. To exclude the interference that this abnormal year may cause, we removed the samples from 2020. (4) The bootstrap method is used to calculate standard errors. Unlike conventional methods, the bootstrap method calculates standardization by repeatedly sampling from the original sample without the need to make specific assumptions about the distribution of data, thus obtaining more robust estimators. (5) Excluding the impact of other policies. In addition to environmental vertical management reform, other factors, such as central environmental inspections (*Inspection*) may also affect the data manipulation of local governments. To exclude this potential interference effect, we generated corresponding policy intervention variables based on the time when central environmental inspections were carried out in each region and included them in the model for control. Table 5 shows the results of the above robustness tests. It can be seen that in all tests, the coefficients of environmental vertical management reform are significantly negative, consistent with the baseline results. This indicates that our conclusions are robust.

Mechanism analysis

In Section 3, we have pointed out that the core purpose of environmental vertical management reform is to transfer the environmental management authority of grassroots departments to higher levels, enhance the management authority of provincial environmental protection departments, and thus strengthen environmental supervision. After the reform, the provincial government coordinated environmental monitoring and inspection through stationed institutions, while the grassroots environmental protection departments mainly exercised environmental law enforcement, and their influence on environmental data was greatly weakened.

Table 6. Mechanism analysis

Variables	(1) Penalty	(2) Manipulate	(3) Employee	(4) Manipulate
Vertical	0.1700***		0.0173**	
	(0.0341)		(0.0087)	
Penalty		−0.0020***		
		(0.0007)		
Employee				−0.0030***
				(0.0010)
_Cons	9.1913***	−0.0178***	0.1527	0.0098
	(1.1833)	(0.0007)	(0.3068)	(0.0086)
Controls	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
N	23489	23489	21773	21773
R^2_within	0.5755	0.0026	0.8968	0.2800

Hence, we use *Penalty* and *Employee* to verify this mechanism. Columns (1) and (3) of Table 6 show the results, indicating that after environmental vertical management reform, the influence of grassroots environmental protection departments on environmental governance rapidly increased, and both their law enforcement strength and number of employees significantly increased. The point estimate in column (1) of Table 6 is 0.17, indicating that after this reform, the number of environmental penalty cases in the treatment group increased by 17 percentage points relative to that in the control group. We also analyze the impact of environmental administrative penalties and the number of environmental protection employees in the public sector on data manipulation, and the results show that both reduce environmental data manipulation. To some extent, these findings suggest that after this reform, the interference of local governments in the environmental law enforcement of environmental protection departments is alleviated, and the independence of enforcement departments is enhanced, thus proving the mechanism proposed in this paper.

Conclusions and discussions

Environmental data manipulation can lead to disastrous social and economic consequences because it directly affects the formulation and implementation of public policies. Theoretically, decentralization increases the amount of data controlled by local governments pursuing their own interests, thereby increasing the likelihood of data manipulation by sub-national entities (Briviba et al. 2024). China's environmental vertical management reform has achieved a redistribution of environmental management power through recentralization, forming a pattern of "soft centralization" at the provincial level. Therefore, can this reform help reduce environmental data manipulation in the public sector? This paper answers this question by studying the impact of environmental vertical management reform on environmental data manipulation by local governments.

Specifically, using China's official and satellite PM2.5 data during 2014–2020, we employ a staggered DID method to examine the impact of environmental vertical management reform on data manipulation. The results show that this reform significantly reduces environmental data manipulation in the public sector. However, if local governments face high economic growth targets, this will reduce the inhibitory effects of this reform and may even lead to a substitution effect. However, public environmental concerns can strengthen the inhibitory effect of the reform on data manipulation. In addition, mechanism analysis shows that environmental law enforcement is an important transmission mechanism. The above conclusions provide evidence for understanding the effectiveness of centralized environmental regulation in different countries.

The experience of the United States in environmental governance shows that the model of rights allocation changes with time and specific circumstances. Since the *Clean Air Act*, the United States has begun to transition to environmental centralization, strengthening the role of the federal government in mitigating air pollution and achieving success in improving air quality (Boffa et al. 2016). However, in the 1980s, as state governments implemented stricter environmental regulations, environmental authority was again decentralized to the state level (Zhang et al. 2018). In many developing countries, especially in Africa, decentralization has had negative impacts on various areas, such as corruption, public service failure, and data manipulation. To achieve good governance, these countries have begun to recentralize (Luu et al. 2022; Luu et al. 2024; Malesky et al. 2014; Sandefur and Glassman 2015). Centralization or decentralization is not fixed in different countries. It depends on the national institutional environment, economic development level, and specific regulatory areas (Briviba et al. 2024). In developing countries such as China, factors such as the constraint of economic growth targets and the negative externalities of environmental problems may limit the impact of decentralization in solving environmental issues (Zhang et al. 2018). Environmental data manipulation is a typical example. Our research, based on China's environmental recentralization, expands the path for addressing the problem of environmental data manipulation in developing countries and provides a solution that can be used as a reference for other countries facing similar challenges.

Although environmental vertical management reform has produced positive impacts, there are some issues that are worth further consideration in the future. For example, the reform has broken down local protectionism, but it also means that provincial governments need to directly manage environmental protection agencies in multiple regions. These agencies all need to be supervised and managed by provincial environmental protection departments. However, in cases where the supervisory role of local peer departments is effective, provincial counterparts may find it difficult to avoid regulatory negligence due to geographical distance constraints, which may lead to problems such as rent-seeking. Therefore, more research needs to focus on environmental vertical management reform in the future to improve possible institutional loopholes and help China's environmental governance policies achieve best practices.

In addition, we acknowledge that there are still some shortcomings in this paper. On the one hand, in terms of measuring the independent variable, since we cannot

obtain the actual time of environmental vertical management reform, we can only use the promulgation time of policy documents commonly used in academia to measure the independent variable, which may overestimate the policy effect. To this end, we indirectly prove the robustness of the causal relationship between environmental vertical management reform and the reduction of data manipulation by changing different measurement methods. On the other hand, although we have demonstrated that environmental recentralization has a positive impact on reducing environmental data manipulation in the public sector, the external validity of this conclusion still needs to be further supplemented and improved by evidence from more developing and developed countries. However, the above limitations cannot affect the main contributions of this paper. We can still remain optimistic about the conclusions because at least we have obtained a new path to reduce data manipulation.

References

Aghion P and J. Tirole 1997. "Formal and Real Authority in Organizations." *Journal of Political Economy* **105** (1): 1–29.

Altonji Joseph G, E. Elder Todd and R. Taber Christopher 2005. "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools." *Journal of Political Economy* **113** (1): 151–84.

Baker AC, DF. Larcker and CCY. Wang 2022. "How much should we trust staggered difference-in-differences estimates? " *Journal of Financial Economics* **144** (2): 370–95.

Bandiera O, MC. Best, AQ. Khan and A. Prat 2021."The Allocation of Authority in Organizations: A Field Experiment with Bureaucrats." *The Quarterly Journal of Economics* **136** (4): 2195–242.

Beck T, R. Levine and A. Levkov 2010. "Big Bad Banks? The Winners and Losers from Bank Deregulation in the United States." *The Journal of Finance* **65** (5): 1637–67.

Bergin MS, JJ. West, TJ. Keating and AG. Russell 2005. "Regional Atmospheric Pollution and Transboundary Air Quality Management." *Annual Review of Environment and Resources* **30** (1): 1–37.

Besley T and A. Case 1995. "Incumbent Behavior: Vote-Seeking, Tax-Setting, and Yardstick Competition." *American Economic Review* **85** (1): 25–45.

Bevan G and C. Hood 2006. "What's Measured is What Matters: Targets and Gaming in the English Public Health Care System." *Public Administration* **84** (3): 517–38.

Boffa F, A. Piolatto and GAM. Ponzetto 2016. "Political Centralization and Government Accountability." *The Quarterly Journal of Economics* **131** (1): 381–422.

Briviba A, B. Frey, L. Moser and S. Bieri 2024."Governments Manipulate Official Statistics: Institutions Matter." *European Journal of Political Economy* **82**: 102523.

Cai Y. 2000. "Between State and Peasant: Local Cadres and Statistical Reporting in Rural China." *The China Quarterly* **163**: 783–805.

Cao G, C. Liu and L-A. Zhou 2023 "Suing the Government Under Weak rule of Law: Evidence from Administrative Litigation Reform in China." *Journal of Public Economics* **222**: 104895.

Chen S. 2024. "Performance Feedback, Blame Avoidance, and Data Manipulation in the Public Sector: Evidence from China's Official City Air Quality Ranking. " *Public Management Review* **26** (7): 1871–91.

Chen S, X. Qiao and Z. Zhu 2021. "Chasing or Cheating? Theory and evidence on China's GDP Manipulation." *Journal of Economic Behavior & Organization* **189**: 657–71.

Chen Y, Z. Zhang, P. Shi, X. Song, P. Wang, X. Wei and F. Tao 2017. "Public Perception and Responses to Environmental Pollution and Health Risks: Evaluation and Implication from a National Survey in China." *Journal of Risk Research* **20** (3): 347–65.

Chu Z, C. Bian and J. Yang 2022."How can Public Participation Improve Environmental Governance in China? A Policy Simulation Approach with Multi-Player Evolutionary Game." *Environmental Impact Assessment Review* **95**: 106782.

Dessein W. 2002. "Authority and Communication in Organizations." *Review of Economic Studies* **69** (4): 811–38.

Dickovick JT. 2011. *Decentralization and Recentralization in the Developing World: Comparative Studies from Africa and Latin America*. University Park, PA: Penn State University Press.

Dobrajska M, S. Billinger and S. Karim 2015. "Delegation Within Hierarchies: How Information Processing and Knowledge Characteristics Influence the Allocation of Formal and Real Decision Authority." *Organization Science* **26** (3): 687–704.

Dong D, R. Ran, B. Liu, J. Zhang, C. Song and J. Wang 2024. "Recentralization and the Long-Lasting Effect of Campaign-Style Enforcement: From the Perspective of Authority Allocation." *Review of Policy Research* **41** (1): 239–75.

Dunlap RE and WM. Michelson. 2002. *Handbook of Environmental Sociology*.Westport, CT: Greenwood Press.

Feiock RC and C. Stream 2001. "Environmental Protection versus Economic Development: A False Trade-Off ?" *Public Administration Review* **61** (3): 313–21.

Gao J. 2009. "Governing by Goals and Numbers: A Case Study in the Use of Performance Measurement to Build State Capacity in China." *Public Administration and Development* **29** (1): 21–31.

Garicano L. 2000. "Hierarchies and the Organization of Knowledge in Production". *Journal of Political Economy* **108** (5): 874–904.

Ghanem D, S. Shen and J. Zhang 2020. "A Censored Maximum Likelihood Approach to Quantifying Manipulation in China's Air Pollution Data." *Journal of the Association of Environmental and Resource Economists* **7** (5): 965–1003.

Ghanem D and J. Zhang 2014. "'Effortless Perfection:' Do Chinese cities manipulate air pollution data?" *Journal of Environmental Economics and Management* **68** (2): 203–25.

Greenstone M and R. Hanna 2014. "Environmental Regulations, Air and Water Pollution, and Infant Mortality in India." *American Economic Review* **104** (10): 3038–72.

Greenstone M, G. He, S. Li and EY. Zou 2021. "China's War on Pollution: Evidence from the First 5 Years." *Review of Environmental Economics and Policy* **15** (2): 281–99.

Han C and X-L. Tian 2022. "Less Pollution Under a More Centralized Environmental System: Evidence from Vertical Environmental Reforms in China." *Energy Economics* **112**: 106121.

Harris PG. 2008. "Green or Brown? Environmental Attitudes and Governance in Greater China." *Nature and Culture* **3** (2): 151–82.

He G, S. Wang and B. Zhang 2020. "Watering Down Environmental Regulation in china." *Quarterly Journal of Economics* **135** (4): 2135–85.

Holmstrom B. 1979. "Moral Hazard and Observability." *The Bell Journal of Economics* **10** (1): 74–91.

Jager NW, J. Newig, E. Challies and E. Kochskämper 2020."Pathways to Implementation: Evidence on How Participation in Environmental Governance Impacts on Environmental Outcomes." *Journal of Public Administration Research and Theory* **30** (3): 383–99.

Jia R and H. Nie 2017. "Decentralization, Collusion, and Coal Mine Deaths. " *Review of Economics and Statistics* **99** (1): 105–18.

Jimenez BS. 2017."The Effects of Hierarchy, Centralization and Formalization on Municipal Fiscal Health: An Empirical Test of the Bureaucratic Ideal." *Public Administration* **95** (3): 791–806.

Jin S and F. Deng 2024. "Impact of Public Environmental Concern on Urban-Rural Economic Income Inequality." *Economic Analysis and Policy* **82**: 1131–43.

Kong D and C. Liu 2024. "Centralization and Regulatory Enforcement: Evidence from Personnel Authority Reform in China." *Journal of Public Economics* **229**: 105030.

Kostka G and W. Hobbs 2012. "Local Energy Efficiency Policy Implementation in China: Bridging the Gap between National Priorities and Local Interests." *The China Quarterly* **211**: 765–85.

Kostka G and J. Nahm 2017. "Central–Local Relations: Recentralization and Environmental Governance in China." *The China Quarterly* **231**: 567–82.

Kräkel M. 2007. "Doping and Cheating in Contest-like Situations." *European Journal of Political Economy* **23** (4): 988–1006.

Kroll A and D. Vogel 2021. "Why Public Employees Manipulate Performance Data: Prosocial Impact, Job Stress, and Red Tape." *International Public Management Journal* **24** (2): 164–82.

Le T, Y. Wang, L. Liu, J. Yang, YL. Yung, G. Li and JH. Seinfeld 2020. "Unexpected Air Pollution with Marked Emission Reductions during the COVID-19 Outbreak in China." *Science* **369** (6504): 702–06.

Li G, Q. He, S. Shao and J. Cao 2018. "Environmental Non-Governmental Organizations And Urban Environmental Governance: Evidence from China. " *Journal of Environmental Management* **206**: 1296–307.

Li H and L-A. Zhou 2005. "Political Turnover and Economic Performance: The Incentive Role of Personnel Control in China." *Journal of Public Economics* **89** (9-10): 1743–62.

Li P, Y. Lu and J. Wang 2016. "Does Flattening Government Improve Economic Performance? Evidence from China." *Journal of Development Economics* **123**: 18–37.

Li X, C. Liu, X. Weng and L-A. Zhou 2019. "Target Setting in Tournaments: Theory and Evidence from China." *The Economic Journal* **129** (623): 2888–915.

Li Y, S. Chen and Y. Peng 2023. "In the Shadow of Administrative Decentralization: The Impact of Devolution on Subnational Service Provision." *The American Review of Public Administration* **53** (7-8): 280–95.

Lieberthal K. 1997. "China's Governing System and its Impact on Environmental Policy Implementation." *China environment series* **1** (1997): 3–8.

Lipscomb M and AM. Mobarak 2017. "Decentralization and Pollution Spillovers: Evidence from the Re-drawing of County Borders in Brazil." *The Review of Economic Studies* **84** (1): 464–502.

Liu E, Y. Lu, W. Peng and S. Wang 2022. "Judicial independence, local protectionism, and economic integration: evidence from china." NBER Working Paper No. 30475. *National Bureau of Economic Research.*

Luu HN, MN. Nguyen and HT. Nguyen 2022. "The Impact of Recentralisation on FDI: Evidence from a Quasi-Natural Experiment." *Post-Communist Economies* **34** (4): 543–63.

Luu HN, TA. Nguyen, NM. Nguyen, DD. Le and KT. Dao 2024. "The Impact of Recentralization Reform on Corruption: Evidence from a Quasi-Natural Experiment." *Kyklos* **77** (1): 118–48.

Malesky EJ, CV. Nguyen and A. Tran 2014. "The Impact of Recentralization on Public Services: A Difference-in-Differences Analysis of the Abolition of Elected Councils in Vietnam." *American Political Science Review* **108** (1): 144–68.

Maskin E, Y. Qian and C. Xu 2000. "Incentives, Information, and Organizational Form." *Review of Economic Studies* **67** (2): 359–78.

Mertha AC. 2005. "China's "Soft" Centralization: Shifting Tiao/Kuai Authority Relations". *The China Quarterly* **184**: 791–810.

Nielsen PA. 2014. "Learning from performance feedback: performance information, aspiration levels, and managerial priorities." *Public Administration* **92** (1): 142–60.

Oates WE. 1972. Fiscal federalism. New York: Harcourt Brace Jovanovich.

Pang R, M. Shi and D. Zheng 2022. "Who Comply Better? The Moderating Role of Firm Heterogeneity on the Performance of Environmental Regulation in China." *Environment, Development and Sustainability* **24** (5): 6302–26.

Pollitt C. 2015. "Decentralized management: agencies and 'arm's-length'bodies." In *Public management and governance*, eds. Tony Bovaird and Elke Löffler. London: Routledge.

Radner R. 1992. "Hierarchy: The Economics of Managing."*Journal of Economic Literature* **30**(3): 1382–415.

Rantakari H. 2012. "Employee Initiative and Managerial Control." *American Economic Journal: Microeconomics* **4** (3): 171–211.

Sandefur J and A. Glassman 2015. "The Political Economy of Bad Data: Evidence from African Survey and Administrative Statistics." *The Journal of Development Studies* **51** (2): 116–32.

Shin K. 2017. "Neither Centre nor Local: Community-Driven Experimentalist Governance in China." *The China Quarterly* **231**: 607–33.

Sigman H. 2014. "Decentralization and Environmental Quality: An International Analysis of Water Pollution Levels and Variation." *Land Economics* **90** (1): 114–30.

Simon HA. 1951. "A Formal Theory of the Employment Relationship." *Econometrica: Journal of the Econometric Society* **19**: 293–305.

Tang X, Y. Wang and H. Yi 2022. "Data Manipulation through Patronage Networks: Evidence from Environmental Emissions in China." *Journal of Public Administration Research and Theory* **33** (2): 342–56.

Wallace JL. 2016. "Juking the Stats? Authoritarian Information Problems in China. " *British Journal of Political Science* **46** (1): 11–29.

Wu Y, H. Xiao and F. Yang 2022. "Government Information Disclosure and Citizen Coproduction during COVID-19 in China." *Governance* **35** (4): 1005–27.

Xie J, G. Yang, G. Wang, Y. Zhu and Z. Guo 2023. "Substitutes or Complements? Exploring the Impact of Environmental Regulations and Informal Institutions on the Clean Energy Utilization Behaviors of Farmers." *Environment, Development and Sustainability* **25** (5): 3893–922.

Xu T. 2022. "The Selective Centralization in Decentralization: China's Environmental Vertical Management Reform with a Case Study in Hebei Province." *International Journal of Water Resources Development* **38** (4): 634–57.

Zhang B, X. Chen and H. Guo 2018. "Does Central Supervision Enhance Local Environmental Enforcement? Quasi-Experimental Evidence from China." *Journal of Public Economics* **164**: 70–90.

Zhang J and C. Wang 2011. "Co-Benefits and Additionality of the Clean Development Mechanism: An Empirical Analysis. " *Journal of Environmental Economics and Management* **62** (2): 140–54.

Zhang P. 2021. "Target Interactions and Target Aspiration Level Adaptation: How Do Government Leaders Tackle the "Environment-Economy" Nexus?" *Public Administration Review* **81** (2): 220–30.

Zhang X, X. Yu and L. You 2020. "Does the Granary County Subsidy Program Lead to manipulation of grain production data in China?" *China Economic Review* **62**: 101347.

Zhu X, T. Qiu and D. Liu 2024. "Curbing Elite Capture or Enhancing Resources: Recentralizing Local Environmental Enforcement in China." *The China Quarterly,* 1–20.

Zhu X and Y. Zhang 2019. "Diffusion of Marketization Innovation with Administrative Centralization in a Multilevel System: Evidence from China." *Journal of Public Administration Research and Theory* **29** (1): 133–50.