INSTITUTIONAL DESIGNS AND ENVIRONMENTAL GOVERNANCE

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CERTIFICATE OF ORIGINALITY

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Abstract

This thesis investigates how institutional design influences environmental governance across countries at different stages of development. I examine China as an example of a developing economy that has shown significant improvement in environmental governance while maintaining rapid economic growth over the past decade. My empirical evidence indicates that reforms to institutions such as the cadre evaluation system, environmental quality measurement, and restructuring political hierarchy of environmental protection agencies have been critical to China's success in environmental governance. Specifically, the inclusion of environmental performance as an important component of the cadre evaluation system has incentivized local officials to prioritize environmental outcomes when allocating public resources, rather than solely focusing on economic achievement. In addition, implementing incentive-oriented performance contracts tied to measurable environmental quality indicators has enabled effective pollution control policies by reducing information asymmetry between central and local governments, as well as and local officials' tendency to game the system. Furthermore, strengthening the independence of environmental protection bureaus through verticalisation reforms has eliminated conflicts of interest with local economic goals, enhancing these agencies' capacity to enforce environmental laws on state-owned enterprises.

I also examine institutional factors that distort climate policy and expand carbon-intensive investment in the United States as a developed economy. My findings suggest that fossil fuel companies, incentivised by goals to improve financial performance, engage in political lobbying which obstructs climate action. My findings also show that lobbying results in an increase in oil and gas investment, as well as an increase in

pollution emissions. This ultimately leads to a greater reliance on fossil fuels, and a further delay in the implementation of climate action. Additionally, real estate companies, which account for approximately 40% of global greenhouse gas emissions, are encouraged to invest in social practices and corporate governance instead of environmental measures, as social and governance practices often lead to better corporate fundamentals and higher market value over the long term. However, this selective approach toward Environmental, Social and Governance (ESG) efforts results in a significant increase in carbon emissions, which the capital market cannot discipline this behaviour and even incentivise higher returns. This highlights the need for appropriate institutional designs in developed countries to overcome political economy challenges and unintended consequences of voluntary corporate measures in order to effectively address greenhouse gas emissions.

The significance of my research is threefold. First, I emphasise the critical role of institutional design in improving environmental governance based on a country's stage of development. Developing economies face distinct challenges compared to advanced economies, and institutions must be tailored accordingly. Second, I highlight the unique challenges faced by both developing and developed economies arising from institutional distortions, such as political affiliation and information asymmetry. Overcoming these requires targeted institutional reforms. Finally, my thesis provides evidence-based assessments of various institutions and policies to inform environmental governance strategies. Policymakers aiming to enhance sustainability can leverage my research findings to identify solutions in accordance with their development stage and political system. Overall, my research elucidates how institutional design are crucial for good environmental governance, which aid policymakers pursuing better environmental policies worldwide.

Publications arising from the thesis

▪ Papers under peer review arising from the thesis

Fan, K., Shen, J., Hui, E., & Cheng, L. (2023). Responsible Investing in the Real Estate Investment Trusts. Under Review at The Journal of Real Estate Finance and Economics.

▪ Manuscripts Under Preparation

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Fan, K., Hui, E., & Shen, J. (2023). Does Integrating Environmental Protection into a Cadre Evaluation System Mitigate Race-to-the-bottom Competition? Evidence from Industrial Land Conveyancing in China.

Shen, J., Peng, D., Hui, E., & **Fan, K.** (2023). Performance Measurability and Air Pollution Control: Evidence from a Quasi-experiment in China.

Shen, J., **Fan, K., &** Hui, E. (2023). Lobbying and Fossil Fuel Investment.

Fan, K., Shen, J., Cheng, L., Chan, K., & Hui, E. (2023). ESG Washing, Materiality and Pillar-mix Strategy: A REIT Perspective.

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For my beloved parents

Zi Huan Fan and Hoi Siu Fok

獻給我深愛的

父親范子歡，母親霍凱紹

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Chapter 1 Introduction

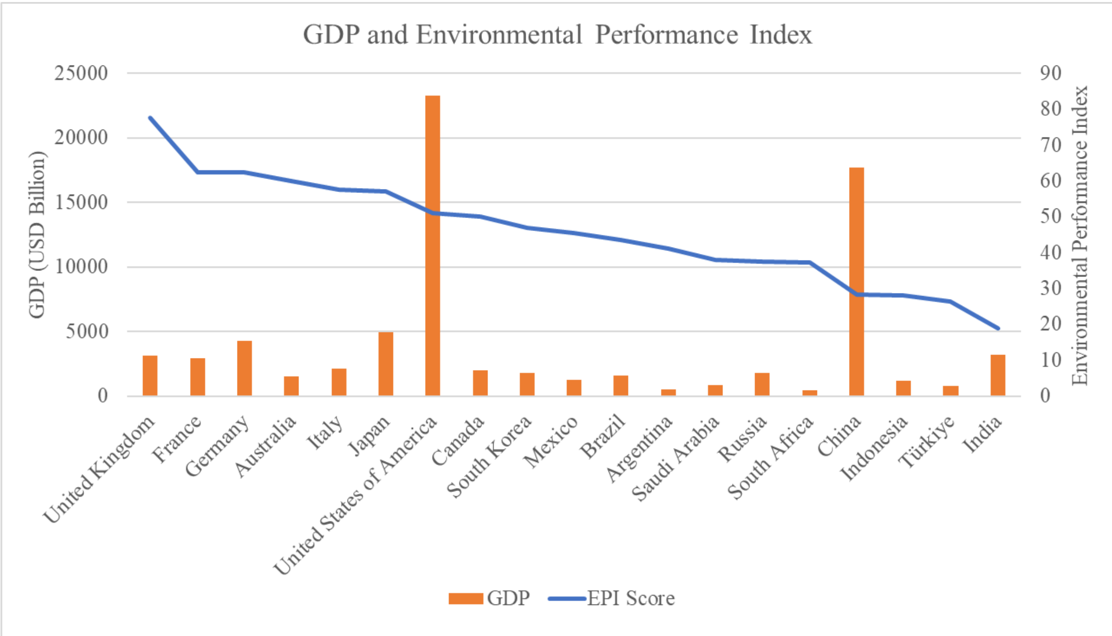
1.1 Research background

Environmental governance is a set of regulatory processes and mechanisms that influence environmental issues and their consequences (Lemos and Agrawal, 2006). Effective environmental governance systems can promote environmental protection by incentivizing sustainable resource use, developing equitable systems for resource allocation and ensuring the effective enforcement of environmental regulations. In contrast, poor environmental governance can also lead to unethical or illegal exploitation of natural resources and fail to protect vulnerable ecosystems, resulting in further environmental degradation. A key influencing factor of environmental governance is institutional design, which refers to the legal, political and organizational structures that influence how decisions are made, who is involved in decision-making and how incentive structures are established and enforced (North, 1991; Goodin, 1998).

Previous studies have often compared environmental governance between authoritarian and democratic countries (Bernauer and Koubi, 2009; Congleton, 1992; Fredriksson et al., 2005; Farzin and Bond, 2006; Pellegrini et al., 2006; Fredriksson and Neumayer, 2013). However, simply categorising countries as authoritarian or democratic obscures important nuances. The development stage of a country is an important factor influencing institutional design choices for environmental governance. Developed and developing countries face different challenges in balancing environmental protection with economic growth. Furthermore, institutional designs adopted at various stages of development can have different impacts on environmental outcomes.

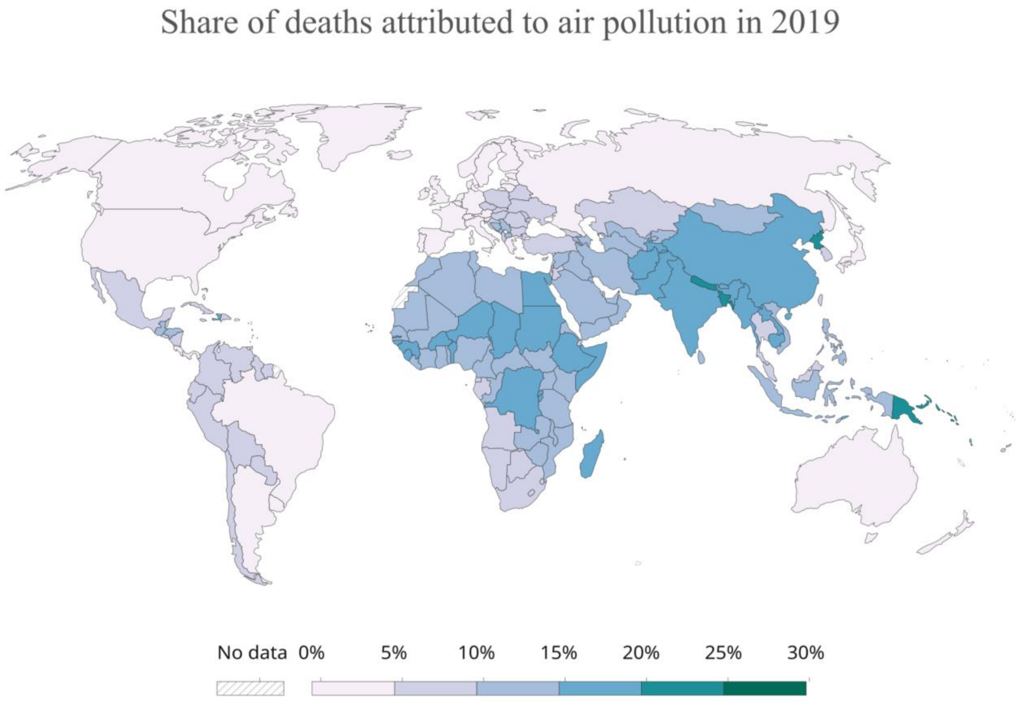
China exemplifies these environmental governance dynamics as a developing country. Breakneck industrialisation and urbanisation, fuelled by an average annual GDP growth rate approaching 10%, dramatically increased energy consumption, air pollution, and greenhouse gas emissions. Poor environmental governance exacerbated these issues through lax enforcement of regulations and lack of incentives for sustainability (Liu and Diamond, 2005; Wang et al., 2008). As a result, China's ecosystems have been subjected to severe strain. As shown in Figure 1.1, despite being the world's second largest economy, China ranks near the bottom among G20 nations in environmental sustainability metrics. Degraded air, water, and soil quality have directly harmed public health, with increased prevalence of cancers, respiratory illness, and cardiovascular disease (Pope et al., 2002; Brook et al., 2010; Cohen et al., 2017). Figure 1.2 illustrates that China has a high mortality rate due to air pollution. It is estimated that air pollution contributed to 16.7% of deaths in China in 2019, which is more than the global average of 11.65% (Ritchie & Roser, 2017). Air pollution alone may contribute to over 16% of deaths in China annually, higher than the global average. The World Health Organization (2023) estimates that air pollution in China leads to two million deaths due to air pollution-related diseases each year.

Figure 1.1 GDP and Environmental Performance Index of G20 countries



Note: This figure shows the gross domestic product (GDP in USD billion) in 2021 (collected from Trading Economics) and the environmental performance index in 2022 (collected from Yale Center for Environmental Law & Policy) of G20 countries.

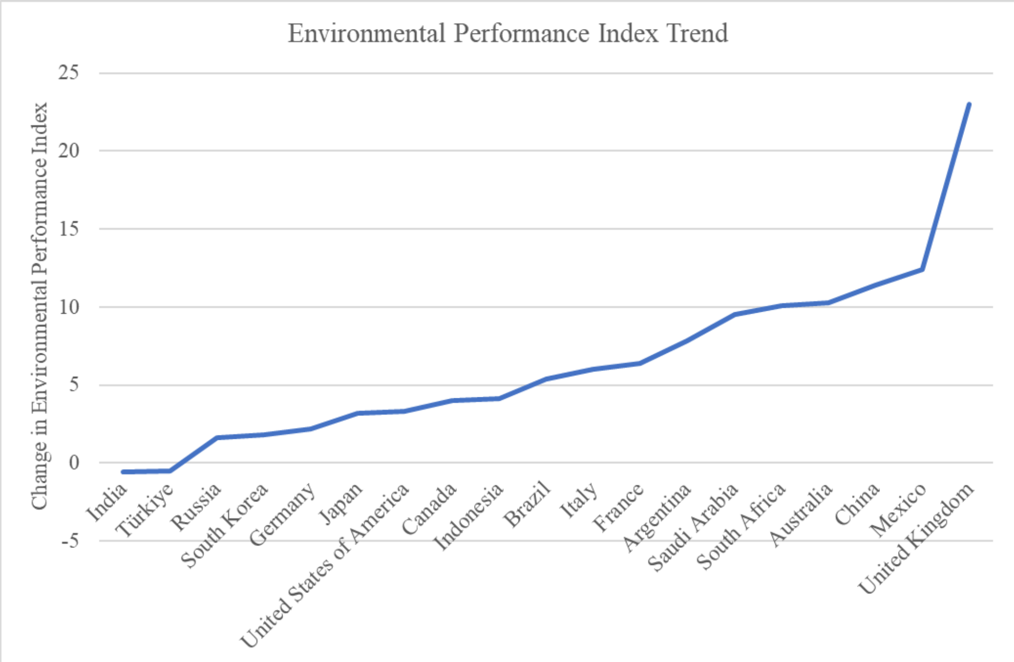
Figure 1.2 Share of deaths attributed to air pollution in 2019



Note: This figure shows the share of deaths attributed to air pollution across the world in 2019 (retrieved from Global Change Data Lab).

China has made significant progress in improving its environmental governance over the past decade through implementing institutional changes. Since declaring a "War on Air Pollution" in 2014, China has achieved substantial reductions in air pollution. The national concentration of PM2.5 decreased by approximately 40% over five years. Concentrations of SO2 and CO also fell by 65% and 33%, respectively (Greenstone et al., 2021). These pollution reductions have contributed to improved public health, including lower mortality rates and decreases in respiratory and cardiorespiratory diseases (Zhong et al., 2017; Chen et al., 2018; Cheung et al., 2020). Despite rapid economic growth, Figure 1.3 indicates that China ranks third among G20 countries for improvements in environmental sustainability, demonstrating the effectiveness of China's institutional designs in curbing pollution and safeguarding health (Wen et al., 2022; Wang et al., 2022). By implementing coordinated institutional reforms, China has made strides in reconciling continued economic development with environmental protection.

Figure 1.3 Change in the Environmental Performance Index of G20 countries



Note: This figure shows the change in environmental performance index from 2012 to 2022 (collected from Yale Center for Environmental Law & Policy) of G20 countries.

As the largest developing country, China has made significant progress in environmental protection by reducing air pollution in the past decade and pledging carbon neutrality by 2060. This is despite China's authoritarian political system which limits public participation in policymaking. China's centralised government has enabled coordinated national strategies on environmental regulation and green technology development. However, local implementation remains a challenge due to misaligned incentives between local and national government. Local governments may exploit information asymmetries by under-enforcing regulations in regions with less rigorous environmental monitoring. The efficacy of China's environmental governance also depends on the political independence of regulatory agencies, as their decisions can be vulnerable to political pressures. What institutional innovations have enabled China to curb its emissions while sustaining economic development?

The United States, as the largest developed economy, pioneered environmental regulation in the 1970s but has lagged in efforts towards carbon neutrality. The U.S. consumed approximately 16 per cent of the world's primary energy in 2021. With just

4 per cent of the world's population, the United States ranks 10th in primary energy consumption per capita (U.S. Energy Information Administration, 2022). What are the inadequacies of institutional design in the model of environmental governance in the U.S.?

Institutional design choices must align incentives of key stakeholders with environmental outcomes. As developed and developing countries face different challenges in terms of environmental governance, the incentives of stakeholders vary accordingly. In developed democracies, transparency and public participation incentivise politicians to balance environmental and economic priorities. However, certain institutional designs in developed democracies may still distort incentives for private sector emissions reductions (Greenstone and Jack, 2015). For example, the influence of powerful fossil fuel interests can distort incentives for politicians, as they have resources to aggressively lobby policymakers to maintain subsidies and prevent climate policies that would hurt their profits. Even companies lack proper incentives to truly commit to ESG principles, as substantive environmental efforts are costly in the short-term and may reduce returns. Responsible investing trends promote ESG, but companies can superficially game these efforts if they are not tied to financial incentives.

In developing countries, officials and enterprises overwhelmingly prioritise rapid economic growth and industrialisation over environmental sustainability. Developing nations often lack regulatory frameworks and incentives to enforce environmental laws and mitigate externalities from unchecked development. However, developing countries also have opportunities to pioneer innovative and contextualised institutional designs that improve environmental governance amidst rapid development. For instance, linking official performance evaluations to environmental targets can incentivise local officials to balance growth and sustainability. The improvement of pollution measurability would mitigate the motivation of local officials gaming the environmental protection system. Independent regulatory agencies with political backing can better enforce rules on pollution-intensive state-owned enterprises that otherwise lack incentives to follow regulations.

This thesis focuses on comprehensively exploring diverse institutional designs for aligning incentives and improving environmental governance in both China and the U.S. I thoroughly assess the various institutional designs that China has adopted to incentivise officials and enterprises to improve its environmental governance and determine how well these have succeeded. Furthermore, I also analyse institutional settings in the U.S. to determine the inadequacies of the system that failed to take action to incentivise substantive climate policies and capital market towards carbon neutrality. The overarching analysis aims to derive actionable insights on tailoring governance institutions to effectively incentivise sustainability based on local political and economic context.

1.2 Literature review and institutional background

Institutional design and development incentives

Institutional design has been identified as a critical factor that influences economic growth and development across countries and over time. It has been argued that institutional design affects the motivation of governments and companies to promote economic growth (North, 1990). Acemoglu et al. (2001) argue that differences in economic development among nations can be attributed to the protection of property rights. They underscore the significance of inclusive institutions in ensuring a level playing field for individuals, empowering them to pursue personal interests and achieve economic benefits (Acemoglu and Robinson, 2012). While some argue that human capital accumulation is more fundamental to explaining cross-country growth differences (Glaeser et al., 2004), others assert that institutional design plays a greater role, as evidenced by the superior historical economic performance of countries like the United States compared to others like Mexico and Peru, despite the latter possessing similar or even greater levels of human capital inherited from colonisers (Acemoglu et al., 2014).

Institutional design also profoundly affects governance quality and rent-seeking behaviours. Weak institutions enable corruption among government officials, misallocation of public resources by political elites for personal gain, and powerful interest groups capturing state resources, all of which distort incentives and severely hinder development (Shleifer and Vishny, 1993; Boone, 1996; Hellman et al., 2003). Well-designed institutions such as decentralized fiscal systems that reduce concentration of power and legal systems that strongly enforce property rights, investor protections, and contracts can mitigate corruption, cronyism, and rent-extraction. This enables fairer and more efficient allocation of resources as opposed to monopolization by special interests, which is crucial for nurturing business environments, deepening capital markets, and sustaining economic growth over the long-run (Fisman and Gatti, 2002; La Porta et al., 1998; La Porta et al., 1997; La Porta et al., 2000; Djankov et al., 2008; Besley and Persson, 2009; Besley and Persson, 2011).

Critically, a country's institutional design also profoundly shapes its environmental governance and advancement of the common good. Prior theoretical work shows how agent behaviors and incentives are fundamentally influenced by the overarching institutional structures in which they are embedded (Holmström and Milgrom, 1991). Well-designed institutions can align private interests with broader social objectives like environmental sustainability and air quality (Tirole, 2017). However, there remain few empirical studies examining how a country's institutional design affects its environmental policies and outcomes based on its stage of economic development. This paper aims to address this critical gap in the literature by exploring how developing countries at various stages of growth can leverage institutional design to balance economic development with environmental sustainability and the common good.

Institutional background of environmental governance in China and the U.S.

China maintains a hierarchical system for appointing personnel, in which the central government has ultimate authority over the appointment and promotion of subnational officials (Blanchard & Shleifer, 2001). Meanwhile, local officials have been given the authority to manage resources within their jurisdictions (Landry, 2008; Xu, 2011) and they are responsible for their performance in a variety of areas, including economic growth, fiscal revenues, education, social security and environmental protection (Qian and Weingast, 1997; Zuo, 2015). Chinese political officials are predominantly promoted through a tournament system, in which officials compete for promotions based on their qualifications and performance. Their performance is measured based on tangible economic results, such as GDP growth and fiscal revenue (Li and Zhou, 2005; Li et al., 2019; Lü and Landry, 2014). As a consequence, economic growth has been the top priority of political officials for several decades, resulting in severe environmental issues such as air pollution and water and soil contamination.

As an authoritarian country, China is heavily criticised for its environmental policies, often being accused of prioritising economic growth over environmental sustainability. Environmental pollution in China has had severe consequences that have affected the health of the population, caused ecological damage and negatively impacted on the economy. The health concerns associated with air pollution in China are particularly severe due to the high levels of pollutants and the large populations exposed to them. Long-term exposure to air pollutants is associated with numerous health issues, including lung cancer and respiratory and cardiovascular diseases (Lepeule et al., 2012;

Zhang et al., 2015; He et al., 2016; Ebenstein et al., 2017; Burnett et al., 2018; Bombardini and Li, 2020; Fan et al., 2020; He et al., 2020). China suffers from water pollution due to the widespread discharge of untreated wastewater into water sources, as well as the extensive use of industrial chemicals and agricultural pesticides. Consequently, water sources have become contaminated with hazardous chemicals and heavy metals, which can cause illness or even death in infants and children (He and Perloff, 2019). Having access to piped water can reduce exposure to contaminated water sources and improve overall health outcomes (Zhang, 2012). Environmental pollution contributes to significant economic losses in China, such as lower productivity, lower efficiency in cumulating human capital and higher healthcare costs (Chang et al., 2019; Graff Zivin et al., 2020; Kahn and Li, 2020).

Given the harmful effects of pollution on the environment and the importance of environmental protection, China adopted the "development of ecological civilization" as a national strategy in 2012 and included it in the Party constitution. This strategy aims to promote green development, ecological conservation and environmental protection. China has played an active role in combating pollution and promoting green development by introducing institutional initiatives. Specifically, the central government declared a national enforcement entitled the "War on Pollution" in 2013 and launched the Air Pollution Prevention and Control Action Plan, which comprised the most stringent regulations in history. As part of the Plan, the central government set strict emission standards for pollutants such as PM10 and PM2.5, and it required all cities to meet these standards by the end of 2017. The central government has implemented new technologies that automatically monitor air quality to encourage local officials to meet these standards without manipulating air pollution data. Additionally, local governments were required to sign a contract with the central government to reduce air pollution. The central government may impose penalties, such as limiting the amount of funds transferred to local government, if local government fails to comply with a contract.

The central government has also implemented a cadre evaluation programme to motivate local officials to enforce pollution reduction policies. "A hero cannot be solely defined by growth in the GDP," said President Xi. The new cadre evaluation system evaluates local officials not only on the basis of economic growth but also on the basis of environmental sustainability. Local officials are, therefore, held accountable for their environmental protection efforts. Moreover, the central government centralised the environmental protection agencies in order to prevent the responsibility for environmental enforcement from conflicting with the economic goals of local governments. This allowed the central government to have greater control over environmental regulations and ensure that local governments would not prioritise economic interests over environmental protection. It also made it easier for the central government to implement and enforce national environmental regulations in a consistent and uniform manner.

To work towards addressing climate change, China has committed to becoming carbon-neutral. Chinese President Xi Jinping stated during his speech in the 75th session of the United Nations General Assembly on 22 September 2020 that "China's carbon dioxide emissions will strive to peak by 2030 and to become carbon-neutral by 2060." In addition, China set working guidelines to increase its non-fossil energy share to about 25 per cent by 2030 and increase its forest coverage rate to 25 per cent and the volume of forest stock to 19 billion cubic metres (Department of Resource Conservation and Environmental Protection, 2021). China is now the largest renewable energy investor and leads the global transition to green growth (Bhutada, 2022). To work towards the Paris Agreement goals, China sets an example for other countries to follow. This commitment is a major step in the fight against climate change. The world is now watching with interest as China shows its commitment and takes action in order to reduce emissions. China should learn from developed countries, such as the United States, in order to reduce its greenhouse gas emissions, regardless of the advantages or pitfalls of their institutional designs.

Environmental governance in the United States has made significant improvements over the years in response to growing concerns about environmental degradation and its adverse effects on health and the economy. The Environmental Protection Agency (EPA) is one of several environmental agencies that are responsible for monitoring and enforcing environmental laws and regulations. Furthermore, bottom-up institutional designs allow local communities and stakeholders to take responsibility for environmental issues and actively participate in their resolution (Hamilton, 1993; Brooks and Sethi, 1997; Reed et al., 2006). The federal government plays an important role in environmental governance by setting national policies and standards, providing funds to states and localities and enforcing environmental regulations. This results in a more efficient system of environmental governance and allows for better implementation of policies. Additionally, it helps to ensure that environmental concerns are addressed in a timely manner and with appropriate resources.

The federal government has enacted several environmental laws that provide the legal basis for regulating pollution and other environmental impacts. These laws include the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act and the Endangered Species Act, among others. The Clean Air Act was initiated in 1970 and amended several times, including in 1977 and 1990. This act is one of the most important and far-reaching environmental statutes enacted in the United States. It established national standards for controlling air pollution and enforcement programmes for enforcing these standards . Recent studies show that the act has reduced emissions of harmful pollutants such as sulphur dioxide, nitrogen oxides and lead (Auffhammer et al., 2009; Environmental Protection Agency, 2011; Deschênes et al., 2017; Barreca et al., 2021; Raff et al., 2022; Bishop et al., 2022). The act has improved public health, resulting in decreases in respiratory illnesses, hospitalisations and infant mortality (Chay and Greenstone, 2003; Deryugina et al., 2019). It has also increased labour income by increasing labour productivity due to improved health and well-being (Isen et al., 2017). It also contributes to rising property values and social equality, since the house prices of households in the lowest quintile appreciate more than those in the top one (Chay and Greenstone 2005; Bento et al., 2015).

The Clean Water Act was enacted in 1972 and is the primary federal law that governs water pollution in the U.S. It was enacted in response to the growing threat of water pollution to public health and the environment. This act prohibits the discharge of pollutants into navigable waters, establishes standards for the quality of water and effluent and provides funding for wastewater treatment programmes. Furthermore, it requires industry to obtain permits before discharging pollutants and to meet certain standards. The act has been successful in reducing pollution discharged into U.S. waterways and improving water quality (Griffiths et al., 2012; Shimshack, 2014; Keiser and Shapiro, 2019). In addition, recent literature suggests that the act could have had a positive impact on health (Flynn and Marcus, 2023). Nevertheless, several cost-benefit analyses of the Clean Water Act have determined that the costs far outweigh the benefits (Carson and Mitchell, 1993; Lyon and Farrow, 1995; Keiser and Shapiro, 2019). Overall, this legislation and government agencies, such as the Environmental Protection

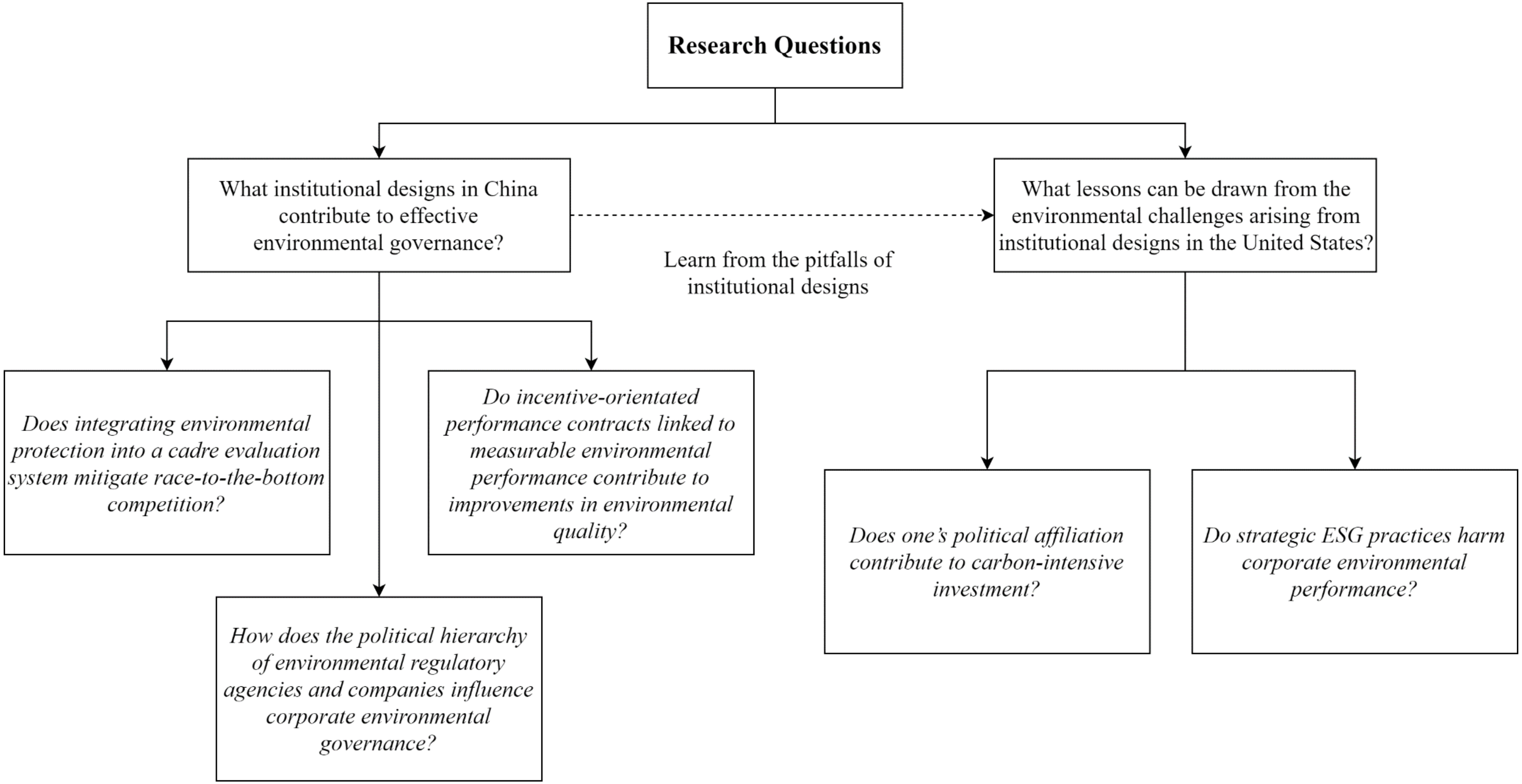
Agency, have enabled the U.S. to remain a leader in the field of environmental protection and quality.

Despite the above institutional designs helping the United States regulate and protect the environment against pollution and environmental degradation, the U.S. is one of the countries with the highest per capita carbon dioxide emissions (Ritchie et al., 2020). Additionally, the U.S. is the second-largest producer of greenhouse gases after China (Matthews et al., 2014). One of the factors contributing to these high emissions is institutional design. For instance, the influence of lobbying on policy decisions has allowed for the weakening of regulations and the passing of legislation that favours industry interests over those of the environment. This has resulted in a lack of meaningful action to reduce greenhouse gas emissions and combat climate change (House Committee on Oversight and Reform, 2021; Carter et al., 2021). To address this issue, businesses should adopt and implement Environmental, Social and Governance (ESG) practices. Generally, these practices are seen as a means of improving environmental quality and reducing emissions, thus contributing to the mitigation of climate change. However, some ESG practices may require significant investment, making them challenging for businesses with limited resources to implement. Thus, if ESG practices are not monitored and enforced adequately, they may not be effective in reducing greenhouse gas emissions. In addition, it is not known whether capital markets reward companies that adopt ESG practices.

1.3 Research questions

The importance of environmental governance in China and the United States cannot be overstated, as these countries are the world's two largest economies and the largest emitters of greenhouse gases, but with completely different political institutions (Acemoglu, Johnson and Robinson, 2005; Song, Storesletten and Zilibotti, 2011; Ritchie et al., 2020). Investigation of the environmental governance of both these countries is crucial to promote sustainable economic growth and avoid environmental degradation under various institutional structures. Despite there being many research gaps in the environmental economics literature, this thesis is limited to focusing on a few of the most important issues. The fundamental goal of my research is to answer the following two questions: (1) What institutional designs in China contribute to effective environmental governance? (2) What lessons can be drawn from the environmental challenges arising from institutional designs in the United States? My research questions are developed as shown in Figure 1.4, below.

Figure 1.4 Framework of Research Questions



Does integrating environmental protection into a cadre evaluation system mitigate race-to-the-bottom competition? In 2013, the central government of China incorporated environmental quality into its cadre evaluation system. Given that economic development is an important factor of winning promotion competitions, it is not clear whether local officials in China take genuine steps to improve the quality of their local environment (e.g. Zheng et al., 2014; Jia, 2017; Wu and Cao, 2021). Land used for industrial purposes plays an important role in economic development as well as environmental quality (He et al., 2014; Wang et al., 2020). Prefectural leaders are authorised to allocate resources, such as industrial land, in their local regions to facilitate economic growth. If economic development dominates the cadre evaluation system, prefectural leaders may reduce industrial land prices to attract pollution-intensive industries, especially when they confront major promotion reviews. Due to this behaviour, the industrial land market is subjected to race-to-the-bottom competitions to attract investment without addressing environmental concerns. If the reform of the cadre evaluation system in 2013 can mitigate this race to the bottom, prefectural leaders are expected to reduce their tendency to manipulate industrial land prices. Thus, this research question evaluates whether the reform of the cadre evaluation system is a good institutional design to improve environmental governance in the public sector.

Do incentive-orientated performance contracts linked to measurable environmental performance contribute to improvements in environmental quality? A moral hazard occurs when performance is difficult to measure (Holmström, 1979), resulting in a trade-off between motivating agents to make authentic efforts and distorting their behaviours to manipulate outcomes. Specifically, agents are more likely to play the system by strategically overperforming on accurately measured tasks (e.g., economic growth) and falling short on tasks that cannot be accurately measured or can be easily manipulated (e.g. environmental quality measures) (Holmström and Milgrom, 1991, Baker, 1992; Baker et al., 1994). To address this moral hazard, it is necessary to develop "non-manipulable" performance measurement indicators and provide agents with quantifiable goals (Propper and Wilson, 2003). To combat the air pollution problem, China launched its Action Plan to tackle air pollution in all prefectural cities in 2013. The central government established quantifiable pollution reduction goals for provincial governments and signed contracts with them to stipulate their responsibilities. Additionally, an automated air quality monitoring system has been implemented to prevent local governments from manipulating the data. The distribution of automated monitoring stations, however, is geographically unbalanced, which results in diversified performance measurability that is advantageous to the research milieu. It is expected that those regions that are subjected to strict monitoring will be able to achieve higher levels of improvement in air quality as a result of a combination of quantifiable goals and transparent indicators. The aim of this research question is to determine whether performance contracts and automated air quality monitoring systems contribute to a reduction in air pollution in China.

How does the political hierarchy of environmental regulatory agencies and companies influence corporate environmental governance? Before the environmental verticalization reforms, local environmental protection bureaus had a low political status in China. The bureaus were directly managed by local governments, which put more emphasis on economic growth than environmental protection. Thus, the duties of the bureaus clashed with the objectives of their leaders. Moreover, SOEs in China also occupy a position in the political hierarchy. There are two types of SOEs: those under the control of local governments and those under the control of central government. This weak political position of the environmental protection bureaus made it difficult for them to effectively enforce environmental regulations, as local governments prioritised economic growth over environmental protection. Furthermore, SOEs controlled by local governments are also driven by economic incentives and are more likely to disregard environmental regulations. The conflict between environmental protection and economic growth is further exacerbated as a result. For the purpose of improving the political position of local environmental protection bureaus, central government introduced an environmental verticalization reform to address the issue of insufficient environmental enforcement. In the aftermath of this reform, prefectural environmental protection bureaus are managed directly by provincial bureaus. Through this reform, the conflicts of interest between local government and bureaus are expected to be resolved, and the environmental protection bureaus are expected to be empowered to manage the environmental governance of SOEs. Thus, this research question evaluates whether the verticalization reform has improved corporate environmental performance.

Does one's political affiliation contribute to carbon-intensive investment? It is common practice for political lobbyists to influence policymaking and legislation that is beneficial to the particular interests of their clients. Lobbying is a method of influencing legislation by obtaining access to political decision-makers. Political lobbyists maintain close relationships with politicians, providing them with information, expertise and advice on issues that are of interest to them. Lobbyists can use this information to influence the drafting of legislation, the content of committee reports and the outcomes of votes during the legislative process (Dür and De Bièvre, 2007; Mahoney, 2007; Bonica et al., 2013). Political lobbyists may influence policymaking and legislation in order to create a more favourable environment for their clients in the context of carbon-intensive investment. This may include reducing or eliminating environmental regulations, providing subsidies or tax breaks for carbon-intensive investment or granting access to natural resources. Therefore, political lobbyists can act as an information transmission mechanism, providing their clients with the necessary information to make informed investment decisions (Austen-Smith and Wright, 1992; Austen-Smith, 1994; Hegde and Sampat, 2015). Oil and gas companies with sufficient capital can take advantage of these opportunities to gain access to political affiliation activities. This can give them a competitive advantage compared to their competitors who are unable to influence the policymaking and legislative process. Thus, oil and gas companies may lobby government to pass laws that reduce restrictions on the development of carbon-intensive industries (House Committee on Oversight and Reform, 2021; Carter et al., 2021). This research question evaluates whether political lobbying facilitates the expansion of fossil-fuel investment.

Do strategic ESG practices harm corporate environmental performance? ESG practices have become increasingly important to investors, causing companies to improve their practices to attract more investors. However, there are differences between the components of ESG practices. Companies in the real-estate industry, for instance, require greater investment to reinforce the environmental pillar than the social and governance pillars, posing a challenge to their financial performance and corporate fundamentals. The real-estate sector contributes almost 40 per cent of global carbon dioxide emissions (Carlin, 2022). Due to limited resources constraints, real-estate companies are encouraged to invest more resources in social and governance pillars, but fewer resources in environmental pillars, in order to maintain high ESG ratings. The real-estate industry may also attach greater priority to social and governance pillars than to environmental pillars, in order to enhance their financial performance and still attract investors. This research question examines whether distorted ESG practices can enhance corporate fundamentals, market valuations and environmental performance.

1.4 Research objectives

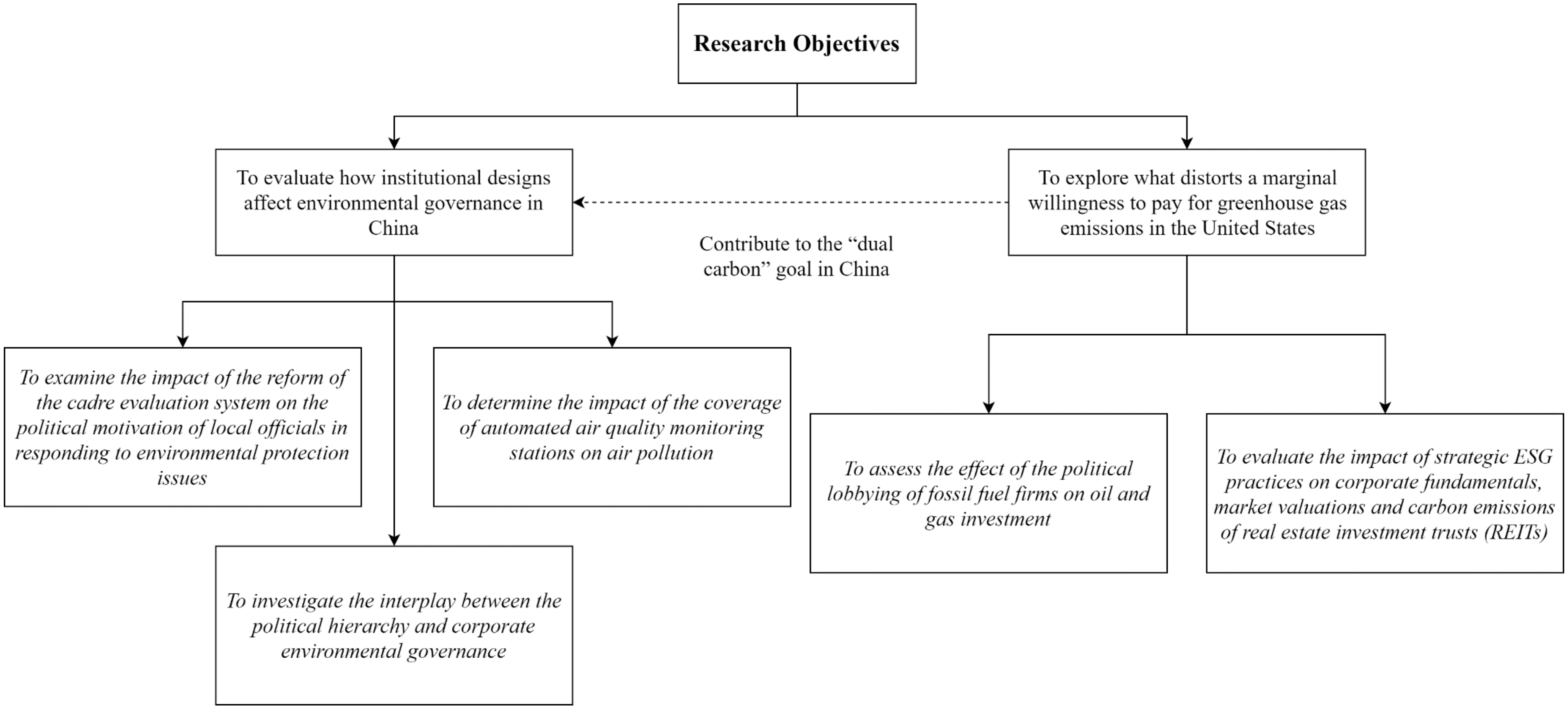
The research objectives of this thesis are based on the research questions listed above. Figure 1.5 summarizes the research objectives of this thesis. The first major objective of this project is to evaluate how institutional design affects environmental governance in China. Specifically, this objective can be subdivided as follows:

1. To examine the impact of the reform of the cadre evaluation system on the political motivation of local officials in responding to environmental protection issues.
2. To determine the impact of the coverage of automated air quality monitoring stations on air pollution.
3. To investigate the interplay between the political hierarchy and corporate environmental governance.

The second major objective is to explore what distorts incentives for reducing greenhouse gas emissions in the United States. With marginal policy costs increasing while improving environmental quality, developing countries will find it increasingly difficult to reduce pollution and carbon emissions. To continuously improve their environmental quality, developing countries must learn from the challenges that developed countries face today. Experience from the United States can contribute to the "dual carbon" goal in China and carbon neutrality goals in other developing countries. This objective can be further divided as follows:

4. To assess the effect of the political lobbying of fossil fuel firms on oil and gas investment.
5. To evaluate the impact of strategic ESG practices on corporate fundamentals, market valuations and carbon emissions of real estate investment trusts (REITs).

Figure 1.5 Framework of Research Objectives



1.5 Significance of the research

My thesis makes an important contribution to understanding how institutional designs evolve to enable more effective environmental governance as a country develops and progresses. This thesis provides an in-depth evaluation of the specific reforms China has implemented over the past decades (Zhang et al., 2019; Yu et al., 2019), including transforming the cadre evaluation system to prioritise environmental targets, establishing extensive real-time pollution monitoring and disclosure systems, implementing incentive-oriented environmental performance contracts between government and firms, and restructuring bureaucracies through the environmental verticalization process. Through comprehensive analysis, I reveal how these institutional changes at multiple levels of government have influenced environmental governance capacity and economic development outcomes of developing countries. The thesis elucidates the complex dynamics between institutional factors, governance processes and on-the-ground environmental and economic results.

The second major contribution of my thesis is to shed light on the institutional challenges and impediments that have hindered environmental progress in developed countries like the United States. Despite having advanced environmental governance system, the U.S. has struggled to significantly reduce its greenhouse gas emissions and transition towards clean energy due to distortion factors including political affiliations and capital market incentives (Li, 2022). As developing countries faces increasing marginal costs of abatement, it may encounter similar hurdles that could impede or slow further environmental quality improvements needed to reach its "dual carbon" goals. Therefore, developing countries must proactively learn from the experience of developed countries to understand potential pitfalls and implement adaptive strategies early on. My thesis provides an in-depth examination of how political affiliations, such as regulatory agency revolving doors, contribute to continued fossil fuel investment and market distortions. This implies developing countries should exercise caution regarding such affiliations as it develops further to avoid impeding decarbonisation. Additionally, I analyse how capital market incentives distort corporate behaviours and under-investment in environmental initiatives. My findings suggest developing countries should consider financial incentives, tax relief and subsidies to encourage green investments in public equities markets.

This thesis holds significance beyond the context of the U.S. and China. Previous studies have revealed that institutional loopholes can lead to poor environmental quality and waste of resources, especially in developing countries (Davis, 2008; Davis et al., 2014; Duflo et al., 2018). By thoroughly evaluating institutional designs that have enabled improved environmental governance in China, it offers insights into common challenges faced by other developing economies. The reforms that have proven successful in China can serve as a model to be adapted to local contexts elsewhere, improving chances of effective outcomes. Thus, my thesis can assist policymakers in diagnosing root causes of environmental issues and developing practical solutions suited to their institutions and stage of development. More broadly, the lessons learned from examining the institutional designs of the United States and China can be applied to other global issues involving tensions between development and environment protection. This provides a useful blueprint for governments and organisations pursuing sustainability agendas. Overall, by elucidating how institutional designs shape environmental governance, my thesis enables more targeted reforms that allow countries at varying stages of development to collaborate in creating a sustainable future.

1.6 Chapter layout

The five research objectives are addressed in five chapters in this thesis. This section provides a summary of the methodologies and findings of these chapters, along with their implications. Moreover, I also point out some inadequacies of reforms in China.

Promotion tournaments, where local officials compete for advancement up the political hierarchy, can incentivise environmentally damaging practices if officials are evaluated primarily on economic growth. This was the case in China prior to 2013, as I demonstrate in Chapter 2. When both environmental and economic goals are assessed holistically in performance evaluations, officials are motivated to make more balanced decisions rather than prioritising growth above all else.

Chapter 2, "**Does Integrating Environmental Protection in Cadre Evaluation System Mitigate the Race-to-the-bottom Competition? Evidence from Industrial Land Conveyancing in China**" (co-authored with Eddie Chi-Man Hui and Jianfu

Shen), examines whether the integration of environmental protection into the cadre evaluation system in China has deterred local officials from engaging in race-to-the-bottom competition in the industrial land markets. By analysing over 250,000 industrial land transactions across 279 cities occurring between 2007 and 2018, this chapter shows that local officials reduced industrial land prices to attract investment when they confronted major reviews offering potential political promotion, especially from pollution-intensive firms and in regions where local officials compete fiercely for economic performance. By employing a difference-in-differences analysis, race-to-the-bottom competition in land conveyancing was mitigated after 2013, when environmental protection became a criterion of the cadre evaluation system. Furthermore, local officials under greater environmental monitoring pressures are less likely to sell industrial land at lower prices. Due to the reform, the conveyance of industrial land at lower prices is no longer an effective strategy for stimulating economic performance. This chapter sheds some light on how political evaluation influences resource allocation for environmental quality and economic performance.

However, the reform fails to address more systemic issues like the centralised power structure, lack of checks and balances, and primacy of economic growth in the incentive system. Relying on top-down management and political incentives has limited effectiveness for sustaining environmental gains, especially in regions where environmental quality is insufficiently monitored, as shown in Chapter 3.

Chapter 3, "**Performance Measurability and Air Pollution Control: Evidence from a Quasi-experiment in China**" (co-authored with Daoju Peng, Eddie C. M. Hui and Jianfu Shen), examines the impact of enhanced measurability for a high-powered incentive scheme in the public sector by exploiting the Air Pollution Prevention and Control Action Plan launched in China in 2013 and a quasi-experiment involving national automated air quality monitoring network installation. Chapter 3 answers an important question concerning whether improved performance measurability can elicit genuine efforts from local governments to curb air pollution or simply induce dysfunctional "gaming the system" behaviours. Using a sample of 285 Chinese cities and PM2.5 concentration data between 2003 and 2017, Chapter 3 finds that cities with strong performance measurability experience significantly more reductions in PM2.5 concentrations than cities with weak performance measurability after the clean air action plan was put into effect. The results remain robust in a sample constructed from a propensity score-matching approach. This chapter sheds light on the importance of performance measurability in the provision of clean air and development sustainability in the context of developing countries.

Air pollution monitoring has improved the incentives of local governments to reduce pollution, but performance metrics can be gamed when environmental targets are prioritised at the expense of economic growth. In addition, to be effective across China's vast bureaucracy, monitoring systems require substantial resources and capacity-building. Chapter 4 examines how a reform of the bureaucracy has motivated state-owned enterprises to comply with environmental protection regulations.

Chapter 4, "**Political Hierarchy and Corporate Environmental Governance: Evidence from the Centralisation of Environmental Administration in China**" (co-authored with Eddie C. M. Hui, Jianfu Shen and Simba Xin Chang), documents how the political hierarchy plays a significant role in determining corporate environmental governance. By conducting difference-in-differences analysis to investigate listed firms in China, Chapter 4 demonstrates that local and central SOEs headquartered in jurisdictions far removed from central government supervision have worse environmental governance than POEs. The verticalization reform implemented in 2016 enables provincial Environmental Protection Bureaus to directly administer lower-level bureaus. The study finds that the corporate environmental governance of local SOEs has significantly improved following the reform, as local environmental protection bureaus no longer have conflicts of interest with local governments. However, the reform has not resulted in improvements to corporate environmental governance in central SOEs, whose executives occupy higher status than provincial Environmental Protection Bureau leaders, nor in POEs, which were already managed before the reform. Lastly, my study reveals that verticalization reform costs are negligible. Local SOEs have not experienced a decline in financial performance or corporate valuation. This chapter suggests that policymakers should consider the political ranking of government agencies and enterprises to improve environmental governance.

While the verticalization reform appears effective based on this analysis, long-run sustainability remains doubtful without greater bottom-up accountability and incentives realignment for SOEs. The reform's negligible costs also seem optimistic—even if financial effects are limited, centralisation likely catalyse resistance by other stakeholders, particularly from the central SOEs that hold higher political positions.

The institutional design in the U.S. fails to provide proper incentives for stakeholders to mitigate climate change. The following chapters identify the flawed institutions and make political suggestions to policymakers for steering the economic system toward sustainability.

Chapter 5, "**Lobbying and Fossil Fuel Investment**" (co-authored with Eddie C. M. Hui and Jianfu Shen), explores the impact of the lobbying activities of oil and gas companies on their corporate investment decisions. Using a sample of listed oil and gas companies in the U.S. from 2000 to 2019, this chapter finds that in comparison with non-lobbying firms, lobbying companies' capital expenditure increased by 6.2% and their oil and gas reserves' growth rate increased by 16.4% in the year following lobbying. The amount of lobbying expenditure is also positively associated with fossil fuel investment. The results remain robust when an instrumental variable approach is applied to address endogeneity concerns. The plant-level analysis indicates that political lobbying by fossil fuel parent companies does not enhance abatement investment alongside conventional energy, but instead, it raises pollution emissions. Further investigation shows that lobbying activities significantly boost the financial performance of fossil fuel companies without reducing their political risks or exposure to climate change policy uncertainty. Taking these factors together, this chapter suggests that lobbying improves the financial performance of oil and gas companies and leads to an increase in their fossil fuel investments. Policymakers should regulate political association activities when they are likely to lead to negative externalities and the misuse of public resources.

Chapter 6, "**ESG Washing, Materiality and Pillar-mix Strategy: A REIT Perspective**" (co-authored with Jianfu Shen, Eddie C. M. Hui, Louis T.W. Cheng and Kalok Chan), explores the role of ESG materiality as part of an ESG Pillar-mix strategy adopted by REITs in the U.S.. Due to cost efficiency and resource constraints, REITs may undertake strategic ESG efforts to raise their overall ESG ratings by committing relatively less resources to costly environmental pillar while enhancing cheaper social and governance pillar. This chapter finds that such strategic ESG practices in REITs are associated with better revenue growth, lower costs, higher profitability and capital expansion. Event studies further indicate that improvements in strategic ESG practices result in positive cumulative abnormal returns. The long-short portfolios which long stocks with a higher percentage of strategic ESG practices and short stocks with a lower percentage generate positive risk-adjusted returns of 0.558% per month under an equal-weighted scheme and 0.821% under a value-weighted scheme. In addition, strategic ESG practices are associated with higher long-term valuations, as measured by Tobin's Q and buy-and-hold returns. The strategic ESG practices, however, have adverse environmental consequences. The improvement in strategic ESG practices results in increased greenhouse gas emissions and environmental damage costs. The negative consequences cannot be corrected by the capital market. REITs engage in strategic ESG practices attracts more institutional investors and results in an influx of institutional capital. This chapter sheds lights on the practice of ESG washing and the challenges of the alignments of emission targets and financial incentives for real estate firms to increase their environmental stewardship.

Chapter 7 summarizes the findings of the previous chapters. The research objectives of this thesis are revisited with the aim of understanding the role of institutional design in environmental governance. The implications of the findings for public policy as well as suggestions for future research are also discussed.

References

Acemoglu, D., Gallego, F. A., & Robinson, J. A. (2014). Institutions, Human Capital, and Development. *Annual Review of Economics*, *6*(1), 875–912. https://doi.org/10.1146/annurev-economics-080213-041119

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review*, *91*(5), 1369–1401. https://doi.org/10.1257/aer.91.5.1369

Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Chapter 6 Institutions as a Fundamental Cause of Long-Run Growth. In *Handbook of Economic Growth* (Vol. 1, pp. 385–472). Elsevier. https://doi.org/10.1016/S1574-0684(05)01006-3

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty* (1. edition). Crown Publishing.

Auffhammer, M., Bento, A. M., & Lowe, S. E. (2009). Measuring the effects of the Clean Air Act Amendments on ambient concentrations: The critical importance of a spatially disaggregated analysis. *Journal of Environmental Economics and Management*, *58*(1), 15–26. https://doi.org/10.1016/j.jeem.2008.12.004

Austen-Smith, D. (1994). Strategic Transmission of Costly Information. *Econometrica*, *62*(4), 955. https://doi.org/10.2307/2951741

Austen-Smith, D., & Wright, JohnR. (1992). Competitive lobbying for a legislator's vote. *Social Choice and Welfare*, *9*(3). https://doi.org/10.1007/BF00192880

Baker, G., Gibbons, R., & Murphy, K. J. (1994). Subjective Performance Measures in Optimal Incentive Contracts. *The Quarterly Journal of Economics*, *109*(4), 1125–1156. https://doi.org/10.2307/2118358

Baker, G. P. (1992). Incentive Contracts and Performance Measurement. *Journal of Political Economy*, *100*(3), 598–614. https://doi.org/10.1086/261831

Barreca, A. I., Neidell, M., & Sanders, N. J. (2021). Long-run pollution exposure and mortality: Evidence from the Acid Rain Program. *Journal of Public Economics*, *200*, 104440. https://doi.org/10.1016/j.jpubeco.2021.104440

Bento, A., Freedman, M., & Lang, C. (2015). Who Benefits from Environmental Regulation? Evidence from the Clean Air Act Amendments. *Review of Economics and Statistics*, *97*(3), 610–622. https://doi.org/10.1162/REST_a_00493

Bernauer, T., & Koubi, V. (2009). Effects of political institutions on air quality. *Ecological Economics*, *68*(5), 1355–1365. https://doi.org/10.1016/j.ecolecon.2008.09.003

Besley, T., & Persson, T. (2009). The Origins of State Capacity: Property Rights, Taxation, and Politics. *American Economic Review*, *99*(4), 1218–1244. https://doi.org/10.1257/aer.99.4.1218

Bhutada, G. (2022). These are the top 10 countries by energy transition investment. *World Economic Forum*. https://www.weforum.org/agenda/2022/02/ranked-10-countries-energy-transition-investment/

Bishop, K., Ketcham, J., & Kuminoff, N. (2022). *Hazed and Confused: The Effect of Air Pollution on Dementia* (No. w24970; p. w24970). National Bureau of Economic Research. https://doi.org/10.3386/w24970

Blanchard, O., & Shleifer, A. (2001). Federalism with and without political centralization: China versus Russia. *IMF Staff Papers*, *48*(Suppl 1), 171–179.

Bombardini, M., & Li, B. (2020). Trade, pollution and mortality in China. *Journal of International Economics*, *125*, 103321. https://doi.org/10.1016/j.jinteco.2020.103321

Bonica, A., McCarty, N., Poole, K. T., & Rosenthal, H. (2013). Why Hasn't Democracy Slowed Rising Inequality? *Journal of Economic Perspectives*, *27*(3), 103–124. https://doi.org/10.1257/jep.27.3.103

Boone, P. (1996). Politics and the effectiveness of foreign aid. *European Economic Review*, *40*(2), 289–329. https://doi.org/10.1016/0014-2921(95)00127-1

Brook, R. D., Rajagopalan, S., Pope, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., Holguin, F., Hong, Y., Luepker, R. V., Mittleman, M. A., Peters, A., Siscovick, D., Smith, S. C., Whitsel, L., & Kaufman, J. D. (2010). Particulate Matter Air Pollution and Cardiovascular Disease: An Update to the Scientific Statement From the American Heart Association. *Circulation*, *121*(21), 2331–2378. https://doi.org/10.1161/CIR.0b013e3181dbece1

Brooks, N., & Sethi, R. (1997). The Distribution of Pollution: Community Characteristics and Exposure to Air Toxics. *Journal of Environmental Economics and Management*, *32*(2), 233–250. https://doi.org/10.1006/jeem.1996.0967

Burnett, R., Chen, H., Szyszkowicz, M., Fann, N., Hubbell, B., Pope, C. A., Apte, J. S., Brauer, M., Cohen, A., Weichenthal, S., Coggins, J., Di, Q., Brunekreef, B., Frostad, J., Lim, S. S., Kan, H., Walker, K. D., Thurston, G. D., Hayes, R. B., …

Spadaro, J. V. (2018). Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. *Proceedings of the National Academy of Sciences*, *115*(38), 9592–9597. https://doi.org/10.1073/pnas.1803222115

Carlin, D. (2022). 40% Of Emissions Come From Real Estate; Here's How The Sector Can Decarbonize. *Forbes*. https://www.forbes.com/sites/davidcarlin/2022/04/05/40-of-emissions-come-from-real-estate-heres-how-the-sector-can-decarbonize/?sh=24ccada563b7

Carson, R. T., & Mitchell, R. C. (1993). The Value of clean water: The public's willingness to pay for boatable, fishable, and swimmable quality water. *Water Resources Research*, *29*(7), 2445–2454. https://doi.org/10.1029/93WR00495

Carter, L., Boren, Z., & Kaufman, A. (2021). *Revealed: BP and Shell Back anti-climate lobby groups despite pledges*. Unearthed. https://unearthed.greenpeace.org/2020/09/28/bp-shell-climate-lobby-groups/

Chang, T. Y., Graff Zivin, J., Gross, T., & Neidell, M. (2019). The Effect of Pollution on Worker Productivity: Evidence from Call Center Workers in China. *American Economic Journal: Applied Economics*, *11*(1), 151–172. https://doi.org/10.1257/app.20160436

Chay, K. Y., & Greenstone, M. (2003). The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession. *The Quarterly Journal of Economics*, *118*(3), 1121–1167. https://doi.org/10.1162/00335530360698513

Chay, K. Y., & Greenstone, M. (2005). Does Air Quality Matter? Evidence from the Housing Market. *Journal of Political Economy*, *113*(2), 376–424. https://doi.org/10.1086/427462

Chen, S., Guo, C., & Huang, X. (2018). Air Pollution, Student Health, and School Absences: Evidence from China. *Journal of Environmental Economics and Management*, *92*, 465–497. https://doi.org/10.1016/j.jeem.2018.10.002

Cheung, C. W., He, G., & Pan, Y. (2020). Mitigating the air pollution effect? The remarkable decline in the pollution-mortality relationship in Hong Kong. *Journal of Environmental Economics and Management*, *101*, 102316. https://doi.org/10.1016/j.jeem.2020.102316

Cohen, A. J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K., Balakrishnan, K., Brunekreef, B., Dandona, L., Dandona, R., Feigin, V., Freedman, G., Hubbell, B., Jobling, A., Kan, H., Knibbs, L., Liu, Y., Martin, R., Morawska, L., … Forouzanfar, M. H. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the Global Burden of Diseases Study 2015. *The Lancet*, *389*(10082), 1907–1918. https://doi.org/10.1016/S0140-6736(17)30505-6

Davis, L. W. (2008). The Effect of Driving Restrictions on Air Quality in Mexico City. *Journal of Political Economy*, *116*(1), 38–81. https://doi.org/10.1086/529398

Davis, L. W., Fuchs, A., & Gertler, P. (2014). Cash for Coolers: Evaluating a Large-Scale Appliance Replacement Program in Mexico. *American Economic Journal: Economic Policy*, *6*(4), 207–238. https://doi.org/10.1257/pol.6.4.207

Department of Resource Conservation and Environmental Protection. (2021). *Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy*. https://en.ndrc.gov.cn/policies/202110/t20211024_1300725.html

Deryugina, T., Heutel, G., Miller, N. H., Molitor, D., & Reif, J. (2019). The Mortality and Medical Costs of Air Pollution: Evidence from Changes in Wind Direction. *American Economic Review*, *109*(12), 4178–4219. https://doi.org/10.1257/aer.20180279

Deschênes, O., Greenstone, M., & Shapiro, J. S. (2017). Defensive Investments and the Demand for Air Quality: Evidence from the NOx Budget Program. *American Economic Review*, *107*(10), 2958–2989. https://doi.org/10.1257/aer.20131002

Djankov, S., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2008). The law and economics of self-dealing. *Journal of Financial Economics*, *88*(3), 430–465. https://doi.org/10.1016/j.jfineco.2007.02.007

Duflo, E., Greenstone, M., Pande, R., & Ryan, N. (2018). The Value of Regulatory Discretion: Estimates From Environmental Inspections in India. *Econometrica*, *86*(6), 2123–2160. https://doi.org/10.3982/ECTA12876

Dür, A., & De Bièvre, D. (2007). The Question of Interest Group Influence. *Journal of Public Policy*, *27*(1), 1–12. https://doi.org/10.1017/S0143814X07000591

Ebenstein, A., Fan, M., Greenstone, M., He, G., & Zhou, M. (2017). New evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River Policy. *Proceedings of the National Academy of Sciences*, *114*(39), 10384–10389. https://doi.org/10.1073/pnas.1616784114

Environmental Protection Agency. (2011). *The Benefits and Costs of the Clean Air Act From 1990 to 2020*. U.S. Environmental Protection Agency Office of Air and Radiation.

Fan, M., He, G., & Zhou, M. (2020). The winter choke: Coal-Fired heating, air pollution, and mortality in China. *Journal of Health Economics*, *71*, 102316. https://doi.org/10.1016/j.jhealeco.2020.102316

Farzin, Y. H., & Bond, C. A. (2006). Democracy and environmental quality. *Journal of Development Economics*, *81*(1), 213–235. https://doi.org/10.1016/j.jdeveco.2005.04.003

Fisman, R., & Gatti, R. (2002). Decentralization and corruption: Evidence across countries. *Journal of Public Economics*, *83*(3), 325–345. https://doi.org/10.1016/S0047-2727(00)00158-4

Flynn, P., & Marcus, M. (2023). *A Watershed Moment: The Clean Water Act and Birth Weight* (No. w29152; p. w29152). National Bureau of Economic Research. https://doi.org/10.3386/w29152

Fredriksson, P. G., & Neumayer, E. (2013). Democracy and climate change policies: Is history important? *Ecological Economics*, *95*, 11–19. https://doi.org/10.1016/j.ecolecon.2013.08.002

Fredriksson, P. G., Neumayer, E., Damania, R., & Gates, S. (2005). Environmentalism, democracy, and pollution control. *Journal of Environmental Economics and Management*, *49*(2), 343–365. https://doi.org/10.1016/j.jeem.2004.04.004

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2004). Do Institutions Cause Growth? *Journal of Economic Growth*, *9*(3), 271–303. https://doi.org/10.1023/B:JOEG.0000038933.16398.ed

Goodin, R. E. (Ed.). (1998). *The theory of institutional design* (1. paperback ed). Cambridge Univ. Press.

Graff Zivin, J., Liu, T., Song, Y., Tang, Q., & Zhang, P. (2020). The unintended impacts of agricultural fires: Human capital in China. *Journal of Development Economics*, *147*, 102560. https://doi.org/10.1016/j.jdeveco.2020.102560

Greenstone, M., He, G., Li, S., & Zou, E. Y. (2021). China's War on Pollution: Evidence from the First 5 Years. *Review of Environmental Economics and Policy*, *15*(2), 281–299. https://doi.org/10.1086/715550

Greenstone, M., & Jack, B. K. (2015). Envirodevonomics: A Research Agenda for an Emerging Field. *Journal of Economic Literature*, *53*(1), 5–42. https://doi.org/10.1257/jel.53.1.5

Griffiths, C., Klemick, H., Massey, M., Moore, C., Newbold, S., Simpson, D., Walsh, P., & Wheeler, W. (2012). U.S. Environmental Protection Agency Valuation of Surface Water Quality Improvements. *Review of Environmental Economics and Policy*, *6*(1), 130–146. https://doi.org/10.1093/reep/rer025

Hamilton, J. T. (1993). Politics and Social Costs: Estimating the Impact of Collective Action on Hazardous Waste Facilities. *The RAND Journal of Economics*, *24*(1), 101. https://doi.org/10.2307/2555955

He, C., Huang, Z., & Wang, R. (2014). Land use change and economic growth in urban China: A structural equation analysis. *Urban Studies*, *51*(13), 2880–2898. https://doi.org/10.1177/0042098013513649

He, G., Fan, M., & Zhou, M. (2016). The effect of air pollution on mortality in China: Evidence from the 2008 Beijing Olympic Games. *Journal of Environmental Economics and Management*, *79*, 18–39. https://doi.org/10.1016/j.jeem.2016.04.004

He, G., Liu, T., & Zhou, M. (2020). Straw burning, PM2.5, and death: Evidence from China. *Journal of Development Economics*, *145*, 102468. https://doi.org/10.1016/j.jdeveco.2020.102468

Hegde, D., & Sampat, B. (2015). Can Private Money Buy Public Science? Disease Group Lobbying and Federal Funding for Biomedical Research. *Management Science*, *61*(10), 2281–2298. https://doi.org/10.1287/mnsc.2014.2107

Hellman, J. S., Jones, G., & Kaufmann, D. (2003). Seize the state, seize the day: State capture and influence in transition economies. *Journal of Comparative Economics*, *31*(4), 751–773. https://doi.org/10.1016/j.jce.2003.09.006

Holmström, B. (1979). Moral Hazard and Observability. *The Bell Journal of Economics*, *10*(1), 74. https://doi.org/10.2307/3003320

Holmstrom, B., & Milgrom, P. (1991). Multitask Principal–Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design. *The Journal of Law, Economics, and Organization*, *7*(special_issue), 24–52. https://doi.org/10.1093/jleo/7.special_issue.24

House Committee on Oversight and Reform. (2021). *Analysis of the Fossil Fuel Industry's Legislative Lobbying and Capital Expenditures Related to Climate Change*. https://oversight.house.gov/sites/democrats.oversight.house.gov/files/Analysis%20of%20the%20Fossil%20Fuel%20Industrys%20Legislative%20Lobbying%20an d%20Capital%20Expenditures%20Related%20to%20Climate%20Change%20-%20Staff%20Memo%20%2810.28.21%29.pdf

Institutions, institutional change, and economic performance. (1990). Cambridge University Press.

Isen, A., Rossin-Slater, M., & Walker, W. R. (2017). Every Breath You Take—Every Dollar You'll Make: The Long-Term Consequences of the Clean Air Act of 1970. *Journal of Political Economy*, *125*(3), 848–902. https://doi.org/10.1086/691465

Jia, R. (2017). Pollution for Promotion. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3029046

Kahn, M. E., & Li, P. (2020). Air pollution lowers high skill public sector worker productivity in China. *Environmental Research Letters*, *15*(8), 084003. https://doi.org/10.1088/1748-9326/ab8b8c

Keiser, D. A., & Shapiro, J. S. (2019). Consequences of the Clean Water Act and the Demand for Water Quality. *The Quarterly Journal of Economics*, *134*(1), 349–396. https://doi.org/10.1093/qje/qjy019

Kostka, G., & Nahm, J. (2017). Central–Local Relations: Recentralization and Environmental Governance in China. *The China Quarterly*, *231*, 567–582. https://doi.org/10.1017/S0305741017001011

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. (2000). Investor protection and corporate governance. *Journal of Financial Economics*, *58*(1–2), 3–27. https://doi.org/10.1016/S0304-405X(00)00065-9

La Porta, R., Lopez-De-Silanes, F., Shleifer, A., & Vishny, R. W. (1997). Legal Determinants of External Finance. *The Journal of Finance*, *52*(3), 1131–1150. https://doi.org/10.1111/j.1540-6261.1997.tb02727.x

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (1998). Law and Finance. *Journal of Political Economy*, *106*(6), 1113–1155. https://doi.org/10.1086/250042

Landry, P. F. (2008). *Decentralized Authoritarianism in China: The Communist Party's control of local elites in the post-Mao era* (Vol. 1). Cambridge University Press New York.

Lemos, M. C., & Agrawal, A. (2006). Environmental Governance. *Annual Review of Environment and Resources*, *31*(1), 297–325. https://doi.org/10.1146/annurev.energy.31.042605.135621

Lepeule, J., Laden, F., Dockery, D., & Schwartz, J. (2012). Chronic Exposure to Fine Particles and Mortality: An Extended Follow-up of the Harvard Six Cities Study from 1974 to 2009. *Environmental Health Perspectives*, *120*(7), 965–970. https://doi.org/10.1289/ehp.1104660

Li, H., & Zhou, L.-A. (2005). Political turnover and economic performance: The incentive role of personnel control in China. *Journal of Public Economics*, *89*(9–10), 1743–1762. https://doi.org/10.1016/j.jpubeco.2004.06.009

Li, Q., & Reuveny, R. (2006). Democracy and Environmental Degradation. *International Studies Quarterly*, *50*(4), 935–956. https://doi.org/10.1111/j.1468-2478.2006.00432.x

Li, X., Liu, C., Weng, X., & Zhou, L.-A. (2019). Target Setting in Tournaments: Theory and Evidence from China. *The Economic Journal*, *129*(623), 2888–2915. https://doi.org/10.1093/ej/uez018

Li, Z. (2022). Connections as Liabilities: The Cost of the Politics–Business Revolving Door in China. *British Journal of Political Science*, 1–21. https://doi.org/10.1017/S0007123422000473

Liu, C., & Kong, D. (2021). Does political incentive shape governments' disclosure of air pollution information? *China Economic Review*, *69*, 101659. https://doi.org/10.1016/j.chieco.2021.101659

Liu, J., & Diamond, J. (2005). China's environment in a globalizing world. *Nature*, *435*(7046), 1179–1186. https://doi.org/10.1038/4351179a

Lü, X., & Landry, P. F. (2014). Show Me the Money: Interjurisdiction Political Competition and Fiscal Extraction in China. *American Political Science Review*, *108*(3), 706–722. https://doi.org/10.1017/S0003055414000252

Lyon, R. M., & Farrow, S. (1995). An Economic Analysis of Clean Water Act Issues. *Water Resources Research*, *31*(1), 213–223. https://doi.org/10.1029/94WR02047

Mahoney, C. (2007). Lobbying Success in the United States and the European Union. *Journal of Public Policy*, *27*(1), 35–56. https://doi.org/10.1017/S0143814X07000608

Matthews, H. D., Graham, T. L., Keverian, S., Lamontagne, C., Seto, D., & Smith, T. J. (2014). National contributions to observed global warming. *Environmental Research Letters*, *9*(1), 014010. https://doi.org/10.1088/1748-9326/9/1/014010

North, D. C. (1991). Institutions. *Journal of Economic Perspectives*, *5*(1), 97–112. https://doi.org/10.1257/jep.5.1.97

Pellegrini, L., & Gerlagh, R. (2006). Corruption, Democracy, and Environmental Policy: An Empirical Contribution to the Debate. *The Journal of Environment & Development*, *15*(3), 332–354. https://doi.org/10.1177/1070496506290960

Pillars of Prosperity: The Political Economics of Development Clusters (Course Book). (2011). Princeton University Press.

Pope III, C. A. (2002). Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. *JAMA*, *287*(9), 1132. https://doi.org/10.1001/jama.287.9.1132

Propper, C. (2003). The Use and Usefulness of Performance Measures in the Public Sector. *Oxford Review of Economic Policy*, *19*(2), 250–267. https://doi.org/10.1093/oxrep/19.2.250

Qian, Y., & Weingast, B. R. (1997). Federalism as a Commitment to Preserving Market Incentives. *Journal of Economic Perspectives*, *11*(4), 83–92. https://doi.org/10.1257/jep.11.4.83

Raff, Z., Meyer, A., & Walter, J. M. (2022). Political differences in air pollution abatement under the Clean Air Act. *Journal of Public Economics*, *212*, 104688. https://doi.org/10.1016/j.jpubeco.2022.104688

Reed, M. S., Fraser, E. D. G., & Dougill, A. J. (2006). An adaptive learning process for developing and applying sustainability indicators with local communities. *Ecological Economics*, *59*(4), 406–418. https://doi.org/10.1016/j.ecolecon.2005.11.008

Ritchie, H., & Roser, M. (2017). Air pollution. *Our World in Data*.

Ritchie, H., Roser, M., & Rosado, P. (2020). CO_2 and greenhouse gas emissions. *Our World in Data*.

Shimshack, J. P. (2014). The Economics of Environmental Monitoring and Enforcement. *Annual Review of Resource Economics*, *6*(1), 339–360. https://doi.org/10.1146/annurev-resource-091912-151821

Shleifer, A., & Vishny, R. W. (1993). Corruption. *The Quarterly Journal of Economics*, *108*(3), 599–617. https://doi.org/10.2307/2118402

Song, Z., Storesletten, K., & Zilibotti, F. (2011). Growing Like China. *American Economic Review*, *101*(1), 196–233. https://doi.org/10.1257/aer.101.1.196

Tirole, J., & Rendall, S. (2017). *Economics for the common good*. Princeton University Press.

U.S. Energy Information Administration,. (2022). *What is the United States' share of world energy consumption?* https://www.eia.gov/tools/faqs/faq.php?id=87&t=1

Wang, M., Janssen, A. B. G., Bazin, J., Strokal, M., Ma, L., & Kroeze, C. (2022). Accounting for interactions between Sustainable Development Goals is essential for water pollution control in China. *Nature Communications*, *13*(1), 730. https://doi.org/10.1038/s41467-022-28351-3

Wang, M., Webber, M., Finlayson, B., & Barnett, J. (2008). Rural industries and water pollution in China. *Journal of Environmental Management*, *86*(4), 648–659. https://doi.org/10.1016/j.jenvman.2006.12.019

Wang, Q., Wang, Y., Chen, W., Zhou, X., Zhao, M., & Zhang, B. (2020). Do land price variation and environmental regulation improve chemical industrial agglomeration? A regional analysis in China. *Land Use Policy*, *94*, 104568. https://doi.org/10.1016/j.landusepol.2020.104568

Wen, Z., Xie, Y., Chen, M., & Dinga, C. D. (2021). China's plastic import ban increases prospects of environmental impact mitigation of plastic waste trade flow worldwide. *Nature Communications*, *12*(1), 425. https://doi.org/10.1038/s41467-020-20741-9

Wolf, M. J., Emerson, J. W., Esty, D. C., de Sherbinin, A., & Wendling, Z. A. (2022). *2022 Environmental Performance Index*. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

World Health Organization. (2023). *Air pollution in China*. https://www.who.int/china/health-topics/air-pollution

Wu, M., & Cao, X. (2021). Greening the career incentive structure for local officials in China: Does less pollution increase the chances of promotion for Chinese local leaders? *Journal of Environmental Economics and Management*, *107*, 102440. https://doi.org/10.1016/j.jeem.2021.102440

Xu, C. (2011). The Fundamental Institutions of China's Reforms and Development. *Journal of Economic Literature*, *49*(4), 1076–1151. https://doi.org/10.1257/jel.49.4.1076

Yu, C., Huang, X., Chen, H., Godfray, H. C. J., Wright, J. S., Hall, J. W., Gong, P., Ni, S., Qiao, S., Huang, G., Xiao, Y., Zhang, J., Feng, Z., Ju, X., Ciais, P., Stenseth, N. Chr., Hessen, D. O., Sun, Z., Yu, L., … Taylor, J. (2019). Managing nitrogen to restore water quality in China. *Nature*, *567*(7749), 516–520. https://doi.org/10.1038/s41586-019-1001-1

Zhang, J. (2012). The impact of water quality on health: Evidence from the drinking water infrastructure program in rural China. *Journal of Health Economics*, *31*(1), 122–134. https://doi.org/10.1016/j.jhealeco.2011.08.008

Zhang, Q., Zheng, Y., Tong, D., Shao, M., Wang, S., Zhang, Y., Xu, X., Wang, J., He, H., Liu, W., Ding, Y., Lei, Y., Li, J., Wang, Z., Zhang, X., Wang, Y., Cheng, J., Liu, Y., Shi, Q., … Hao, J. (2019). Drivers of improved $PM_{2.5}$ air quality in China from 2013 to 2017. *Proceedings of the National Academy of Sciences*, *116*(49), 24463–24469. https://doi.org/10.1073/pnas.1907956116

Zheng, S., Kahn, M. E., Sun, W., & Luo, D. (2014). Incentives for China's urban mayors to mitigate pollution externalities: The role of the central government and public environmentalism. *Regional Science and Urban Economics*, *47*, 61–71. https://doi.org/10.1016/j.regsciurbeco.2013.09.003

Zheng, X., Ding, H., Jiang, L., Chen, S., Zheng, J., Qiu, M., Zhou, Y., Chen, Q., & Guan, W. (2015). Association between Air Pollutants and Asthma Emergency Room Visits and Hospital Admissions in Time Series Studies: A Systematic Review and Meta-Analysis. *PLOS ONE*, *10*(9), e0138146. https://doi.org/10.1371/journal.pone.0138146

Zhong, N., Cao, J., & Wang, Y. (2017). Traffic Congestion, Ambient Air Pollution, and Health: Evidence from Driving Restrictions in Beijing. *Journal of the Association of Environmental and Resource Economists*, *4*(3), 821–856. https://doi.org/10.1086/692115

Zuo, C. (Vera). (2015). Promoting City Leaders: The Structure of Political Incentives in China. *The China Quarterly*, *224*, 955–984. https://doi.org/10.1017/S0305741015001289

Chapter 2 Does Integrating Environmental Protection in Cadre Evaluation System Mitigate the Race-to-the-bottom Competition? Evidence from Industrial Land Conveyancing in China[1]

2.1 Introduction

Since the 1980s, China has experienced nearly double-digit annual GDP growth. Some studies attribute this economic success to a growth model centred on a political tournament system: local officials who achieve high economic performance in their jurisdictions are more likely to be promoted (Li and Zhou, 2005; Li et al., 2019). However, this promotion tournament also results in unexpected drawbacks. Local officials are motivated to engage in a race-to-the-bottom competition: thus they may reduce environmental regulation and enforcement in their jurisdiction for the sake of economic performance. Land is an important resource for local governments to stimulate economic growth in China (Huang and Du, 2017a). Local governments commonly offer industrial land at preferential prices to attract foreign investment and foster business development (Tao et al., 2010). Reductions in land prices, however, attract investments from low-quality and pollution-intensive industries, which reduces environmental quality (Huang and Du, 2018; Hu et al., 2019; Fu et al., 2021).

Pursuing economic growth is considered the principal task for local officials in China (Li and Zhou, 2005), while environmental protection often falls by the wayside (Wu et al., 2013; Deng et al., 2019). In 2013, the central government in China integrated environmental quality to evaluate the performance of local officials. This study investigates whether this reform has mitigated the race-to-bottom competition among local officials in industrial land conveyancing. Given the importance of economic development in winning promotion competitions, the evidence on whether local officials in China take genuine steps to improve local environmental quality is still mixed (e.g. Zheng et al., 2014; Yu et al., 2019; Jiang and Li, 2021; Wu and Cao, 2021; Liu, Tan and Zhang, 2021). More importantly, whether cadre evaluation reform can mitigate the tendency of local officials to sacrifice environmental quality so as to win political competitions has not been fully examined. In this study, I explore the above question in the context of industrial land conveyancing, which impacts significantly on

[1] This chapter is coauthored with Eddie Chi-Man Hui and Jianfu Shen.

both environmental quality and economic growth (Tao et al., 2010; Fu et al., 2021) and is greatly influenced by bureaucratic institutions. Specifically, I use industrial land conveyancing transaction-level data to examine whether and how bureaucratic institutions affect the behaviours of local officials in their deployment of resources to promote economic growth and environmental protection in China.

I analysed over 250,000 industrial land transactions in 279 Chinese cities between 2007 and 2018. Before the 2013 reform of the cadre evaluation system, my empirical findings show that industrial land prices exhibited a U-shaped relationship with the tenure of local officials. Industrial land prices decreased as the years of service of mayors and party secretaries increased for the first five years (the first term), but gradually increased after that. I found that industrial land prices were at their lowest by the fifth year of an official's tenure, with a fall of 8.6% for party secretaries and a fall of 15.5% for mayors after controlling for other factors that might affect the results. These indicate that a low conveyancing price strategy was increasingly adopted by local officials depending on how close they were to a major performance review and possible political promotion. This negative relationship is especially strong for mayors, who are primarily responsible for, and promoted for, good economic performance of a prefectural city. However, local officials were not motivated to sell industrial land at lower prices after their first term as they missed a critical period for political turnover. I found that industrial land prices varied in line with the promotion cycle of local officials in China.

Given that industrialisation may have a detrimental impact on environmental quality, I found that the 2013 cadre evaluation reform, which emphasised environmental protection, reduced the motivation of local officials to attract industrial investment by offering lower industrial land prices. The former U-shaped relationship no longer existed after the reform. My difference-in-differences analysis indicates that industrial land prices had increased by 13.9% for party secretaries, and 14.5% for mayors, in the fifth year of their tenure after the reform. An endogeneity concern is that some omitted factors, rather than motivation for political promotion, such as local officials' experience in resource allocation, may affect decisions concerning industrial land conveyancing. I leveraged an important bureaucratic situation whereby local officials are not eligible for promotion if they reach an age threshold to address the endogeneity issue. My results show that the U-shaped relationship between tenure and land prices, and the reversal of this relationship following the 2013 reform, only survived when local officials were eligible for political promotion. The estimates are robust when controlling for alternative modelling choices regarding sample selection, variables and outcome construction. Additional analysis suggests that the results are unlikely to be driven by the anti-corruption campaign launched by the Chinese government.

The low industrial land price strategy often attracts investment from pollution-intensive firms, which tend to have low capital intensity and can only afford low land prices (Hu et al., 2022; Wang et al., 2020). My empirical findings show that the U-shaped relationship is more pronounced for land conveyed to heavily-polluting industries rather than to others. Land prices declined by 11.7% and 15.5% for party secretaries and mayors, respectively, by the fifth year of their tenure for polluting industries. In contrast, the decline for other industries was negligible. The reform of the cadre evaluation system, however, which includes environmental quality as one of the evaluation criteria for local officials, discourages local governments from attracting environmentally damaging industries. Indeed, by the fifth year of tenure, the prices of land conveyed for pollution-intensive firms increased by 35.7% and 31.0% after the reform, while land prices for other industries were unchanged.

The U-shaped relationship between local officials' tenure and land prices was found to be stronger in the eastern regions, where local officials compete fiercely to attract foreign investment (Huang and Du, 2017a). Industrial land prices in the eastern cities declined by 11.3% for party secretaries and 13.1% for mayors by the fifth year of their tenure. After the reform of the cadre evaluation system, land prices experienced a reversal and increased by 19.7% and 19.1%, respectively. This U-shaped relationship is more pronounced for land conveyed to pollution-intensive firms, and a larger reversal was also experienced. On the other hand, I observed no U-shaped relationship, or its reversal, after the reform in the central and western regions, probably because local economic growth in those regions is less dependent on land resources, so local officials are not motivated to reduce industrial land prices (Ding and Lichtenberg, 2011).

To better enforce the reform of the cadre evaluation system, the central government introduced an automated air quality monitoring system across prefectural cities and conducted environmental inspections across provinces. The monitoring system sent air quality information to central government in real-time from monitored cities. Local officials may be punished due to environmental problems discovered during environmental inspections, e.g. being made ineligible to be promoted in the following two years. Local government officials in these regions, therefore, were placed under greater pressure to improve environmental quality. Exploiting variations in the provision of monitoring systems and environmental inspections by a generalised difference-in-differences analysis, I found that local officials in monitored cities, or after inspections, were less likely to convey industrial land at lower prices than officials in cities that were not monitored. Specifically, the implementation of a monitoring system increased the price of industrial land conveyed to pollution-intensive firms by 25.2% for party secretaries and 24.6% for mayors when they confronted major reviews for political performance at the end of their first term, while environmental inspections increased land prices by 31.6% for party secretaries and 19.7% for mayors. My findings suggest that the race-to-the-bottom competition is significantly mitigated when environmental performance is directly observable by central government.

Lastly, the consequences of the 2013 reform of the cadre evaluation system for economic development were investigated. I found a negative relationship between economic growth rate and industrial land prices: a one-standard-deviation increase in land prices results in a 0.054% decrease in GDP growth rate, which amounts to 55.7 million yuan. The results are consistent with previous studies that found that lower prices of industrial land attract investment and contribute to local economic development (Liu et al., 2008; Tao et al., 2010). My analysis shows, however, that after the reform of the cadre evaluation system, the city GDP growth rate increased by 0.060% for a one-standard-deviation increase in land prices. The results imply that economic growth is less dependent on price manipulation after the reform. Furthermore, the impact of the reform on the land price-economic growth relationship is mainly concentrated in land conveyed to high-pollution industries. Combined with the previous results, the reform has discouraged local officials from engaging in a race-to-the-bottom competition. Transferring land to pollution-intensive industries at lower prices is ineffective in stimulating economic growth.

This study contributes to three strands of literature. First, to the substantial literature on the determination of resource allocation by political institutions. In countries run by democratic systems, incumbent political leaders are more likely to expand fiscal spending and invest in visible projects, such as road construction, prior to an election to support voters (Block, 2002; Shi and Svensson, 2006; Brender and Drazen, 2005; Drazen and Eslava, 2010; Katsimi and Sarantides, 2012). Previous studies on China show that local officials increase budgetary expenditure along with their tenure up to the optimal time for political promotion (Guo, 2009; Vortherms, 2019). It is also common for officials to invest in "image projects" to indicate their competence for better promotion prospects (Chen and Kung, 2016). My study adds the finding that industrial land allocation is an important activity affecting political advancement. Local officials act to control land prices in order to foster business development and economic growth. Moreover, the integration of environmental quality into the cadre evaluation system also affects resource allocation strategies by local governments.

Second, this study contributes to the literature on race-to-the-bottom competition and its effects on environmental quality. It has been hypothesised that free capital flow increases economic production in regions where environmental progress is poorly regulated (Copeland and Taylor, 1994; Gallagher, 2010). In order to attract foreign direct investment (FDI), economic managers are incentivised to weaken their environmental policies (Copeland and Taylor, 2004; Sheldon, 2006). In the United States, manufacturing plants avoid investing in those States with stringent environmental regulations (List and Co, 2000). Environmental enforcement is in some states racing to the bottom. Woods (2006) found that a state's environmental enforcement stringency reduces if it exceeds that of its neighbours. The establishment of comprehensive national environmental protection regulations may reduce race-to-the-bottom competition between regions (Engel, 1996; Potoski, 2001). However, local governments in China have strong powers over the enforcement of environmental policies and economic resource allocation, so bureaucratic institutions play an important role in determining regional environmental quality. Recent studies have demonstrated that local officials might soften environmental regulations to promote economic performance (Hong et al., 2019; Kamp et al., 2017). This study adds the finding that local officials in China may lower land prices to attract investment from pollution-intensive industries. I further provide causal evidence that the reform of the cadre evaluation system induces local officials to engage in a race-to-the-bottom competition. Implementing a monitoring system, which increases the transparency of government information, can deter local officials from reducing land prices to attract investment from pollution-intensive firms.

Lastly, this study also investigated the relationship between land prices and economic growth. Previous studies have argued that land conveyancing has a significant impact on economic development (Dale, 1997), and that industrial land provision can foster industrialisation and business investment (Tao et al., 2010). The area of land and the number of parcels transacted are positively correlated with the budgetary revenues of local governments and regional economic growth (Liu et al., 2008; Tao et al., 2010). To the best of my knowledge, no study has directly evaluated the relationship between industrial land prices and economic growth rate. This paper shows that lower industrial land prices are conducive to regional economic development. I further document the causal effect that the inclusion of environmental quality within the cadre evaluation system disentangles the negative relationship between land prices and economic performance. There are many reasons for the slowdown of China's GDP growth in the past decade, and the reform of political institutions may be one of them.

The remainder of the paper is organized as follows. The next section conducts a review of the cadre evaluation system's institutional background and industrial land prices. In Section 2.3, a conceptual framework is developed and four hypotheses are stated, which guided my empirical studies. Section 2.4 discusses the data, sampling and variables taken into account in this study. Empirical evidence on industrial land prices and the effect of the reform of the cadre evaluation system on the motivation of officials is illustrated in Section 2.5. Section 2.6 discusses my results.

2.2 Institutional background

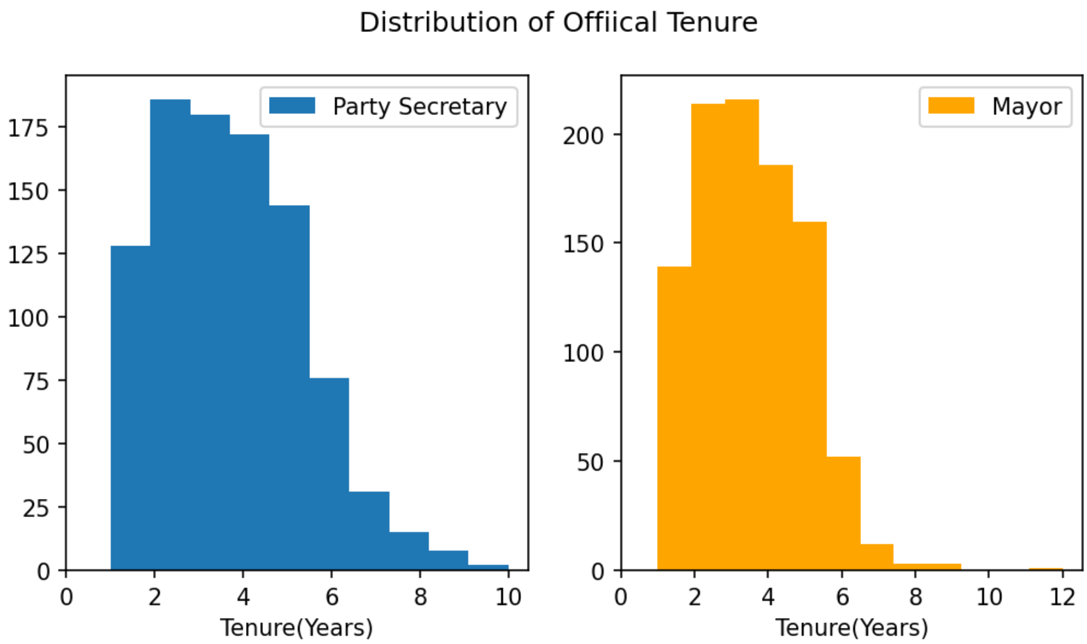
Cadre evaluation system and the motivation of officials in China

The cadre evaluation system for political advancement is an important institution affecting economic performance in China. Central government maintains a hierarchical system for appointing personnel, also known as political centralization (Blanchard and Shleifer, 2001). The performance of local officials is appraised by their leaders at one level higher under the multidivisional-form (M-form) of organizational structure (Qian and Xu, 1993; Maskin, Qian and Xu 2000). Local officials have been given the authority to manage resources within their own jurisdictions (Landry, 2008; Xu, 2011). They also take responsibility for performance in many areas, including economic performance, fiscal revenues, education, social security and environmental protection (Qian and Weingast, 1997; Zuo, 2015). In spite of the fact that political achievements are evaluated in relation to a number of criteria, economic performance plays a significant role in evaluating the performance of Chinese officials (Whiting, 2006; Li and Zhou, 2005; Jia et al., 2015).

With regard to political selection rules, the term-limit imposition is the most important institutional factor significantly impacting on the career prospects of local leaders. As stipulated by the General Office of the Central Committee (2006), local leaders serve a five-year term, and they are allowed to remain in the same post for a maximum of two terms. Normally, officials serve five years in post, followed by a major assessment of their competence for political advancement. Promotion may also follow when a senior position is made available for application, but applicants must meet a range of eligibilities, such as age and experience (Kou and Tsai, 2014). As indicated above, economic performance is a key determinant of whether prefectural officials can be promoted when their cases are reviewed by 'one-level-up' leaders. With increasing tenure, or length of service period, evaluators have a clearer picture of the competence of officials, and economic growth performance is less likely to be seen as the achievement of predecessors (Guo, 2009; Vortherms, 2019). Although local officials can be promoted at any time, the promotion rate increases with length of tenure, peaking at the end of the first term (or the first five years). If an official is not promoted during their first term, the chance of promotion declines substantially for the rest of their time in that position (Chen and Kung, 2016; Jia et al., 2015; Opper, Nee and Brehm, 2015). Figure 2.1 shows the distribution of tenure length (number of years in office) of party secretaries and mayors. It indicates that most local officials serve for less than five years, and term limits are strictly enforced.[2]

[2] The distribution of tenure length for prefectural leaders in my sample is similar to Yao and Zhang (2015). Ge Honglin is the only exception who served for over 10 years. From 2003 to 2014, he served as the mayor of Chengdu, the capital city of Sichuan province.

Figure 2.1 Distribution of tenures for party secretaries and mayors in Chinese cities



Note: The figure depicts the distribution of tenures of party secretaries and mayors in my sample.

The term limit motivates local officials to allocate resources strategically during their political cycle. For instance, previous studies have found that local officials tend to increase government spending to fuel economic growth when there are prospects of promotion (Guo, 2009; Tsai, 2016). Furthermore, Piotroski and Zhang (2014) found that initial public offering (IPO) approvals increase when political promotions are imminent. In the real-estate market, the land revenue obtained from sales of residential and commercial lands is positively correlated with the length of time in post of local leaders (Hsu et al., 2017), because land revenue is a source of extra-budget revenue to boost economic performance (Wu et al., 2013; Chen and Kung, 2016).

The age restriction for promotion also affects officials' motivation to demonstrate their competence. The purpose of age restrictions is to rejuvenate the cadre system by providing positions for younger politicians (Bo, 2005). The age of ineligibility for promotion is determined by the position ranking system (see Appendix A2.1). Specifically, the age limit for local leaders is 55 years in prefecture-level cities and 58 in sub-provincial cities (Kou and Tsai, 2014). Officials over the age limit are unlikely to gain promotion (Yu et al., 2016). Although some local officials have become prefectural leaders when very young (the youngest in my sample is 38 for mayors and 42 for party secretaries), the median age of officials in my sample is 54 for party secretaries and 51 for mayors (see Table 2.1). After finishing their terms of office, local officials reaching the age threshold are usually moved 'horizontally' to a second-line post in the People's Congress or People's Political Consultative Conference (Lawrence and Martin, 2013; Yu and Li, 2021). It is difficult for officials to find jobs outside the bureaucratic system once they are dismissed. This lock-in effect strengthens the motivation of local officials to seek political promotion within their term of office and before reaching the age limit (Zhou, 2007).

Industrial land conveyancing in China

Prefectural leaders are the highest level of local leaders not directly subject to central government control in China. They are given the pre-eminent autonomy to allocate resources and formulate policies for local development. Local governments tend to increase budgetary expenditure on infrastructure to boost economic performance and attract business investment (Munnell, 1992; Démurger, 2001; Wu et al., 2013). Before 1994, budget revenues relied strongly on local taxation income. However, the tax-sharing reform of 1994 undermined the tax autonomy of local governments.[3] It became difficult for local officials to boost economic performance, thus relying solely on budget revenues.

Local governments turned their eyes to land conveyancing. The land market did not exist before 1987, and Shenzhen was the first city to separate land use rights from land ownership rights. Even though land remains state-owned, local governments can sell land usage rights to private users in accordance with their urban development plans. Based on these usage rights, most land in China can be classified into residential land, commercial land or industrial land. Local officials adopt different land conveyancing strategies, normally selling residential and commercial land rights at a higher price for

[3] The tax reform assigned some major taxes, such as custom duties and consumption tax, from local government to central government. Value-added tax (VAT) and enterprise income tax were local taxes before the reform, but were shared between central government and local governments after it. Central government claims 75% of VAT revenues. For enterprise income tax, 50% was allocated to central government in 2002 and the proportion increased to 60% in 2003 (Tao et al., 2010).

land revenue purposes and industrial land at a lower price for development purposes (Tao et al., 2010; Lin et al., 2020).

Industrial land plays a significant role in economic development in China, and local governments have incentives to sell industrial land at extremely low prices. First, cheap industrial land attracts business investment and foreign capital (He et al., 2014), especially in cost-sensitive industries (Huang et al., 2015). Manufacturing activities directly contribute to GDP growth and generate tax revenue (Liu et al., 2008). Second, development in the manufacturing sector leads to an increase in labour wages and consumption power of the community with strong spillover effects on other economic sectors (Tao et al., 2010; Tsai et al., 2020) and increases local GDP and tax revenues. Rapid industrialization also contributes to urbanization, leading to an increase in residential and commercial land demand. Local governments can sell this land at high prices to obtain extra-budgetary revenues for urban development and infrastructure investment (Liu et al., 2008; Tao et al., 2010; Su and Tao, 2017; Wang and Hui, 2017).

With economic performance very often being the key criterion for evaluating the performance of local officials, they are prompted to engage in a race-to-the-bottom competition. The cheap conveyancing of industrial land has become a common strategy to attract investment, often in competition with neighbouring governments (Zhou et al., 2021; Wu et al., 2014). This distortion of the industrial land market, however, reduces the quality of foreign investment and degrades the quality of the environment. Previous studies have revealed that pollution-intensive firms are sensitive to the price of industrial land (Hu et al., 2022), and that they usually require an unrelenting supply of land subsequently (Lu et al., 2017). Therefore, low industrial land prices bring about an agglomeration of pollution-intensive industries and worsen environmental conditions (Cheng, 2016; Wang et al., 2020).

The 2013 reform of the cadre evaluation system and the "development of ecological civilization"

The "development of ecological civilization" was initiated as a national strategy and written into the party constitution as one component of the five major goals of the party at the 18th National Congress of China's Communist Party (CCP), held in December

2012.[4] In response to the "development of ecological civilization", fundamental changes have been made to the cadre evaluation system. A speech given by President Xi in June 2013 at the National Conference on Organisational Work discussed how to improve the Chinese official's evaluation system. A cadre must be evaluated in a comprehensive manner, and the cadre evaluation system should include more components, such as social development and ecological efficiency. "A hero cannot be defined solely on the basis of GDP growth," said Xi. It was the first time that the central government criticised economic growth as the sole criterion for assessing local officials.

A subsequent official document, Notice on Improving the Performance Evaluation of Local Party Leaders and Government Leaders, issued by the central government in December 2013, provided clear guidance on changes to the cadre evaluation system. A scientific official promotion and evaluation system was emphasised. Specifically, cadre evaluation should be based on economic, political, cultural, social and ecological factors. Regional GDP growth rates cannot be the only criterion used to assess political achievement. Environmental quality and sustainable economic development prove to be essential components of the evaluation system. In January 2014, an amendment to the Regulations on the Selection and Appointment of Party and Government Leaders stated that sustainable economic development and the development of ecological civilization should be included as important evaluation criteria. The document specifies that environmental protection and resource consumption would be emphasised in the

[4]As the most important political event in China, the National Congress of CCP has been held every five years since the death of Chairman Mao Zedong. Attendees at the congress vote on amendments to the constitution of the CCP and elect candidates to party leadership positions, including members of the Politburo Standing Committee. This Committee consists of the top leadership of the Chinese Communist Party. It includes five to 11 top executives in the history of the Chinese Communist Party. At the 18th National Congress of CCP, seven members, including Xi Jinping and Li Keqiang, were elected to the Politburo Standing Committee. Xi became the President and Li became the Premier at the subsequent 12th National People's Congress.

At the 18th National Congress of CCP, the development of ecological civilization was added to the general programme of the party constitution as “the Party must promote all-round economic, political, cultural, social development and ecological civilization in accordance with the overall arrangements for the cause of socialism with Chinese characteristics”. At the 13th National People's Congress in March 2018, some Amendments to the Constitution of the People's Republic of China were adopted, several paragraphs were amended and ecological civilization were added to the constitution. The Preamble to the Constitution, "to promote the coordinated development of material, political, and spiritual civilizations to turn China into a socialist country that is prosperous, powerful, democratic, and civilized", was amended to read: "to promote the coordinated development of material, political, spiritual, social, and ecological civilization to build China into a great modern socialist country that is prosperous, powerful, democratic, civilized, harmonious, and beautiful and achieve the grand rejuvenation of the Chinese nation". In Article 89 of the Constitution, "to direct and administer economic affairs and urban and rural development" was amended to read: "to direct and administer economic affairs, urban and rural development, and development of ecological civilization".

evaluation system. As a consequence, the inclusion of environmental quality in the cadre evaluation system undermines the significance of pure GDP growth. As a national strategy, the development of ecological civilization reinforces the need for local officials to strike an appropriate balance between economic and ecological development.

2.3 Hypotheses development

Public resource allocation is influenced variously by the cadre evaluation system according to the length of time in office of local leaders (Guo, 2009; Vortherms, 2019). With increasing time in post, the motivation of officials to strive for higher economic performance increases. Officials may not choose to aim for strong economic performance immediately on taking up their responsibilities in office, because their efforts may be unjustly credited to their predecessors (Jiang, 2018). Later, however, they seize all possible opportunities to achieve economic growth and increase their chances of promotion, including the conveyancing of industrial land at lower prices to attract business investment (Tao et al., 2010; Tian et al., 2019). Local officials serve a term of five years and then face a major review carried out by provincial leaders. The chances of promotion are small if they remain in the same position for over five years. It is to be expected, therefore, that the incentive to promote economic performance strengthens with the length of tenure in the first five years and weakens on finishing the first term (Guo, 2009; Vortherms, 2019). In this case, the prices of industrial land will reduce with the increase in officials' length of tenure and bounce back after officials finish their first term. Thus, a U-relationship exists between the length of tenure and industrial land prices.

This U-relationship, however, may disappear as a result of the reform of the cadre evaluation system in 2013. It is usually thought that industrialization has a detrimental effect on environmental quality (Antle and Heidebrink, 1995; Jorgensons and Clark, 2012; Cherniwchan, 2012), especially in developing countries with rising populations, as few set environmental standards and lack enforcement of environmental laws (Cropper and Griffiths, 1994; Panayotou, 1997; Stern, 2004). By integrating environmental protection with the cadre evaluation system, the incentive for local officials to pursue economic growth at the expense of environmental quality is weakened; furthermore, they might be penalized if industrial activities damage the environment. Thus, it is expected that local officials will refrain from conveying industrial land at lower prices as a result of the new cadre evaluation system. My first hypothesis, then, is as follows:

H1: There is a U-shaped relationship between the period of tenure of prefectural leaders and industrial land prices. However, this U-shaped relationship no longer exists once environmental quality is integrated into the cadre evaluation system.

Land cost is a major concern for the operation of pollution-intensive industries (Zheng and Kahn, 2013). Highly polluting firms tend to have low capital intensity and production efficiency levels, and their profitability is related to land costs. Lower land prices often attract investment from highly polluting industries (Hu et al., 2022; Wang et al., 2020), which in turn helps local governments achieve strong economic performance. On the other hand, other industries are less sensitive to industrial land prices, and local officials offer favourable conditions other than low land prices, such as easy access to markets, easy access to suppliers, lower production costs, large industrial agglomeration, more tax credits and subsidies and favourable loan rates (Amiti and Javorcik, 2008; Wu et al., 2019; Tian et al., 2020). A U-shaped relationship is more likely to occur in polluting industries than in other industries (Lu et al., 2017; Du and Li, 2021). After the reform of cadre evaluation, local officials balance economic performance and environmental quality and may choose not to use low land prices to attract firms in pollution-intensive industries. A sub-hypothesis of H1 is thus:

H1a: The U-shaped relationship between the period of service of prefectural leaders and industrial land prices is stronger in the case of polluting industries than other industries. After the reform, the U-shaped relationship between leaders' period of service and industrial land prices for polluting industries is mitigated.

I then examined variations in the relationship between the length of service of prefectural leaders within their tenure period and industrial land prices and the impact of the cadre evaluation reform on the relationship in two dimensions: the fierceness of the race-to-bottom competition among local officials and the effectiveness of the assessment of environmental quality by central government.

The political advancement of local officials in eastern regions of the country depends more on economic performance than in western regions (Pu and Fu, 2018). Local governments in the eastern regions compete fiercely to attract investments for economic growth and are more likely to distort industrial land prices (Huang and Du, 2017a; Huang and Du, 2017b).[5] Economic performance in eastern coastal regions is mainly driven by manufacturing industries and foreign investment. Foreign capital inflows and reliance on manufacturing industries motivate local governments to compete fiercely to attract investors. In contrast, there is much 'idle' land in central and western regions, where most land is used for agriculture and land is not a constraint on economic growth (Ding and Lichtenberg, 2011). The competition between local governments in the industrial land market is less fierce in the central and western regions. Taken together, it is predicted that a U-relationship between officials' length of service and industrial land prices will be more pronounced in the cities than in central and western regions. Local officials in eastern regions, therefore, are expected to become more aggressive in pursuing a race-to-the-bottom competition to attract manufacturing industry investment, and the U-shaped relationship is anticipated to be more pronounced for land conveyed to pollution-intensive firms.

Due to the environmental overload of the eastern coastal region, central government advocated that eastern cities shall optimise their industrial structure, improve energy efficiency, reduce resources consumption and protect environmental quality after the development of ecological civilization became a national strategy.[6] To reduce the regional disparities in economic development, local governments in central and western regions are to accommodate industries relocated from coastal regions. Overall, central government emphasised environmental protection in eastern areas and more economic development in central and western areas after 2013. Thus, it is expected that local officials, especially those in eastern regions, will refrain from conveying industrial land at lower prices after the reform of the cadre evaluation system. The reversal of the U-shaped relationship, therefore, is likely to be more pronounced in eastern regions,

[5]The regional disparities in local government competition can be explained by historical background and resource endowments. China has prioritized economic development in the eastern regions since the economic reform in 1979 (Yang, 1990; Tsui, 1996). Foreign companies can better access both suppliers and markets in coastal regions, and almost 90% of foreign direct investment goes there (Amiti and Javorcik, 2008).

[6] To better achieve the development of ecological civilization, the central government introduced the National New Urbanization Plan (2014–2020) in March 2014.

especially land conveyancing to pollution-intensive firms. My second hypothesis is thus as follows:

H2: The U-shaped relationship between the length of service of prefectural leaders and industrial land prices is more pronounced in eastern cities than in central and western cities. After the reform, the U-shaped relationship becomes less pronounced in eastern regions.

H2a: The U-shaped relationship between the length of service of prefectural leaders and industrial land prices is stronger among pollution-intensive firms in eastern cities and becomes less pronounced after the reform of the cadre evaluation system than in the case of other firms in eastern cities and firms in central and western cities.

Two environmental regulations were developed by central government to integrate environmental quality into the cadre evaluation system. The first step was the installation of automated systems to monitor air quality and better assess the environmental performance of local governments. Pollution levels are reported to central government in real-time and released to the public. Information on local environmental quality is made more transparent, and the environmental air quality performance of local governments can be measured precisely (Greenstone et al., 2022). As pollution cannot be concealed (Liu and Kong, 2021; Ghanem et al., 2020), local officials, in areas where such monitoring applies, have to take genuine action to improve air quality, including reducing the oversupply of industrial land, especially to heavy-pollution firms. Local officials are more likely to refrain from selling land at low prices when subject to automated monitoring. It is expected that reversal of the U-shaped relationship is more likely to occur in cities with monitoring systems. The U-shaped relationship should be more pronounced for land conveyed to pollution-intensive firms before introducing the monitoring system and exhibit greater mitigation, i.e. become less pronounced, after the system was launched in the cities.

The second step was environmental inspection. A number of inspection teams were sent directly by central government to prefectural cities to inspect local environmental enforcement. These teams had the power to investigate local officials and interview stakeholders. Additionally, hotline numbers and mailboxes were established to encourage local citizens to report any environmental problems to the inspectors.

Inspection reports provided important information for evaluating local environmental performance and determining the political advancement of local officials. Environmental inspections have been shown to improve air quality (Zheng and Na, 2020; Jia and Chen, 2019; Wang et al., 2021), reduce transboundary water pollution (Lu, 2022) and add to the volume of environmental legislation (Ding et al., 2021). It is expected that local officials under environmental inspection will refrain from conveying industrial land at lower prices, especially to attract pollution-intensive firms. My third hypothesis is thus as follows:

H3a: Local officials under pressure due to automated environmental monitoring are less inclined to use a cheap land price strategy than are local officials not so monitored. Therefore, the U-shaped relationship between industrial land prices and the length of service of local officials is substantially reversed once cities are monitored automatically.

H3b: The magnitude of the reversal of the relationship between the service length of prefectural leaders and industrial land prices is larger in the case of land conveyed to pollution-intensive industries than for other industries once cities are monitored automatically.

H3c: Local officials are less inclined to use a cheap land price strategy after environmental inspections. Therefore, the U-shaped relationship between industrial land prices and the length of service of local officials is substantially reversed.

H3d: The magnitude of the reversal of the relationship between the service length of prefectural leaders and industrial land prices is larger in the case of land conveyed to pollution-intensive industries than for other industries once environmental inspections are enforced.

The relationship between industrial land prices and economic growth is expected to attenuate after the reform. Previous studies have argued that low land prices lead to better economic performance in China (Tao et al., 2010). Local officials may abandon the low land price strategy because the reform incorporates environmental quality as an evaluation criterion for political promotion. Recent studies document that local governments may use alternative methods to boost economic growth without compromising environmental quality, such as the development of low-carbon industrial parks, the provision of subsidy schemes for renewable energy industries and participating in the carbon trading market (Zheng et al., 2019; Shen and Xie, 2018; Liu et al., 2015). Economic growth should be less reliant on manipulating land prices to attract investment, especially from pollution-intensive firms, given that the new cadre evaluation system emphasises sustainable development. In other words, the integration of environmental performance within the cadre evaluation system mitigates, or reduces, the incentive for local officials to pursue low-quality development and polluting activity driven economic growth through a low land price strategy. My final hypotheses are thus as follows:

H4: The negative relationship between industrial land prices and economic growth is mitigated after environmental quality assessment criteria are integrated into the cadre evaluation system.

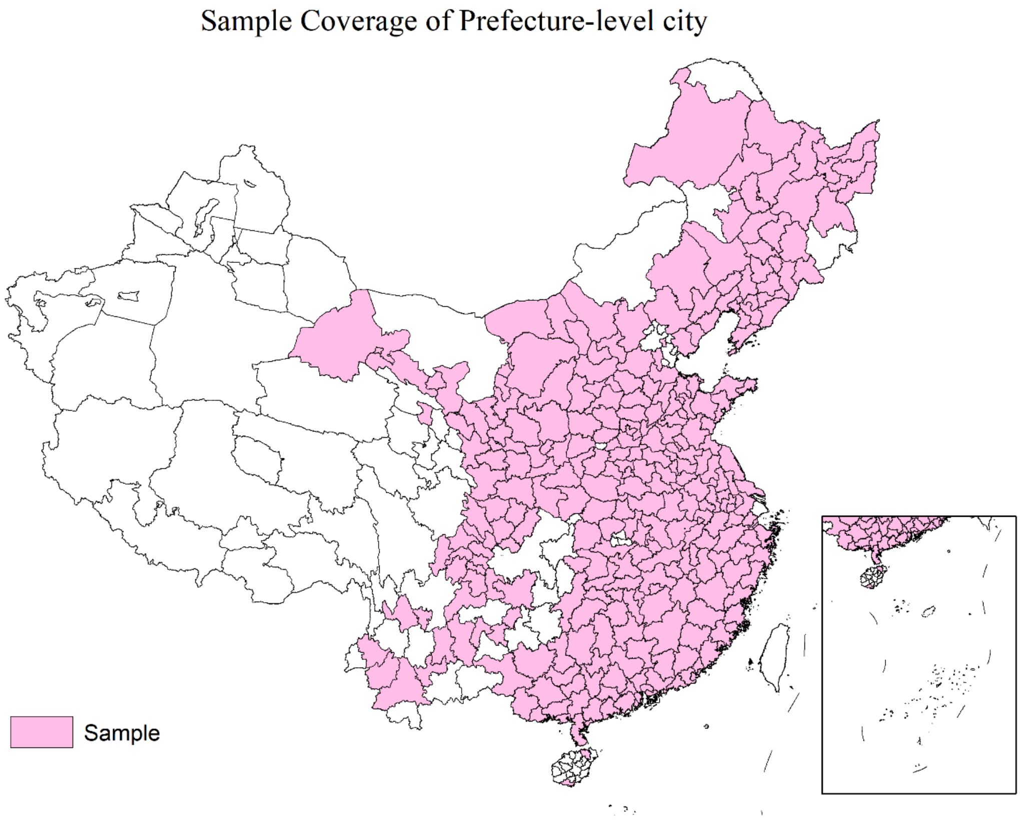
H4a: This negative relationship displays a greater degree of mitigation in the case of land conveyed to firms in pollution-intensive industries than for firms in other industries.

2.4 Sample, data and variables

I investigated the relationship between the length of service of local leaders within their tenure periods and industrial land prices. I constructed 2007–2018 data sets consisting of land transactions, information on local officials and prefecture-level city characteristics. I excluded all autonomous administrative division.[7] After eliminating observations with incomplete data, 279 prefectural cities were finally included in my sample (Figure 2.2). Table 2.1 provides summary statistics for the variables. Variable definitions are listed in Appendix A2.2.

[7] My sample excludes directly administered municipalities (Beijing, Tianjin, Shanghai and Chongqing), since they have the same rank as provinces in China's administrative divisions. My sample excludes Tibet and Xinjiang, two of the most remote ethnic autonomous regions in China (Yao and Zhang, 2015). Tibet is excluded because of its special sociopolitical conditions and lack of several important economic indicators (Jiang, 2018). The exclusion of Xinjiang is due to the fact that land there is not owned solely by local governments, but also by the Xinjiang Production and Construction Corps, which is a state-owned economic and paramilitary organization in China. Additionally, I exclude autonomous prefectures, leagues (meng) and districts (diqu), as their government structures differ from those of other prefectural cities and the political mission of local officials is not related to economic productivity (such as maintaining social stability and natural resources).

Figure 2.2. Prefecture cities in the sample



Note: The figure depicts the sample of prefectural cities included in this study.

Land parcel data

Land parcel transaction data were collected from the Land Transaction Monitoring System. The system was set up by the Ministry of National Land & Resources in 2003. The ministry requested local governments to provide detailed information on land transactions, including transaction price, parcel size, land type, location, buyer's industry and transaction date. However, such data reporting is voluntary, and data quality is, therefore, poor. Many local governments do not report detailed information on land transactions. In response, the ministry made reporting mandatory in 2007. Between 2007 and 2018, a total of 2 million land parcel transactions (2,077,765) were recorded in the database, of which 22% (466,894) consisted of industrial land. I only included transactions in prefectural cities and excluded those made in autonomous administrative areas. My sample consists of 257,142 industrial land transactions, after data cleaning.[8] Table 2.1 reports land price and parcel area statistics. The average land price in my sample is 169.52 yuan per square metre, and the average area of a parcel is 1.58 hectares, which is consistent with Tian et al. (2019) and Tian et al. (2020).

[8] Following Tian et al. (2020) and Yin et al. (2016), I define industrial land as land that is used for industry, warehousing or mining. I discard observations that contain missing or negative information on transaction price and parcel area. I then remove observations with a price of zero, which are usually conveyances by local government for public infrastructure. Using transaction price divided by area of the land, I determine the unit land price (yuan per square metre). I finally trim land prices at 0.1% and 99.9% to remove outliers.

Table 2.1. Summary statistics

	Obs.	Mean	Median	Std. Dev	Min	Max
Land parcel data						
Land price (Log)	254,494	5.133	5.159	0.754	-0.289	8.323
Land area (Log)	254,494	0.460	0.493	1.295	-7.339	6.714
Event						
Post	254,494	0.496	0	0.500	0	1
Monitor	254,494	0.399	0	0.490	0	1
Inspection	254,494	0.145	0	0.352	0	1
Local official information						
Party secretary tenure	249,807	2.827	2	1.799	1	10
Party secretary age	249,807	53.273	54	3.408	42	62
Party secretary female	249,807	0.041	0	0.198	0	1
Party secretary education	249,807	19.129	19	1.909	15	22
Mayor tenure	245,700	2.656	2	1.697	1	12
Mayor age	245,700	51.157	51	3.661	38	61
Mayor female	245,700	0.068	0	0.252	0	1
Mayor education	245,700	19.224	19	1.897	12	22
Prefectural city characteristics						
GDP (Log)	254,494	7.531	7.550	0.867	4.151	10.055
GDP growth index	254,494	111.407	111.600	3.251	86.000	132.900
Population (Log)	254,494	6.175	6.265	0.534	2.896	7.269
Rural population (Log)	254,494	5.644	5.783	1.135	-32.331	7.073
GDP per capita (Log)	254,494	10.500	10.567	0.832	5.396	12.579
City area (Log)	254,494	9.347	9.345	0.653	7.015	12.443
Population density (Log)	254,494	6.031	6.248	0.757	1.548	7.882
Wage (Log)	254,494	10.540	10.578	0.404	8.509	11.828
Firm number (Log)	254,494	7.342	7.358	0.997	2.944	9.527
Fix-asset investment (Log)	254,494	16.316	16.354	0.885	12.709	18.359
Real estate investment (Log)	254,494	14.395	14.416	1.162	8.586	17.330
Loan to deposit ratio	254,494	0.695	0.688	0.277	0.085	7.076
Share of GDP in secondary sector	254,494	0.502	0.505	0.075	0.144	0.856
Share of GDP in tertiary sector	254,494	0.390	0.383	0.075	0.112	0.871
Farmland area (Log)	254,494	5.624	5.694	0.780	1.099	7.688
Grain output to farmland area (Log)	254,494	-0.420	-0.429	0.582	-4.605	4.202
Grain output per capita (Log)	254,494	-0.956	-0.855	0.686	-4.605	1.576
Budgetary ratio	254,494	0.596	0.593	0.242	0.027	1.541
Budgetary revenue to GDP	254,494	0.074	0.071	0.024	0.005	0.362
Share of education expenditure	254,494	0.188	0.187	0.041	0.010	0.377

Notes: Land price and Land area are obtained from the Land Transaction Monitoring System. Local leaders characteristics (tenure, age, sex and education of party secretaries and mayors) are obtained from the China Political Elite Database and extended by manual collection. City characteristics (including GDP, GDP growth index, population, GDP per capita, city area, population density, wage, firm number, fix-asset investment, real estate investment, loan-to-deposit ratio, share of GDP in secondary sector, share of GDP in tertiary sector, farmland area, grain output to farmland area, grain output per capita, budgetary ratio, budgetary revenue to GDP, and share of education expenditure) are obtained from Statistical Yearbooks on Regional Economy, China City Statistical Yearbook and statistical yearbooks issued by local governments. The variable definition is listed in Appendix A2.2.

Local official information

I also collected data on local officials themselves from the China Political Elite Database (CPED), provided by Jiang (2018). This database contains biographical information on prefectural leaders (mayors and prefectural party secretaries) from 2000 to mid-2015. I extended the period to 2018 by gathering information from online sources.[9] I quantify tenure, age, highest education level (proxied by years of schooling) and sex. The key independent variable in my study is the length of service within the period of tenure of local leaders (mayors and prefectural party secretaries), which has commonly been used as a proxy for political motivation in previous studies (Guo, 2009; Vortherms, 2019; Tian et al., 2019). This indicates how many years a local leader has been in office. For example, Wang Rong became party secretary of Shenzhen, a prefectural city in Guangdong Province, in 2010. The tenure variable in Shenzhen would then be 1 for 2010, 2 for 2011, 3 for 2012 and so on, until he left the position in 2015. I calculated the square term of the tenure following the previous literature because the political motivation of officials is at its highest at the end of the first term (the fifth year in office) and decreases if officials do not win promotion.[10] I also calculated the square term of age to control for the impact of promotion-eligible age on officials. Table 2.1 reports the characteristics of local officials in my sample. The average length of service of party secretaries and mayors is 2.82 and 2.67 years, respectively. It is not surprising that the average age of party secretaries (53 years old) is higher than that of mayors (51 years old), since party secretary is considered to be a more senior position. Local leaders have been in education for an average of 19 years, which is equivalent to reaching a master's degree level.

Prefectural city characteristics

I collected data on the economic characteristics of prefectural cities from three sources: Statistical Yearbooks on Regional Economies, China City Statistical

[9] I primarily obtained biographical information about prefectural leaders from Baidu Baike (Chinese Wikipedia). I then verified these data in the Database of Local Officials, which is maintained by people.cn (official CCP media source). The Database of Local Officials only contains biographical information on current local officials. For other officials, I verified information using the Database of Local Leaders, which is maintained by ce.cn (another official CPP media source).

[10] Using Shenzhen as an example, the square term of the tenure variable would be 1 for 2010, 4 for 2011, 9 for 2012 and so on.

Yearbooks and statistical yearbooks issued by local governments. I also collected data on GDP, GDP growth index, population size, rural population size, GDP per capita, city area and population density to control for the basic characteristics of a prefectural city. In addition, I obtained information relating to the business environment, including labour wage levels, the number of firms above a designated size, fixed-asset investment, real estate investment, loan-to-deposit ratio and share of GDP in secondary and tertiary sectors, which may affect land prices.[11] I also considered factors relating to the cost of converting rural land to industrial use, such as farmland area, grain production per unit of farmland and grain production per capita. The fiscal condition of prefectural governments was measured using several indicators, including budgetary ratio (budgetary revenue divided by budgetary expenditure), budgetary revenue to GDP and share of education expenditure in the budget.

2.5 Empirical results

Relationship between land price and official tenure

H1 predicts that local officials will be motivated to convey industrial land at lower prices, as a strategy to boost economic performance. This strategy is more likely to be followed when officials are nearing the end of their first term and face a major review related to their political promotion. To test this hypothesis, I regress the length of tenure of prefectural party secretaries and mayors on industrial land prices. I took account of land parcel area, some information about officials themselves and city characteristics as control variables in my model. Furthermore, year fixed effects and city fixed effects were taken into account to control for the aggregate time-varying economic conditions and time-invariant characteristics of cities. The regression equation is as follows:

$$LandPrice_{i,c,t} = \alpha + \beta_1 \times Tenure_{c,t} + \beta_2 \times (Tenure_{c,t})^2 + \gamma_{i,c,t} + \eta_{c,t} + X_{c,t-1} + CityFE_c + YearFE_t + \epsilon_{i,c,t} \qquad (2.1)$$

[11] Previous studies have argued that industrial firms are sensitive to wage costs, especially pollution-intensive industries (Zheng and Kahn, 2013). It is expected that firm number and economic structure will affect industrial land prices (Tian et al., 2020). The term "firm above a designated size" refers to an enterprise with annual sales of at least 5 million yuan in China. This standard was increased to 20 million yuan or above from 2011 onwards.

where $LandPrice_{i,c,t}$ is my dependent variable, which denotes the land price (log) of parcel i conveyed by city c in year t. The key explanatory variable $Tenure_{c,t}$ is defined as the number of years that a party secretary or a mayor has been in post and $(Tenure_{c,t})^2$ is the squared tenure term. $\gamma_{i,c,t}$ is the land parcel area. $\eta_{c,t}$ is a vector of biographical information for officials including age, a squared term for age, years of schooling and a female dummy. $X_{c,t-1}$ is a vector for prefectural city characteristics in year *t-1*. $CityFE_c$ and $YearFE_t$ refer to prefectural-city fixed effects and year fixed effects, respectively. I tackled potential concerns relating to serial correlation and heteroskedasticity by clustering standard errors at the prefectural city level, following Bertrand et al. (2004).

Before the reform of the cadre evaluation system in 2013, coefficient β_1 is expected to be significantly negative, as local officials would tend to lower industrial land prices to attract business investment as this affected their chances of promotion. Coefficient β_2 should be positive, as the motivation to attract investment declines once the promotion competition is over. This indicates a U-shaped relationship between the time in post of local leaders and industrial land prices. The implementation of the new cadre evaluation system is thought likely to make both β_1 and β_2 insignificant, as local officials would no longer focus on a low industrial land price strategy as a primary method of attracting manufacturing activity and promoting economic growth.

Additionally, I applied a difference-in-differences (DID) model to explore the effects on political motivation of the reform of the cadre valuation system. Taking into account this policy effect, I develop the following equation:

$$\begin{aligned} LandPrice_{i,c,t} = {} & \alpha + \beta_1 \times Tenure_{c,t} + \beta_2 \times (Tenure_{c,t})^2 \\ & + \beta_3 \times Tenure_{c,t} \times Post_t + \beta_4 \times (Tenure_{c,t})^2 \times Post_t + \gamma_{i,c,t} \\ & + \eta_{c,t} + X_{c,t-1} + CityFE_c + YearFE_t + \epsilon_{i,c,t} \end{aligned} \tag{2.2}$$

where $Post_t$ indicates a dummy variable equal to one for land parcel transactions occurring after 2012. If the reform of the cadre evaluation system does affect the previous motivation of local officials to promote economic growth by sacrificing environmental quality, then the negative relationship between length of service by officials and industrial land prices should weaken after 2013. The interaction coefficients β_3 and β_4 should be positive and negative, respectively, indicating a lapse in the U-shaped relationship.

Table 2.2. Tenure of prefectural leaders and industrial land price

Panel A. Party secretary's tenure and industrial land price

	Full sample	Before reform	After reform	Full sample
	(1)	(2)	(3)	(4)
Tenure	-0.025	-0.047**	-0.003	-0.050**
	(-1.61)	(-2.02)	(-0.34)	(-2.08)
Tenure^2	0.003*	0.006**	-0.000	0.006**
	(1.65)	(2.10)	(-0.05)	(2.22)
Tenure*Post				0.061**
				(2.21)
Tenure^2*Post				-0.007**
				(-2.08)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	249,807	128,166	121,641	249,807
Adjusted R2	0.508	0.469	0.602	0.508

Panel B. Mayor's tenure and industrial land price

	Full sample	Before reform	After reform	Full sample
	(1)	(2)	(3)	(4)
Tenure	-0.049***	-0.082***	-0.002	-0.081***
	(-3.78)	(-3.35)	(-0.31)	(-3.43)
Tenure^2	0.006***	0.010***	0.001	0.010***
	(4.44)	(3.25)	(1.20)	(4.00)
Tenure*Post				0.062**
				(2.42)
Tenure^2*Post				-0.007***
				(-2.67)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	245,700	128,166	117,534	245,700
Adjusted R2	0.513	0.471	0.606	0.513

Notes: The dependent variable is the natural log of the land transaction price. The main independent variables are the tenure and the square term of tenure for party secretaries (Panel A) and mayors (Panel B) and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Columns (1) and (4) give the estimations based on the full sample, column (2) is based on the subsample before the 2013 reform of the cadre evaluation system, and column (3) is based on the subsample in and after 2013. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Table 2.2 columns (1) to (3) report the results of equation (2.1). Panel A column (1) reports the regression results of party secretary length of tenure and industrial land prices between 2007 and 2018. The result shows that the coefficient of time in post is negative, and the coefficient of the squared term is positive. A U-shaped relationship is shown between the tenure of prefectural party secretaries and industrial land prices, although the coefficients are not significant. Column (2) reports the results before the reform of the cadre evaluation system. The coefficients of length of the tenure and its squared term are significant at a 5% level. When party secretaries approach the end of their first term (from year one to year five), industrial land prices reduce by 4.3%.[12] This result is in line with my expectation that local government officials would depress the price of industrial land to help secure their political promotion.

Following the reform of 2013, column (3) shows that the U-shaped relationship between the length of tenure and land prices no longer exists. The coefficients involved are close to zero. Consistent with *H1*, local officials did not adopt a cheap land conveyancing strategy following the reform. I further conducted DID analysis in relation to equation (2.2), and the result is shown in column (4). The coefficient for the tenure of party secretaries is significantly negative, and that for the interaction term between tenure and the dummy for cadre evaluation reform is significantly positive. The reform resulted in a 13.9% increase in industrial land prices when party secretaries came to face major performance reviews at the end of their first term[13]. This indicates that the reform of the cadre evaluation system has eliminated the motivation of prefectural party secretaries to participate in a race-to-the-bottom competition.

Panel B shows the analysis for mayors. Column (1) demonstrates a U-shaped relationship between tenure and land prices. The coefficients for tenure are significant at a 1% level. Columns (2) and (3) report the results before and after the reform, respectively. Before the reform, the coefficient for mayor tenure was significantly negative. Industrial land prices had decreased by 8.4% when mayors faced major

[12] The coefficient for tenure is -0.047; and the coefficient for the square term of tenure is 0.006. The decrease in land prices from the first year to the fifth of party secretaries' tenure can be calculated as: $\exp((-0.047*5 + 0.006*25) - (-0.047*1 + 0.006*1)) - 1 = 4.3\%$.

[13] The coefficient for the interaction term between tenure and policy effect is 0.061, and that for the interaction term between the square term of tenure and policy effect is -0.007. The increase in land prices in the fifth year of party secretaries' tenure resulting in a policy effect is estimated as: $\exp(0.061*5 - 0.007*25) - 1 = 13.9\%$.

reviews in the fifth year of their term compared to prices when they came into post at the start of their tenure. After the reform, column (3) shows that the association between length of tenure and land prices has disappeared, and the coefficient for tenure is close to zero. The DID analysis in column (4) indicates that the 2013 reform had caused a significant increase in industrial land prices, by 14.4% in the fifth year of 2018. In view of the results in Panels A and B, my findings strongly suggest that the cadre evaluation system has greatly influenced the economic strategies employed by local officials. The inclusion of environmental quality in the new assessment system for officials has reduced the motivation of local officials to control industrial land prices as a means tto attract manufacturing investment. My results support *H1*.

In Appendix A2.3, I pooled the length of tenure of both party secretaries and mayors in my model. The results indicate that the tenure of mayors has a greater effect on the reduction in industrial land prices than that of party secretaries. This is not surprising because mayors are usually responsible for economic performance and party secretaries are responsible for executing orders from central government (Yao and Zhang, 2015). After the 2013 reform, no negative relationship exists between time in post and land prices for both party secretaries and mayors.

With respect to coefficients of the controlling variables (not tabulated), I revealed that parcel size is negatively related to land prices, and industrial land prices are lower in cities where economic performance is highly dependent on the industrial sector. This is consistent with previous studies (Tian et al., 2020). I also found that those cities embracing larger rural populations had lower industrial land prices. Rural populations are more prevalent in poorer regions, so local governments tend to reduce land prices to accelerate urban development and create jobs for rural residents (Wu et al., 2014). Furthermore, my results show a positive relationship between industrial land prices and budgetary ratio. This finding is consistent with Huang and Du (2017b), i.e. that local governments with fiscal deficits are likely to transfer more land at lower prices to attract industrial firms and expand their tax base.

The results in Table 2.2 show that industrial land prices vary with the tenure of local officials. I further investigated industrial land prices in each year of officials' time in post before and after the 2013 reform of the cadre evaluation system. I revise the fixed effects model in equation (2.1) and regress industrial land prices on the dummy of officials' tenure before and after the reform, and the results are presented in Figure 2.3. Panel A shows the results for party secretaries. Before the reform, there was a U-shaped relationship between time in post and industrial land prices. Industrial land prices fall by 8.6% and reach their lowest point when party secretaries reach the end of their first term, the fifth year of their tenure.[14] Industrial land prices then rebound to a high level after party secretaries have completed their first term. This U-shaped pattern is consistent with my argument that local politicians reduce industrial land prices to bet on fostering economic development when faced with the major reviews and potential political promotion. After that critical moment for political advancement, land prices revert to their previous higher level. This rebound alleviates the concern that price reductions of industrial land might be a function of experience in deploying regional resources. The figure also shows that after incorporating environmental protection performance in the cadre evaluation system, the U-shaped relationship is no longer present. Panel B reports similar results for mayors. Before the reform, a U-shaped relationship was found to exist between mayors' time in post and land prices, with land prices falling by 15.5% to their lowest in the fifth year of the term of office. However, a flat line was found to exist in the years following the reform. Overall, Figure 2.3 clearly documents a U-shaped relationship between tenure and industrial land prices before the reform and shows that this pattern disappears after the reform.

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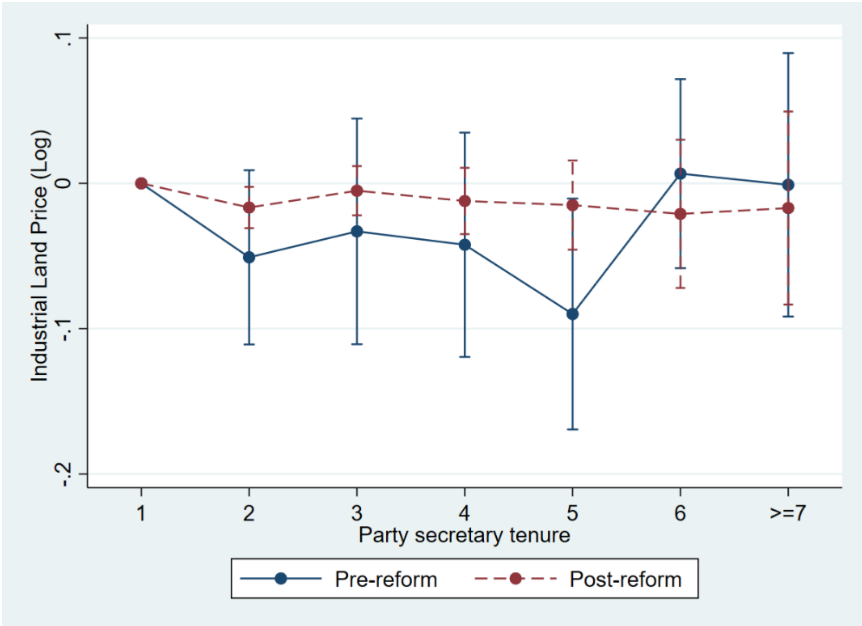
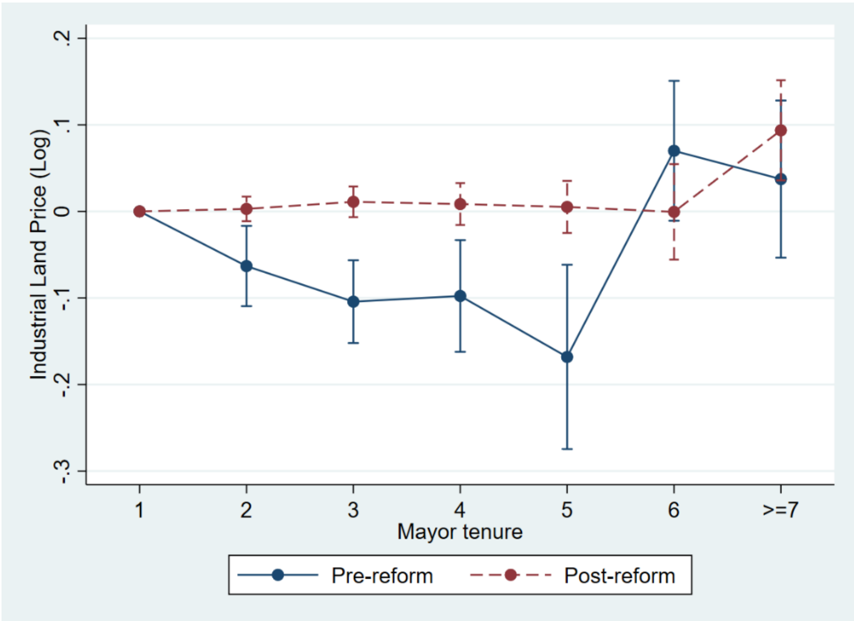
[14] Calculated by the untabulated coefficient of -0.09 in the model: exp(-0.09) – 1 = 8.6%.

Figure 2.3. Tenure and industrial land price

Panel A. Party secretary's tenure and industrial land price



Panel B. Mayor's tenure and industrial land price



Note: The figures depict the relationships between the tenure of local officials (Panel A for party secretaries and Panel B for mayors) and the industrial land prices and their 90% confidence intervals. The relationship is obtained by OLS regression of the natural log of industrial land prices on the dummy of officials' tenure before and after the reform. The solid lines represent relationships before and in 2012, and dashed lines represent relationships after 2012. The regressions include land area, career variables and economic variables, city fixed effect and year fixed effects. Standard errors are clustered at the city level.

Alternative explanations and endogeneity concerns

Endogeneity issues One endogeneity concern is that some omitted variables, other than promotion incentives, might drive the relationship between the length of time in post and industrial land prices. For instance, length of tenure might reflect officials' experience rather than their motivation. Generally, a newly appointed official needs time to become familiar with the local bureaucratic system and is cautious in offering industrial land soon after their appointment. When local officials have gained sufficient experience and choose to increase the land supply, the prices of industrial land drop and remain unchanged for the remainder of their term. This may also result in a negative coefficient for tenure and a positive coefficient for its square in equation (2.1).

I leveraged the political institution of promotion-eligible age to address the endogeneity concern. Local officials above the age thresholds (over 55 for leaders in prefecture-level cities and 58 for leaders in sub-provincial cities) are ineligible for further promotion. They will either retire or be transferred to relatively unimportant positions after completing their current term. They will probably make relatively little effort to boost economic performance in their regions. On the other hand, young officials below the cut-off age are likely to seize any opportunity for promotion, including price manipulation in the industrial land market. If it is indeed the promotion incentive that determines industrial land prices, the U-shaped relationship should be most pronounced when local officials are eligible for promotion but may not be at all evident with respect to officials above promotion-eligible age. I divided my sample into two groups based on the cut-off age to evaluate the above arguments. The results are reported in Appendix A2.4. Columns (1) and (2) give the results for those within the promotion-eligible age group. Those officials are more likely to reduce industrial land prices and respond to the reform of the cadre evaluation system. The U-shaped relationship between industrial land prices and officials' length of time in post is significant at the 5% level before 2013. However, their motivation significantly reduces after the 2013 reform of the cadre evaluation system. Columns (3) and (4) indicate, however, that local officials above the promotion-eligible age are unlikely to reduce the price of industrial land. The coefficients for officials' tenure are insignificant. My results confirm that the U-shaped relationship between industrial land prices and tenure is due to the promotion incentives of local officials. The willingness of local officials to engage in a race-to-the-bottom competition does not exist if officials are ineligible for further promotion.

Political motivation or land revenues An alternative explanation for my baseline results could be that local officials are concerned about land revenues and intentionally depress industrial land prices to increase land conveyancing. Industrial land prices in a parcel may be lower; however, the overall revenue from industrial land conveyancing may increase. If local officials have the motivation to increase land revenues at the end of the first term due to some reasons such as a budget deficit, it is possible that industrial land prices could vary with tenure. To tackle this concern, I explored the relationship between the tenure of local officials and industrial land revenues, as well as the total area of industrial land conveyancing. In Appendix A2.5, columns (1) and (2) demonstrate that the tenure of local leaders is not associated with the conveyancing area of industrial land. It indicates that a reduction in industrial land prices does not result in an increase in land area across the officials' tenure. Column (3) shows that industrial land revenues do not change significantly across the tenure of party secretaries. Column (4) shows that land revenues exhibit a marginally significant U-shape relation with the tenure of mayors before the reform, and the U-shape relationship is mitigated after the reform. This result rejects the concern that local officials aim to increase land revenues for better promotion prospects across their tenure.

I also compared residential and commercial land. As discussed before, the conveyancing of residential and commercial land constitutes a source of extra-budgetary revenue, and local officials have the incentive to convey residential and commercial land at high prices to maximise land revenues (Tao et al., 2010; Wang and Hui, 2017). Therefore, residential and commercial land prices may not be related to local officials' tenure. Furthermore, land used for residential and commercial purposes does not adversely affect the environment: commercial and residential properties do not emit as much pollution as industrial sites. The inclusion of environmental quality in the cadre evaluation system should not change the motivation of local officials to convey residential and commercial land. Empirical evidence is shown in Appendix A2.6. The coefficients for the tenure of local officials and its square term are statistically insignificant for both party secretaries and mayors. In addition, I did not observe a change in the motivation of local officials in the conveyancing of residential and commercial land after 2012. An analysis of the graphical evidence in Appendix A2.7 finds that no significant correlation exists between the tenure of local officials and the price of residential and commercial land. The above results suggest that the U-shaped relationship between tenure and land prices and the reversal after 2012 apply uniquely to industrial land.

Robustness tests

In Appendix A2.8, I give the results of robustness checks conducted to evaluate whether my results hold true if alternative sample selections, covariates and models are applied. Panels A and B present the results for party secretaries and mayors, respectively. In China, corruption is very prevalent in the land market (Cai et al., 2017; Deng, 2017; Fang et al., 2022). Previous studies indicate that local officials reduce residential and commercial property prices to favour political leaders for better career prospects (Chen and Kung, 2019). In response to growing concerns about corruption, central government launched a series of anti-corruption inspections after May 2013. Chen and Kung (2019) found that the anti-corruption inspections could effectively curtail the price discounting of residential and commercial land conveyed to "princeling firms", i.e. firms controlled by the family members of political leaders. To mitigate the impact of anti-corruption inspections on my study, I excluded transactions that occurred under inspections (see Appendix A2.9). Appendix A2.8 column (1) shows that my results remain significant.[15] I also examined the effect of anti-corruption inspections via a difference-in-differences model. In untabulated results, inspections do not significantly affect local officials' intentions to lower land prices across their tenure. The results indicate that the industrial land market is much less prone to corruption, so anti-corruption inspections do not affect local officials' intention to reduce industrial land prices when they confront promotion evaluations. My results echo that industrial land is already sold at low prices compared with residential and commercial land; therefore, the resale of industrial land is less likely to result in immediate personal gains (Fang et al., 2022; Chen and Kung, 2019). To conclude, my findings rule out the possibility that anti-corruption initiatives deter local officials from reducing land prices.

[15] It is worth noting that central government (19th Central Committee) launched a second wave of inspections in Qinghai, Gansu, Hubei, Guangxi, Tibet, Chongqing, Shannxi, Xinjiang, Inner Mongolia, Jilin, Anhui, Jiangxi and Yunnan from October 2018 to November 2018. However, the theme of this wave was poverty alleviation rather than anti-corruption. Therefore, it is not incorporated into my regression. In untabulated results, I consider this wave, and the results remain robust.

Compared with private companies, state-owned enterprises (SOEs) in China are likely to have greater financial resources (Cull and Xu, 2003; Li et al., 2008; Shen et al., 2016), and more access to private information (Allen, Qian and Qian, 2005). Recent studies show that SOEs have information advantages and acquire land in favourable locations before official announcements of development projects are made (Wu et al., 2012; Wang and Yang, 2021). To reduce the concern that local officials may cooperate with large SOEs and sell them parcels of land at the beginning of their periods in office at higher prices, I removed those transactions applying to SOEs. The remaining results are presented in column (2),[16] My results remain robust, indicating that variations in industrial prices are not driven by transactions with SOEs. Real estate developers commonly speculate in the primary land market in China (Chen et al., 2016). They may purchase land parcels at lower prices, hoard them for price appreciation and earn lucrative profits in the future (Zhang et al., 2015). Some real estate developers speculate not only in residential and commercial markets, but also in the industrial land market. They may lobby local governments to convert industrial land to residential use, thereby making huge profits (Zhu, 2012). In column (3), I excluded land bought by real estate developers. The results remain significant at the same levels, which means that my results are not affected by the speculation of real estate firms. Local officials in sub-provincial cities have greater authority over resource allocations, so there was a concern that my results might only be robust in sub-provincial cities. Column (4) excludes sub-provincial city transactions but, again, the results of my study continue to hold up.

In 2007, central government dictated that land conveyancing must be done through public auctions, including tenders, English auctions and two-stage auctions. Previous studies found that industrial land conveyancing procedural characteristics could significantly affect land prices (Wang and Yang, 2021). I included the dummy variable of auction type in column (5). The results are robust despite a slight decline in coefficient magnitude. In December 2006, central government implemented minimum price standards for industrial land. Minimum prices are set for each of 15 land grades and range between 60 and 840 yuan per square metre. Following Tian et al. (2020), I used administration code and land parcel location to identify grades of industrial land

[16] I obtained information about land buyers from the National Enterprise Credit Information Publicity System (NECIPS). About 1.23% of industrial land transactions in my sample are related to SOEs.

in my sample. Column (6) shows the results after taking land grade into account in the model. My results remain significant. In column (7), I changed my dependent variable to a dummy variable equal to one if the transaction price of a land parcel is below the minimum land price.[17] My logistic regression indicates that local officials are more likely to convey industrial land below the minimum price when they face major assessment reviews relating to political promotion. The reform of the cadre evaluation system has deterred local officials from breaking the floor price. These results again support hypothesis *H1*.

Pollution-intensive industries and local official motivation

Pollution-intensive firms are more sensitive to the cost of land (Zheng and Kahn, 2013). To win promotion competitions, local officials may engage in race-to-the-bottom competitions and convey industrial land at lower prices to attract investment from pollution-intensive firms. To test this hypothesis, I divided my sample into pollution-intensive industries and other industries, and conducted a DID analysis on each subsample. Following Yin et al. (2016) and Hu et al. (2022), I defined pollution-intensive industries according to the First National Pollution Source Census Scheme in 2007.[18] Prior to the reform of the cadre evaluation system, it was expected that a low industrial land price strategy would be more effective among pollution-intensive industries as pollution-intensive firms are more sensitive to industrial land prices. After environmental quality performance was included as an evaluation criterion in the 2013 reform, officials might have been deterred from using low land prices to attract polluting firms.

[17] There are 17.2% of transactions that have land prices below the minimum price, which is similar to the statistics in Tian et al. (2020).

[18] The scheme lists 11 heavily polluting industries, including (1) Papermaking and paper product industry, (2) Manufacturing of agricultural and non-staple foodstuffs, (3) Chemical feedstocks and chemical manufacturing industry, (4) Textile industry, (5) Ferrous metal smelting and extrusion, (6) Foodstuffs manufacturing industry, (7) Production and supply of electric power and heat power, (8) Manufacturing industry of leather, fur, feather (cloth with soft nap) and related products, (9) Petroleum processing, coking and nuclear fuel manufacture, (10) Non-metallic minerals product industry and (11) Non-ferrous smelting and extrusion.

Table 2.3. Tenure of prefectural leaders and industrial land price in pollution-intensive industries and other industries

	Pollution-intensive industries		Other industries	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.091***	-0.126***	-0.012	-0.022*
	(-2.60)	(-3.71)	(-1.07)	(-1.67)
Tenure^2	0.010**	0.014***	0.002	0.004**
	(2.50)	(3.39)	(1.63)	(2.31)
Tenure*Post	0.141***	0.119***	0.009	0.002
	(3.38)	(3.07)	(0.54)	(0.11)
Tenure^2*Post	-0.016***	-0.013***	-0.003	-0.001
	(-2.77)	(-2.81)	(-1.20)	(-0.81)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	80,357	79,255	169,450	166,445
Adjusted R2	0.505	0.506	0.560	0.563

Notes: The dependent variable is the natural log of the land transaction price. Columns (1) and (2) are based on the subsample of lands conveyed to pollution-intensive industries, and columns (3) and (4) are based on the subsample of other industries. The main independent variables are the tenure and the square term of tenure for party secretaries (columns 1 and 3) and mayors (columns 2 and 4) and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Table 2.3 columns (1) and (2) report the results for pollution-intensive industries. Column (1) shows that the tenure of party secretaries is negatively correlated with the price of industrial land conveyed to pollution-intensive firms. The coefficient of time in post is -0.091 and for the squared term it is 0.010. This implies that party secretaries reduce industrial land prices by 11.7% at the end of their first term. The positive coefficient for the interaction term indicates that the reform of the cadre evaluation system has altered the motivation of local officials. The coefficient of the interaction term between policy effect and tenure is 0.141, which is significant at a 1% level. The reform has led to a surge in land prices of 35.7% by the fifth year in office. The results indicate that party secretaries do not intend to reduce the price of industrial land to attract investments from pollution-intensive firms since environmental protection has become a key criterion affecting their promotion criteria. Column 2 shows a similar analysis in the case of mayors. Industrial land prices had dropped by 15.5% when mayors were in the fifth year of their tenure. The 2013 reform, however, led to an increase in land prices of 31.0% at the end of the mayors' five-year tenure. Comparing the coefficients in columns (1) and (2) shows that mayors are more motivated to participate in a race-to-the-bottom competition than party secretaries. On the other hand, the reaction of party secretaries to the reform was more pronounced. They are more motivated to raise the price of industrial land conveyed to pollution-intensive firms. Previous studies have revealed that the promotion incentive of local officials is negatively associated with environmental protection policies (Yu, Yang and Li, 2019; Jiang and Li, 2021). My research suggests that environmental pollution may be exacerbated by the cheap conveyancing of industrial land since investment from pollution-intensive companies is attracted.

Columns (3) and (4) show the results for other, non-polluting industries. The coefficient for time in post is negative, and the coefficient for the interaction term is positive. Both, however, are generally insignificant. The magnitude of the coefficients is much smaller than those relating to pollution-intensive firms. The results suggest that the cheap conveyancing of land is more effective in attracting investment from pollution-intensive industries than from other industries. Local officials are more motivated to engage in a race-to-the-bottom competition, which boosts economic performance, but at the expense of environmental quality, to further their political careers. The incorporation of environmental quality into the cadre evaluation system corrects these behaviour characteristics. To conclude, my findings support *H1a*.

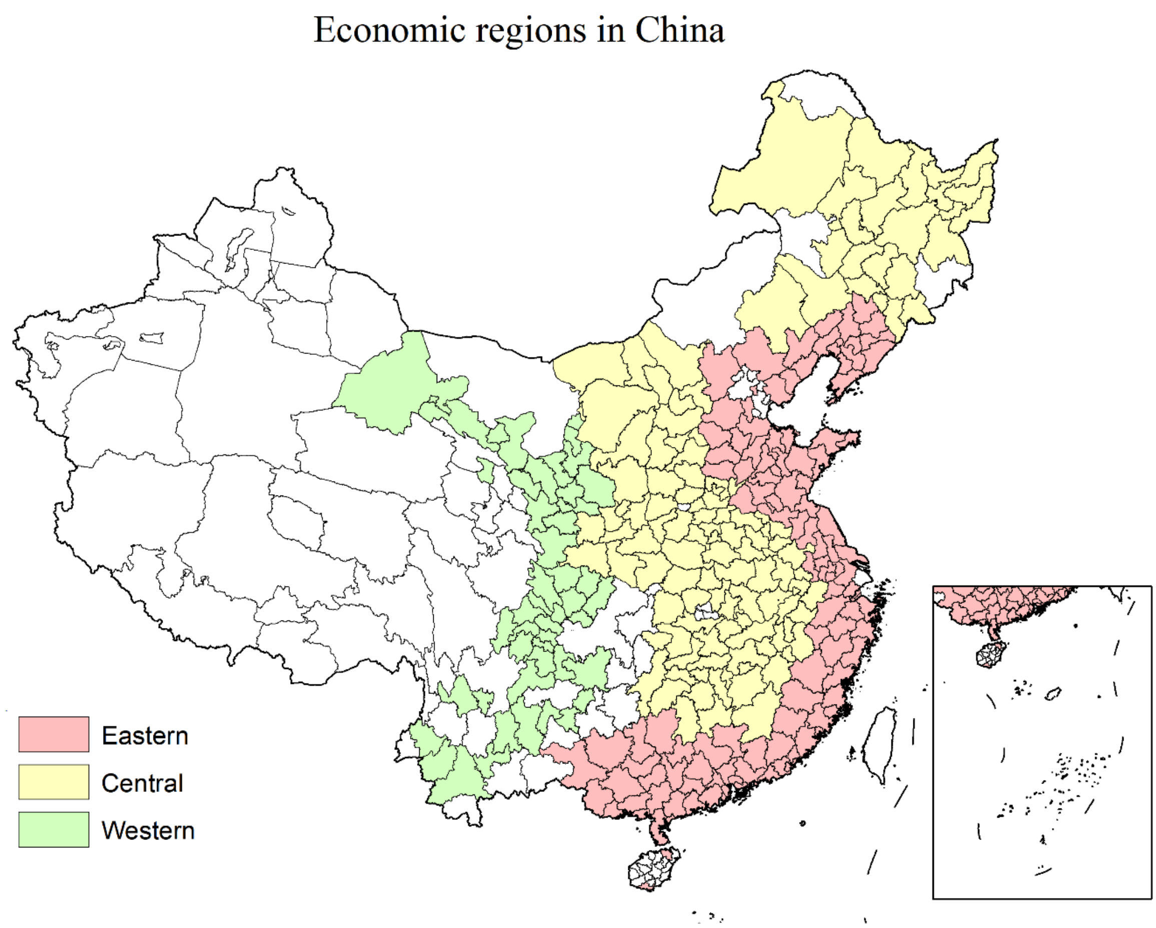
Regional disparities and local official motivation

Regional disparities in economic performance in China have been widely discussed in the literature (e.g. Kanbur and Zhang, 2005, Fleisher et al., 2010). Although central government has implemented a series of regional economic support policies for western regions since 1999, economic development of the eastern regions still outpaces that of the western and central ones.[19] When the economic performance of incumbent leaders was compared with that of their predecessors (Chen et al., 2005), the rapid economic growth in eastern regions prompted incumbent leaders to compete fiercely in the land market (Yu et al., 2019). I hypothesize, therefore, that the U-shaped relationship between the length of time in post of local officials and industrial land prices is more pronounced in the eastern regions. To evaluate this hypothesis, I define the eastern, central and western regions in accordance with the 7th Five Year Plan in 1986 (see Figure 2.4).[20]

[19] The Great Western Development Strategy was adopted in 1999. The strategy supports western regions to develop infrastructure and attract foreign investment. The central regions are supported by the Rise of Central China Plan, which mainly focuses on upgrading the agricultural, energy and manufacturing industries. However, regional disparities in economic development remain. In my sample, the per capita GDP in the eastern regions increased from 174,500 yuan to 379,570 yuan from 2007–2018, while in the central and western regions it rose from 91,681 to 241,539 yuan.

[20] According to the 7th Five Year Plan, eastern regions include Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan. Central regions include Heilongjiang, Jilin, Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Shaanxi and Inner Mongolia. Western regions include Xinjiang, Tibet, Qinghai, Yunnan, Guizhou, Ningxia and Gansu.

Figure 2.4. Economic regions in China



Note: The figure shows cities in the economic regions according to 7th Five Year Plan in 1986 in China.

My sample was separated into two groups, eastern and non-eastern regions, and I conducted analyses for each subsample. Table 2.4 Panel A reports the results. Columns (1) and (2) show that officials in eastern regions are more likely to convey industrial land at lower prices when they face major reviews relating to their political promotion. Industrial land prices reduce by 11.3% for party secretaries and 13.1% for mayors in the fifth year of their tenure. My results show that the 2013 reform of the evaluation system reduced local officials' motivation to convey industrial land at lower prices, since land prices increased by 19.7% for party secretaries and 19.1% for mayors in the fifth year of their tenure. Columns (3) and (4) show that the comparable results for central and western regions are insignificant. My findings support *H2*. Huang and Du (2017a) found that local governments compete more fiercely in the conveyancing of industrial land in the eastern regions. My results again support the proposition that this competition is driven by the motivation of local officials to gain political promotion.

Table 2.4. Regional disparity in political motivation, tenure of prefecture leaders and industrial land price

Panel A. Regional disparity in political motivation

	Eastern regions		Central and western regions	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.072**	-0.119***	0.013	-0.002
	(-2.37)	(-3.47)	(0.54)	(-0.15)
Tenure^2	0.007**	0.014***	0.000	0.002
	(2.27)	(3.59)	(0.10)	(1.20)
Tenure*Post	0.086**	0.130***	-0.010	-0.002
	(2.24)	(3.12)	(-0.31)	(-0.09)
Tenure^2*Post	-0.010**	-0.019***	-0.000	-0.001
	(-2.24)	(-3.38)	(-0.04)	(-0.54)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	148,877	146,339	100,930	99,361
Adjusted R2	0.497	0.508	0.451	0.444

Panel B. Pollution-intensive industries and regional disparity in political motivation

	Pollution-intensive industries			
	Eastern regions		Central and western regions	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.111**	-0.199***	-0.002	0.008
	(-2.59)	(-4.99)	(-0.06)	(0.35)
Tenure^2	0.011**	0.023***	0.002	0.000
	(2.29)	(4.82)	(0.42)	(0.01)
Tenure*Post	0.176***	0.218***	0.034	0.006
	(2.99)	(4.41)	(0.91)	(0.19)
Tenure^2*Post	-0.021***	-0.031***	-0.004	0.000
	(-2.81)	(-4.61)	(-0.71)	(0.09)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	47,057	46,337	33,300	32,918
Adjusted R2	0.540	0.548	0.439	0.429

Panel C. Other industries and regional disparity in political motivation

	Other industries			
	Eastern regions		Central and western regions	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.020	-0.022	-0.010	-0.023
	(-1.44)	(-1.40)	(-0.51)	(-1.39)
Tenure^2	0.003	0.004*	0.003	0.005**
	(1.54)	(1.85)	(1.40)	(2.19)
Tenure*Post	0.014	0.018	0.006	0.010
	(0.75)	(0.67)	(0.25)	(0.60)
Tenure^2*Post	-0.003	-0.005	-0.003	-0.003
	(-1.19)	(-1.23)	(-1.07)	(-1.49)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	101820	100002	67630	66443
Adjusted R2	0.509	0.513	0.490	0.487

Notes: The dependent variable is the natural log of the land transaction price. Columns (1) and (2) are estimated based on the land conveyed in the eastern regions, and columns (3) and (4) are based on transactions in the central and western regions (see Figure 4). The main independent variables are the tenure and the square term of tenure for party secretaries (columns 1 and 3) and mayors (columns 2 and 4) and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Panel A is estimated based on the full sample, Panel B is based on the subsample of lands conveyed to pollution-intensive industries, and Panel C is based on the subsample of other industries. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

I further divided my subsamples into pollution-intensive industries and other industries. Panel B shows the results for pollution-intensive industries. Columns (1) and (2) show that officials in eastern regions convey industrial land to pollution-intensive firms at lower prices when they face major reviews affecting their political promotion. Land prices reduce by 16.5% for party secretaries and 21.7 % for mayors in the fifth year of their tenure. The 2013 reform of the cadre evaluation system, however, resulted in an increase of 42.6% for party secretaries and 37.0% for mayors. Columns (3) and (4) present the motivation levels of officials regarding conveying land for pollution-intensive firms in central and western regions. The results are insignificant, showing that there is no such specific motivation. Panel C shows estimated results for other industries. Although a U-shaped relationship is seen just before the reform of the cadre evaluation system, the results are not significant. My findings support *H2a*, i.e. that officials in eastern regions are more likely to engage in a race-to-the-bottom competition.

Enforcement of regulations and local officials' motivation

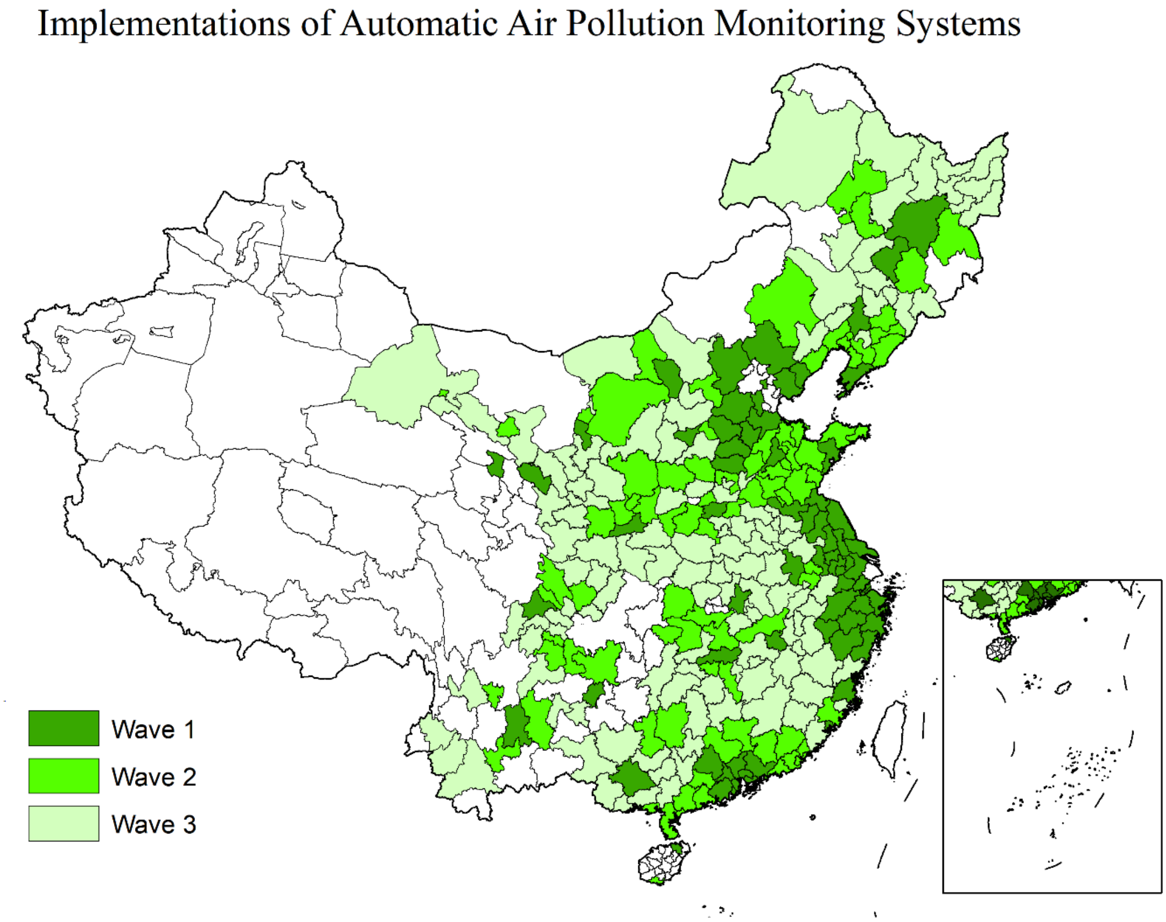
The new cadre evaluation system emphasises environmental quality. Local governments, however, may mislead central government by manipulating their self-reported pollution data. In the early 2000s, the Chinese government initiated an opaque air pollution indicator called the Air Quality Index (AQI), based on measured concentrations of pollutants such as SO_2, PM10, and NO_2. Local governments are responsible for reporting AQI readings to central government. An air quality index (AQI) below 100 represents a blue-sky day. A city is eligible for a "national environmental protection model city" award if at least 80 per cent of its days are blue-sky days throughout the year.[21] Local governments, therefore, are incentivised to misreport AQI values in order to win an award. A previous study demonstrated that distributions of AQI values near 100 are unsmoothed, which implies that AQI is suspected of data manipulation (Chen et al., 2012). According to Ghanem and Zhang (2014), roughly half of Chinese cities report questionable AQI, and those local

[21] The award was set up in 2003. The threshold was raised to 85% of blue-sky days from 2007.

government officials eligible for its promotion are more likely to manipulate air quality data (Liu and Kong, 2021).

Central government implemented an automated air quality monitoring system to obtain accurate pollution data in regional areas. This system was deployed in three waves in different prefectural cities. The first wave covered 74 cities in 2013, which must report readings of pollutants to central government in real-time. The second wave consisted of 116 cities required to join the system in 2014. The last wave, in 2015, includes the remaining 177 cities. (See cities in three waves in Figure 2.5). The new system measures six pollution indicators: SO_2, PM10, NO_2, PM2.5, O_3 and CO, and real-time readings of pollutants and AQI are automatically sent to central government. This monitoring system reduces information asymmetry between central government and local governments regarding environmental quality and avoids the manipulation of environmental quality information (Ghanem et al., 2020; Greenstone et al., 2022). Having accurate information about air quality allows central government to take appropriate action, including punishing and rewarding local officials, as required.

Figure 2.5. The waves of implementation of Automatic Air Pollution Monitoring Systems



Note: The figure shows cities that the automated air pollution monitoring systems were implemented in each wave.

Local officials in cities within the automated monitoring system catchment area may be under pressure to improve the quality of their environment. They may be less inclined, therefore, to sell industrial land at reduced prices to attract pollution-intensive investments. In order to examine the effectiveness of the monitoring system in this context, I conducted a generalised difference-in-differences analysis to account for the staggered implementation of the system across different cities. My model is specified as:

$$\begin{aligned} LandPrice_{i,c,t} = {} & \alpha + \beta_1 \times Tenure_{c,t} + \beta_2 \times (Tenure_{c,t})^2 \\ & + \beta_3 \times Tenure_{c,t} \times Monitor_{c,t} + \beta_4 \times (Tenure_{c,t})^2 \times Monitor_{c,t} \\ & + \beta_5 \times Monitor_{c,t} + \gamma_{i,c,t} + \eta_{c,t} + X_{c,t-1} + CityFE_c + YearFE_t \\ & + \epsilon_{i,c,t} \end{aligned} \tag{2.3}$$

where $Monitor_{c,t}$ is a dummy variable equal to 1 if a city is included in the automated monitoring system. If the monitoring system demotivates local officials to convey industrial land at lower prices, it is expected that the coefficient of the interaction term, β_3, will be positive.

Table 2.5. Implementation of automated monitoring system, tenure of prefectural leaders and industrial land price

Panel A. Full sample

	Party secretary	Mayor
	(1)	(2)
Tenure	-0.038*	-0.072***
	(-1.80)	(-3.48)
Tenure^2	0.004*	0.009***
	(1.93)	(4.08)
Tenure*Monitor	0.039	0.051**
	(1.51)	(2.23)
Tenure^2*Monitor	-0.005	-0.006**
	(-1.37)	(-2.54)
Monitor	-0.047	-0.056
	(-1.18)	(-1.37)
Land area	Y	Y
Career variables	Y	Y
Economic variables	Y	Y
Year fixed effect	Y	Y
City fixed effect	Y	Y
Observations	249,807	245,700
Adjusted R2	0.508	0.513

Panel B. Pollution-intensive industries and other industries

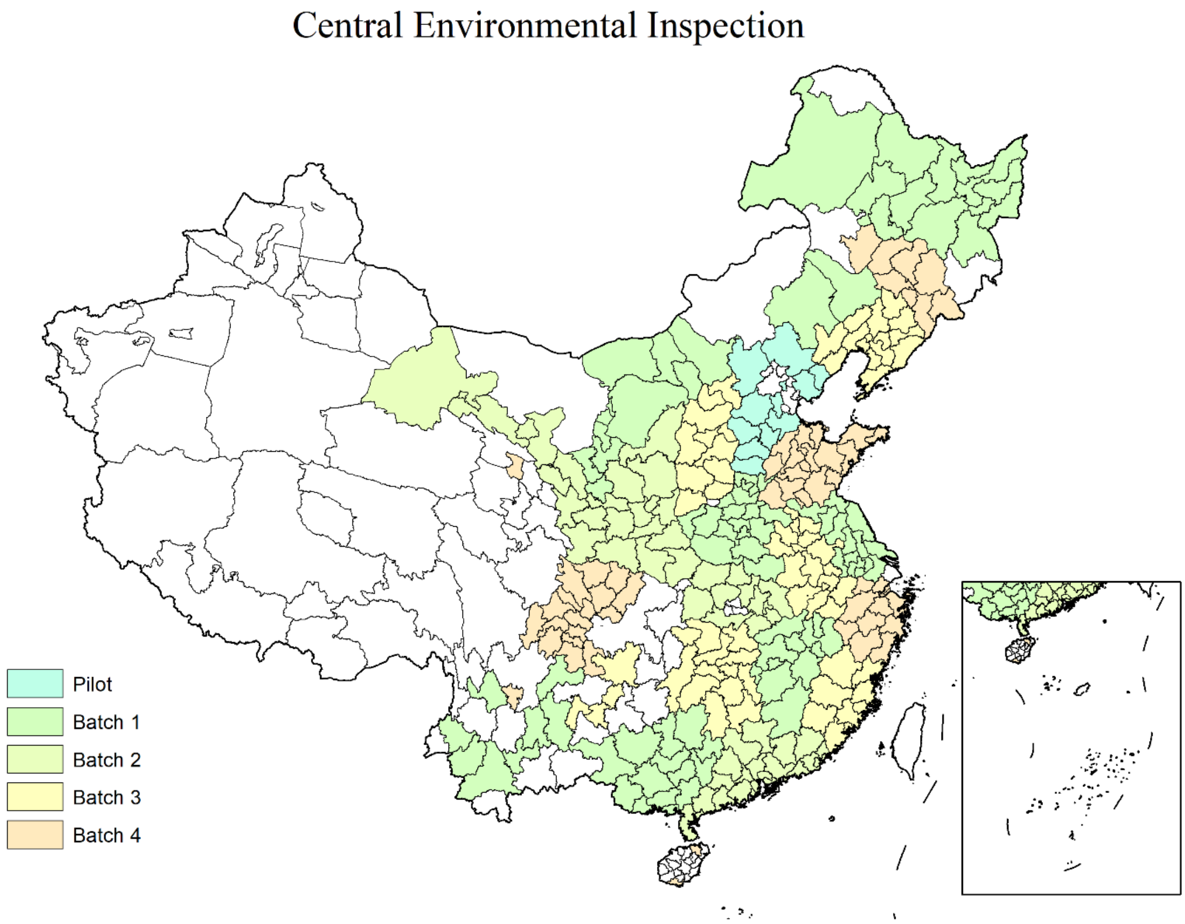
	Pollution-intensive industries		Other industries	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.070**	-0.112***	-0.010	-0.020
	(-2.22)	(-3.63)	(-1.06)	(-1.63)
Tenure^2	0.008**	0.012***	0.002	0.004**
	(2.14)	(3.31)	(1.63)	(2.23)
Tenure*Monitor	0.105**	0.104***	0.006	-0.005
	(2.53)	(2.91)	(0.33)	(-0.38)
Tenure^2*Monitor	-0.012*	-0.012***	-0.002	-0.001
	(-1.95)	(-2.72)	(-1.05)	(-0.33)
Monitor	-0.094	-0.087	-0.025	-0.008
	(-1.53)	(-1.49)	(-1.01)	(-0.36)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	80,357	79,255	169,450	166,445
Adjusted R2	0.504	0.506	0.561	0.563

Notes: The dependent variable is the natural log of the land transaction price. The main independent variables are the tenure and the square term of tenure for party secretaries or mayors and their interaction term with Monitor, which is a dummy variable equal to one if the land parcel is conveyed in the city joined the automated monitoring system. Panel A is estimated based on the full sample, Panel B columns (1) and (2) are based on the subsample of lands conveyed to pollution-intensive industries, and Panel B columns (3) and (4) are based on the subsample of other industries. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Table 2.5 illustrates the results of equation (2.3). Panel A gives the results for the entire sample, while columns (1) and (2) describe the analyses for party secretaries and mayors, respectively. The coefficients for tenure suggest that local officials had a strong incentive to transfer land at reduced prices before they came under the umbrella of the automated monitoring system. The magnitude of the coefficient of tenure for mayors is much higher than that for party secretaries. Land prices drop by 5.4% for party secretaries and 6.9% for mayors when they confront major reviews in the fifth year of their tenure. The motivation of local officials experiences a dramatic reduction, however, when strict monitoring of environmental quality applies. The pressure applied by automatic monitoring results in an increase in land prices of 7.3% for party secretaries and 11.1% for mayors at the end of their first term. The results support *H3a*, i.e. that local officials under pressure from direct monitoring are less inclined to use a cheap land price strategy to attract investment.

I split my sample into pollution-intensive and other industries. Panel B reports the results of these subsamples. My findings suggest that local officials were more likely to offer low land prices to attract pollution-intensive firms than other industries before implementing the monitoring system. The price of land conveyed to heavy-polluting firms was reduced by 8.4% for party secretaries and 14.8% for mayors in the fifth year of their tenure. Upon implementation of monitoring, however, it is observed that the motivation towards low land prices experiences a significant reversal in the case of land parcels conveyed to polluting companies. The price of industrial land increased by 25.2% for party secretaries and 24.6% for mayors in the fifth year of tenure. However, land prices did not vary significantly with officials' tenure in the case of non-polluting industries. The results support *H3b*, i.e. that local officials under pressure because of direct monitoring should carefully consider their career paths before transferring land parcels to industries that cause pollution. This implies the implementation of automated monitoring systems underpinning better enforcement of the new cadre evaluation system.

Figure 2.6. Central Environmental Inspection in China



Note: The figure shows cities that were inspected in the different batches of environmental inspection launched by the central government in China. The details for the start of each batch are listed in Appendix A2.10.

Additional environmental enforcement led by central government was environmental inspections. Central government sent environmental inspection teams to investigate potential environmental violations throughout the nation. According to the Measures for the Accountability of Party and Government Leaders for Damage to the Ecological Environment (Trail) issued by central government in 2015, local officials under investigation due to local environmental deterioration were not allowed to be promoted within two years. These inspections exerted considerable pressure on local governments to enforce environmental regulations and refrain from environmental pollution policies. There were five batches of environmental inspections. A pilot batch was conducted in January 2016 in Hebei, and the rest were gradually introduced to all provinces in subsequent years (see Figure 2.6). Additionally, central government indicated that environmental inspections would become routine.[22] It is expected that prefectural officials will be more disciplined even after inspections are complete. Like the previous analysis, a generalised difference-in-differences analysis is conducted to account for environmental inspections across different provinces. My model is specified as:

$$
\begin{aligned}
LandPrice_{i,c,t} = \alpha &+ \beta_1 \times Tenure_{c,t} + \beta_2 \times (Tenure_{c,t})\hat{}2 \\
&+ \beta_3 \times Tenure_{c,t} \times Inspection_{c,t} \\
&+ \beta_4 \times (Tenure_{c,t})\hat{}2 \times Inspection_{c,t} + \beta_5 \times Inspection_{c,t} + \gamma_{i,c,t} \\
&+ \eta_{c,t} + X_{c,t-1} + CityFE_c + YearFE_t + \epsilon_{i,c,t}
\end{aligned}
\tag{2.4}
$$

where $Inspection_{c,t}$ is a dummy variable equal to 1 if the province of city c is undergoing or has had an environmental inspection. It is expected that the coefficient of the interaction term β_3 will be positive, as an inspection will demotivate local officials to convey industrial land at lower prices.

[22] The second wave of environmental inspections started in May 2018, and ten provinces were included in this wave.

Table 2.6. Environmental inspections, tenure of prefectural leaders and industrial land price

Panel A. Full sample

	Party secretary	Mayor
	(1)	(2)
Tenure	-0.031*	-0.054***
	(-1.88)	(-3.70)
Tenure^2	0.004*	0.006***
	(1.95)	(4.36)
Tenure*Inspection	0.052**	0.076**
	(2.08)	(2.29)
Tenure^2* Inspection	-0.006*	-0.011**
	(-1.79)	(-2.21)
Inspection	0.013	-0.026
	(0.33)	(-0.55)
Land area	Y	Y
Career variables	Y	Y
Economic variables	Y	Y
Year fixed effect	Y	Y
City fixed effect	Y	Y
Observations	249,807	245,700
Adjusted R2	0.508	0.513

Panel B. Pollution-intensive industries and other industries

	Pollution-intensive industries		Other industries	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.052*	-0.081***	-0.012	-0.021***
	(-1.96)	(-3.49)	(-1.36)	(-2.90)
Tenure^2	0.006*	0.009***	0.002	0.004***
	(1.85)	(3.00)	(1.55)	(3.80)
Tenure* Inspection	0.125***	0.101**	0.006	0.037
	(2.90)	(2.28)	(0.30)	(1.31)
Tenure^2* Inspection	-0.014**	-0.013**	-0.002	-0.007
	(-2.46)	(-2.09)	(-0.62)	(-1.52)
Inspection	-0.078	-0.066	0.063**	0.024
	(-1.15)	(-0.93)	(2.00)	(0.64)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	80,357	79,255	169,450	166,445
Adjusted R2	0.504	0.506	0.560	0.563

Notes: The dependent variable is the natural log of the land transaction price. The main independent variables are the tenure and the square term of tenure for party secretaries or mayors and their interaction term with Inspection, which is a dummy variable equal to one if the land parcel is conveyed after the environmental inspections in corresponding provinces. Panel A is estimated based on the full sample, Panel B columns (1) and (2) are based on the subsample of lands conveyed to pollution-intensive industries, and Panel B columns (3) and (4) are based on the subsample of other industries. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Table 2.6 illustrates the results of equation (2.4). The significant and positive coefficients for tenure in Panel A suggest that local officials are motivated to lower industrial land prices before environmental inspections. Land prices drop by 2.8% for party secretaries and 6.9% for mayors when they confront major reviews in the fifth year of their tenure. However, their motivation to lower prices reduces after an environmental inspection begins. An inspection results in an increase in land prices of 11.6% for party secretaries and 11.1% for mayors in the fifth year of their tenure. The results support *H3c*, i.e. that local officials are less likely to reduce land prices to attract investment after environmental inspections have been conducted.

Panel B reports the results for the subsample of land conveyed to pollution-intensive industries and other industries. The U-shaped relationship between tenure and land prices is more pronounced for land conveyed to heavily polluting firms before an environmental inspection. An inspection significantly increases the price of land conveyed to polluting firms by 31.6% for party secretaries and 19.7% for mayors in the fifth year of their tenure. On the other hand, inspections do not significantly affect officials' motivation to reduce land prices for non-polluting industries. The results support *H3d*, i.e. that local officials refrain from reducing land prices to attract pollution-intensive firms once environmental inspections are launched in their provinces. It implies that environmental inspections are an effective means to enforce environmental protection and the new cadre evaluation system.

Industrial land prices and economic growth

The results in the section above show that local officials were motivated to convey industrial land at lower prices before the 2013 new cadre evaluation system was implemented. In this section, I explore the consequences of that low land-price strategy on regional economic performance. Although previous studies (e.g. Tao et al., 2010) suggest that low land prices can attract foreign investment and boost economic performance, no empirical studies have directly examined this argument due to the previous limitations on available data.[23] To assess how industrial land prices affect the

[23] Previous studies mainly used data source from the National Statistical Yearbook of Land Resources to examine the relationship between land conveyancing and economic performance. However, the yearbook does not include industrial land revenues and conveyance areas at the prefectural level.

economic performance of prefectural cities, I utilized a fixed effects model, as follows:

$$EconGrowth_{c,t+1} = \alpha + \beta_1 \times LandPrice_{c,t} + \gamma_{c,t} + X_{c,t-1} + CityFE_c + YearFE_t + \epsilon_{c,t} \tag{2.5}$$

where $EconGrowth_{c,t+1}$ is the future economic growth rate of city c in year *t+1*. $LandPrice_{c,t}$ represents industrial land prices at the prefectural city level and $\gamma_{c,t}$ is the area of land conveyed.[24] If a lower industrial land price strategy can stimulate economic growth, the coefficient of land prices β_1 is expected to be negative.

As above, the 2013 reform of the cadre evaluation system by central government put emphasis not only on economic growth but also on environmental protection in the selection of political leaders. Local governments might consider alternative strategies to maintain economic performance without compromising environmental quality. They are considered likely to abandon cheap industrial land price strategies and race-to-the-bottom competition. It is expected that the negative relationship between industrial land prices and economic growth will be disentangled, especially in the case of pollution-intensive firms, which cause more harm to environmental quality.

I investigated the impact of the reform of the cadre evaluation system on the consequences of a low industrial land price strategy for economic performance. The model is specified as follows:

$$EconGrowth_{c,t+1} = \alpha + \beta_1 \times LandPrice_{c,t} + \beta_2 \times LandPrice_{c,t} \times Post_t + \gamma_{c,t} + X_{c,t-1} + CityFE_c + YearFE_t + \epsilon_{c,t} \tag{2.6}$$

Therefore, they use land area and number of land parcels (including residential, commercial and industrial land) to evaluate the impact of land conveyancing on regional economic performance. For instance, Liu et al. (2008) found that the area of land leased is positively associated with budgetary revenue and economic performance. Tao et al. (2010) show that tax revenues increase with the number of land sites leased. Moreover, recent studies have revealed that local governments can increase the area of industrial land conveyed to boost fixed asset investment and economic growth (Lu et al., 2017).

[24] Industrial land prices at the prefectural city level are calculated from total industrial land revenue divided by total industrial land area conveyed for city *c* in year *t*. I removed observations if there were no transactions during a given year.

If a low industrial land price strategy is deemed invalid after the reform of the cadre evaluation system, the coefficient of the interaction term β_2 is expected to be positive.

Table 2.7 presents the relationship between industrial land prices and economic performance at the prefectural level. Column (1) shows the result for the model in equation (2.5). It shows a negative relationship between economic growth rate and industrial land prices. The coefficient for land prices is -0.472, which indicates that a one-standard-deviation increase in industrial land prices results in a 0.054% drop in economic growth, or approximately 55.7 million yuan for a prefectural city.[25] The result is significant at a 1% level. Column (2) presents the results for equation (2.6), which includes an interaction term for industrial land prices and a dummy for cadre evaluation reform. The coefficient for land prices remains negative at -0.646. The coefficient for the interaction term is 0.526, which is significantly positive. Because of the reform, GDP increased by 0.060% for a one-standard-deviation increase in land prices. These results indicate that implementation of the reform mitigated the negative association between land prices and economic growth rate.

[25] The percentage of GDP reduction is calculated by multiplying the coefficient for land prices by the logarithm of one plus the ratio of standard deviation of land prices, divided by the average of land prices: -0.472*ln(1+0.608/5.039) = -0.054%. The amount of reduction is approximated by the average GDP of the prefectural city: -0.054%*exp(6.938)*100 = 55.7 million yuan. Summary statistics at the city level are shown in Appendix A2.11.

Table 2.7. Industrial land price and economic growth in cities

	GDP growth	GDP growth	GDP growth	GDP growth	GDP growth
	(1)	(2)	(3)	(4)	(5)
Land Price	-0.472***	-0.646***			
	(-2.70)	(-3.33)			
Land Price*Post		0.526**			
		(2.41)			
Land Price (Pollution)			-0.205	-0.406***	-0.344**
			(-1.64)	(-2.87)	(-2.28)
Land Price (Pollution)*Post				0.669***	0.753***
				(3.16)	(2.67)
Land Price (Others)					-0.641**
					(-2.22)
Land Price (Others)*Post					0.045
					(0.14)
Land area	Y	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y	Y
Observations	3,203	3,203	3,084	3,084	3,030
Adjusted R2	0.680	0.680	0.688	0.690	0.693

Notes: Observations are at the city level. The dependent variable is the GDP growth index (t+1). The main independent variables are the average industrial land price (t) and its interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Columns (1) and (2) include the industrial land price in the full sample, columns (3)-(5) include the industrial land price for lands conveyed to pollution-intensive industries and column (5) adds the industrial land price for lands conveyed to other industries. Control variables include land area and economic variables. Land area is the natural log of land parcel area. Economic variables include the city characteristics (such as the natural log of GDP and population) shown in Appendix A11. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Overall, my analyses have shown that low land prices can boost economic growth, so local officials adopted a strategy of cheap land conveyancing to further their careers, indirectly promoting political advancement. The reform of the cadre evaluation system, however, served to mitigate the negative association between industrial land prices and economic performance. This finding is consistent with *H4*.

My previous findings show that local officials are more motivated to reduce industrial land prices and attract pollution-intensive firms. Columns (3) and (4) investigate the relationship between the price of land conveyed to these firms and regional economic performance. In column (3), the industrial land prices of pollution-intensive firms are also negatively associated with economic growth. The coefficient is negative, -0.205. Column (4) incorporates an interaction term for the reform. The coefficient for the land price variable is significantly negative, and the coefficient for the interaction term variable is significantly positive. Prior to the 2013 reform, the coefficient for the price of land conveyed to pollution-intensive firms was -0.406, which implies that a one-standard-deviation decrease in the price of land conveyed to heavy-polluting industries increased GDP by 0.047%.[26] This result supports that a race-to-the-bottom strategy for land conveyancing to pollution-intensive firms can boost economic growth. The positive coefficient of 0.669 for the interaction term implies that the reform of the cadre evaluation system reduces GDP by 0.078% for a one-standard-deviation increase in land prices. This result meets my prediction as firms with high pollution levels are more sensitive to land prices. The reform of the cadre evaluation system discouraged local officials from lowering land prices to attract investment from heavily polluting industries. Since the reform, the negative relationship between land price and economic growth has been completely disentangled.

In column (5), I consider land prices for other industries in my model. Before the reform, the stimulation of local economic growth through low industrial land prices applied to both pollution-intensive and other industries. However, the reform only changed the relationship between economic performance and the price of land sold to pollution-intensive firms; the impact on other industries was negligible. The strategy of

[26] The percentage of GDP reduction is calculated by the coefficient of price of land conveyed to pollution-intensive industries times the logarithm of one plus the ratio of standard deviation of land price over the average of land price: -0.406*ln(1+0.618/5.012) = -0.047%.

race-to-the-bottom was effective only prior to the implementation of the new cadre evaluation system. After the reform, economic growth became less dependent on the conveyancing of industrial land at lower prices to attract investment from pollution-intensive firms. However, the cheap conveyancing of industrial land to other industries can still boost economic performance. My results support *H4a*.

2.6 Conclusion and discussion

My study has strong implications for environmental protection in authoritarian countries such as China with a centralized personnel appointment system. The functioning characteristics of political institutions have a substantial impact on environmental quality. Previous studies by other researchers have indicated that democratic countries tend to achieve and maintain higher levels of environmental quality, while authoritarian countries tend to pollute more (Congleton, 1992; Fredriksson et al., 2005; Farzin and Bond, 2006; Bernauer and Koubi, 2009). In democratic countries, governments may strengthen environmental regulation in response to citizens' demands and political pressure from other non-governing parties (Potoski, 2001). In authoritarian countries, central government usually designs and formulates environmental policies, and local governments are responsible for enforcing them. Local governments are the bodies that ultimately allocate resources through local officials who are motivated to promote economic performance. My research investigated how bureaucratic institutions affect the career ambitions of local officials and in turn the quality of the environment by exploring the impact of a new cadre evaluation system on the conveyancing of industrial land in China.

The cadre evaluation system in China emphasises economic performance, and local officials eventually engage in a race-to-the-bottom land price competition to win competitions between officials vying for promotion. Industrial land is often conveyed at lower prices to attract investment, especially from pollution-intensive firms in spite of likely environmental degradation. In response to the escalation of environmental pollution, central government amended the cadre evaluation system in 2013 and also included "ecological civilization" as a national goal. Since then, the incentive for local officials to reduce industrial land prices has diminished, especially in cities where local officials compete fiercely for political advancement and central government puts more emphasis on environmental enforcement. I found that controlling industrial land prices to attract investments from heavily polluting companies is no longer a viable strategy to pursue with the overall aim of promoting economic growth.

China has experienced nearly double-digit economic growth since the 1980s, partially due to an economic growth model centred on a political tournament. Land policy also plays an important role in the economic performance of China (Lin and Ho, 2005). The new cadre evaluation system in 2013 caused economic growth to become less dependent on the manipulation of industrial land prices by local officials. This research presents a possible channel for the slowdown in the economic performance of China, from the perspective of local officials' motivation, over the last decade. However, my study does not lead to the conclusion that economic performance no longer plays an important role in political promotion. Central government encourages the transformation and upgrading of manufacturing industries so as to maintain economic performance as well as environmental quality. Specifically, the 18th CPC National Congress advocated transforming traditional industries into high-quality industries (Wei, 2020). Central government has launched "Made in China 2025", a programme intended to transform the country's manufacturing industries from labour-intensive workshops to technology-intensive powerhouses. Recent studies have also documented and evaluated the industrial upgrade policies launched by local governments (Li et al., 2020). Future studies will no doubt examine the effectiveness of alternative methods for improving economic performance and environmental quality as determined by the reform of the cadre evaluation system.

References

Allen, F., Qian, J., & Qian, M. (2005). Law, finance, and economic growth in China. *Journal of Financial Economics*, *77*(1), 57-116.

Amiti, M., & Javorcik, B. S. (2008). Trade costs and location of foreign firms in China. *Journal of Development Economics*, *85*(1-2), 129-149.

Antle, J. M., & Heidebrink, G. (1995). Environment and development: theory and international evidence. *Economic Development and Cultural Change*, *43*(3), 603-625.

Bernauer, T., & Koubi, V. (2009). Effects of political institutions on air quality. *Ecological Economics*, *68*(5), 1355-1365.

Bertrand, M., Duflo, E., & Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics*, *119*(1), 249-275.

Blanchard, O., & Shleifer, A. (2001). Federalism with and without political centralization: China versus Russia. *IMF staff papers*, *48*(1), 171-179.

Block, S. A. (2002). Political business cycles, democratization, and economic reform: the case of Africa. *Journal of Development Economics*, *67*(1), 205-228.

Bo, Z. Y. (2005). Political succession and elite politics in twenty-first century China: Toward a perspective of "power balancing". *Issues & Studies*, *41*(1), 162-189.

Brender, A., & Drazen, A. (2005). Political budget cycles in new versus established democracies. *Journal of Monetary Economics*, *52*(7), 1271-1295.

Cai, H., Wang, Z., & Zhang, Q. (2017). To build above the limit? Implementation of land use regulations in urban China. *Journal of Urban Economics*, *98*, 223-233.

Chen, T., & Kung, J. K. S. (2016). Do land revenue windfalls create a political resource curse? Evidence from China. *Journal of Development Economics*, *123*, 86-106.

Chen, T., & Kung, J. K. S. (2019). Busting the "Princelings": The campaign against corruption in China's primary land market. *The Quarterly Journal of Economics*, *134*(1), 185-226.

Chen, T., Liu, L. X., Xiong, W., & Zhou, L. A. (2016). *The speculation channel and crowding out channel: Real estate shocks and corporate investment in China*. Peking: Peking University Working Paper.

Chen, Y., Jin, G. Z., Kumar, N., & Shi, G. (2012). Gaming in air pollution data? Lessons from China. *The BE Journal of Economic Analysis & Policy*, *13*(3).

Chen, Y., Li, H., & Zhou, L. A. (2005). Relative performance evaluation and the turnover of provincial leaders in China. *Economics Letters*, *88*(3), 421-425.

Cheng, Z. (2016). The spatial correlation and interaction between manufacturing agglomeration and environmental pollution. *Ecological Indicators*, *61*, 1024-1032.

Cherniwchan, J. (2012). Economic growth, industrialization, and the environment. *Resource and Energy Economics*, *34*(4), 442-467.

Congleton, R. D. (1992). Political institutions and pollution control. *The Review of Economics and Statistics*, 412-421.

Copeland, B. R., & Taylor, M. S. (1994). North-South trade and the environment. *The Quarterly Journal of Economics*, *109*(3), 755-787.

Copeland, B. R., & Taylor, M. S. (2004). Trade, growth, and the environment. *Journal of Economic Literature*, *42*(1), 7-71.

Cropper, M., & Griffiths, C. (1994). The interaction of population growth and environmental quality. *The American Economic Review*, *84*(2), 250-254.

Cull, R., & Xu, L. C. (2003). Who gets credit? The behavior of bureaucrats and state banks in allocating credit to Chinese state-owned enterprises. *Journal of Development Economics*, *71*(2), 533-559.

Dale, P. (1997). Land tenure issues in economic development. *Urban Studies*, *34*(10), 1621-1633.

Démurger, S. (2001). Infrastructure development and economic growth: an explanation for regional disparities in China? *Journal of Comparative Economics*, *29*(1), 95-117.

Deng, F. (2017). Anti-corruption in Chinese urban planning: The case of adjusting FAR. *Cities*, *70*, 65-72.

Deng, Y., Wu, Y., & Xu, H. (2019). Political turnover and firm pollution discharges: An empirical study. *China Economic Review*, *58*, 101363.

Ding, C., & Lichtenberg, E. (2011). Land and urban economic growth in China. *Journal of Regional Science*, *51*(2), 299-317.

Ding, Z., Gao, X., Qian, X., & Wang, H. (2021). Governmental inspection and local legislation on environmental protection: Evidence from China. *Journal of Economic Surveys*, Forthcoming.

Drazen, A., & Eslava, M. (2010). Electoral manipulation via voter-friendly spending: Theory and evidence. *Journal of Development Economics, 92*(1), 39-52.

Du, W., & Li, M. (2021). The impact of land resource mismatch and land marketization on pollution emissions of industrial enterprises in China. *Journal of Environmental Management*, *299*, 113565.

Engel, K. H. (1996). State environmental standard-setting: is there a race and is it to the bottom. *Hastings Law Journal*, *48*, 271.

Fang, H., Wu, J., Zhang, R., & Zhou, L. A. (2022). *Understanding the Resurgence of the SOEs in China: Evidence from the Real Estate Sector*. Working paper.

Farzin, Y. H., & Bond, C. A. (2006). Democracy and environmental quality. *Journal of Development Economics*, *81*(1), 213-235.

Fleisher, B., Li, H., & Zhao, M. Q. (2010). Human capital, economic growth, and regional inequality in China. *Journal of Development Economics*, *92*(2), 215-231.

Fredriksson, P. G., Neumayer, E., Damania, R., & Gates, S. (2005). Environmentalism, democracy, and pollution control. *Journal of Environmental Economics and Management*, *49*(2), 343-365.

Fu, S., Ma, Z., Ni, B., Peng, J., Zhang, L., & Fu, Q. (2021). Research on the spatial differences of pollution-intensive industry transfer under the environmental regulation in China. *Ecological Indicators*, *129*, 107921.

Gallagher, K. (Ed.). (2010). *Handbook on Trade and the Environment*. Edward Elgar Publishing.

General Office of the Central Committee (2006). *The Interim Provisions on the Implementation of the Accountability System for the Leaders of the Party and Government.*

Ghanem, D., & Zhang, J. (2014). 'Effortless Perfection:'Do Chinese cities manipulate air pollution data? *Journal of Environmental Economics and Management*, *68*(2), 203-225.

Ghanem, D., Shen, S., & Zhang, J. (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.

Greenstone, M., He, G., Jia, R., & Liu, T. (2022). Can Technology Solve the Principal-Agent Problem? Evidence from China's War on Air Pollution. *American Economic Review: Insights*. Forthcoming.

Guo, G. (2009). China's local political budget cycles. *American Journal of Political Science*, *53*(3), 621-632.

He, C., Huang, Z., & Wang, R. (2014). Land use change and economic growth in urban China: A structural equation analysis. *Urban Studies*, *51*(13), 2880-2898.

Hong, T., Yu, N., & Mao, Z. (2019). Does environment centralization prevent local governments from racing to the bottom?--Evidence from China. *Journal of Cleaner Production*, *231*, 649-659.

Hsu, W. T., Li, X., Tang, Y., & Wu, J. (2017). Determinants of urban land supply in the people's republic of China: how do political factors matter? *Asian Development Review*, *34*(2), 152-183.

Hu, J., Liang, J., Fang, J., He, H., & Chen, F. (2022). How do industrial land price and environmental regulations affect spatiotemporal variations of pollution-intensive industries? Regional analysis in China. *Journal of Cleaner Production*, 130035.

Hu, J., Liu, Y., Fang, J., Jing, Y., Liu, Y., & Liu, Y. (2019). Characterizing pollution-intensive industry transfers in China from 2007 to 2016 using land use data. *Journal of Cleaner Production*, *223*, 424-435.

Huang, Z., & Du, X. (2017a). Government intervention and land misallocation: Evidence from China. *Cities*, *60*, 323-332.

Huang, Z., & Du, X. (2017b). Strategic interaction in local governments' industrial land supply: Evidence from China. *Urban Studies*, *54*(6), 1328-1346.

Huang, Z., & Du, X. (2018). Urban land expansion and air pollution: evidence from China. *Journal of Urban Planning and Development*, *144*(4), 05018017.

Huang, Z., Wei, Y. D., He, C., & Li, H. (2015). Urban land expansion under economic transition in China: A multi-level modeling analysis. *Habitat International*, *47*, 69-82.

Jia, K., & Chen, S. (2019). Could campaign-style enforcement improve environmental performance? Evidence from China's central environmental protection inspection. *Journal of Environmental Management*, *245*, 282-290.

Jia, R., Kudamatsu, M., & Seim, D. (2015). Political selection in China: The complementary roles of connections and performance. *Journal of the European Economic Association*, *13*(4), 631-668.

Jiang, J. (2018). Making bureaucracy work: Patronage networks, performance incentives, and economic development in China. *American Journal of Political Science, 62*(4), 982-999.

Jiang, S. S., & Li, J. M. (2021). Do political promotion incentive and fiscal incentive of local governments matter for the marine environmental pollution? Evidence from China's coastal areas. *Marine Policy*, *128*, 104505.

Jorgenson, A. K., & Clark, B. (2012). Are the economy and the environment decoupling? A comparative international study, 1960–2005. *American Journal of Sociology*, *118*(1), 1-44.

Kamp, D., Lorentzen, P., & Mattingly, D. (2017). Racing to the bottom or to the top? Decentralization, revenue pressures, and governance reform in China. *World Development*, *95*, 164-176.

Kanbur, R., & Zhang, X. (2005). Fifty years of regional inequality in China: a journey through central planning, reform, and openness. *Review of Development Economics*, *9*(1), 87-106.

Katsimi, M., & Sarantides, V. (2012). Do elections affect the composition of fiscal policy in developed, established democracies? *Public Choice, 151*(1), 325-362.

Kou, C. W., & Tsai, W. H. (2014). "Sprinting with small steps" towards promotion: solutions for the age dilemma in the CCP cadre appointment system. *The China Journal*, (71), 153-171.

Landry, P. F. (2008). *Decentralized Authoritarianism in China: the Communist Party's control of local elites in the post-Mao era* (Vol. 1). New York: Cambridge University Press.

Lawrence, S. V., & Martin, M. F. (2013). *Understanding China's political system*. Library of Congress Washington DC Congressional Research Service.

Li, H., & Zhou, L. A. (2005). Political turnover and economic performance: the incentive role of personnel control in China. *Journal of Public Economics, 89*(9-10), 1743-1762.

Li, H., Meng, L., Wang, Q., & Zhou, L. A. (2008). Political connections, financing and firm performance: Evidence from Chinese private firms. *Journal of Development Economics*, *87*(2), 283-299.

Li, X., Liu, C., Weng, X., & Zhou, L. A. (2019). Target setting in tournaments: theory and evidence from China. *The Economic Journal*, *129*(623), 2888-2915.

Li, X., Hui, E. C. M., Lang, W., Zheng, S., & Qin, X. (2020). Transition from factor-driven to innovation-driven urbanization in China: A study of manufacturing industry automation in Dongguan City. *China Economic Review*, *59*, 101382.

Lin, G. C., & Ho, S. P. (2005). The state, land system, and land development processes in contemporary China. *Annals of the Association of American Geographers*, *95*(2), 411-436.

Lin, Y., Qin, Y., Yang, Y., & Zhu, H. (2020). Can price regulation increase land-use intensity? Evidence from China's industrial land market. *Regional Science and Urban Economics*, *81*, 103501.

List, J. A., & Co, C. Y. (2000). The effects of environmental regulations on foreign direct investment. *Journal of Environmental Economics and Management*, *40*(1), 1-20.

Liu, C., & Kong, D. (2021). Does political incentive shape governments' disclosure of air pollution information? *China Economic Review*, *69*, 101659.

Liu, L., Chen, C., Zhao, Y., & Zhao, E. (2015). China′ s carbon-emissions trading: Overview, challenges and future. *Renewable and Sustainable Energy Reviews*, *49*, 254-266.

Liu, M., Tan, R., & Zhang, B. (2021). The costs of "blue sky": environmental regulation, technology upgrading, and labor demand in China. *Journal of Development Economics*, *150*, 102610.

Liu, M., Tao, R., Yuan, F., & Cao, G. (2008). Instrumental land use investment-driven growth in China. *Journal of the Asia Pacific Economy*, *13*(3), 313-331.

Lu, J. (2022). Can the central environmental protection inspection reduce transboundary pollution? Evidence from river water quality data in China. *Journal of Cleaner Production*, *332*, 130030.

Lu, J., Yu, L., & Chen, S. (2017). Industrial land conveyance, the investment quality race in the bottom line and environmental pollution. *China Population, Resources and Environment*, *27*(3), 90–98.

Maskin, E., Qian, Y., & Xu, C. (2000). Incentives, information, and organizational form. *The Review of Economic Studies*, *67*(2), 359-378.

Munnell, A. H. (1992). Policy watch: infrastructure investment and economic growth. *Journal of Economic Perspectives*, *6*(4), 189-198.

Opper, S., Nee, V., & Brehm, S. (2015). Homophily in the career mobility of China's political elite. *Social Science Research*, *54*, 332-352.

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: turning a black box into a policy tool. *Environment and Development Economics*, *2*(4), 465-484.

Piotroski, J. D., & Zhang, T. (2014). Politicians and the IPO decision: The impact of impending political promotions on IPO activity in China. *Journal of Financial Economics*, *111*(1), 111-136.

Potoski, M. (2001). Clean air federalism: Do states race to the bottom? *Public Administration Review*, *61*(3), 335-343.

Pu, Z., & Fu, J. (2018). Economic growth, environmental sustainability and China mayors' promotion. *Journal of Cleaner Production*, *172*, 454-465.

Qian, Y., & Weingast, B. R. (1997). Federalism as a commitment to reserving market incentives. *Journal of Economic Perspectives*, *11*(4), 83-92.

Qian, Y., & Xu, C. G. (1993). *Why China's economic reforms differ: the M-form hierarchy and entry/expansion of the non-state sector.*

Sheldon, I. (2006). Trade and environmental policy: A race to the bottom? *Journal of Agricultural Economics*, *57*(3), 365-392.

Shen, J., Firth, M., & Poon, W. P. (2016). Credit expansion, corporate finance and overinvestment: recent evidence from China. *Pacific-Basin Finance Journal*, *39*, 16-27.

Shen, W., & Xie, L. (2018). The political economy for low-carbon energy transition in China: towards a new policy paradigm? *New Political Economy*, *23*(4), 407-421.

Shi, M., & Svensson, J. (2006). Political budget cycles: Do they differ across countries and why? *Journal of Public Economics*, *90*(8-9), 1367-1389.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development*, *32*(8), 1419-1439.

Su, F., & Tao, R. (2017). The China model withering? Institutional roots of China's local developmentalism. *Urban Studies*, *54*(1), 230-250.

Tao, R., Su, F., Liu, M., & Cao, G. (2010). Land leasing and local public finance in China's regional development: Evidence from prefecture-level cities. *Urban Studies*, *47*(10), 2217-2236.

Tian, W., Wang, Z., & Zhang, Q. (2020). *The Micro-foundations of China's Industrial Land Market Post-2007*. Working paper.

Tian, W., Yu, J. & Gong. L. (2019). Promotion incentive and industrial land conveyance price: a study based on regression discontinuity design. *Economic Research Journal*, *10*, 89-105.

Tsai, P. (2016). Fiscal incentives and political budget cycles in China. *International Tax and Public Finance*, *23*(6), 1030–1073.

Tsai, P. H., Huang, C. Y., & Chiang, T. F. (2020). Fiscal expenditure and industrial land price in China: theory and evidence. *Contemporary Economic Policy*, *38*(4), 593-606.

Tsui, K. Y. (1996). Economic reform and interprovincial inequalities in China. *Journal of Development Economics*, *50*(2), 353-368.

Vortherms, S. A. (2019). Disaggregating China's local political budget cycles: "Righting" the U. *World Development*, *114*, 95-109.

Wang, L., & Yang, Y. (2021). Political connections in the land market: Evidence from China's state-owned enterprises. *Real Estate Economics*, *49*(1), 7-35.

Wang, Q., Wang, Y., Chen, W., Zhou, X., Zhao, M., & Zhang, B. (2020). Do land price variation and environmental regulation improve chemical industrial agglomeration? A regional analysis in China. *Land Use Policy*, *94*, 104568.

Wang, W., Sun, X., & Zhang, M. (2021). Does the central environmental inspection effectively improve air pollution?-An empirical study of 290 prefecture-level cities in China. *Journal of Environmental Management*, *286*, 112274.

Wang, Y., & Hui, E. C. M. (2017). Are local governments maximizing land revenue? Evidence from China. *China Economic Review*, *43*, 196-215.

Wei, J. (2020). *China's Industrial Policy: Evolution and Experience* (Report No. UNCTAD/BRI PROJECT/RP11). United Nations Conference on Trade and Development.

Whiting, S. H. (2006). *Power and Wealth in Rural China: The Political Economy of Institutional Change*. Cambridge University Press.

Woods, N. D. (2006). Interstate competition and environmental regulation: a test of the race-to-the-bottom thesis. *Social Science Quarterly*, *87*(1), 174-189.

Wu, J., Deng, Y., Huang, J., Morck, R., & Yeung, B. (2013). *Incentives and Outcomes: China's Environmental Policy* (No. w18754). National Bureau of Economic Research.

Wu, J., Gyourko, J., & Deng, Y. (2012). Evaluating conditions in major Chinese housing markets. *Regional Science and Urban Economics*, *42*(3), 531-543.

Wu, M., & Cao, X. (2021). Greening the career incentive structure for local officials in China: Does less pollution increase the chances of promotion for Chinese local leaders? *Journal of Environmental Economics and Management*, *107*, 102440.

Wu, Y., Zhang, X., Skitmore, M., Song, Y., & Hui, E. C. (2014). Industrial land price and its impact on urban growth: A Chinese case study. *Land Use Policy*, *36*, 199-209.

Wu, Y., Zhu, X., & Groenewold, N. (2019). The determinants and effectiveness of industrial policy in china: A study based on Five-Year Plans. *China Economic Review*, *53*, 225-242.

Xu, C. (2011). The fundamental institutions of China's reforms and development. *Journal of Economic Literature*, *49*(4), 1076-1151.

Yang, D. (1990). Patterns of China's regional development strategy. *The China Quarterly*, *122*, 230-257.

Yao, Y., & Zhang, M. (2015). Subnational leaders and economic growth: evidence from Chinese cities. *Journal of Economic Growth*, *20*(4), 405-436.

Yin, J., Zheng, M., & Li, X. (2016). Interregional transfer of polluting industries: a consumption responsibility perspective. *Journal of Cleaner Production*, *112*, 4318-4328.

Yu, A., & Li, Z. (2021). *The Last Strike: Evaluating the Distortionary Effect of Career Incentives on Taxation in China.* The University of Chicago.

Yu, J., Zhou, L. A., & Zhu, G. (2016). Strategic interaction in political competition: Evidence from spatial effects across Chinese cities. *Regional Science and Urban Economics*, *57*, 23-37.

Yu, Y., Yang, X., & Li, K. (2019). Effects of the terms and characteristics of cadres on environmental pollution: Evidence from 230 cities in China. *Journal of Environmental Management*, *232*, 179-187.

Zhang, X., Bao, H., & Skitmore, M. (2015). The land hoarding and land inspector dilemma in China: An evolutionary game theoretic perspective. *Habitat International*, *46*, 187-195.

Zheng, J., Mi, Z., Coffman, D. M., Milcheva, S., Shan, Y., Guan, D., & Wang, S. (2019). Regional development and carbon emissions in China. *Energy Economics, 81*, 25-36.

Zheng, L., & Na, M. (2020). A pollution paradox? The political economy of environmental inspection and air pollution in China. *Energy Research & Social Science*, *70*, 101773.

Zheng, S., & Kahn, M. E. (2013). Understanding China's urban pollution dynamics. *Journal of Economic Literature*, *51*(3), 731-72.

Zheng, S., Kahn, M. E., Sun, W., & Luo, D. (2014). Incentives for China's urban mayors to mitigate pollution externalities: the role of the central government and public environmentalism. *Regional Science and Urban Economics*, *47*, 61-71.

Zhou, L. (2007). Governing China's local officials: An analysis of promotion tournament model. *Economic Research Journal*, *7*, 36-50.

Zhou, L., Tian, L., Cao, Y., & Yang, L. (2021). Industrial land supply at different technological intensities and its contribution to economic growth in China: A case study of the Beijing-Tianjin-Hebei region. *Land Use Policy, 101*, 105087.

Zhu, J. (2012). The Shadow of the Skyscrapers: real estate corruption in China. *Journal of Contemporary China*, *21*(74), 243-260.

Zuo, C. V. (2015). Promoting city leaders: the structure of political incentives in China. *The China Quarterly*, *224*, 955-984.

2.A Appendices

Appendix A2.1. Local position rank and age of ineligibility for promotion

Panel A. Position rank and age of ineligibility for promotion

Local position	Position rank	Age of ineligibility for promotion
Provincial leaders	Minister (zheng bu)	63
Deputy provincial leaders	Deputy Minister (fu bu)	58
Sub-provincial city leaders	Deputy Minister (fu bu)	58
Deputy sub-provincial city leaders	Bureau Director (zheng ju)	55
Prefectural city leaders	Bureau Director (zheng ju)	55
Deputy prefectural city leaders	Deputy Bureau Director (fu ju)	52
County leaders	Division Head (zheng chu)	50
Deputy county leaders	Deputy Division Head (fu chu)	45
Township leaders	Section Head (zheng ke)	40

Panel B. A list of sub-provincial cities

Sub-provincial cities	Province
Changchun	Jilin
Chengdu	Sichuan
Dalian	Liaoning
Guangzhou	Guangdong
Hangzhou	Zhejiang
Harbin	Heilongjiang
Jinan	Shandong
Nanjing	Jiangsu
Ningbo	Zhejiang
Qingdao	Shandong
Shenyang	Liaoning
Shenzhen	Guangdong
Wuhan	Hubei
Xi'an	Shaanxi
Xiamen	Fujian

Notes: Panel A compiles the position rank and the age of ineligibility for promotion in China's bureaucratic system following (Kou and Tsai, 2014). The corresponding positions for local officials are given in the left column. Panel B gives a list of sub-provincial cities in China. Note that prefectural city leaders cannot be promoted if they are older than 55, while sub-provincial city leaders cannot be promoted if they are older than 58.

Appendix A2.2. Variable definition

Variable	Definition
Land parcel data	
Land price (Log)	The natural log of industrial land prices
Land area (Log)	The natural log of conveyance area of land parcel
Event	
Post	Dummy variable equal to one if the land parcel is conveyed after 2012
Monitor	Dummy variable equal to one if the land parcel is conveyed in the city covered by the automated air quality monitoring system
Inspection	Dummy variable equal to one if the land parcel is conveyed in the province during or after the environmental inspection (Appendix A2.9)
Local official information	
Party secretary tenure	The tenure of a party secretary
Party secretary age	The age of a party secretary
Party secretary female	Dummy variable equal to one if a party secretary is a female
Party secretary education	The number of years of education completed of a party secretary (High school = 12; College = 15; Bachelor = 16; Master = 19; Doctor = 22)
Mayor tenure	The tenure of a mayor
Mayor age	The age of a mayor
Mayor female	Dummy variable equal to one if a mayor is a female
Mayor education	The number of years of education completed of a mayor (High school = 12; College = 15; Bachelor = 16; Master = 19; Doctor = 22)
Prefectural city characteristics	
GDP (Log)	The natural log of GDP (in 100,000,000 yuan) in a region
GDP growth index	The percentage growth rate of GDP
Population (Log)	The natural log of population (in 10,000) in a region
Rural population (Log)	The natural log of rural population (in 10,000) in a region
GDP per capita (Log)	The natural log of GDP per capita (in 10,000 yuan) in a region
City area (Log)	The natural log of prefectural city area (in square kilometers)
Population density (Log)	The natural log of number of people in a region per square kilometers
Wage (Log)	The natural log of average wage (in yuan) of workers

Firm number (Log)	The natural log of firm numbers in a region above designated size (revenue with 5 million before 2011 and with 20 million in or after 2011)
Fix-asset investment (Log)	The natural log of fixed-asset investment (in 10,000 yuan) of a region
Real estate investment (Log)	The natural log of investment in real estate projects (in 10,000 yuan) of a region
Loan to deposit ratio	The ratio of loans to deposit balance of financial institutions
Share of GDP in secondary sector	Share of GDP in secondary sector
Share of GDP in tertiary sector	Share of GDP in tertiary sector
Farmland area (Log)	The natural log of arable land area (in square hectometer)
Grain output to farmland area (Log)	The natural log of grain output (tons) per square hectometer
Grain output per capita (Log)	The natural log of grain output (tons) per capita
Budgetary ratio	The ratio of budgetary revenue to budgetary expenditure
Budgetary revenue to GDP	The ratio of budgetary revenue to GDP
Share of education expenditure	The share of educational expenditure to budgetary expenditure

Appendix A2.3. Tenure of prefectural leaders and industrial land price: party secretary and mayor

	Full sample	Before reform	After reform	Full sample
	(1)	(2)	(3)	(4)
Secretary Tenure	-0.014	-0.018	-0.001	-0.026
	(-1.03)	(-0.81)	(-0.15)	(-1.32)
Secretary Tenure^2	0.002	0.002	-0.001	0.003
	(1.01)	(0.88)	(-0.52)	(1.31)
Mayor Tenure	-0.046***	-0.078***	-0.001	-0.073***
	(-4.07)	(-3.47)	(-0.13)	(-3.60)
Mayor Tenure^2	0.006***	0.010***	0.001	0.009***
	(4.60)	(3.42)	(0.96)	(4.15)
Sec. Tenure*Post				0.041*
				(1.67)
Sec. Tenure^2*Post				-0.005
				(-1.45)
Mayor Tenure*Post				0.051**
				(2.22)
MayorTenure^2*Post				-0.006**
				(-2.47)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	242,130	128,166	113,964	242,130
Adjusted R2	0.509	0.472	0.599	0.509

Notes: Observations are at the land parcel transaction level. The dependent variable is the natural log of the land transaction price. The main independent variables are the tenure and the square term of tenure for party secretaries and mayors and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Columns (1) and (4) are the estimations based on the full sample, column (2) is based on the subsample before the 2013 reform of the cadre evaluation system, and column (3) is based on the subsample in and after 2013. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Appendix A2.4. Tenure, political motivation and industrial land price

	Within promotion-eligible age		Above promotion-eligible age	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	-0.075**	-0.087***	-0.003	-0.037
	(-2.53)	(-3.51)	(-0.12)	(-0.62)
Tenure^2	0.009**	0.010***	0.001	0.007
	(2.52)	(4.00)	(0.26)	(1.00)
Tenure*Post	0.069*	0.061**	-0.006	0.007
	(1.87)	(2.24)	(-0.15)	(0.06)
Tenure^2*Post	-0.008*	-0.007**	0.002	-0.003
	(-1.73)	(-2.46)	(0.39)	(-0.16)
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	189,040	226,943	60,767	18,757
Adjusted R2	0.523	0.519	0.561	0.502

Notes: Observations are at the land parcel transaction level. The dependent variable is the natural log of the land transaction price. Columns (1) and (2) are based on the subsamples that party secretaries and mayors are within the promotion-eligible age, and columns (3) and (4) are based on the subsamples that party secretaries and mayors are above the promotion-eligible age. The promotion-eligible age is 55 for prefectural city leaders and 58 for sub-provincial city leaders (see Appendix A2.1). The main independent variables are the tenure and the square term of tenure for party secretaries (columns 1 and 3) and mayors (columns 2 and 4) and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Appendix A2.5. Tenure, industrial land area and land revenue

Dependent variable	Land area		Land revenue	
	Party secretary	Mayor	Party secretary	Mayor
	(1)	(2)	(3)	(4)
Tenure	0.001	-0.029	-0.021	-0.086*
	(0.03)	(-0.63)	(-0.43)	(-1.85)
Tenure^2	-0.004	0.003	0.001	0.010
	(-0.60)	(0.43)	(0.09)	(1.58)
Tenure*Post	0.019	0.035	0.048	0.093
	(0.30)	(0.63)	(0.75)	(1.64)
Tenure^2*Post	0.002	-0.002	-0.003	-0.010
	(0.27)	(-0.31)	(-0.36)	(-1.30)
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	3,156	3,091	3,156	3,091
Adjusted R2	0.659	0.657	0.729	0.729

Notes: Observations are at the prefectural city level. The dependent variable in columns (1) and (2) is the natural log of industrial land area. The dependent variable in columns (3) and (4) is the natural log of industrial land revenue. The main independent variables are the tenure and the square term of tenure for party secretaries (columns 1 and 3) and mayors (columns 2 and 4) and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Control variables include career variables and economic variables. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index). All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Appendix A2.6. Tenure and residential and commercial land price

Panel A. Party secretary's tenure and residential and commercial land price

	Full sample	Before reform	After reform	Full sample
	(1)	(2)	(3)	(4)
Tenure	-0.008	-0.028	-0.017	0.007
	(-0.29)	(-0.89)	(-0.43)	(0.18)
Tenure^2	0.002	0.005	0.002	-0.000
	(0.47)	(1.08)	(0.55)	(-0.05)
Tenure*Post				-0.037
				(-0.58)
Tenure^2*Post				0.005
				(0.75)
Commercial land	Y	Y	Y	Y
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	307,922	142,502	165,420	307,922
Adjusted R2	0.491	0.496	0.512	0.491

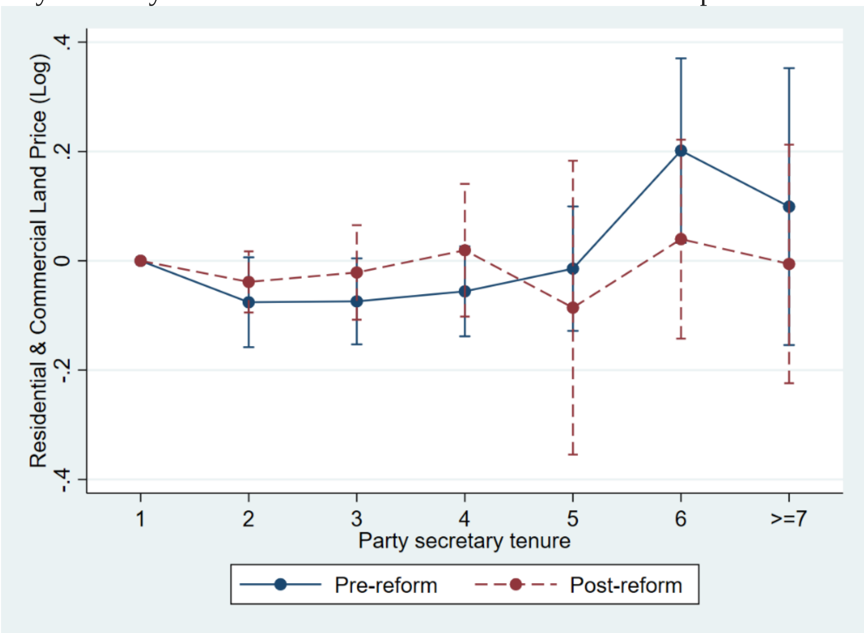
Panel B. Mayor's tenure and residential and commercial land price

	Full sample	Before reform	After reform	Full sample
	(1)	(2)	(3)	(4)
Tenure	0.004	-0.015	0.015	-0.014
	(0.18)	(-0.47)	(0.58)	(-0.34)
Tenure^2	-0.000	0.002	-0.003	0.001
	(-0.14)	(0.47)	(-0.68)	(0.30)
Tenure*Post				0.034
				(0.75)
Tenure^2*Post				-0.003
				(-0.60)
Commercial land	Y	Y	Y	Y
Land area	Y	Y	Y	Y
Career variables	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Observations	298,859	142,502	156,357	298,859
Adjusted R2	0.490	0.496	0.507	0.490

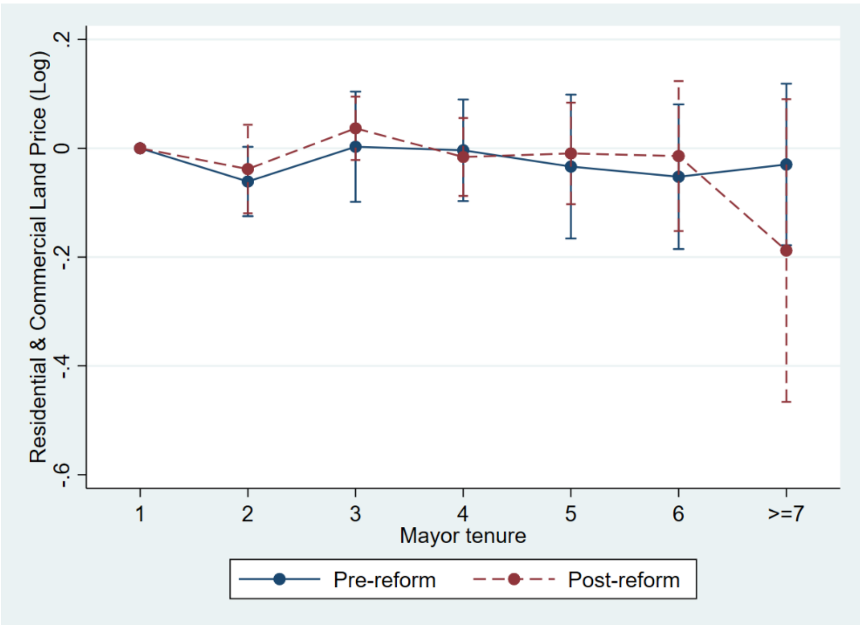
Notes: Observations are at the land parcel transaction level. The dependent variable is the natural log of the land transaction price. The main independent variables are the tenure and the square term of tenure for party secretaries (Panel A) and mayors (Panel B) and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Columns (1) and (4) are the estimations based on the full sample, column (2) is based on the subsample before the 2013 reform of the cadre evaluation system, and column (3) is based on the subsample in and after 2013. Control variables include land area, career variables and economic variables. Commercial land is a dummy variable equal to 1 if the land is for commercial use. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Appendix A2.7. Tenure and residential and commercial land price

Panel A. Party secretary's tenure and residential and commercial land price



Panel B. Mayor's tenure and residential and commercial land price



Note: The figures depict the relationships between the tenure of local officials (Panel A for party secretaries and Panel B for mayors) and the residential and commercial land prices and their 90% confidence intervals. The solid lines represent relationships before and in 2012, and dashed lines represent relationships after 2012. The regression considers land area, career variables and economic variables, city fixed effect and year fixed effects. Standard errors are clustered at the city level.

Appendix A2.8. Robustness test of the baseline results

Panel A. Party secretary

Dependent variables	Land price	Land price	Land price	Land price	Land price	Land price	Below floor
Sample	Exclude anti-corruption inspections	Exclude SOEs	Exclude real estate firms	Exclude sub-provincial cities	Full sample	Full sample	Full sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tenure	-0.052**	-0.050**	-0.050**	-0.061**	-0.044*	-0.044*	0.128
	(-2.16)	(-2.07)	(-2.09)	(-1.99)	(-1.89)	(-1.93)	(1.45)
Tenure^2	0.006**	0.006**	0.006**	0.007**	0.005**	0.005**	-0.018*
	(2.30)	(2.19)	(2.21)	(2.10)	(2.03)	(1.97)	(-1.67)
Tenure*Post	0.063**	0.061**	0.062**	0.081**	0.052*	0.053**	-0.082
	(2.24)	(2.21)	(2.27)	(2.47)	(1.94)	(2.02)	(-0.69)
Tenure^2*Post	-0.008**	-0.007**	-0.007**	-0.009**	-0.006*	-0.006*	0.016
	(-2.16)	(-2.04)	(-2.11)	(-2.27)	(-1.76)	(-1.86)	(1.02)
Land area	Y	Y	Y	Y	Y	Y	Y
Career variables	Y	Y	Y	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y	Y	Y	Y
Auction type	Y	N	N	N	Y	N	N
Land grade	N	N	N	N	N	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y	Y	Y	Y
Observations	237,721	246,744	245,688	218,729	249,807	249,807	249,807
Adjusted R2	0.507	0.509	0.511	0.505	0.522	0.562	
Pseudo R2							0.409

Panel B. Mayor

	Land price	Land price	Land price	Land price	Land price	Land price	Below floor
Sample	Exclude anti-corruption inspections	Exclude SOEs	Exclude real estate firms	Exclude sub-provincial cities	Full sample	Full sample	Full sample
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tenure	-0.082***	-0.080***	-0.080***	-0.093***	-0.076***	-0.075***	0.345***
	(-3.47)	(-3.40)	(-3.39)	(-3.02)	(-3.17)	(-3.43)	(4.23)
Tenure^2	0.010***	0.010***	0.010***	0.012***	0.009***	0.009***	-0.046***
	(4.03)	(3.97)	(3.99)	(2.77)	(3.74)	(4.07)	(-4.44)
Tenure*Post	0.064**	0.061**	0.060**	0.105***	0.057**	0.058**	-0.190*
	(2.48)	(2.39)	(2.37)	(3.05)	(2.19)	(2.39)	(-1.90)
Tenure^2*Post	-0.008***	-0.007***	-0.007***	-0.015***	-0.007**	-0.007***	0.027**
	(-2.74)	(-2.65)	(-2.62)	(-2.92)	(-2.47)	(-2.70)	(2.17)
Land area	Y	Y	Y	Y	Y	Y	Y
Career variables	Y	Y	Y	Y	Y	Y	Y
Economic variables	Y	Y	Y	Y	Y	Y	Y
Auction type	Y	N	N	N	Y	N	N
Land grade	N	N	N	N	N	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y	Y	Y	Y
Observations	234,096	242,720	241,710	214,072	245,700	245,700	245,700
Adjusted R2	0.512	0.514	0.516	0.508	0.526	0.567	
Pseudo R2							0.408

Notes: Observations are at the land parcel transaction level. In columns (1)-(5), the dependent variable is the natural log of the land transaction price. The dependent variable in column (6) is a dummy variable equal to one if the land price is below the minimum transaction price designated by the central government. The main independent variables are the tenure and the square term of tenure for party secretaries and mayors and their interaction term with Post, which is a dummy variable equal to one if the land parcel is sold after 2012. Column (1) excludes the transactions occurred during the anti-corruption inspections by the central government (listed in Appendix A2.9); column (2) excludes the lands conveyed to SOEs; column (3) excludes the lands conveyed to real estate firms; column (4) excludes the transactions in the sub-provincial cities; column (5) includes the dummy variables of auction types (negotiation, tenders, English auctions and two-stage auctions) in the full sample, and columns (6) and (7) include the grade of industrial land. Control variables include land area, career variables and economic variables. Land area is the natural log of land parcel area. Career variables include age, the square term of age, sex and education of party secretaries or mayors. Economic variables include the city characteristics (such as the natural log of GDP and GDP growth index) shown in Table 2.1. All regressions include year fixed effects and city fixed effects. Standard errors are clustered at the city level, and t-statistics are reported in parentheses. Significance level: *p<0.10 **p<0.05 ***p<0.01.

Appendix A2.9. Anti-corruption inspections launched by the central government

Central Committee	Wave	Period	Provinces under Anti-corruption Inspection
18th	1	May 2013 - Aug 2013	Inner Mongolia, Chongqing, Guizhou. Hubei, Jiangxi
18th	2	Oct 2013 - Dec 2013	Guangdong, Jilin, Hunan, Shanxi, Anhui, Yunnan
18th	3	Mar 2014 - May 2014	Fujian, Xinjiang, Hainan, Shandong, Ningxia, Beijing, Tianjin, Henan, Liaoning, Gansu
18th	4	Jul 2014 - Sep 2014	Heilongjiang, Qinghai, Hebei, Jiangsu, Shanghai, Shaanxi, Sichuan, Guangxi, Tibet, Zhejiang
18th	9	Feb 2016 - Apr 2016	Liaoning, Shandong, Anhui, Hunan
18th	10	Jun 2016 - Aug 2016	Tianjin, Hubei, Jiangxi. Henan
18th	11	Nov 2016 - Jan 2017	Gansu, Guangxi, Beijing, Chongqing
18th	12	Feb 2017 - Apr 2017	Inner Mongolia, Jilin, Shannxi, Yunnan
19th	1	Feb 2018 - May 2018	Fujian, Henan, Sichuan, Guizhou, Liaoning, Heilongjiang, Ningxia, Guangdong, Hainan, Hebei, Shanxi

Note: This table shows the summary the anti-corruption inspections launched by the central government between May 2013 and May 2018.

Appendix A2.10. Environmental inspections launched by the central government

Batch	Period	Provinces under Environmental Inspection
Pilot	01/01/2016 – 01/31/2016	Hebei
1	07/12/2016 – 08/19/2016	Inner Mongolia, Heilongjiang, Jiangsu, Jiangxi, Henan, Guangxi, Yunnan, Ningxia
2	11/24/2016 – 12/30/2016	Beijing, Shanghai, Hubei, Guangdong, Chongqing, Shanxi, Gansu
3	04/24/2017 – 05/28/2017	Shanxi, Anhui, Tianjin, Hunan, Fujian, Liaoning, Guizhou
4	08/07/2017 – 09/04/2017	Jilin, Zhejiang, Shandong, Hainan, Sichuan, Tibet, Qinghai, Xinjiang

Note: This table shows the summary the environmental inspections launched by the central government from 2016 to 2017.

Appendix A2.11. Summary statistics at city level

	Obs.	Mean	Median	Std. Dev	Min	Max
GDP growth index (t+1)	3,203	109.951	109.600	3.950	86.000	126.100
Land price (Log)	3,203	5.039	0.608	1.163	5.045	8.011
Land price (Pollution)	3,084	5.012	5.033	0.618	0.405	6.963
Land price (Other)	3,149	5.068	5.059	0.609	1.163	8.011
Land area (Log)	3,203	5.004	5.218	1.334	-1.609	8.094
GDP (Log)	3,203	6.938	6.917	0.936	4.151	10.055
GDP growth index	3,203	111.315	111.700	4.083	86.000	132.900
Population (Log)	3,203	5.866	5.913	0.642	2.896	7.269
Rural population (Log)	3,203	5.296	5.504	1.543	-32.331	7.073
GDP per capita (Log)	3,203	10.291	10.311	0.741	5.396	12.579
City area (Log)	3,203	9.359	9.404	0.796	7.015	12.443
Population density (Log)	3,203	5.721	5.837	0.897	1.548	7.882
Wage (Log)	3,203	10.459	10.514	0.451	8.509	11.828
Firm number (Log)	3,203	6.520	6.480	1.078	2.944	9.527
Fix-asset investment (Log)	3,203	15.741	15.761	1.007	12.709	18.359
Real estate investment (Log)	3,203	13.636	13.639	1.299	8.586	17.330
Loan to deposit ratio	3,203	0.646	0.627	0.244	0.085	7.076
Share of GDP in secondary sector	3,203	0.485	0.485	0.103	0.144	0.856
Share of GDP in tertiary sector	3,203	0.381	0.372	0.087	0.112	0.871
Farmland area (Log)	3,203	5.435	5.518	0.949	1.099	7.688
Grain output to farmland area (Log)	3,203	-0.532	-0.482	0.648	-4.605	4.202
Grain output per capita (Log)	3,203	-0.944	-0.892	0.748	-4.605	1.576
Budgetary ratio	3,203	0.471	0.435	0.227	0.027	1.541
Budgetary revenue to GDP	3,203	0.069	0.065	0.027	0.005	0.362
Share of education expenditure	3,203	0.185	0.184	0.044	0.010	0.377

Notes: Variables are observed at the city level. Land price and Land area are obtained from the Land Transaction Monitoring System. City characteristics (including GDP growth index, GDP, population, GDP per capita, city area, population density, wage, firm number, fix-asset investment, real estate investment, loan-to-deposit ratio, share of GDP in secondary sector, share of GDP in tertiary sector, farmland area, grain output to farmland area, grain output per capita, budgetary ratio, budgetary revenue to GDP, and share of education expenditure) are obtained from Statistical Yearbooks on Regional Economy, China City Statistical Yearbook and statistical yearbooks issued by local governments.

Chapter 3 Performance Measurability and Air Pollution Control: Evidence from a Quasi-experiment in China[27]

3.1 Introduction

Governments often use incentive-orientated performance contracts with explicit and measurable pre-set performance targets (i.e., high-powered incentive schemes[28]) to guide government official's efforts towards the achievement of their organization's objectives. However, they often produce unintended consequences, due to some features that are particularly prominent in the public sector, for example, multiple tasks (Dixit, 2002). At the center of the theoretical argument is the tasks' measurement problem.

This problem is more prominent in air pollution control as it is hard to trace the source of emissions and therefore creates rooms for manipulation. The general insight from theoretical multitasking literature pioneered by Holmström and Milgrom (1991) and Baker (1992) suggests high-powered incentive schemes would distort an agent's efforts away from hard-to-measure tasks (e.g., quality and equity) and invites gaming, measure manipulation, and myopia under pressures[29]. The failures of high-powered incentives lead economists to consider the optimal measurement design in an incentive scheme (Propper and Wilson, 2003). Yet, there is still surprisingly little and direct empirical evidence on performance measurability impact on outcomes. This study aims to fill this gap by exploiting a quasi-experiment in China—the installation of a national automated air quality monitoring network—together with an environmental protection regulation, namely the Air Pollution Prevention and Control Action Plan (the Action Plan).

To battle against the severe air pollution, China's government launched a high-stakes air pollution prevention and control program, the Action Plan, aimed to curb severe air pollution (i.e., PM2.5 and PM10 concentrations in urban areas) in China. The Action Plan has clear pre-set targets of air pollution reductions for local governments with

[27] This chapter is co-authored with Daoju Peng, Eddie C. M. Hui and Jianfu Shen.

[28] The terms high-powered incentives and low-powered incentives were first introduced by Williamson (1985).

[29] Indeed, there have been many studies on incentive schemes that have been deemed to be failures owing to several reasons including counterproductive timing strategies (Courty and Marschke, 1997, 2004), cream-skimming (Dranove et al. 2003), and direct data manipulation (Jacob and Levitt, 2003; Fisman and Wang, 2017).

strong enforcement through signing contracts with the central government[30]. High-powered financial incentives and career concerns are structured in those contracts. Failing to achieve the target results in the suspension of new project approvals, cut of special funding transfer from the upper-level government and year-end reward (financial incentive), and the prohibition on participating in the year-end assessment for promotion (career concern) for local leading cadres. Another important feature is the introduction of an automated monitoring system in all prefecture-level cities that provide non-manipulable readings for PM2.5 and PM10 concentration. Performance measurability is therefore greatly improved.

I analyzed the program to answer the question of whether such a high-powered incentive scheme together with enhanced performance measurability can elicit genuine efforts to curb air pollution or just dysfunctional "gaming the system" behavior. I compare the PM2.5 concentration satellite data before and after the launch of the Action Plan and exploit the spatial distribution of automatic monitoring site data in 285 prefecture-level (and above) Chinese cities from 2003 to 2017[31]. I used the distribution of automatic monitoring sites within a city to proxy the performance measurability. In response to the Action Plan, the optimal strategy for an agent (local government), whose preference is often misaligned with that of principal (central government)[32], would exert more efforts on enforcement around the sites as to improve performance and impress the principal, but less so in the not-measured regions. If this is the case, I would observe a larger reduction in PM2.5 concentration in cities with more comprehensive monitoring (i.e., better performance measurability) than those with incomplete monitoring coverage.

I find that cities with better performance measurability have greater environmental performance improvement. On average, after the Action Plan was implemented, PM2.5 concentration in cities with better performance measurability reduced significantly more by 14.07% per year—a level that is even higher than the target of PM2.5

[30] All 31 provinces signed contracts with the central government, targeting reduction in PM2.5 (or PM10) concentrations by 5% to 25%.

[31] Only the PM2.5 measure is used as to maintain clear causal inference between the introduction of monitoring technology and better public sector performance.

[32] Local governments in China face multiple tasks set by the central government, including economic growth, environmental protection, social stability, etc. Environmental policies are not wholeheartedly implemented by local governments in China, as a trade-off exists between economic growth and environmental protection (Zhang et al, 2012), and local officials are incentivized to pursue economic growth (e.g. Li and Zhou, 2005).

concentration reduction mandated by the central government for heavily-polluted regions—compared to cities with poor performance measurability. The results remain robust for different measures of performance measurability and different samples of cities constructed from the propensity score matching method.

My contributions are twofold. First, this study contributes to the literature on the effectiveness of high-powered incentives in the public sector. The literature is mostly concentrated on frontline tasks, such as teaching and tax collecting. I analyze the effectiveness of high-powered incentive schemes on environmental protection, which is subject to severe measurement problems. My paper shows that high-powered incentive is effective in this environment that breeds dysfunctional behavior, but its effects vary significantly with performance measurability. Second, this study contributes to the literature on environmental regulation. Most of the studies on environmental regulation focused on firms' responses to environmental regulation (e.g., He et al., 2020; Cai et al., 2016). I provide a first investigation on how the incentive structured in regulations and performance measurability affect outcomes. My study reveals the importance of performance measurement design in environmental protection.

The paper is structured as follows. Section 3.2 provides institutional background. Section 3.3 gives the literature review and also derives the main hypothesis in this study. Section 3.4 discusses the data, variables, and research models. Empirical results are presented in Section 3.5. The last section in this chapter concludes the study and provides policy implications from its findings.

3.2 Institutional background

In September 2013, the Ministry of Environmental Protection (MEP) in China launched the Action Plan as the most stringent regulation against air pollution. The Action Plan starts a war against PM10 and PM2.5 pollution in all prefectural cities, particularly in some key polluting areas. The Action Plan specified ten strict measures that local government should follow to reduce air pollutions, including imposing high standards on emission control, eliminating outdated high-pollution capacity, promoting clean energy, and controlling vehicle emissions.

To enforce the Action Plan, MEP adopted a unique performance management system in China, "objective responsibility system" (ORS). Following the principles of "management by objective" defined in ORS, the Action Plan sets the goals for subnational governments and cascades them in a top–down approach to the individual leading cadres responsible at the government's lowest levels or even state-owned enterprises, forming a target pyramid. Each province is required to sign a contract with the central government, which stipulates the local government's responsibility, the assessment of the performance, and the associated rewards or penalties. Career concern incentives and financial incentives have been structured in this series of contracts, based on the assessment of performance. Air quality was evaluated each year from 2014 with a mid-review in 2015 and a final review in 2017[33]. The MEP developed a sophisticated quantitative measurement system to assess the performance of air quality improvement and the achievement of key tasks, based on PM2.5 and PM10 data from the automatic air quality monitoring stations that are directly managed by the central government.

The assessment results are rated as "excellent," "good," "pass," and "fail". If provincial governments are rated as "fail", they are subject to financial penalties, including the deduction of the special fund granted from the central government for air pollution prevention and control and suspension of new project approval. Those rated as "excellent" would receive extra funds from the central government. The assessment results are also reported to enable promotion evaluations. If targets are not achieved, the leading cadres, party secretary and the mayor, cannot be promoted and year-end assessment of leadership teams would be rated as "not qualified.”

A key feature of the Action Plan is the adoption of technology—an automated air quality monitoring system—for measuring more precisely the air quality. To tackle serious air quality problems, in 2012, MEP revised the National Ambient Air Quality Standard in which PM2.5 has been included for the first time. The automated national air quality monitoring network was then upgraded or established to integrate new equipment for monitoring PM2.5 and other pollutants in all prefectural cities (or above) by The Chinese National Environmental Monitoring Center (CNEMC). A total of 1,436 air quality stations that are directly managed and maintained by the central government have been set up in 338 prefecture-level cities (or above) by 2015 (Greenstone et al.,

[33] The performance in 10 provinces including Beijing and Shanghai was evaluated by both air quality improvement and accomplishment of key tasks on air pollution control and prevention. The remaining provinces were assessed by only air quality improvement. The details of performance assessment measures can be found here: http://www.mee.gov.cn/gkml/hbb/bwj/201407/t20140725_280516.htm.

2020). Surveillance cameras outside the monitoring sites were also installed to prevent further the local interferences. Under the new system, concentrations of different air pollutants are updated hourly and available simultaneously on the MEP and CNEMC websites, local environmental bureau websites, mobile apps and third-party websites, and used for evaluating the tasks set in the Action Plan. Any data anomaly across different monitoring sites would trigger alerts automatically to the central government and result in a further investigation (Greenstone et al., 2020).

The new automated national monitoring network is geographically unbalanced, which create a diversified performance measurability, with the most intensively monitored cities having the most accurately measured performance. On the one hand, according to Technical Regulation for Selection of Ambient Air Quality Monitoring Stations (TRSAAQMS, MEP, 2013), the minimum required number of monitoring sites in each prefectural city is determined by its population or built-up area, which has a large regional disparity in China. Small cities with population of less than 250 thousand or 20 km^2 build-up areas are required to install only one monitoring station. In contrast, large cities with population of more than 3 million or 400 km^2 built-up areas are required to set up no less than ten monitoring sites[34]. On the other hand, the actual numbers of national automated monitoring stations change with local conditions, which also have large variations across different cities. For instance, the built-up area of Shanghai was approximately 919 km^2 in 2013. According to the technical regulation, the minimum number of monitoring stations should at least be 15. However, there are only 10 national automated monitoring stations covering eight districts in the city[35]. Therefore, the geographic disparity enables us to examine the differentiated effect of performance measurability across cities.

[34] The minimum number of stations in a city is set as: 1 station if the population is less than 25,000 or if the built-up area is less than 20 km^2; 2 if the population is between 25 and 50,000 or the built-up area is between 20 and 50 km^2; 4 if the population between 50 and 100,000 or the built-up area is between 50 and 100 km^2; 6 if the population is between 100 and 200,000 or the built-up area is between 100 and 200 km^2; and 8 if the population is between 200 and 300,000 or the built-up area is between 200 and 400 km^2. For large cities with a population of more than 3 million or a built-up area more than 400 km^2, 1 station is set up per 50–60 km^2.

[35] There are a total of 16 districts in Shanghai. The districts covered by the automatic monitoring are Pudong (3 stations), Hongkou (1 station), Huangpu (1 station), Jingan (1 station), Putou (1 station), Qingpu (1 station), Xuhui (1 station), and Yangpu (1 station). The distribution of the national automatic monitoring stations can be found on the government website of Shanghai Municipal Bureau of Ecology and Environment: https://sthj.sh.gov.cn/.

3.3 Literature review and hypotheses development

The most commonly used incentive scheme in the last three decades is to pay for performance. However, unlike private sector, pay-for-performance may not be applicable to the public sector (see, e.g., Dixit, 2002 among others). Indeed, empirical studies have found mixed results. The pay-for-performance incentive scheme is found to be positively associated with the performance of some types of tasks in the public sector, mostly frontline task, such as tax collecting (Kahn et al., 2001), but fails in so many others, such as quality targeting tasks (Baker et al. 1994), team works (Burgess et al. 2017), teaching (Jacob and Levitt, 2003), and health care (Dranove et al., 2003). The use of less explicit incentives, such as career concerns, in the public sector would be also less effective than that in the private sector as it often distorts agents' efforts in performing emphasized tasks in promotion rules (Holmström, 2017; DeVaro and Gürtler, 2016).

At the center of the debate on the effectiveness of high-powered incentives is the extent to which performance outcome is measurable. When performance is easy to measure, contracting tasks would be optimal for both principals and agents and for providing motivations (Holmström, 1979). However, it has been long recognized that moral hazard may arise when the performance is imperfectly measured (Holmström, 1979), creating a trade-off between motivating agents and distorting their incentives. The general insight from multitasking literature (Holmström and Milgrom, 1991, Baker, 1992) is that agents tend to game the system, strategically overperform on accurately measured tasks (e.g., quantity measure), but underperform on those that are not (e.g., quality measure). Courty and Marschke (2011) further distinguished three types of dysfunctional responses to high-powered incentive schemes in a multitasking model. These dysfunctional responses occur when performance and effort are poorly measured and do not reflect the true value creation. Therefore, the mapping from efforts to performance cannot be accurately inferred (Holmström and Milgrom, 1991) and even when it can be, it is often not conducive for value-enhancing (Holmström, 2017). One natural way to deal with measurement problems and their associated dysfunction behavior is to develop "non-manipulable" performance measurement indicators that can force agents to focus on true value creation (Propper and Wilson, 2003). However, although theoretical models are centered on performance measurability, empirical studies are very limited, partly because of the difficulties of identifying performance measurability and the causal effect from performance measurability to outcomes.

The quasi-experiment—newly installed automated monitoring station aimed to provide non-manipulable performance measure for a high-stakes incentive scheme in China in 2013—enable us to directly examine how performance measurability affects outcomes. Several other studies also pay attention to the incentive problem in China's war against pollution. Some argue that career concerns of local government officials are important for environmental protection (Zheng et al. 2013, Jia, 2017, Wu et al. 2012, Chen et al. 2018; Wang and Lei, 2020). Gaming behavior like data manipulation is also found when air pollution control performance is linked to promotions of local government officials (Chen et al. 2012). However, none of these studies examines the role of performance measurability, which has been the main focus of the theoretical models. Other studies examined the effect of environmental regulation on pollution at the firm- and industry-levels (e.g., He et al., 2020; Cai et al., 2016), but did not examine the incentive problem in general.

I rely on two rationales to identify the effect of performance measurability. First, location-based monitoring data cannot attribute the actual origin of emissions and therefore lack accountability (Dechelepretre et al., 2019). Second, across cities, the distribution of automatic monitoring stations is unbalanced. Therefore, cities differ in the level of accountability, with the most intensively monitored cities having the highest level of accountability, thereby highest level of performance measurability. I expected that enhanced measurability of performance by national automatic monitoring stations would strengthen the effect of the Action Plan. The main hypothesis in this research is thus given as:

Hypothesis: Cities with more comprehensive coverage of automatic air quality monitoring stations reduce PM2.5 concentrations more than cities without adequate coverage.

3.4 Data, variables, and research methodology

I construct a sample that contains 285 prefectural-level (or above) cities in China[36].

[36] In 2012, there were 285 prefectural-level cities and 4 municipalities in China. I excluded four prefectural-level cities (Bijie, Laiwu, Sansha, and Tongren) due to missing data in the city-level statistics of the CEIC China Premium Database.

Until early 2015, all these cities were covered by national automated air quality monitoring stations. Locations of these stations are extracted from CNEMC[37]. I geocoded the monitoring stations and obtained the number of stations in each city and each district in a city; numbers and names of districts in cities are collected from the Chinese Ministry of Civil Affairs[38]. The size of built-up areas in each city is extracted from the China City Statistical Yearbook. The city data are collected from CEIC China Premium Database, which is retrieved from the Chinese National Bureau of Statistics. Among others, the data include GDP, urban population, and fixed asset investment. The sample period is from 2003 to 2017.

I collect air pollution data in China provided by the Atmospheric Composition Analysis Group at Washington University in St. Louis (van Donkelaar et al, 2019; Hammer et al, 2020)[39]. The group provides geophysical-statistical estimates of surface PM2.5 in China, an annual surface PM2.5 combining aerosol optical depth (AOD) retrievals from multiple satellite instruments, and ground-based PM2.5 measures. AOD method is commonly used to infer ground-level pollution, particularly for fine particles, such as PM2.5 and PM10, from how much direct sunlight is prevented from reaching the ground by aerosol particles. Ground-based monitor observations of PM2.5 concentrations are used to calibrate PM2.5 estimates from the AOD. The gridded geophysical-statistical estimates of PM2.5 data are then geocoded using China's city map and ArcGIS software.

The dependent variable in this study is the natural logarithm of annual mean

[37] The list of stations with geographic coordinates can be downloaded from: https://quotsoft.net/air/.

[38] This information is available here: http://www.mca.gov.cn/article/sj/xzqh/1980/?. I used the districts in the cities in my sample in 2014.

[39] The surface PM2.5 data were obtained from https://sites.wustl.edu/acag/datasets/surface-pm2-5/. The Socioeconomic Data and Applications Center (SEDAC) of NASA's Earth Observing System Data and Information System (EOSDIS) also provides a similar dataset of global PM2.5 grids. However, its data are only updated to 2016.

concentrations of PM2.5 in a city[40]. The key independent variable is the coverage of the national automatic stations in a city, which captures the performance measurability of environmental outcome in a city. I constructed two variables to proxy performance measurability. The first variable (STRATIO) is the ratio of the number of automatic stations over the minimum number of stations required by MEE based on the built-up urban area in a city in 2014. A dummy variable (ACHIEVE) is equal to 1, if the number of automatic stations can achieve or exceed the minimum requirement, and 0 otherwise. The second variable (DISTCOV) is the percentage of districts in a city that is covered by the automatic monitoring stations. I then constructed a dummy variable (FULCOV) equal to 1 if all districts in a city are covered and 0 otherwise.

I then employ a difference-in-difference (DID) estimation to explore whether a city with comprehensive coverage of automated monitoring stations reduces PM2.5 concentration more than a city without. The estimation is performed by comparing the change in PM2.5 concentration in the tightly monitored cities (the treatment group) before and after Action Plan in 2013 to the corresponding change in loosely monitored cities (the control group). The regression model is given as follows (e.g., Cai et al., 2016; Kahn et al., 2015):

$$LNPM2.5_{i,t} = \alpha + \beta_1 \times POST_t \times COV_i + Control_{i,t} + CityFE_i + YearFE_t + \epsilon_{i,t} \tag{3.1}$$

The dependent variable (LNPM2.5) is the natural logarithm of PM2.5 concentration

[40] Provincial and prefectural governments also set some air quality monitoring stations in their administrative regions. I considered the national monitoring stations based on (1) if only the readings from national stations were used as data to evaluate the air quality and whether a province achieved its environmental target; (2) real-time data from the stations managed by local governments could not be released to the public; and (3) local governments could not directly modify the data from national stations but exert discretions to report the data from locally managed stations. In other words, only the coverage of national automatic monitoring can enforce local governments to protect the environment.

in each city i and year t (Luo et al., 2018). I created a time dummy variable (POST) indicating the post-treatment period, which equals 1 after 2013 when the Action Plan is implemented and 0 otherwise. The key variable is the interaction variable between POST and COV. COV nests the two variables for performance measurability (ACHIEVE and FULCOV). I include a series of city characteristics (CONTROL) as control variables, including income, as measured by the natural logarithm of GDP per capita (LNGDP), the share of secondary GDP and tertiary GDP in aggregate GDP (SECGDP and TRDGDP), economic growth (GDPGROWTH), population density (LNPOPDEN) and investment, which is measured by the natural logarithm of foreign direct investment (LNFDI) and the natural logarithm of fixed capital investment (LNFAINV). As found in the literature, environmental quality depends on development (e.g., Kuznets, 1955; Selden and Song, 1994; Kearsley and Riddel, 2010), economic structure (Llop, 2007), population density (e.g., Chen et al., 2018), and investment (e.g., Keller and Levinson, 2002; He, 2006). In addition, city and year fixed effects are incorporated in the regression model. City fixed effect absorbs the impacts of time-invariant city characteristics on PM2.5 concentrations, such as the reduction goal set by the central government and targeted air pollutant (PM2.5 or PM10), location, climate, and heating policy in winter[41]. Year fixed effect controls the impact of the aggregate time trend in the PM2.5 concentration in Chinese cities.

I conducted a parallel pretreatment trend test using the following specification (Jacobson et al., 1993) to obtain an unbiased estimate:

[41] The environmental goal in the Action Plan is further allocated to provincial governments: 11 provinces are required to reduce annual mean PM2.5 concentrations by the end of 2017 by at least 10%; 17 provinces have targets to reduce annual mean PM10 concentrations by the end of 2017 by at least 5%; and three provinces should continuously improve air quality without specific targets on PM2.5 or PM10 concentration reduction. Including the city fixed effect in the regression model controls the impact of environmental targets on PM2.5 concentration reduction. My main results are similar if I only analyze cities in the provinces with targets on PM2.5 concentration reductions, or the province fixed effect is incorporated in the model.

$$LNPM2.5_{i,t} = \alpha + \beta_1 \times \sum_{k=-2}^{4} Year_{2013+k} \times COV_i + Control_{i,t} + CityFE_i + YearFE_t + \epsilon_{i,t} \tag{3.2}$$

In equation (3.2), $Year_{2013+k}$ represents a series of calendar year dummies and test whether the performance measurability affects a city's PM2.5 concentration before the Action Plan in 2013. It is expected that performance measurability may only affect the public sector performance after the Action Plan is adopted.

One potential concern in the regression analysis is the endogeneity issue in the coverage of automatic monitoring stations. For instance, the central government may decide to establish more monitoring stations in the heavily polluted cities and mandate these cities to reduce more PM2.5 concentrations[42]. Additionally, some unobservable factors may affect both the coverage and PM2.5 reduction in a city. To address these concerns, I employ a propensity score matching approach to control for the unobserved variations between the cities that are comprehensively covered and those that are not (Rosenbaum and Rubin, 1983). I firstly run a logistic regression of the treatment effect hat a city is comprehensively covered by the monitoring station in 2014 on the city characteristics, which include built-up urban area (logged; in 2013), urban population (logged; in 2013), GDP per capita (logged; in 2013), the portion of GDP of secondary industry in total GDP (in 2013), whether the city is located in a key control region, and whether the city's environmental performance is evaluated by the reduction of PM2.5 concentrations[43].

[42] Nevertheless, this possibility may not be valid as I show later that the three key regions indeed have lower coverage of automatic monitoring stations than other regions.

[43] After the revision of the air quality standard in 2012, the Ministry of Environmental Protection announced a list of 74 cities that were to be key monitoring cities and released air quality data from automatic monitoring stations in these cities from January 2013.

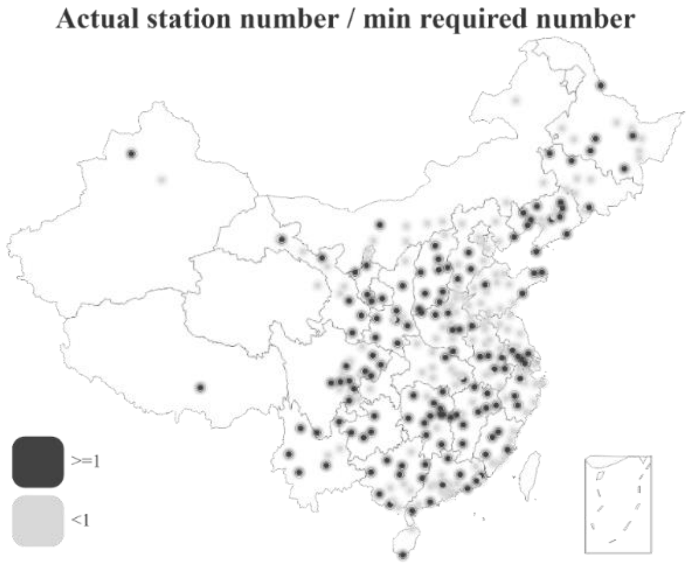
3.5 Empirical results and discussion

Descriptive statistics

Table 3.1 displays the average concentration of PM2.5 in all the cities from 2003–2017. The PM2.5 concentration was averaged at 43.09 μg/m³, with 46.63 μg/m³ in key cities and 41.85 μg/m³ in other cities. Time-series patterns show that the average concentration of PM2.5 in China first increased from 2003 to 2007 and then generally decreased from 2007 to 2012. After the launch of the Action Plan in 2013, air quality was improved greatly and the concentration of PM2.5 decreases. Table 3.2 shows the coverage of automated national monitoring stations. In total, 48.42% of cities have achieved or exceed minimum requirements. Moreover, 51.23% of cities have national automatic monitoring stations in all urban districts, whereas 41.05% of cities have less than 75% coverage. Figure 3.1 displays the geographical distribution of automated monitoring stations. Both Panel A and Panel B show that the coverage varies across cities even that they are under the same provincial environmental goal. The high coverage by monitoring stations (measured by ACHIEVE and FULCOV) is balanced across cities and largely independent of economic conditions, air quality, and mandated targets, reassuring the exogeneity of monitoring station sites to local government. Table 3.3 reports the descriptive statistics of the air quality and other control variables. The variable definitions are contained in Appendix A3.1.

Figure 3.1. Automated air monitoring coverage

Panel A: coverage measured by the actual station number over minimum required station number



Panel B: the percentage of urban districts covered by the automated national monitoring station

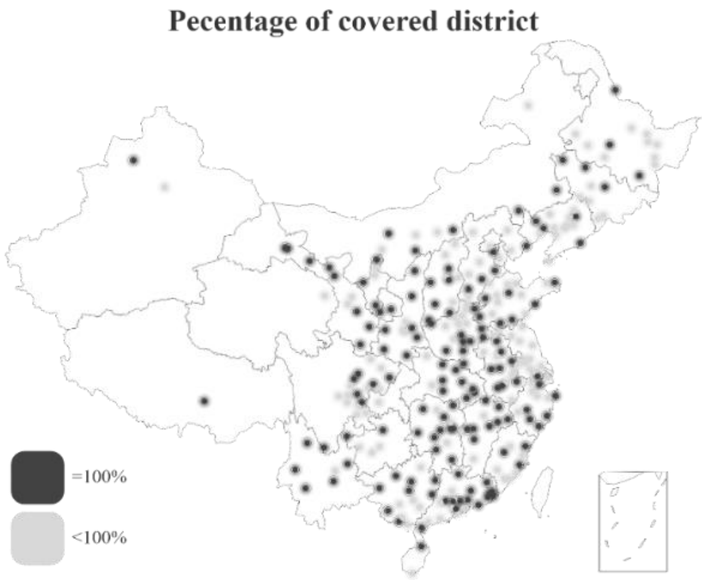


Table 3.1. Average PM2.5($\mu g/m^3$) by year

Year	All cities	Key cities	Non-key cities	Difference	t-stat
2003	38.45	39.72	37.61	2.12	1.04
2004	38.05	38.80	37.55	1.25	0.70
2005	42.55	43.62	41.84	1.78	0.85
2006	46.35	47.29	45.73	1.56	0.62
2007	47.73	49.02	46.89	2.13	0.83
2008	45.25	46.65	44.32	2.33	1.10
2009	44.69	45.98	43.85	2.13	1.03
2010	44.98	46.00	44.31	1.69	0.74
2011	42.19	43.56	41.29	2.27	1.07
2012	39.81	40.76	39.18	1.58	0.78
2013	45.72	47.17	44.77	2.40	0.98
2014	45.68	47.27	44.63	2.64	1.18
2015	42.82	44.49	41.72	2.77	1.30
2016	37.91	39.27	37.02	2.25	1.14
2017	44.19	45.20	43.53	1.67	0.87
Total	43.09	44.32	42.28	2.04	3.60

Note: Key cities indicate the 113 environmental important cities which has been monitored by the government since 2007.

Table 3.2. The coverage of stations in cities

STRATIO:	N	percentage	DISTCOV:	N	percentages
> 1	67	23.51%	= 1	146	51.23%
= 1	71	24.91%	[>= 0.75, < 1]	22	7.72%
[>= 2/3, < 1]	84	29.47%	[>= 0.5, < 0.75]	88	30.88%
< 2/3	63	22.11%	< 0.5	29	10.18%
Overall	285		Overall	285	

Note: STRATIO is calculated by the number of automatic monitoring stations divided by the minimum required number in a city. DISCOVER is the percentage of districts in a city covered by the monitoring station. N is the number of cities in each category.

Table 3.3. Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
PM2.5	4,275	43.09	18.14	2.82	107.50
LNPM2.5	4,275	3.66	0.49	1.04	4.68
NUM	4,275	4.09	2.64	0	19
STRATIO	4,275	0.93	0.43	0	3
ACHIEVE	4,275	0.48	0.50	0	1
DISTCOV	4,275	0.78	0.26	0	1
FULLCOV	4,275	0.51	0.50	0	1
POST	4,275	0.27	0.44	0	1
LNGDP	4,275	4.45	1.09	1.16	8.03
SECGDP	4,275	0.48	0.11	0.15	0.91
TRDGDP	4,275	0.38	0.09	0.09	0.81
GDPGROWTH	4,275	0.14	0.11	-0.37	2.09
LNPOPDEN	4,275	3.90	0.87	0.19	6.39
LNFDI	4,275	4.76	2.18	-3.91	10.10
LNFAINV	4,275	10.84	1.22	7.41	14.37

The main result of monitoring on air pollution control

Table 3.4 provides the baseline regression analysis based on equation (3.1)[44]. Columns (1)-(4) test the moderation effect of coverage. They show that comprehensive performance measurability, proxied by monitoring station coverage, strengthens the effects of environmental regulation. The result in Column (1) shows that cities with more monitoring stations decreased PM2.5 concentrations during the period of the Action Plan significantly more compared with the cities with fewer monitoring stations. The coefficient on the interaction term POST x ACHIEVE in Column (2) is significantly negative, indicating that PM2.5 concentrations reduced more by 3.47%

[44] In unreported results, I test the effect of the Action Plan on PM2.5 reductions using a regression model with *POST* dummy, city-level controls, and city fixed effects. The coefficient in *POST* dummy is 0.0366. The findings indicate that in all the 285 cities, PM2.5 concentrations reduce by 3.59% on average per year from 2014 to 2017. The cumulative reduction in the period of 2014–2017 is 13.62%, which exceeds the target of 10% reduction of PM2.5 concentrations by 2017 in the entire nation in the Action Plan.

per year from 2014 to 2017 in the cities where the number of monitoring stations achieves or exceeds the minimum requirement by MEE than in the cities without sufficient stations. Column (3) shows that air pollutions in a city decrease significantly more after the implementation of the Action Plan if the percentage of city districts covered by monitoring stations increases. The result in the last column shows that cities with 100% of districts covered by stations decrease PM2.5 concentrations more by 3.67% per year after the implementation of the Action Plan than cities whose districts are not fully monitored.

The coefficients on control variables are generally consistent with the results in previous studies. PM2.5 concentrations decrease in the cities with large GDP per capita, high GDP growth rate, and a large portion of GDP from tertiary industry (Selden and Song, 1994; Chen et al., 2018; Luo et al., 2018). Urban population density does not significantly affect PM2.5 concentrations in a city. Cities with more foreign direct investment and less fixed asset investments are associated with more air pollutions.

In the untabulated results, I use alternative regression models by including province fixed effect or province-year fixed effect to control for impacts of air quality targets in the Action Plan. The results remain similar. In sum, the findings confirm the main hypothesis that the coverage of monitoring stations significantly affects air pollution control in Chinese cities after the introduction of the Action Plan. Moreover, the findings suggest that performance measurability is an important factor that affects the effectiveness of a high-powered incentive scheme in the public sector (Holmström and Milgrom, 1991). Although automatic monitoring can improve the measurability of outcomes in an environmental problem, gaming response by local governments due to incomplete measurement could lead to suboptimal consequences of environmental protection.

Table 3.4. The coverage of automated monitoring station and the reduction of PM2.5

	(1)	(2)	(3)	(4)
POST x STRATIO	-0.0429			
	(-4.10)***			
POST x ACHIEVE		-0.0353		
		(-4.15)***		
POST x DISTCOV			-0.0840	
			(-4.61)***	
POST x FULLCOV				-0.0374
				(-4.28)***
LNGDP	-0.1174	-0.1210	-0.1222	-0.1255
	(-6.01)***	(-6.18)***	(-6.26)***	(-6.37)***
SECGDP	-0.1298	-0.1155	-0.0978	-0.0910
	(-1.35)	(-1.20)	(-1.01)	(-0.94)
TRDGDP	-0.3623	-0.3468	-0.3303	-0.3279
	(-2.83)***	(-2.70)***	(-2.60)***	(-2.56)**
GDPGROWTH	-0.0848	-0.0840	-0.0840	-0.0850
	(-3.44)***	(-3.40)***	(-3.42)***	(-3.45)***
LNPOPDEN	0.0030	0.0032	0.0012	0.0014
	(0.33)	(0.35)	(0.13)	(0.16)
LNFDI	0.0050	0.0048	0.0039	0.0039
	(1.87)*	(1.78)*	(1.45)	(1.44)
LNFAINV	-0.0272	-0.0262	-0.0231	-0.0229
	(-3.11)***	(-3.01)***	(-2.65)***	(-2.61)***
Constant	4.3655	4.3565	4.3298	4.3344
	(33.81)***	(33.77)***	(33.99)***	(33.62)***
City fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
N of cities	285	285	285	285
N of obs.	4,275	4,275	4,275	4,275
adj. R-squared	0.9475	0.9475	0.9476	0.9475

Note: The dependent variable is the natural logarithm of PM2.5 in a city in a year. The *t*-statistics adjusted by robust standard error are reported in parentheses. ***, **, * represent the statistical significance at 1%, 5% and 10% level, respectively.

Parallel trend test

I run a parallel pretreatment regression based on equation (3.2) to test whether the outcome trends of both treatment and control groups are parallel before the implementation of the Action Plan. The results are reported in Table 3.5. To conserve space, I do not report coefficients on control variables. As indicated in this table, coefficients of the coverage interaction term and post dummy are generally insignificant before the Action Plan takes effect ($k < 1$). The results are also consistent with previous studies reporting that performance measurability affects the consequences in the public sector only when the high-powered incentive scheme is in effect. After the Action Plan was in effect for a year ($k \geqslant 1$), the coefficient becomes statistically significant and increasingly negative from 2014 to 2016. The result is consistent with the parallel trend assumption for DID analyses.

Specifically, Column (1) of Table 3.5 shows that cities whose station numbers achieve or exceed minimum requirement did not have more PM2.5 reduction before the implementation of the Action Plan (2011–2013) than cities without a sufficient number of stations. PM2.5 concentration even increased more in the year 2012. After the Action Plan was in effect in the period 2014–2016, cities with more coverage of monitoring stations decreased PM2.5 concentration more by 3.57%, 3.84%, and 4.06% each year. Similar patterns appear in the cities with all districts that are covered by monitoring stations. PM2.5 concentrations decreased more by 3.45%, 4.71% and 4.25% in 2014, 2015 and 2016, respectively. Cities with more coverage in Column (1) have less significant and smaller coefficients as compared to column (2). This can be attributed to geographical gaming behavior still being severe, as not all districts of a city are covered by monitoring stations. Combining the coefficients on four interaction terms, the results indicate that tightly monitored cities decrease PM2.5 concentrations by 12.67% (monitoring coverage measured by number of stations) and 14.07% (coverage measured by monitored districts) more than loosely monitored cities. Overall, the parallel trend tests confirm my hypothesis that PM2.5 reductions are heterogeneous across cities because of the performance measurability introduced by the Action Plan, whereas the coverage of automatic monitoring did not affect the air pollution control before the Action Plan was in effect.

Table 3.5. Parallel trend test

	(1)		(2)
YR2011 x ACHIEVE	0.0070	YR2011 x FULLCOV	-0.0062
	(0.64)		(-0.57)
YR2012 x ACHIEVE	0.0261	YR2012 x FULLCOV	0.0099
	(1.91)*		(0.72)
YR2013 x ACHIEVE	-0.0174	YR2013 x FULLCOV	-0.0086
	(-1.57)		(-0.77)
YR2014 x ACHIEVE	-0.0364	YR2014 x FULLCOV	-0.0351
	(-2.48)**		(-2.38)**
YR2015 x ACHIEVE	-0.0391	YR2015 x FULLCOV	-0.0482
	(-2.33)**		(-2.83)***
YR2016 x ACHIEVE	-0.0414	YR2016 x FULLCOV	-0.0434
	(-3.08)***		(-3.10)***
YR2017 x ACHIEVE	-0.0186	YR2017 x FULLCOV	-0.0249
	(-0.99)		(-1.32)
Control variable	Yes	Control variable	Yes
City fixed effect	Yes	City fixed effect	Yes
Year fixed effect	Yes	Year fixed effect	Yes
N of cities	285	N of cities	285
N of obs.	4,275	N of obs.	4,275
adj. R-squared	0.9359	adj. R-squared	0.9360

Note: The dependent variable is the natural logarithm of PM2.5 in a city in a year. The *t*-statistics adjusted by robust standard error are reported in parentheses. ***, **, * represent the statistical significance at 1%, 5% and 10% level, respectively.

Robustness checks by propensity score matching

In this section, I test the main hypothesis by the propensity score matching approach. Panel A of Appendix A3.2 reports the results from logistic regressions of two dummy variables of coverage on the city characteristics. The results indicate that cities with smaller urban areas in 2013 and higher economic growth rates are more likely to achieve the minimum standard of the station number or 100% of monitoring coverage in all urban districts in 2014. City characteristics including urban population, the ratio of secondary GDP in total GDP, and whether a city is located in key control regions do not significantly affect the monitoring coverage in terms of the number of stations or covered districts. Propensity scores are estimated from the regressions for cities. A city in the treatment group is matched with a city in the control group based on the closest propensity score. Unreported results show that after the matching, the differences in covariates between treatment and control groups are insignificant.

Table 3.6 shows the result of DID estimation combined with the PSM strategy. I continue to find significant and negative estimates for PM2.5 concentration, implying the robustness of my result. Panel A of Table 3.6 shows that PM2.5 concentrations reduce significantly more after the implementation of the Action Plan in cities that achieve the minimum standard of monitoring stations and cities whose all urban districts are monitored compared with matched cities with similar covariates. The reduction magnitudes per year are even larger than the results from the full sample and amount to 3.64% and 5.37%. Panel B of Table 3.6 gives the parallel trend analysis based on the matched sample. The results indicate again that treated cities decrease air pollutions more only after 2013, when the Action Plan was in effect. These results are consistent with my argument in the hypothesis that cities with full monitoring coverage (and hence better performance measurement) have larger air pollution reductions than similar cities without sufficient monitoring coverage after the Action Plan.

Table 3.6. The impact of automated coverage on PM2.5 reduction in the PSM sample

Panel A. Main effect in the PSM sample

	(1)	(2)
POST x ACHIEVE	-0.0371	
	(-3.37)***	
POST x FULLCOV		-0.0552
		(-3.99)***
Control variable	Yes	Yes
City fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
N of cities	170	126
N of obs.	2,550	1,905
adj. R-squared	0.9473	0.9465

Panel B. Parallel trend test in the PSM sample

	(1)		(2)
YR2011 x ACHIEVE	-0.0050	YR2011 x FULLCOV	-0.0221
	(-0.39)		(-1.22)
YR2012 x ACHIEVE	0.0088	YR2012 x FULLCOV	-0.0211
	(0.48)		(-0.91)
YR2013 x ACHIEVE	-0.0137	YR2013 x FULLCOV	-0.0099
	(-1.04)		(-0.52)
YR2014 x ACHIEVE	-0.0414	YR2014 x FULLCOV	-0.0504
	(-2.23)**		(-2.17)**
YR2015 x ACHIEVE	-0.0367	YR2015 x FULLCOV	-0.0717
	(-1.68)*		(-2.64)***
YR2016 x ACHIEVE	-0.0330	YR2016 x FULLCOV	-0.0553
	(-1.98)**		(-2.28)**
YR2017 x ACHIEVE	-0.0408	YR2017 x FULLCOV	-0.0636
	(-1.68)*		(-2.09)**
Control variable	Yes	Control variable	Yes
City fixed effect	Yes	City fixed effect	Yes
Year fixed effect	Yes	Year fixed effect	Yes
N of cities	170	N of cities	126
N of obs.	2,550	N of obs.	1,905
adj. R-squared	0.9359	adj. R-squared	0.9360

Note: The dependent variable is the natural logarithm of PM2.5 in a city in a year. The t-statistics adjusted by robust standard error are reported in parentheses. ***, **, * represent the statistical significance at 1%, 5% and 10% level, respectively.

3.6 Conclusion

This study investigates the effects of the performance measurability on the air quality improvement after the launch of an environmental regulation and relevant high-powered incentive scheme. After 2013, MEE has established an automated national monitoring station network in all cities in China. The network provides data on real-time PM2.5 concentrations and other pollutants, including to the public, on an hourly basis and is managed and maintained directly by the central government. As a consequence, the network improves performance measurement of environmental protection outcomes, forms a binding environmental enforcement force to local government officials, and provides a quasi-natural experiment for examining the effects of performance measurability on public sector performance. However, since 2014, the incomplete coverage of automatic monitoring results and the insufficient measurement of air pollutions in all urban areas in a city leave room for geographic gaming response of local government officials when implementing the air pollution control initiatives of the Action Plan. In this study, I find that cities with better performance measurability have strengthen the Action Plan effects and achieve a larger reduction in PM2.5 concentration.

The findings yield several policy implications. First, my findings show that automatic monitoring by the central government helps improving performance measurement and incentivizes local governments to achieve the pre-set environmental targets, which can be a solution to insufficient implementation of environmental protection by local governments in China (Zhang et al., 2018). However, environmental improvements are not equal across regions, depending on the intensity of the monitoring. An immediate policy implication is that the central government should extend the monitoring network to cover more evenly and comprehensively all distractions in all prefectural-level or above cities, which mitigate the potential gaming response of local officials due to incomplete measurability of overall environmental performance. Second, the principal-agent problem in the environmental protection between the central government and local governments can only be partially solved by improved performance measurement through non-manipulable data from automatic monitoring stations (Greenstone et al., 2020). By gaming response, local governments improve air quality only in the districts covered by monitoring stations, but not in the whole governed areas; and even worse, polluting activities can be strategically allocated between the monitored and non-monitored districts. To further improve air quality, the inherent conflict of economic growth and environmental protection needs to be resolved.

References

Baker, G. (1992). Incentive contracts and performance measurement. *Journal of Political Economy*, *100*(3), 598-614.

Baker G., Gibbons, R. & Murphy, K., (1994). Subjective performance measures in optimal incentive contracts. *Quarterly Journal of Economics*, *109*(4), 1125-1156.

Burgess, S., Propper, C., Ratto, M., & Tominey, E. (2017). Incentives in the public sector: Evidence from a government agency. *The Economic Journal*, *127*(605), 117-141.

Cai, H., Chen, Y., & Gong, Q. (2016). Polluting thy neighbor: Unintended consequences of China′ s pollution reduction mandates. *Journal of Environmental Economics and Management*, *76*, 86-104.

Chen, Y. J., Li, P., & Lu, Y. (2018). Career concerns and multitasking local bureaucrats: Evidence of a target-based performance evaluation system in China. *Journal of Development Economics*, *133*, 84-101.

Chen, Y.Y, Jin, Z., Kumar, N. & Shi, G. (2012). Gaming in Air Pollution Data? Lessons from China. *The B.E. Journal of Economic Analysis & Policy*, 13(3), 1-43.

Courty, P., & Marschke, G. (1997). Measuring government performance: lessons from a federal job-training program. *American Economic Review*, *87*(2), 383-388.

Courty, P., & Marschke, G. (2004). An empirical investigation of gaming responses to explicit performance incentives. *Journal of Labor Economics*, *22*(1), 23-56.

Courty, P., & Marschke, G. (2011). Measuring government performance: an overview of dysfunctional responses. In The Performance of Performance Standards, MI: W.E. Upjohn Institute for Employment Research, 203-230.

DeVaro, J., & Gürtler, O. (2016). Strategic shirking in promotion tournaments. *The Journal of Law, Economics, and Organization*, *32*(3), 620-651.

Dechelepretre, A., Koźluk, T., Kruse, T. Nachtigall, D. & Serres, A. (2019). Do Environmental and Economic Performance Go Together? A Review of Micro-level Empirical Evidence from the Past Decade or So. *International Review of Environmental and Resource Economics, 13*(1-2), 1 – 118.

Dixit, A. (2002). Incentives and organizations in the public sector: An interpretative review. *Journal of human resources*, 696-727.

Dranove, D., Kessler, D., McClellan, M., & Satterthwaite, M. (2003). Is more information better? The effects of "Report Cards" on health care providers. *Journal of Political Economy*, *111*(3), 555-588.

Fisman, R., & Wang, Y. (2017). The distortionary effects of incentives in government: Evidence from China's" death ceiling" program. *American Economic Journal: Applied Economics*, *9*(2), 202-218.

Greenstone, M., He, G., Jia, R., & Liu, T. (2020). Can Technology Solve the Principal-Agent Problem? Evidence from China's War on Air Pollution. *NBER Working Paper* (w27502).

He, J. (2006). Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO2) in Chinese provinces. *Ecological Economics, 60*(1), 228-245.

He, G., Wang, S., & Zhang, B. (2020). Watering down environmental regulation in China. *Quarterly Journal of Economics*, *135*(4), 2135-2185.

Holmström, B. (1979). Moral hazard and observability. *The Bell Journal of Economics*, *10*(1), 74-91.

Holmström, B. (2017). Pay for performance and beyond. *American Economic Review, 107*(7), 1753-1777.

Holmström, B., & Milgrom, P. (1991). Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design. *Journal of Law, Economics, & Organization*, *7*, 24-52.

Jacob, B. & Levitt, S. (2003). Rotten Apples: An Investigation of the Prevalence and Predictors of Teacher Cheating. *Quarterly Journal of Economics*, *118*(3), 843-877.

Jacobson, L. S., LaLonde, R. J., & Sullivan, D. G. (1993). Earnings losses of displaced workers. *The American Economic Review*, *85*(4) 685-709.

Jia R. (2017). Pollution for Promotion. Working paper.

Kahn, C. M., Silva, E. C. D., & Ziliak, J. P. (2001). Performance-based wages in tax collection: the Brazilian tax collection reform and its effects. *The Economic Journal*, *111*(468), 188-205.

Kahn, M. E., Li, P., & Zhao, D. (2015). Water pollution progress at borders: the role of changes in China's political promotion incentives. *American Economic Journal: Economic Policy*, *7*(4), 223-242.

Kearsley, A., & Riddel, M. (2010). A further inquiry into the Pollution Haven Hypothesis and the Environmental Kuznets Curve. *Ecological Economics*, *69*(4), 905-919.

Keller, W., & Levinson, A. (2002). Pollution abatement costs and foreign direct investment inflows to U.S. states. *Review of Economics and Statistics*, *84*(4), 691-703.

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review*, *45*(1), 1-28.

Lavy, V. (2009). Performance Pay and Teachers' Effort, Productivity, and Grading Ethics. *American Economic Review*, *99*(5), 1979-2011.

Li, H., & Zhou, L.-A. (2005). Political turnover and economic performance: the incentive role of personnel control in China. *Journal of Public Economics*, *89*(9-10), 1743-1762.

Llop, M. (2007). Economic structure and pollution intensity within the environmental input–output framework. *Energy Policy*, *35*(6), 3410-3417.

Ministry of Environmental Protection (MEP). (2013). Technical Regulation for Selection of Ambient air Quality Monitoring Stations (on Trial) HJ 664-2013, The Ministry of Environmental Protection of People's Republic of China, People's Republic of China (2013)

Propper, C., & Wilson, D. (2003). The use and usefulness of performance measures in the public sector. *Oxford Review of Economic Policy*, *19*(2), 250-267.

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41-55.

Selden, T. M., & Song, D. (1994). Environmental quality and development: is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, *27*(2), 147-162.

Wang, J., & Lei, P. (2020). The tournament of Chinese environmental protection: Strong or weak competition? *Ecological Economics*, 106888.

Williamson, O.E. (1985). The Economic Institutions of Capitalism. New York: The Free Press.

Wu, J., Deng, Y. Morck, R. & Yeung, B. (2014). Incentives and outcomes: China's environmental policy. *Capitalism and Society*, 9(1):1-41.

World Health Organization. (2006). *Air quality guidelines: global update 2005: particulate matter, ozone, nitrogen dioxide, and sulfur dioxide*. World Health Organization.

Zhang, Q., He, K., & Huo, H. (2012). Cleaning China's air. *Nature*, *484*(7393), 161-162.

Zhang, B., Chen, X., & Guo, H. (2018). Does central supervision enhance local environmental enforcement? Quasi-experimental evidence from China. *Journal of Public Economics, 164*, 70-90.

Zheng S., Kahn M. E., Sun W. & Luo, D. (2013). Incentives for China's urban mayors to mitigate pollution externalities: the role of the central government and public environmentalism. *Regional Science and Urban Economics, 47*, 61-71.

3.A Appendices

Appendix A3.1. Variable definitions

Variable	Definition
PM2.5	Annual PM2.5 (μg/m³) in a city in a year
LNPM2.5	Natural log of annual PM2.5 in a city in a year
NUM	Actual number of automatic air quality monitoring stations in a city
STRATIO	The ratio of actual number of monitoring stations in a city over the minimum required number of stations by its built-up area
ACHIEVE	Dummy variable, equal to 1 if a city achieves the minimum requirement of the number of monitoring stations
DISTCOV	Percentage of urban districts covered by the monitoring station in a city
FULLCOV	Dummy variable, equal to 1 if all urban districts in a city are covered by the monitoring station
POST	Dummy variable, equal to 1 if a year is after 2013, the announcement of the Action Plan
LNGDP	Natural log of GDP per capita in a city in a year
LNPOP	Natural log of urban population in a city in 2013
LNAREA	Natural log of urban built-up area in a city in 2013
SECGDP	The ratio of secondary GDP in the overall GDP in a city in a year
TRDGDP	The raito of tertiary GDP in the overall GDP in a city in a year
GDPGROWTH	GDP growth rate in a city in a year
LNPOPDEN	Natural log of population density in a city in a year; population density is urban population (thousand) per square km of urban area
LNFDI	The log of FDI (in million USD) in a city in a year
LNFAINV	The log of fixed asset investment (in million) in a city in a year
KEY	Dummy variable, equal to 1 if a city is listed as key city to control air pollution
OLD	Dummy variable, equal to 1 if a city is an environmental protection city and has been already monitored since 2007
ENVWORD	The logarithm of the number of words related to environmental protection in local government working reports
TARGETPM25	Dummy variable, equal to 1 if environmental task is related to PM2.5 reduction in a city

Appendix A3.2. Logistic regressions for propensity score matching in the cities

	(1)	(2)
	DV = ACHIEVE	DV = FULLCOV
LNAREA	-1.8552	-1.9050
	(-4.81)***	(-4.82)***
LNPOP	0.1563	-0.2344
	(0.49)	(-0.74)
LNGDP	0.6310	0.8979
	(2.05)**	(2.81)***
SECGDP	-0.5607	-1.0072
	(-0.39)	(-0.68)
KEY	0.4296	-0.3802
	(1.02)	(-0.89)
TARGETPM25	-0.8160	0.0385
	(-2.44)**	(0.11)
Constant	4.8083	5.7767
	(3.78)***	(4.34)***
N of obs.	285	285
Pseudo R-squared	0.1412	0.1734

Note: The t-statistics adjusted by robust standard error are reported in parentheses. ***, **, * represent the statistical significance at 1%, 5% and 10% level, respectively.

Chapter 4 Political Hierarchy and Corporate Environmental Governance: Evidence from the Centralization of Environmental Administration in China[45]

4.1 Introduction

This paper investigates the interplay of political hierarchy and corporate environmental governance in China. China has the world's second largest economy and its largest population. It is also one of the world's largest polluters, with a long history of environmental degradation (Liu and Diamond, 2005). One of the major obstacles to environmental protection in China is that local Environmental Protection Bureaus (EPBs) have a low position in the political hierarchy and they are in conflict with the interests of local governments, their direct administrators. Recently, the Chinese government has taken steps to address the issue of weak environmental enforcement by local EPBs, including the implementation of an environmental vertical administration reform between 2016 and 2019. Under the reform, the administration of sub-provincial EPBs is transferred from local governments to provincial EPBs. This reform has changed the entire structure of environmental administration in China; however, no study has been carried out to evaluate its effects at the corporate level. This paper aims to evaluate the effectiveness of the verticalization reform and how it affects corporate environmental governance.

This study investigates the impact of the verticalization reform on 2,741 listed firms from 2012 to 2021 in China. To measure corporate environmental governance, this study evaluates the environmental pillar of Sino-Securities Index (SSNI) ESG Ratings. Before the verticalization reform, the environmental regulation of local governments was supervised by Supervision Centres for Environmental Protection (SCEPs), established by central government. A recent study found that environmental quality decreases with increasing geographical distance from SCEPs due to increased supervision costs (Chen, Xu and Qi, 2022). Via a difference-in-differences analysis, my study adds that local and central state-owned enterprises (SOEs) have lower environmental performance compared with privately owned enterprises (POEs) as supervision costs increase. These results establish the preconditions for my research.

[45] This chapter is co-authored with Eddie C. M. Hui, Jianfu Shen and Simba Xin Chang.

Because SOEs have equal or higher rankings in political hierarchies than local EPBs and local governments protect SOEs for economic development, local EPBs cannot regulate the pollution caused by SOEs without the assistance of SCEPs.

By taking advantage of the staggered implementation of the verticalization reform across provinces from 2016 to 2019, my generalised difference-in-difference analysis shows that the verticalization reform improves the environmental performance of local SOEs, along with an increase in supervision costs by SCEPs. However, the verticalization reform does not significantly impact on the environmental governance of central SOEs and POEs. The results indicate that the transfer of sub-provincial EPBs to provincial EPBs allows them to regulate the environmental problem of local SOEs. However, as provincial EPBs are still ranked lower in the political hierarchy than central SOEs, local EPBs have no authority to enforce their powers on central SOEs. POEs were already managed by local EPBs before the verification reform, so they are not affected. The results remain valid after adjusting for the potential estimation bias of the staggered difference-in-differences analysis (Sun and Abraham, 2021). In addition, this study conducts a series of robustness tests to ensure that my conclusion is robust, including using social and governance ratings as placebos, substituting alternative proxies for supervision costs by central government, using environmental incidents as an alternative measure of corporate environmental governance, controlling for additional firm characteristics and evaluating confounding events and explanations.

Furthermore, my study indicates that local governments that pay less attention to environmental protection experience greater impacts from the verticalization reform on the environmental performance of their local SOEs. The results meet my expectation that local SOEs that previously received greater protection from local government are more likely to be affected by the verticalization reform. Moreover, my study shows that the verticalization reform increases the abatement investments of local SOEs as the distance between them and SCEPs increases, but that their financial performance and corporate valuation do not suffer significantly as a result. This implies that the verticalization reform has improved corporate environmental governance without affecting operating efficiency or company valuations.

My paper contributes to the existing literature in three ways. First, this paper offers insights into how the political hierarchy affects social welfare. Political power distribution within the government hierarchy is essential for the proper functioning of government and economic performance (Markevich and Zhuravskaya, 2011; Bardhan, 2016). Over the past few decades, numerous developing countries have established subnational administrative units to improve the efficiency of government administration (Grossman and Lewis, 2014). Nevertheless, these efforts may lead to further reductions in social welfare and administrative capacity, as local capture leads to an increased risk of corruption as politicians seek to expand their patronage networks (Bardhan and Mookherjee, 2000; Fan et al., 2009; Grossman et al., 2017). Although a recent study provides guidelines to determine the optimal structure of political hierarchies in democratic countries (Boffa et al., 2016), the ideal government structure for authoritarian states remains a matter of debate. In China, local governments have the right to determine the fiscal resources and appointments of lower-level divisions, depending on their political preferences (Xu, 2011). Recent studies indicate that the promotion in political rank of a region in China could result in a substantial increase in economic performance, as well as environmental quality (Jia et al., 2021; Yang and Shi, 2022). SOEs in China have their own political rank, and their managers can be promoted to government positions (Wu, 2005; Liang et al., 2015). Despite this, the interaction between government and SOEs has not been previously been studied based on political hierarchy. This study fills a research gap and demonstrates the importance of considering the political ranks of both government departments and SOEs when promoting social welfare.

Furthermore, this paper provides insights into the effectiveness of centralisation in promoting public welfare. According to theoretical studies, decentralisation improves resource allocation and social welfare, because local governments strive for efficiency and have a better understanding of local conditions (Hayek, 1945; Tiebout, 1956; Qian and Roland, 1998; Alonso et al., 2008). However, recent environmental studies document that decentralisation can result in a free-riding problem and exacerbate pollution externalities (Sigman, 2005; Boffa et al., 2014; Lipscomb et al., 2017). Studies in China further suggest that decentralisation decreases environmental quality as local governments put greater emphasis on dominating political missions, such as economic development (Kahn et al., 2015; He et al., 2020; Fan et al., 2023), and central supervision may mitigate pollution (Zhang et al., 2018; Shen et al., 2022). However, few studies hav evaluated how change in the political hierarchy system impacts on environmental quality directly. My research is closely aligned with that of Chen, Shi, Zhang and Zhang (2022), who found that the verticalization reform can improve air quality in China. Their study examines the readings of air quality monitoring stations across different provinces, as well as the response of local government at the prefectural city level. In contrast to their study, my study examines the effects of verticalization directly at the corporate level. Furthermore, my analysis provides insights into how the political hierarchy of enterprises responds differently following the centralisation reform. To assist policymakers in evaluating the benefits and costs of the verticalization reform, the consequences of financial performance as well as corporate valuations in the financial market are also considered.

Lastly, this study also adds to the growing body of literature on the impact of environmental regulation on pollution in developing countries. As stated by Greenstone and Jack (2015), political economy factors undermine efficient policymaking, which is a major cause of poor environmental quality in developing countries. Several papers have found that failures of environmental policy implementation can result from loopholes in policy design and poor targeting (Davis, 2008; Davis et al., 2014; Duflo et al., 2018), whereas those that are able to overcome these problems can improve environmental quality (Foster et al., 2009; Greenstone et al., 2020). My study further adds that the effectiveness of environmental regulation depends on the political rank of SOEs. Previous studies suggest that heterogeneity in the performance of SOEs is positively correlated with geographical distance, which in turn is positively correlated with supervision costs (Huang et al., 2017). The empowerment of local EPBs might improve the environmental governance of local SOEs in regions with high supervision costs, but it does not improve the environmental performance of central SOEs.

4.2 Institutional background

Political Hierarchy and Supervision Centers for Environmental Protection (SCEPs)

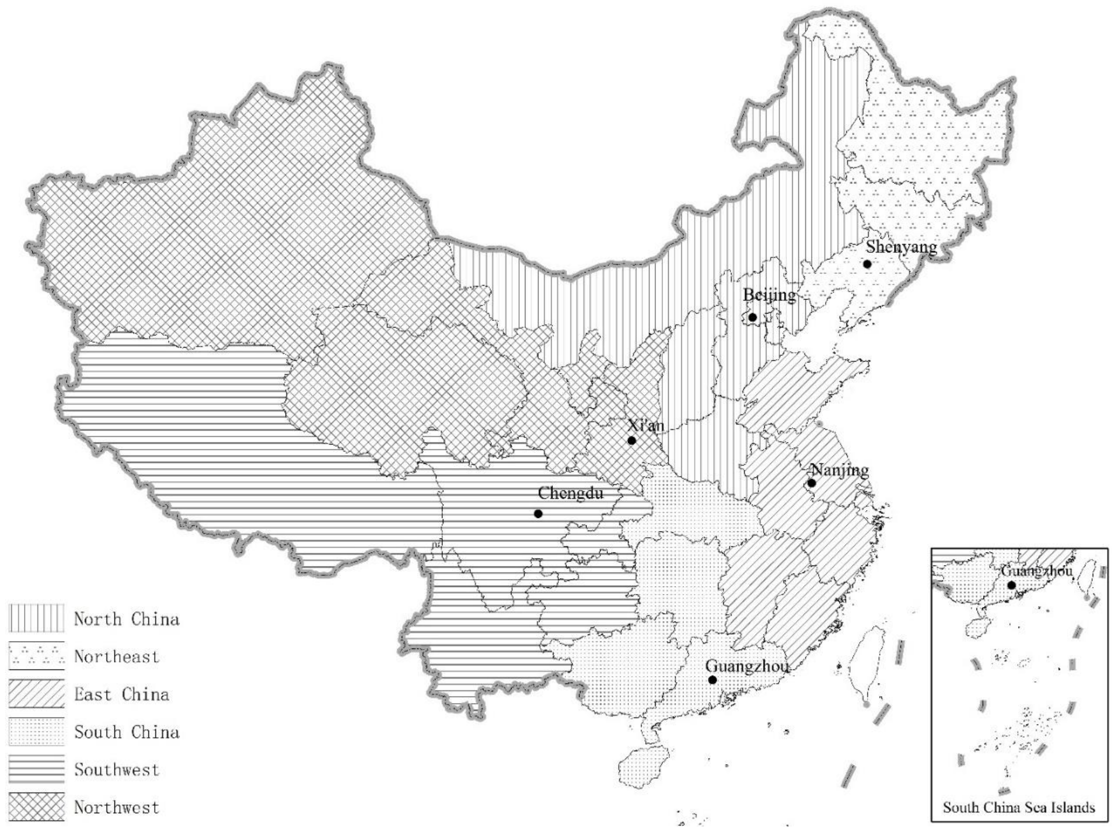
Before the environmental vertical administration reform, local Environmental Protection Bureaus (EPBs) were directly administered by local governments.

Considering that local officials with greater economic achievement are more likely to be promoted, local governments have a strong incentive to promote economic growth (Li and Zhou, 2005; Li et al., 2019). When economic growth and environmental quality are competing for resources, local governments will prioritize economic growth over environmental protection. Local governments may even deliberately reduce environmental quality in order to attract business investment, resulting in race-to-the-bottom competition (Wu et al., 2013; Deng et al., 2019; Fan et al., 2023). As a result, the duty of local EPBs conflicts with the interests of their direct administrators. In response, local governments allocate limited resources and capital to support local EPBs in the enforcement of their responsibilities. Alternatively, local EPBs may select environmental regulations that they believe have a lesser impact on the political objectives of their superiors (Kostka and Nahm, 2017).

Furthermore, local EPBs' low position in the political hierarchy contributes to their inability to enforce their duties effectively; therefore, it is difficult for local EPBs to police SOEs which possess higher political rank. In China political system, SOEs hold ranks within the bureaucratic hierarchy, and their managers are also entitled to political promotion within the government sector. Central (local) SOEs are under the authority of central (local) government, and their political rank is usually the same as or higher than that of local EPBs in most cases. Due to the lack of political authority of local EPBs and the presence of central (local) protectionism, local EPBs are often unable to impose regulatory requirements on SOEs that pollute within their jurisdiction due to a lack of regulatory capacity. A good analogy to describe the regulatory status of local EPBs is "The cat wants to catch the mouse, but the mouse is bigger than the cat" (Wang et al., 2008).

To resolve the issue of insufficient environmental enforcement, the central government established six regional Supervision Centres for Environmental Protection (SCEPs) after 2006 (see Fig. 4.1). SCEPs perform three key functions: collecting pollution data, conducting inspections and coordinating regional environmental regulations. However, SCEPs only perform supervisory functions and are explicitly prohibited from interfering in the environmental protection activities of local governments and EPBs. As SCEPs lack direct authority to regulate environmental misconduct, their primary responsibility is to supervise local government and EPBs, as well as to relay pollution information to central government for further review. Because SCEPs are directed by central government, their supervision ensures that local EPBs adhere to environmental laws and perform their duties. This can mitigate the problem of central (local) protectionism and the low level of political hierarchy of local EPBs when regulating the environment.

Figure 4.1. Supervision Centers for Environmental Protection (SCEP)



Due to the large size of China, there has long been a lack of effective communication between local and central governments. When central government monitors local governments across the regions, the supervision cost increases with geographical distance (Huang et la., 2017). In regions where SCEPs have high supervision costs, SOEs and EPBs are more likely to be accountable to their direct administrators. This undermines the effectiveness of environmental oversight by the central government.

Although SCEPs have alleviated the problem of insufficient political rank in environmental regulation by local EPBs, high supervision costs make these initiatives less effective in distant regions (Chen, Xu and Qi, 2022). In this regard, distance is considered to be an important factor affecting the intensity of environmental supervision by central government.

Environmental Vertical Administration Reform

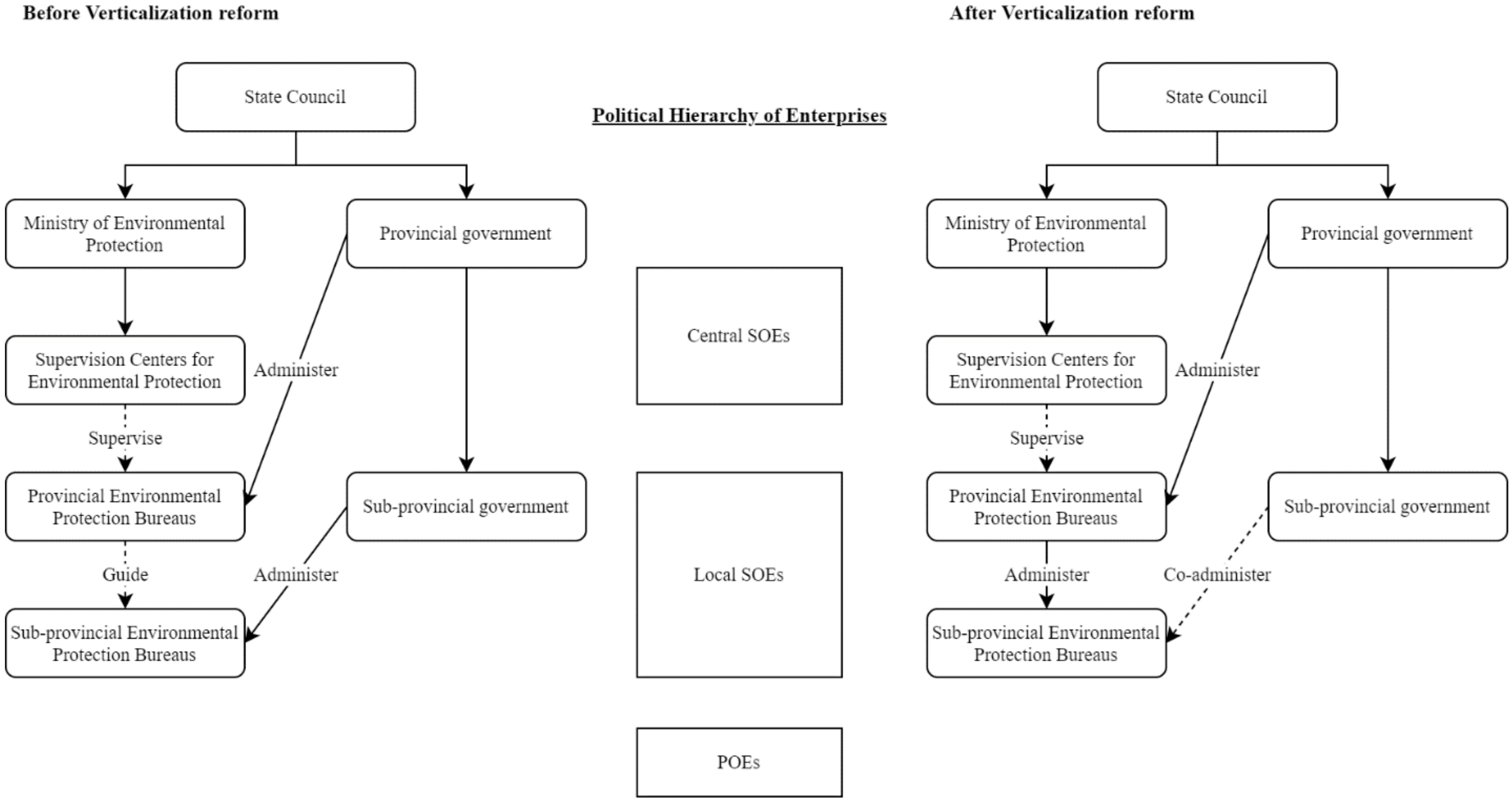
To boost the environmental enforcement power of sub-provincial EPBs, the General Office of the Chinese Communist Party (CCP) Central Committee and the General Office of the State Council in China published its " Guiding Opinions on the Pilot Reform Program for the Vertical Administration System for Law Enforcement in Monitoring and Supervision by Environmental Protection Institutions at or Below the Provincial Level" in September 2016. Essentially, this document seeks to boost the authority of provincial Environmental Protection Bureaus to administer lower-level Environmental Protection Bureaus, so as to mitigate the interference of lower-level governments in environmental protection.

Previously, prefectural governments had the authority to nominate the director and deputy director of prefecture EPBs, but this was transferred to provincial EPBs under the environmental verticalization reform. In addition, prefectural governments are not permitted to veto nominations, although they may express their opinions on nominees. Furthermore, the power to appoint or dismiss the secretary, deputy secretary and members of the CCP committees of prefectural EPBs has also been transferred from prefectural governments to provincial EPBs. Rather than being directly administered by county governments, county EPBs were reorganized into branches of prefectural EPBs. Prefecture EPBs now have the authority to appoint or dismiss the executives and party committees of county EPBs. Following the reform, provincial EPBs are responsible for monitoring, evaluating and assessing the environmental quality of prefectural cities and counties. Leaders and officials of sub-provincial EPBs are now evaluated by upper level EPBs rather than local governments. Due to their alignment with interests, sub-provincial EPBs avoid conflicts of interest between their duties and career prospects and can better enforce their own environmental protection regulations.

My study illustrates the political hierarchy of EPBs and enterprises, following Chen, Shi, Zhang and Zhang (2022), in Figure 4.2. Before the verticalization reform, SCEPs supervised provincial and sub-provincial EPBs to enforce environmental regulations. However, their supervision costs increased with increasing geographical distance from local EPBs. In distant regions, local EPBs were more likely to collude with or capitulate to local governments; therefore, local and central SOEs would prioritise economic growth in exchange for environmental protection. After the verticalization reform, the power to administer and nominate sub-provincial leaders in EPBs was transferred from sub-provincial governments to provincial EPBs. Sub-provincial EPBs are now free of any conflicts of interest in environmental protection, so they can oversee some local SOEs. Due to the boosting of environmental regulation, the corporate environmental governance of local SOEs should be strengthened, especially in distant regions where the supervision costs of central government are particularly high.

According to the Guiding Opinions, pilot provinces were required to implement the verticalization reform before June 2017, and the rest by June 2018. In spite of the fact that the actual roll-out time was later than what was required, the verticalization reform was implemented in every province. The actual timeline for the announcement of environmental verticalization reforms by each province is shown in Appendix A4.1.

Figure 4.2. Political hierarchy before and after the verticalization reform



4.3 Hypotheses development

Previous studies suggest that heterogeneity in the performance of SOEs is positively correlated with geographical distance, which is in turn positively correlated with the costs of communication and supervision (Huang et al., 2017). Despite central government establishing SCEPs to address insufficient environmental supervision by local EPBs, the high supervision costs associated with distance have eroded the effectiveness of supervision in distant regions (Chen, Xu, and Qi, 2022). This erosion may be greater among local SOEs and central SOEs, since they are at the same or higher level of the political hierarchy than local EPBs. SOEs are directly administered by local (or central) governments, and one of their primary objectives is economic growth rather than environmental protection. In pursuit of promotion, their managers are likely to prioritise economic growth over environmental quality. In this way, they are able to circumvent the environmental regulations of local EPBs, wherein local governments are in conflict with their political duties and offer little assistance to them. Therefore, it is expected that local SOEs and central SOEs will have worse corporate environmental governance than POEs as distances from SCEPs increase.

After the verticalization reform, the power of sub-provincial EPBs was transferred from sub-provincial governments to provincial EPBs. Sub-provincial EPBs are now free of conflicts of interest in environmental protection, so they can oversee some local SOEs. With the verticalization reform, the administration power of sub-provincial EPBs is transferred from local governments to provincial EPBs. When it comes to environmental protection, sub-provincial EPBs are now free from conflicts of interest with the political objectives of local governments, thereby allowing sub-provincial EPBs to supervise local SOEs to some extent. Thus, local SOEs are expected to improve their corporate environmental governance, particularly those in regions less subject to central government oversight. However, the corporate environmental governance of enterprises has been strictly regulated before (i.e. private enterprises), or enterprises with a higher level in the political hierarchy than provincial EPBs (i.e. central SOEs), and thus are not likely be affected by the verticalization reform.

4.4 Sample, data and variables

This paper investigates the impact of the environmental verticalization reform on the corporate environmental performance of public companies in China. Corporate environmental performance is measured by the environmental pillar of Sino-Securities Index ESG Ratings (SNSI ESG ratings). Sino-Securities ESG ratings incorporate international mainstream ESG evaluation frameworks and assign ratings for each of the three fundamental pillars: environmental, social and governance.[46] The environmental pillar (*ENV*) evaluates the environmental risk exposure and environmental risk management capabilities of listed firms. Environmental risk exposure is related to the overall operating characteristics of industries that cause enterprises to have relatively large cost constraints or regulatory constraints related to the environment, whereas environmental risk management capabilities are related to an enterprise's response to environmental risk measures.[47] The SNSI assigns nine grades of ESG ratings from C to AAA. Following existing literature, this paper converts ESG rating grades from low to high on a scale of one to nine (Feng et al., 2022; Ferrell et al., 2016; Krüger, 2015). This paper considers the environmental performance of listed firms as the ratings of the environmental pillar at the end of each year.[48]

[46] The SNSI follows these procedures in their ESG rating system. First, it sets a theoretical benchmark for each indicator according to previous literature research, international/ national standards and practical experience. Second, it categorizes data into structured data and unstructured data. It then uses machine learnings algorithms, such as NLP technology and semantic analysis, to analyse unstructured data. Lastly, statistical methods are employed to determine the impact of ESG events based on their effect time and influence level, and then ratings are assigned to each ESG pillar.

[47] Specifically, 15 key issues in five environment-related themes are assessed by SNSI using machine learning and big data analysis, including greenhouse gas emissions, a greenhouse gas emissions reduction roadmap, response to climate change (climate change theme); water consumption, land use and biodiversity, materials consumption (resources utilization theme); industrial emissions, electronic waste, hazardous waste (environmental pollution theme); renewable energy, green buildings, green factories (environmentally friendly theme); sustainable certification, environment penalty, sustainable supply chain management (environmental management theme).

[48] Comparing with other ESG databases in China, SNSI ESG ratings have numerous advantages. First, SNSI ESG ratings cover almost all A-share listed companies. Other alternative ESG databases (including SynTao ESG ratings, Refinitiv's ASSET4, MSCI KLD and Bloomberg) only cover large cap stocks in China (Broadstock et al., 2021; Ben-Nasr and Ghouma, 2018; Wei et al., 2020; Chen et al., 2023). In addition, SNSI ESG ratings have covered the China stock market for a longer period of time since 2009, in contrast to other alternative ESG databases that have only recently covered the market. Furthermore, it provides separate ratings for each E/S/G metric and updates each metric continuously, enabling this study to focus solely on the corporate environmental governance of listed firms in China. Lastly, SNSI ESG ratings analyse over 20 million pieces of data, including company disclosures, media news and NGO reports, using machine learning algorithms to determine the ESG metrics of each listed firm in China. Its ratings system is more suitable for and objective in my analysis than those of other

Additional analysis uses data from RepRisk to measure the environmental consequences of listed companies using an event-based outcome measure of firm-level environmental incidents following recent studies (Li and Wu, 2020; Bansal et al., 2022; Houston and Shan, 2022). RepRisk compiled an extensive database, derived from over 100,000 public sources in 23 languages, on more than 200,000 companies from 2007 to 2021. RepRisk covers almost all A-shared listed companies in China. Using rule-based algorithms based on machine learning and linguistic analysis, RepRisk translates big data into structured data in order to identify material ESG risks that could threaten a company's reputation, compliance and financial stability. Issues relating to environmental incidents can be divided into six categories: (1) animal mistreatment; (2) climate change, GHG emissions and global pollution; (3) impacts on landscapes, ecosystems and biodiversity; (4) local pollution; (5) overuse and wasting of resources; (6) waste issues. This paper considers the environmental consequences of listed firms as the number of environmental incidents that occur over the course of a year (*REPENV*).

This paper measures the environmental supervision costs of central government as the geographical distance from regional Supervision Centres for Environmental Protection (SCEPs) following Chen, Xu and Yi (2022). SCEPs were established between 2006 and 2009 and supervise pollution emissions in 31 provinces. Each SCEP is headquartered in a provincial capital (or directly administered municipality) but must administer several provinces. In this respect, the supervisory cost of listed companies is positively related to the distance between the headquarters of SCEP and the jurisdictions where companies are located. Geographical distance can capture transportation, time and information costs, which raise regulatory and supervision costs (Huang et al., 2017; Campante and Do, 2014). Therefore, geographical distance can serve as a proxy for central government supervision costs before the environmental verticalization reform in 2016. Following Chen, Xu and Yi (2022), this study takes the logarithm of geographical distance between the jurisdiction of SCEPs and listed firms, and then the distance is standardised as an interval of [0,1].

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alternative ESG rating agencies which may put greater emphasis on policy or disclosure than on actual ESG performance (Yuan et al., 2022).

My paper manually collects the announcement time of the environmental verticalization reform in each province from the official websites of provincial governments.[49] For provinces that launched environmental verticalization reforms during the first half of the year, the verticalization reform year was set as the same year as the announcement. Provinces that announced the verticalization reform in the second half of the year were assigned the following year as their verticalization reform year. The above identification provides listed companies with sufficient time to incorporate the impact of environmental verticalization reforms into their corporate environmental governance by the end of the year. Appendix A4.1 shows the announcement time for environmental verticalization reforms by province and the verticalization reform year utilised in this study.

The ownership of companies is identified by the actual controller based on the database of China Stock Market and Accounting Research (CSMAR). CSMAR classifies the nature of actual controlling shareholders, such as central government authorities, local government enterprises or non-state entity (Wang et al., 2008; Bradshaw et al., 2019; Chen et al., 2020; Chen et al., 2011). Table 4.1 presents the number of local state-owned enterprises (LSOE/ local SOEs), central state-owned enterprises (CSOE/ central SOEs) and privately owned enterprises (POE). During the sample period from 2012 to 2021, the number of local SOEs increased from 698 to 783, while the number of central SOEs remained around 260 to 270. Privately owned enterprises increased from 1,085 in 2012 to 1,703 in 2018, and then declined slightly to 1,573 in 2021.

[49] Some provincial governments do not officially announce the exact date of the environmental verticalization reform. To acknowledge the announcement date, I review official media and leave a message on the local government's official website. In addition, I verify that the announcement date is in accordance with the recent study conducted by Chen et al. (2022).

Table 4.1. Number of firms by the nature of actual controllers per year

	LSOE	CSOE	POE
2012	698	274	1,085
2013	699	269	1,100
2014	691	273	1,176
2015	694	271	1,300
2016	711	266	1,423
2017	726	263	1,680
2018	726	265	1,703
2019	733	275	1,673
2020	764	269	1,629
2021	783	259	1,573
Total	7,225	2,684	14,342

According to previous literature, this study examines the investments in abatement facilities made by firms to measure their response to environmental verticalization reforms (Chen, Shi, Zhang and Zhang, 2022; Zhang et al., 2019). In my paper, abatement investment projects are identified by item under the "construction in process" account within firms' annual financial statements using textual analysis. Investment projects that promote cleaner production, emission reductions and energy savings are classified as environmental protection projects. Total abatement investment is then obtained by aggregating the expenditure on abatement projects each year. Abatement investments are then standardised by dividing the total assets of the company (*ABATE1*) and its total revenue (*ABATE2*).

The paper considers returns on assets (*ROA*) and Tobin's Q to measure the financial performance and valuation of companies (*TOBINQ*). A broad range of firm-level control variables is constructed to measure the financial performance of public companies, including logarithm of total assets (*LNAT*), returns on assets (*ROA*), net-fixed assets to total assets ratio (*TANG*), Leverage ratio (*LEV*), Cash holdings to total asset ratio (*CASH*) and book-to-price ratio (*PB*). This study also considers board independence, institutional ownership and analyst coverage, which may have an impact on environmental performance. My analysis considers the following variables: duality of the CEO (*DUALITY*), logarithm of director number (*DIRNUM*), proportion of independent directors (*INDIR*), proportion of female directors (*FEMDIR*), logarithm of institutional investors (*INSNUM*), proportion of institutional holdings (*IO*) and logarithm of the number of analysts following the company (*ANALYST*). Definitions of the variables mentioned above are presented in Appendix A4.2. Only A-share stocks listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange are considered in my studies. Financial institutions are excluded from my analysis. The variables are winsorised at 1% and 99% to mitigate the effect of outliers in my analysis.

Table 4.2 shows summary statistics for the variables. There is a mean score of 1.926 for the environmental pillar (*ENV*) of SNSI ESG ratings, which corresponds to a "CC" grade on the rating scale. The standard deviation of environmental ratings is 1.185, which is equivalent to one grade. Social (*SOC*) and governance (*GOV*) ratings, on the other hand, have means of 4.300 and 5.178, respectively. The average number of environmental incidents per year (*REPENV*) is 0.042, with a standard deviation of 0.243. This implies that around one environmental incident will occur in every 24 companies. In general, social (*REPSOC*) and governance (*REPGOV*) incidents occur more frequently than environmental ones, with averages of 0.046 and 0.091. It is estimated that average abatement investment is 0.071% of total assets (*ABATE1*) and 0.143% of total revenues (*ABATE2*). The average return on assets ratio is 2.9% and average Tobin's Q ratio is 2.046, which is consistent with previous studies (Xu et al., 2021; Wang et al., 2019).

Table 4.2. Summary statistics

	N	Mean	Std. Dev.	1st Perc.	99th Perc.
ENV	24,032	1.926	1.185	1	6
SOC	24,032	4.300	1.976	1	9
GOV	24,032	5.178	1.523	1	8
REPENV	24,207	0.042	0.243	0	1
REPSOC	24,207	0.046	0.262	0	2
REPGOV	24,207	0.091	0.397	0	2
ABATE1	24,251	0.071	0.322	0	2.453
ABATE2	24,247	0.143	0.680	0	5.272
ROA	24,251	0.029	0.074	-.0366	0.198
TOBINQ	23,718	2.046	1.518	.842	10.142
Vertical	24,251	0.372	0.483	0	1
Distance	24,251	0.574	0.292	0.000	0.958
NDistance2	24,251	2.662	1.066	1	4
RouteDistance	24,251	0.575	0.292	0	0.954
LNAT	24,251	22.393	1.368	19.511	26.379
LNSALE	24,251	21.677	1.536	17.566	25.822
TANG	24,251	0.221	0.167	0.001	0.708
LEV	24,251	0.460	0.212	0.066	0.979
CASH	24,251	0.168	0.118	0.011	0.586
BP	24,251	0.487	0.358	0.006	1.948
DUALITY	24,251	0.247	0.431	0.000	1.000
DIRNUM	24,251	2.249	0.176	1.792	2.773
INDIR	24,249	0.375	0.056	0.333	0.571
FEMDIR	24,249	0.148	0.131	0.000	0.545
INSNUM	24,251	3.266	1.211	1.099	6.269
IO	24,251	46.169	23.642	0.31	90.791
ANALYST	24,251	1.304	1.188	0.000	3.761

4.5 Empirical evidence

Political Hierarchy and Supervision Costs before the Verticalization Reform

SOEs under central government or local authorities may have the same or higher administrative level as local Environmental Protection Bureaus (EPBs) in the Chinese political system. In comparison to private enterprises, SOEs have greater political influence, which enables them to resist pressure to improve their environmental performance. In most cases, local EPBs lack sufficient authority to regulate enterprises with higher administrative levels without the support of central government or provincial governments (Eaton and Kostka, 2017). However, the supervision costs of SOEs increase with the distance from central government or authorities because of transportation cost, communication cost and information asymmetries (Huang et al., 2017). The costs of environmental supervision by central government also increase as the distance between polluting enterprises and regional Supervision Centres for Environmental Protection (SCEPs), which are managed by central government, increases. Therefore, enterprises located far from SCEPs emit more pollutants than those located nearby (Chen, Xu, and Qi, 2022). However, no research has been conducted to examine the heterogeneous effects of environmental supervision costs on the corporate environmental performance of SOEs and privately owned companies (POEs). The following model is used to evaluate the impact of supervision costs on the environmental performance of local and central SOEs before the environmental verticalization reforms:

$$\begin{aligned} ENV_{i,j,c,t}/SOC_{i,j,c,t}/GOV_{i,j,c,t} & \\ &= \alpha + \beta_1 \times Distance_c \times LSOE_{i,j,c,t} \\ &+ \beta_2 \times Distance_c \times CSOE_{i,j,c,t} + \beta_3 \times LSOE_{i,j,c,t} + \beta_4 \times CSOE_{i,j,c,t} \\ &+ Control_{i,j,c,t} + IndustryFE_j + CityFE_c + YearFE_t + \epsilon_{i,j,c,t} \end{aligned} \tag{4.1}$$

where $ENV_{i,j,c,t}$ is my key dependent variable, which denotes the environmental ratings of listed firm *i* in industry *j* headquartered in city *c* in year *t*. Social ratings (*SOC*) and governance ratings (*GOV*) are treated as placebos for the purpose of avoiding the possibility that my results are driven by the preference bias inherent in SNSI ESG ratings rather than a reflection of corporate environmental performance. $Distance_c$ represents the distance between the city of SCEPs and the city of listed firms in the corresponding region. *LSOE* and *CSOE* are dummy variables equal to one if a firm is a local SOE or central SOE. The key explanatory variables are $Distance \times LSOE$ and $Distance \times CSOE$, which illustrates the effect of supervision costs on local and central SOEs rather than POEs. *Control* is a series of control variables including the logarithm of total assets (*LNAT*), return on assets (*ROA*), net-fixed asset to total asset ratio (*TANG*), Leverage ratio (*LEV*), Cash holdings to total assets ratio (*CASH*) and book-to-price ratio (*PB*). The model also considers industry fixed effects, city fixed effects and year fixed effects.[50] Standard errors are clustered at the firm level to tackle potential concerns relating to serial correlation and heteroskedasticity.

Table 4.3 column (1) reports the results of the impact of supervision cost on the corporate environmental performance of local SOEs and central SOEs. Coefficients for the interaction between distance and local SOEs (and central SOEs) are significantly negative, -0.310 (and -0.319). Compared to POEs, a one-standard-deviation increase in distance results in a 0.09 reduction in the environmental rating for local SOEs and central SOEs, which is about 5% of the average rating.[51] The results indicate that local and central SOEs have lower environmental performance as the supervision costs of the central government increase. However, my results do not contradict previous studies that found that SOEs have better environmental performance than POEs (Wang and Jin, 2007; Cai et al., 2016; Hsu et al., 2021; Wang et al., 2022; Zhang, 2017). My analysis documents that local SOEs and central SOEs typically have significantly higher environmental ratings of 0.231 and 0.393, respectively, than POEs. For control variables, my results indicate that firms with greater assets, revenues and a higher proportion of fixed assets have better environmental performance, which is consistent with previous studies (Liu et al., 2018; Dyck et al., 2019; Zhang et al., 2021).

[50] This study examines industry fixed effects rather than examining firm fixed effects, since firm fixed effects are closely correlated with my key explanatory variables $Distance \times LSOE$ and $Distance \times CSOE$. Industry fixed effects can control the heterogeneity of corporate environmental governance across industries.

[51] According to untabulated summary statistics, the average of environmental ratings before the environmental verticalization reforms was 1.833, while the standard deviation of geographical distance was 0.295. In consequence, a one-standard-deviation increase in geographical distance results in a reduction of 0.091 in environmental ratings, which is equivalent to 0.091/1.833 = 5% of the average environmental rating. A similar calculation can be done for central SOEs.

On the other hand, Table 4.3 columns (2) and (3) indicate that the social and governance ratings of local and central SOEs are not influenced by the environmental supervision cost of central government. My results confirm that the negative relationship between supervision costs and the corporate environmental governance of local and central SOEs cannot be attributed to the preference bias inherent in SNSI ESG ratings. My results confirm the argument that, without sufficient support from central government, local EPBs are unable to manage the environmental problem of local or central SOEs, which have a higher administrative level and political power than local EPBs.

Table 4.3. Geographical distance and environmental performance before vertical reform

VARIABLES	(1) ENV	(2) SOC	(3) GOV
LSOExDistance	-0.310**	-0.259	-0.181
	(-2.41)	(-1.28)	(-1.46)
CSOExDistance	-0.319*	-0.307	-0.198
	(-1.87)	(-1.24)	(-1.20)
LSOE	0.231***	-0.052	0.615***
	(2.68)	(-0.39)	(7.53)
CSOE	0.393***	-0.153	0.661***
	(3.50)	(-1.01)	(6.90)
LNAT	0.134***	0.147***	0.188***
	(4.80)	(2.73)	(5.72)
ROA	0.195	0.864***	1.297***
	(1.05)	(2.70)	(4.85)
LNSALE	0.072***	0.275***	0.036
	(3.22)	(6.06)	(1.28)
TANG	0.204*	-0.717***	0.383***
	(1.77)	(-3.54)	(2.87)
LEV	-0.122	-0.310**	-2.110***
	(-1.42)	(-2.06)	(-19.31)
CASH	-0.143	-0.225	0.946***
	(-1.28)	(-1.19)	(7.28)
BP	-0.008	-0.057	0.098
	(-0.14)	(-0.59)	(1.38)
Observations	15,010	15,010	15,010
R-squared	0.301	0.371	0.319
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
City FE	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The verticalization reform has strengthened the capacity of local EPBs to regulate environmental problems, since provincial EPBs now directly administer sub-provincial EPBs. After the reform, local SOEs with political levels above those of sub-provincial EPBs are not immune from investigation, and local SOEs with political levels similar to or lower than sub-provincial EPBs that are economically significant to the local economy are no longer protected by local government. Hence, it is anticipated that the reform will improve corporate environmental governance for local SOEs; however, this improvement is less pronounced for firms located around SCEPs, which are already under strict supervision from central government.

Provincial EPBs, however, are typically situated at a lower political level than central SOEs. Despite sub-provincial EPBs being empowered and directly managed by provincial EPBs, they still have no authority to enforce their power on central SOEs. On the other hand, POEs were already managed by local EPBs regardless of the verification reform, so they are not affected by this change. Thus, the reform is expected to have a greater impact only on local SOEs, especially those that were far removed from SCEPs before.

Preliminary Difference-in-differences analysis To evaluate the impact of the verticalization reform on corporate environmental performance, the following staggered difference-in-differences model is considered in my study:

$$ENV_{i,c,t} = \alpha + \beta_1 \times Vertical_{c,t} + Control_{i,c,t} + FirmFE_i + CityFE_c + YearFE_t + \epsilon_{i,c,t} \tag{4.2}$$

where $Vertical_{c,t}$ is the key explanatory variable, which is a dummy variable equal to one if city *c* has implemented the environmental verticalization reform in year *t*. Firm fixed effect is considered to better control firm-level heterogeneity.[52]

[52] Firm fixed effects are closely correlated with industry fixed effects, although some companies change their industry across the sample. It is important to note that my results remain unchanged when industry fixed effects are taken into account.

Table 4.4 Panel A illustrates the results of the regression. Column (1) indicates that the verticalization reform reduces the environmental ratings of listed companies, but the coefficient is not significant. Column (2) conducts a regression on the subsample of local SOEs. The verticalization reform has slightly increased environmental ratings for local SOEs, but the coefficient remains insignificant. Columns (3) and (4) present the regression results for central SOEs and POEs, respectively. These results indicate that the verticalization reform insignificantly reduced the environmental ratings of firms.

Table 4.4. Verticalization reform and environmental ratings

Panel A. Difference-in-difference regression

	(1)	(2)	(3)	(4)
	All	LSOE	CSOE	POE
VARIABLES	ENV	ENV	ENV	ENV
Vertical	-0.029	0.014	-0.101	-0.032
	(-1.04)	(0.25)	(-1.08)	(-0.91)
Observations	24,032	7,189	2,647	14,196
R-squared	0.685	0.685	0.738	0.693
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
City FE	YES	YES	YES	YES

Panel B. Difference-in-difference regression in geographical distance subsample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Distant	Distant	Distant	Distant	Near	Near	Near	Near
	All	LSOE	CSOE	POE	All	LSOE	CSOE	POE
VARIABLES	ENV	ENV	ENV	ENV	ENV	ENV	ENV	ENV
Vertical	-0.002	0.132*	0.016	-0.038	-0.055	-0.099	-0.138	-0.027
	(-0.06)	(1.83)	(0.15)	(-0.85)	(-1.25)	(-1.15)	(-0.73)	(-0.50)
Observations	12,382	3,875	1,355	7,593	11,650	3,314	1,292	6,603
R-squared	0.695	0.664	0.744	0.703	0.696	0.707	0.734	0.693
Control	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The verticalization reform may have a greater impact on firms that previously did not receive much government supervision. In this study, the sample is divided into distant regions and nearby regions based on the median distance between listed firms and SCEPs. In columns (1) to (4), the regression results for listed firms in regions distant from SCEPs are given, while in columns (5) to (8), the regression results for firms located near SCEPs are given. Column (1) indicates that the verticalization reform does not have a significant impact on all listed companies in distant regions. However, column (2) shows a positive coefficient for the verticalization reform for local SOEs in distant regions. The verticalization reform significantly improves environmental ratings by 0.132, which is equivalent to 6.85% of average environmental ratings.[53] In columns (3) and (4), the verticalization reform does not affect the environmental ratings of central SOEs and POEs in distant regions. Columns (5) to (8) present the impact of the verticalization reform on listed firms near SCEPs. The results for the full sample, the local SOEs sample, the central SOEs sample and the POEs sample are all insignificant.

Baseline Estimates This study further considers a generalised and staggered difference-in-differences model to evaluate the impact of the verticalization reform on corporate environmental governance by considering the heterogeneity of the supervision costs of central government following previous literature (Angrist and Pischke, 2009; Nunn and Qian, 2011; Chen, Xu and Qi, 2022). My baseline model is constructed to incorporate the gradual intensity of supervision cost proxied by geographical distance:

$$\begin{aligned} ENV_{i,c,t} = \alpha + \beta_1 \times Distance_c \times Vertical_{c,t} + \beta_2 \times Vertical_{c,t} + Control_{i,c,t} \\ + FirmFE_i + CityFE_c + YearFE_t + \epsilon_{i,c,t} \end{aligned} \tag{4.3}$$

where *Distance*×*Vertical* is the key explanatory variable, which indicates the impact of verticalization reform on environmental ratings after considering the geographical distance to SCEPs.

Table 4.5 presents the results of the regression. The coefficients for

53 The average of environmental ratings is 1.926. The proportion increase in environmental ratings is calculated as 0.132/1.926 = 6.85%.

Distance×*Vertical* and *Vertical* are insignificant in Column (1), which indicates that the verticalization reform does not have a significant impact on the environmental ratings of all the firms, even considering the supervision costs of central government. Column (2) performs a regression analysis on the subsample of local SOEs. The coefficients for *Distance*×*Vertical* are positive, 0.261, which is statistically significant at a 5% level. A standard deviation increases in distance results in a 3.96% improvement in environmental rating.[54] The coefficient for verticalization alone slightly reduces he environmentally ratings. Columns (3) and (4) illustrate the impact of the verticalization reform on central SOEs and POEs with respect to their geographical distance from SCEPs. The coefficients for *Distance*×*Vertical*, however, are all negative, and none of them are significant. To sum up, the verticalization reform only improves the environmental performance of local SOEs. The reform complements the insufficient supervision by central government in distant regions and successfully overcomes the political protection from environmental investigations conducted by sub-provincial EPBs.

[54] According to Table 4.2, the standard deviation of distance is 0.292 and the average of environmental ratings is 1.926. The proportion increase in environmental ratings for one standard deviation increase in distance is calculated as 0.261*0.292/1.926 = 3.96%. Because of the logarithmic transformation, the impact of supervision costs may be underestimated. For instance, Tianjin is a directly administered municipality located near SCEPs in Beijing. Tianjin has a logarithmic distance measure of 0.591, which means that the verticalization reform improves the environmental ratings of local SOEs by 8.96%. On the other hand, Zhengzhou, the capital and largest city of Henan Province, is far from SCEPs in Beijing city. (The distance between Zhengzhou and Beijing is six times greater than that between Tianjin and Beijing). The logarithmic distance measure of Zhengzhou is 0.805; thus, the verticalization reform has improved the environmental ratings of local SOEs there by 10.9%, not six times the distance between Tianjin and Beijing. This paper will discuss other distance measures in more detail in a later section.

Table 4.5. Baseline results - Vertical reform and environmental ratings

VARIABLES	(1) All ENV	(2) LSOE ENV	(3) CSOE ENV	(4) POE ENV
DistancexVertical	-0.031	0.261**	-0.112	-0.132
	(-0.53)	(2.37)	(-0.82)	(-1.50)
Vertical	-0.010	-0.142*	-0.040	0.050
	(-0.23)	(-1.69)	(-0.34)	(0.79)
Observations	24,032	7,189	2,647	14,196
R-squared	0.685	0.686	0.738	0.693
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
City FE	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

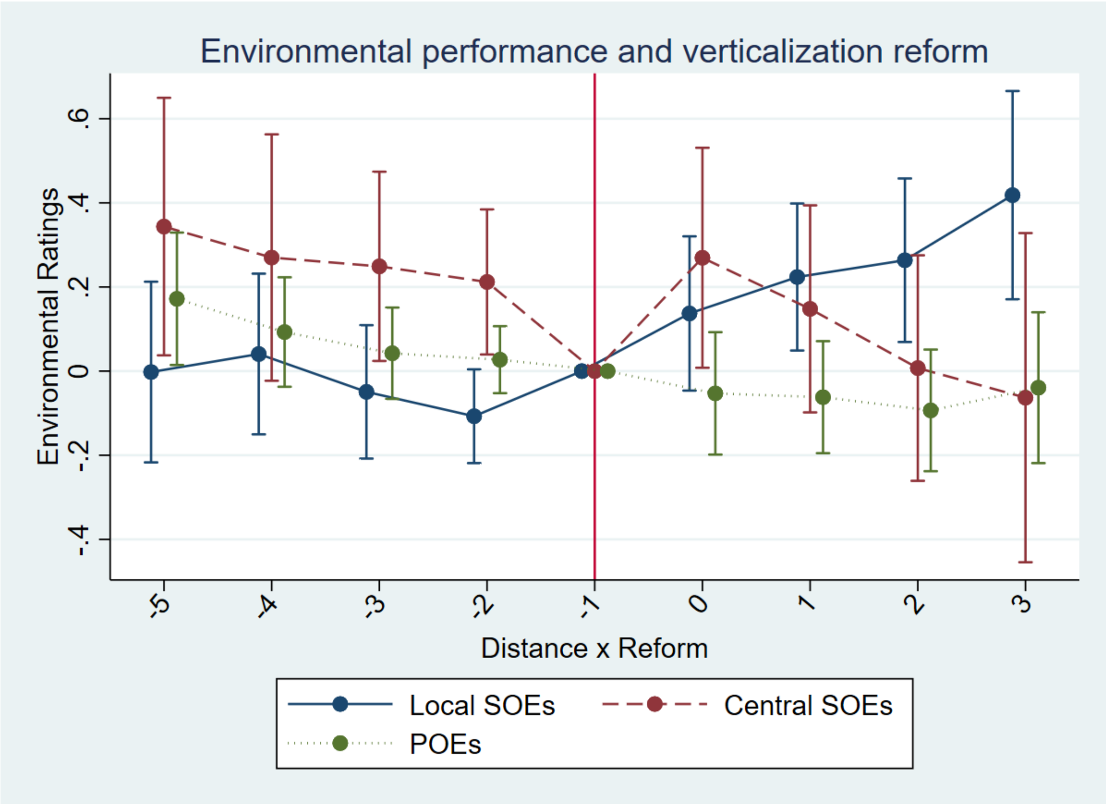
Parallel Trend Assumption Following an event-study specification, my study constructs the following method in order to analyze whether the parallel trend assumption is supported.

$$ENV_{i,c,t} = \alpha + \sum_{-5}^{3} \beta_{1,\tau} \times Distance_c \times Reform_{c,t,\tau} + \sum_{-5}^{3} \beta_{2,\tau} Reform_{c,\tau} + Control_{i,c,t} + FirmFE_i + CityFE_c + YearFE_t + \epsilon_{i,c,t} \tag{4.4}$$

where $Reform_{c,t,\tau}$ is a series of dummy variables equal to one if the listed firm is located in city c in the τ year of the verticalization reform in year t. τ takes a value from -5 to 3 to capture the dynamic impact of the verticalization reform. This study sets τ to -5 if the time period is five or more years before the reform. In total, there are nine event periods in the model. The baseline period is set as τ equals -1. *Distance×Reform* is the key explanatory variable in the regression. If the parallel trend assumption holds, the coefficients for *Distance×Reform* do not significantly deviate from the baseline when τ equals -5, -4, -3 or -2. If the verticalization reform can improve the corporate environmental governance of local SOEs, it is expected that the coefficients for *Distance×Reform* will become significantly positive when τ equals 0, 1, 2 or 3.

Figure 4.3 illustrates the results of my event study. The blue solid line indicates the regression in the subsample of local SOEs. There is no significant pre-trend before the verticalization reform, which supports the parallel trend assumption. After the verticalization reform is implemented, the coefficient for *Distance*×*Reform* climbs from 0.13 to 0.42, which is statistically significant in event periods 1–3. The result implies that the verticalization reform results in continuous improvements in the corporate environmental governance of local SOEs in regions with insufficient central government oversight.

Figure 4.3. Verticalization Reform and Environmental Ratings



The red dashed line symbolises the result for central SOEs. There is a downward pattern in the coefficients for *Distance*×*Reform* before and after the verticalization reform, except for an unpredictable bounce immediately after the reform; however, the coefficients are generally insignificant. Central SOEs have a higher political hierarchy level, so the result meets the expectation that the environmental regulations of local EPBs do not significantly affect them before or after the verticalization reform. The green dotted line presents the event study of POEs. The pattern of coefficients for *Distance×Reform* is relatively flat and does not significantly deviate from the baseline. The result meets my conjuncture that POEs are already managed by local EPBs; therefore, the verticalization reform does not affect their environmental performance.

Staggered DID estimates Because the environmental verticalization reform involves staggered implementation across provinces, traditional two-way fixed effects (TWFE) staggered difference-in-differences (DID) may produce biased estimates since the treatment effect of early treatment groups, which are regarded as control groups before treatment, is not stable over time (Goodman-Bacon, 2021; de Chaisemartin & D'Haultfoeuille, 2020; Baker et al., 2022). To tackle the potential estimation bias, this study adopts two-stage imputation difference-in-differences analysis following Gardner (2021).

In the first stage, this study regresses environmental ratings on control variables, firm fixed effects, city fixed effects and year fixed effects using only the sample prior to the verticalization reform. Based on these estimates, environmental ratings are predicted for each firm before and after the verticalization reform. Finally, the residuals from this prediction are used in the baseline regression without control variables or fixed effects. The Gardner (2021) method identifies the average treatment effect across all treated units once group and period fixed effects have been removed and assigns equal weight to each treatment unit in each period.

The results of the two-stage imputation method are shown in Table 4.6. Column (1) illustrates the impact of the verticalization reform on local SOEs. With a magnitude greater than my baseline regression, the coefficient for *Distance×Vertical* is 0.321 and has statistical significance at a 1% level. The results indicate that baseline estimation may underestimate the effect of the verticalization reform on the corporate environmental governance of local SOEs in regions with high supervision costs. Columns (2) and (3) demonstrate negative coefficients for *Distance×Vertical*, which implies that the verticalization reform may even reduce the environmental governance of central SOEs of POEs in distant regions.

Table 4.6. Staggered difference-in-differences

VARIABLES	(1) LSOEs ENV	(2) CSOEs ENV	(3) POE ENV
Second-stage regression			
DistancexVertical	0.321***	-0.256*	-0.138
	(3.11)	(-1.85)	(-1.63)
Vertical	-0.070	0.523***	0.293***
	(-1.02)	(6.57)	(5.18)
Observations	7,189	2,647	14,196
R-squared	0.012	0.064	0.018
First-stage regression			
Control	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
City FE	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This study also considers stacked difference-in-differences analysis following Cengiz et al. (2019), Gu et al. (2021) and Chen, Shi, Zhang and Zhang (2022). Stacked difference-in-differences analysis estimates the effects of the verticalization reform by reconstructing the sample into a balanced panel with clean controls. In light of the fact that all provinces have adopted the verticalization reform, the clean control group is defined as those provinces that adopted the reform at least one year later than other provinces. The final sample should only include the period in which the control group was in existence before the verticalization reform. Specifically, Hainan adopted verticalization in July 2019, and so the verticalization year is 2020 by my definition. Companies headquartered in Hainan are regarded as the control group in my specification of the stacked difference-in-differences model. For each verticalization year before 2020, there are separate data sets for provinces that implemented verticalization reform in the same year, except the control group. These data sets are then matched with the control group and stacked together to estimate the average treatment effect of the verticalization reform according to my baseline model.

Appendix A4.3 demonstrates the results of stacked difference-in-differences analysis. Column (1) shows a positive and significant coefficient for $Distance \times Vertical$, while the coefficients in columns (2) and (3) are insignificant. The results are consistent with my baseline estimation, which implies that the verticalization reform only improves the environmental governance of local SOEs in regions with insufficient supervision by central government. However, one limitation of this estimation is that only a small number of firms are headquartered in Hainan province (my control group). Hainan province only has 25 listed companies, while local SOEs, central SOEs and POEs comprise 7, 1 and 17, respectively. To avoid a potential estimation problem, this study estimates the stacked difference-in-differences analysis again by taking provinces that implemented the verticalization reform in or after 2019 as the control group. My untabulated results remain the same so that the verticalization reform only improves the environmental performance of local SOEs.

Robustness One of my concerns is that SNSI ESG ratings may assign ESG ratings based on favouritism, or the ratings may be susceptible to bias due to other firm characteristics. For instance, large firms tend to receive greater media coverage and attention, which may lead to better environmental ratings through machine learning algorithms in the rating system. Hence, this study examines whether the verticalization reform also improves social and corporate governance ratings to mitigate the above concern. Appendix A4.4 presents the results of placebo tests. The verticalization reform has no influence on social ratings and corporate governance ratings in local SOEs, central SOEs or POEs. The results indicate that my baseline estimation is not influenced by ratings favouritism or the co-movement of ESG metrics.

There is a great deal of variation in the geographical terrain of China from one region to another. Therefore, the supervision costs of central government will vary depending on the quality of the transportation infrastructure in a given region, particularly where a region is underdeveloped. To account for variations in supervision costs caused by transportation infrastructure, this paper considers the route distance (*RouteDistance*) between SCEPs and the jurisdiction of companies.

Furthermore, my study also considers institutional distance (*NDistance*) instead of geographical distance. As supervision costs are not limited to physical transportation distance, the communication costs may increase as they pass through the layers of organisation. SCEPs should be able to better monitor the cities they are located in, and then other cities in the same provinces (since SCEPs are located in the capital cities of provinces or direct-administered municipalities where provincial EPBs can provide assistance with environmental regulations). Supervision costs will increase in the capital cities of other provinces in which SCEPs provide direct guidance to provincial EPBs there, and the rest of the cities are expected to incur the highest supervision costs. Therefore, institutional distance is 1 if firms are in cities where SCEPs are located; institutional distance is 2 if firms are in other cities where SCEPs are located in the same province; institutional distance is 3 if they are located in other capital cities or direct-administered municipalities; lastly, institutional distance is 4 if they are located in any other cities.

Table 4.7 shows the results for alternative distance measures. Columns (1) to (3) present the results that replace geographical distance with route distance. The results are similar to my baseline estimation, which implies that route distance and geographical distance are interchangeable in measuring supervision costs. Columns (4) to (6) present the results estimated by institutional distance. Column (4) indicates the impact of the verticalization reform on local SOEs. The coefficient for $NDistance \times Vertical$ is 0.066 and is statistically significant at a 5% level. Following the verticalization reform, an increase of one level in institutional distance improves environmental ratings by 3.43%. Columns (5) and (6) shows the results for the sample of central LOEs and POEs, which are insignificant.

Table 4.7. Alternative measures of distance

VARIABLES	(1) LSOE ENV	(2) CSOE ENV	(3) POE ENV	(4) LSOE ENV	(5) CSOE ENV	(6) POE ENV
RouteDistancexVertical	0.261**	-0.115	-0.134			
	(2.37)	(-0.83)	(-1.52)			
NDistancexVertical				0.066**	-0.042	-0.025
				(2.14)	(-1.01)	(-1.16)
Vertical	-0.142*	-0.039	0.052	-0.171*	0.009	0.037
	(-1.69)	(-0.34)	(0.81)	(-1.72)	(0.06)	(0.53)
Observations	7,189	2,647	14,196	7,189	2,647	14,196
R-squared	0.686	0.738	0.693	0.686	0.738	0.693
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This study also examines the number of environmental incidents (*REPENV*) as an alternative measure of corporate environmental governance. If the verticalization reform improves the environmental governance of local SOEs, it is expected that the number of environmental reputation incidents will decrease, especially in regions far from the supervision of central government.

Table 4.8 presents the results of environmental incidents. The coefficient for the interaction variable in column (1) is significant and negative at 0.039, which indicates that an increase in geographical distance results in a reduction of 27.11% in the chances of having an environmental incident after verticalization reform.[55] The verticalization reform alone demonstrates a positive coefficient. On the other hand, columns (2) and (3) indicate that verticalization reform does not have a significant impact on central SOEs and POEs after considering supervision costs, but it does significantly increase the number of environmental incidents. My study also considers the RPP index which incorporates the severity (magnitude of the perceived impact of an incident) and reach (the influence or readership of media source) of environmental incidents following

[55] The average number of environmental incidents is 0.042, and the standard deviation of distance is 0.292. Thus, the proportion of environmental incidents reduced is calculated as 0.039*0.292/0.042 = 27.11%.

Bansal et al. (2022). My untabulated results also indicate that geographical distance is negatively associated with environmental incidents after the verticalization reform, but only limited in local SOEs.

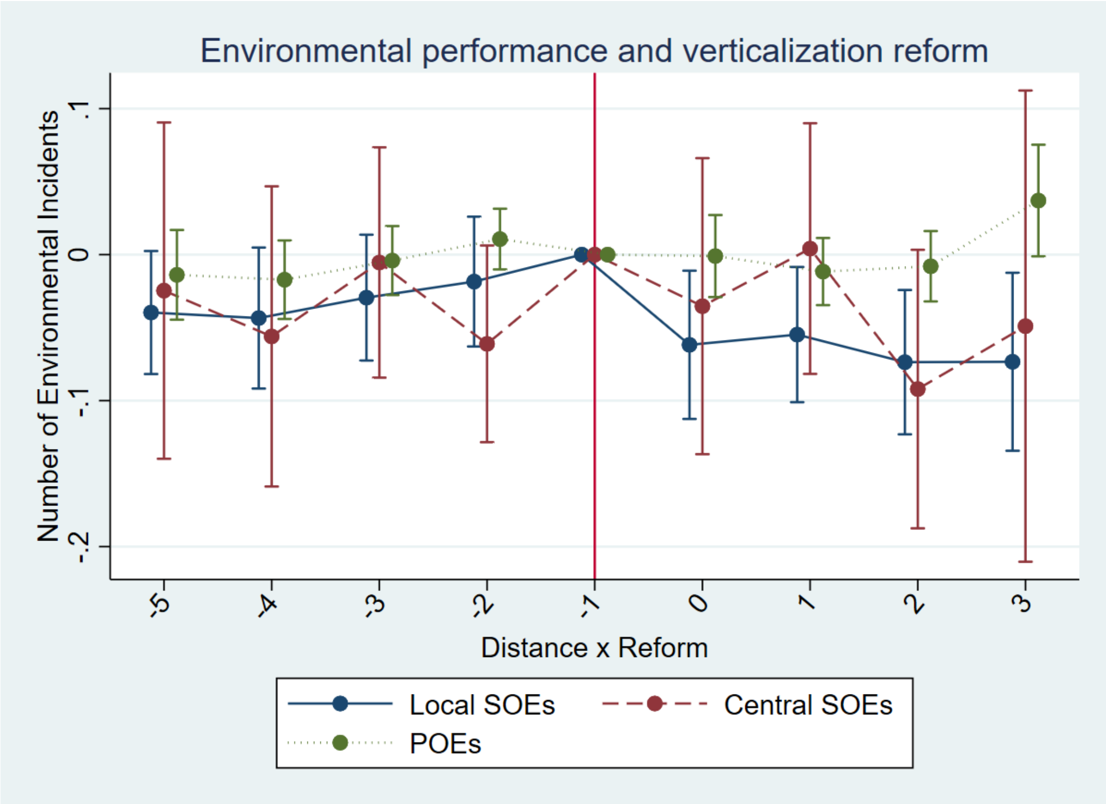
Table 4.8. Verticalization reform and environmental incidents

VARIABLES	(1) LSOE REPENV	(2) CSOE REPENV	(3) POE REPENV
DistancexVertical	-0.039**	-0.015	0.003
	(-2.01)	(-0.33)	(0.26)
Vertical	0.047*	0.138**	0.013
	(1.88)	(2.55)	(0.98)
Observations	7,214	2,651	14,342
R-squared	0.379	0.583	0.251
Control	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
City FE	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Furthermore, my study examined event-study specifications to investigate whether my analysis supports the parallel trend assumption. Figure 4 presents the results of an event-study analysis of environmental incidents. The blue solid lines indicate that there was no significant pre-trend before the verticalization reform; however, the number of environmental incidents decreased significantly following the reform after taking geographical distance into account. While central SOEs (red dashed line) and POEs (green dotted line) do not show any pre-trend before the reform, the reform does not have a significant impact on the subsequent numbers of environmental incidents.

Figure 4.4. Verticalization Reform and Environmental Incidents



Moreover, two-stage difference-in-differences analysis is conducted to reduce the possibility of estimation bias caused by staggered difference-in-differences. Appendix A4.5 presents a similar result. After considering distance, the verticalization reform increases the environmental incidents of local SOEs by 25.5%, while it has no effect on the environmental incidents of central SOEs and POEs. The RepRisk database also provides details of social and governance incidents; therefore, my study also considers the number of social and governance incidents as placebos. Appendix A4.6 indicates that the verticalization reform has no significant impact on social incidents but does increase governance incidents for central SOEs and POEs in distant areas.

The study also considers a series of control variables that have been previously documented to affect the ESG performance of firms. These variables can be categorised as board independence, institutional ownership and analyst coverage. Table 4.9 presents the result of regressions after including the above variables. Columns (1) and (2) indicate that the verticalization reform may improve corporate environmental governance after controlling for additional variables. Environmental ratings increase and the number of environmental incidents decreases with increasing distance from SCEPs. Nevertheless, distance does not significantly influence the environmental governance of central SOEs and POEs under the reform.

Table 4.9. Robustness: Additional control variables

VARIABLES	(1) LSOE ENV	(2) LSOE REPENV	(3) CSOE ENV	(4) CSOE REPENV	(5) POE ENV	(6) POE REPENV
DistancexVertical	0.261**	-0.039**	-0.108	-0.009	-0.138	0.003
	(2.38)	(-2.03)	(-0.79)	(-0.20)	(-1.56)	(0.28)
Vertical	-0.143*	0.048*	-0.041	0.135**	0.054	0.013
	(-1.70)	(1.92)	(-0.36)	(2.42)	(0.86)	(0.97)
Observations	7,189	7,214	2,646	2,650	14,195	14,341
R-squared	0.687	0.379	0.738	0.585	0.694	0.252
Control	YES	YES	YES	YES	YES	YES
Board Independency	YES	YES	YES	YES	YES	YES
Institutional ownership	YES	YES	YES	YES	YES	YES
Analyst coverage	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Discussion of Confounding Explanations

Pollution-intensive Firms and the Verticalization Reform In this study, the key argument is that the political hierarchy determines corporate environmental performance after the verticalization reform. A possible explanation for my findings is that local SOEs are more likely to be pollution-intensive companies. In this case, my results appear to be incorrectly driven by the correlation that the verticalization reform appears to improve the environmental governance of pollution-intensive firms, so that the reform has no effect on central SOEs or POEs. To rule out this confounding explanation, my study investigates the proportion of pollution-intensive firms in local SOEs, central SOEs and POEs, respectively. The local SOEs sample consists of 39.12% pollution-intensive firms, the central SOEs sample consists of 37.30% and the POEs sample consists of 37.62%. Local SOEs generally have more pollution-intensive firms than other firms.

My study further examines the alternative explanation by dividing the sample into pollution-intensive firms and other firms. The results are shown in Table 4.10 Panel A. It appears that verticalization reform has little impact on the environmental ratings of pollution-intensive companies and other firms, regardless of whether supervision costs are considered. Furthermore, Appendix A4.7 Panel A illustrates an increase in environmental incidents among pollution-intensive firms following the verticalization reform, which indicates that the reform has had a negative impact on corporate environmental governance, rather than made an improvement. Consequently, my findings cannot be explained by the existence of more pollution-intensive firms in local SOEs.

Table 4.10. Alternative explanations: polluting industries

Panel A. Vertical reforms and polluting firms

VARIABLES	(1) Polluting firms ENV	(2) Polluting firms ENV	(3) Other firms ENV	(4) Other firms ENV
DistancexVertical		0.048		-0.065
		(0.51)		(-0.86)
Vertical	-0.007	-0.038	-0.041	-0.003
	(-0.16)	(-0.51)	(-1.16)	(-0.05)
Observations	9,153	9,153	14,879	14,879
R-squared	0.688	0.688	0.689	0.689
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
City FE	YES	YES	YES	YES

Panel B. Vertical reforms, polluting firms and SOEs

VARIABLES	(1) Polluting LSOE ENV	(2) Polluting CSOE ENV	(3) Polluting POE ENV	(4) Other LSOE ENV	(5) Other CSOE ENV	(6) Other POE ENV
DistancexVertical	0.408**	0.014	-0.187	0.201	-0.121	-0.126
	(2.24)	(0.07)	(-1.39)	(1.45)	(-0.67)	(-1.11)
Vertical	-0.244	-0.130	0.128	-0.099	-0.044	0.019
	(-1.60)	(-0.55)	(1.28)	(-0.99)	(-0.32)	(0.23)
Observations	2,811	995	5,347	4,378	1,652	8,849
R-squared	0.693	0.679	0.711	0.682	0.769	0.690
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Another explanation for my findings is that local SOEs have a higher concentration of pollution-intensive firms in distant regions than central SOEs and POEs. In this case, my distance measure is closely correlated with the proportion of pollution-intensive firms in local SOEs. Hence, my model may mistakenly compare the environmental performance of pollution-intensive firms with that of other companies following the reform. To rule out the above hypothesis, each of the local SOEs, central SOEs and POEs samples is further divided into pollution-intensive companies and other companies. In this analysis, supervision costs are only compared with pollution-intensive firms (or other firms). Table 4.10 Panel B demonstrates the results of this analysis. Columns (1) to (3) indicate the environmental performance of pollution-intensive firms operated by local SOEs, central SOEs and POEs, respectively. Within the pollution firms sample, local SOEs experience a significant improvement in environmental ratings after the verticalization reform as distance increases. On the other hand, environmental performance does not significantly affect the environmental ratings of central SOEs or POEs. In contrast, the reform has no significant impact on the environmental ratings of pollution firms among central SOEs and POEs. Columns (4) to (6) indicate the results of other firms. The reform also increases the environmental ratings of non-polluters operated by local SOEs along with an increase in distance, although the coefficient is insignificant. In contrast, the reform has a negative but insignificant impact on the environmental ratings of central SOEs and POEs in non-polluter samples. Appendix A4.7 Panel B describes the impact of the verticalization reform on environmental incidents in divided samples. Similar to environmental ratings, environmental incidents have also decreased significantly for polluters operated by local SOEs due to the increase in distance following the verticalization reform. As a result, my findings are not driven by comparing pollution-intensive firms and non-polluters within the local SOE sample.

Discussion on Confounding Events My results might also be biased by concurrent events that may also affect the corporate environmental governance of listed firms. The first concurrent event is environmental inspections conducted by China's central government. Central government began inspecting the enforcement of environmental regulations by local governments in 2016 (Wang et al., 2021; Tan and Mao, 2021). The inspections are carried out in a staggered manner. A pilot inspection was conducted in Hebei in January 2016, and then it was expanded to all provinces; the last batch of inspections was conducted in August 2017 (see Appendix A4.8). An inspection is not a one-time event. Central government coordinates the inspections conducted by local governments. Furthermore, central government engages in a "looking back" inspection and a subsequent round of inspections after an initial inspection. If the implementation of the verticalization reform overlapped with environmental inspections, my baseline estimates would be biased upwards. Therefore, this study considers a dummy variable of inspection (*Inpsect*) to measure the impact of environmental inspection. Provinces that undergo environmental inspections during the first half of the year have a dummy variable equal to one in that year. If an environmental inspection occurs in the second half of a year, the dummy variable is equal to one after that year.

The second concurrent event is the new Environmental Protection Tax Law in 2018. Before the tax law, enterprises were charged pollution discharge fees by local EPBs. However, the local government does not enforce the collection of emission fees in a mandatory manner because they want to stimulate economic development and attract new investment. In 2018, the Environmental Protection Tax Law largely contributed to an increase in the illegal costs of evading pollution charges. The tax is collected by the tax authorities rather than local EPBs. Therefore, polluters who evade environmental taxes will be held criminally liable. Furthermore, the tax level is much higher than the previous pollution emission fees. In heavily polluted areas, such as Beijing, the government has imposed a tax nearly nine times higher than before. In less developed regions, the tax is twice as high as the emission fee. The new tax law significantly increases the burden on enterprises and forces them to engage in better environmental governance (Li and Masui, 2019). My study considers a dummy variable, *Post18*, which equals one if the fiscal year is after 2018, to evaluate the impact of the new tax law.

Studies indicate that companies subject to mandatory ESG disclosure requirements reduce pollution emissions and improve their environmental performance (Chen, Hung and Wang, 2018; Ren et al., 2020). The Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE) mandate CSR disclosure for firms listed in the Corporate Governance Index and the SZSE 100 Index to ensure that their CSR activities have been transparent since 2008. The Corporate Governance Index is a compilation of 230 listed companies that have the best governance practices in the SSE, while the SZSE 100 Index represents the top 100 A-share listed companies based on total market capitalisation, free-float market capitalisation and share turnover in the SZSE. My findings may be biased upwards if the verticalization reform is confounded by changes in the constituents of the above index. This study considers the status of mandatory disclosure (*MandatoryDisc*), which is a dummy variable equal to one if a firm is a constituent of either the Corporate Governance Index or the SZSE 100 Index.

Table 4.11 shows the results of confounding events in the local SOEs sample. Columns (1) and (2) demonstrate that environmental inspections alone slightly increase the environmental ratings of local SOEs; however, the verticalization reform still significantly improves the environmental performance of local SOEs in distant regions. Columns (3) and (4) show the impact of the new Environmental Protection Tax Law. Environmental ratings increased significantly following the enforcement of the new law in 2018, but environmental ratings do not increase significantly as the supervision costs of central government increase. On the other hand, the impact of the verticalization reform remains significant, though the magnitude of the coefficient decreases in column (4) as the policy effect for provinces implementing the reform in 2018 has been absorbed. Columns (5) and (6) indicate that companies subject to mandatory disclosure experience significant increases in environmental ratings, consistent with previous studies (Chen, Huang and Wang, 2018; Ren et al., 2020); however, the effect is mitigated in regions that are supervised less by the central government. Mandatory disclosure, however, does not mitigate the positive impacts of the verticalization reform on environmental governance. Appendix A4.9 shows the impact of confounding events on environmental incidents, and my findings remain unchanged. Thus, baseline findings are not driven by confounding events. My study also examines the impact of confounding events on central SOEs and POEs; however, the verticalization reforms still have no impact on the corporate environmental governance of these firms.

Table 4.11. Confounding Events

VARIABLES	(1) LSOE ENV	(2) LSOE ENV	(3) LSOE ENV	(4) LSOE ENV	(5) LSOE ENV	(6) LSOE ENV
DistancexVertical	0.254**	0.235**	0.245**	0.198*	0.257**	0.215*
	(2.31)	(2.32)	(2.21)	(1.78)	(2.35)	(1.95)
Vertical	-0.136	-0.126	-0.090	-0.108	-0.147*	-0.118
	(-1.62)	(-1.53)	(-1.23)	(-1.31)	(-1.75)	(-1.39)
Inspect	0.090*	0.071				
	(1.84)	(0.87)				
Distancexinspect		0.033				
		(0.30)				
Post18			0.098**			
			(2.10)			
DistancexPost18				0.074		
				(0.59)		
MandatoryDisc					0.162**	0.421***
					(2.31)	(2.89)
DistancexMandatoryDisc						-0.472**
						(-2.18)
Observations	7,189	7,189	7,189	7,189	7,189	7,189
R-squared	0.686	0.686	0.692	0.686	0.687	0.687
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	NO	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Further Discussion

Environmental Attention by Local Governments Before the verticalization reform, the attitudes and efforts of local governments towards environmental protection could play a major role in moderating corporate environmental governance. Consequently, my study anticipates that the effectiveness of the reform as regards improving corporate environmental governance will also vary depending on how much attention local governments devote to environmental problems. Local governments in regions that pay less attention to environmental quality are more likely to protect their local SOEs for economic growth at the expense of environmental quality, thus resulting in a greater impact of the environmental verticalization reform.

This study collects *Reports on the Work of the Government* from 228 governments of prefectural cities and directly-administered municipalities in 2015.[56] Following Chen, Shi, Zhang and Zhang (2022) and Chen, Kahn, Liu and Zhang (2018), this study calculates the ratio of words associated with environmental protection to the total number of words in reports to evaluate the attention paid to environmental concerns by local governments. The following five types of target words are considered to be associated with environmental protection: environmental protection (such as pollution prevention and control, emissions reductions), environmental pollutants (such as SO2, PM2.5, CO, atmospheric pollution), energy consumption (such as water consumption, clean energy, renewable energy), ecological governance (such as river governance responsible systems, collaborative pollution control, ecological barriers) and greenness (greenfield, *lucid water and lush mountains*, returning farmland to forest). Then my study splits the sample into high government attention and low government attention based on the sample median of the ratio of environmental protection words used in local SOEs, central SOEs and POEs. It is expected that the effects of the verticalization reform will be stronger in regions where local governments pay relatively little attention to the environment.

Table 4.12 presents the regression results. As shown in Column (1), the

[56] My study selects some works for my study in 2015 in order to evaluate the attention paid to environmental protection prior to the verticalization reform. The study does not cover all reports since some prefectural cities do not publish their Reports on the Work of the Government on their government websites or announce them to the public.

verticalization reform may still be able to improve the environmental ratings of local SOEs in distant regions where local governments pay more attention to the environment; however, the impact is not significant. In columns (2) and (3), the verticalization reform also does not indicate a significant effect on the environmental ratings of central SOEs and POEs in governments paying high attention. In contrast, the verticalization reform leads to a significant improvement in the environmental ratings of local SOEs in distant regions with low environmental governance, as indicated in column (4). Meanwhile, the verticalization reform still does not have a significant impact on central SOEs and POEs according to columns (5) and (6). Consequently, the impact of the verticalization reform varies with the level of local government attention paid to environmental concerns.

Table 4.12. Verticalization reform and government environmental attention

VARIABLES	(1) High LSOE ENV	(2) High CSOE ENV	(3) High POE ENV	(4) Low LSOE ENV	(5) Low CSOE ENV	(6) Low POE ENV
DistancexVertical	0.140	-0.234	-0.175	0.322***	0.041	-0.114
	(0.69)	(-1.21)	(-1.26)	(2.72)	(0.19)	(-0.76)
Vertical	-0.098	-0.068	0.149	-0.202*	-0.066	0.055
	(-0.69)	(-0.37)	(1.57)	(-1.92)	(-0.39)	(0.49)
Observations	2,980	1,467	5,943	3,786	1,104	5,855
R-squared	0.684	0.726	0.687	0.691	0.755	0.704
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Consequences of the Verticalization Reform A company can improve its environmental governance and reduce its environmental burden in two ways: by investing in abatement facilities or by reducing production. This study examines whether the verticalization reform improves corporate abatement investment, based on abatement investment in total assets (*ABATE1*) and abatement investment in total revenue (*ABATE2*). Table 4.13 indicates the results of the regressions. Columns (1) and (2) indicate that the verticalization reform significantly increases the proportion of abatement investment for local SOEs along with an increase in the distance from SCEPs. A standard deviation increase in geographical distance raises the abatement investment by 27.55% (20.22%) relative to the average of abatement investment to total assets (total revenue) in my sample following the verticalization reform.[57] In contrast, geographical distance does not significantly affect the abatement investment of central SOEs and POEs following the vertical reform, according to columns (3) to (6).

Table 4.13. Verticalization reform and abatement investment

VARIABLES	(1) LSOE ABATE1	(2) LSOE ABATE2	(3) CSOE ABATE1	(4) CSOE ABATE2	(5) POE ABATE1	(6) POE ABATE2
DistancexVertical	0.067***	0.099*	-0.046	-0.158	0.024	0.056
	(2.70)	(1.87)	(-0.94)	(-1.59)	(1.45)	(1.52)
Vertical	-0.034	-0.045	0.017	0.089	-0.031**	-0.051*
	(-1.53)	(-0.91)	(0.47)	(1.19)	(-2.04)	(-1.81)
Observations	7,225	7,225	2,684	2,684	14,342	14,338
R-squared	0.551	0.583	0.522	0.507	0.484	0.491
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[57] The standard deviation of geographical distance is 0.292, while the abatement to total asset (total revenue) ratio is 0.071% (0.143%). Thus, a one-standard-deviation increase in geographical distance coucanld increase abatement investment by 0.067 * 0.292 / 0.071 = 27.55% (0.099 * 0.292 / 0.143 = 20.22%) after the verticalization reform.

Lastly, this study examines whether the verticalization reform affects the financial performance (measured by returns on assets) and corporate valuation (measured by Tobin's Q) of companies. Table 4.14 shows that the verticalization reform does not significantly affect either financial performance or corporate valuations of local SOEs, central SOEs and POEs. Consequently, the results indicate that the verticalization reform can improve corporate environmental governance without reducing the operating efficiency of companies or affecting their valuations in financial markets.

Table 4.14. Verticalization reform, financial performance and corporate valuation

VARIABLES	(1) LSOE ROA	(2) LSOE TOBINQ	(3) CSOE ROA	(4) CSOE TOBINQ	(5) POE ROA	(6) POE TOBINQ
DistancexVertical	0.005	0.033	0.009	-0.058	0.009	-0.061
	(1.01)	(0.35)	(1.45)	(-0.37)	(1.31)	(-0.56)
Vertical	0.000	0.088	-0.005	-0.057	0.002	-0.011
	(0.06)	(1.42)	(-0.76)	(-0.54)	(0.35)	(-0.15)
Observations	7,148	7,019	2,667	2,622	13,656	13,307
R-squared	0.513	0.744	0.511	0.712	0.433	0.700
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.6 Conclusion

This paper examines how political hierarchy matters in corporate environmental governance in China by exploiting the staggered implementation of the environmental verticalization reform, which strengthens the political position of environmental regulatory departments and mitigates their conflicts of interest with economic growth. My difference-in-differences analysis shows that local SOEs and central SOEs had worse environmental governance than POEs once they were away from central government oversight before the verticalization reform. The verticalization reform implemented from 2016 onwards leads to an improvement in the corporate environmental governance of local SOEs as local regulatory departments are empowered by their new administrators who hold higher political positions than local SOEs' executives. The improvement in corporate environmental governance among local SOEs is more pronounced in cities where less attention is paid to environmental protection by local governments. However, the reform does not significantly improve corporate environmental governance in central SOEs, which are higher in political rank, and in POEs, which were already managed before the reform. Further, my study documents that local SOEs improve environmental governance by increasing abatement investments, but that they do not suffer from a reduction in financial performance or corporate valuations as a result of the reform.

My research indicates that governments in authoritarian countries must consider the political hierarchy of government departments and SOEs for the purpose of achieving their political objectives. My study indicate that direct political administrators play a crucial role in supporting government authorities to enforce their obligations, particularly for developing countries that are heavily dependent on SOEs.

References

Alonso, R., Dessein, W., & Matouschek, N. (2008). When does coordination require centralization? *American Economic Review*, *98*(1), 145-79.

Angrist, J. D., & Pischke, J. S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.

Bansal, R., Wu, D., & Yaron, A. (2022). Socially responsible investing in good and bad times. *The Review of Financial Studies*, 35(4), 2067-2099.

Bardhan, P. (2016). State and development: The need for a reappraisal of the current literature. *Journal of Economic Literature*, *54*(3), 862-92.

Bardhan, P. K., & Mookherjee, D. (2000). Capture and governance at local and national levels. *American Economic Review*, *90*(2), 135-139.

Ben-Nasr, H., & Ghouma, H. (2018). Employee welfare and stock price crash risk. *Journal of Corporate Finance*, 48, 700-725.

Boffa, F., Piolatto, A., & Ponzetto, G. A. (2013). *Centralization and accountability: theory and evidence from the Clean Air Act*. CEPR Discussion Paper No. 9514.

Boffa, F., Piolatto, A., & Ponzetto, G. A. (2016). Political centralization and government accountability. *The Quarterly Journal of Economics*, *131*(1), 381-422.

Bradshaw, M., Liao, G., & Ma, M. S. (2019). Agency costs and tax planning when the government is a major shareholder. *Journal of Accounting and Economics*, 67(2-3), 255-277.

Broadstock, D. C., Chan, K., Cheng, L. T., & Wang, X. (2021). The role of ESG performance during times of financial crisis: Evidence from COVID-19 in China. *Finance Research Letters*, 38, 101716.

Cai, H., Chen, Y., & Gong, Q. (2016). Polluting thy neighbor: Unintended consequences of China′ s pollution reduction mandates. *Journal of Environmental Economics and Management*, *76*, 86-104.

Campante, F. R., & Do, Q. A. (2014). Isolated capital cities, accountability, and corruption: Evidence from U.S. states. *American Economic Review*, 104(8), 2456-81.

Chen, G., Xu, J., & Qi, Y. (2022). Environmental (de) centralization and local environmental governance: Evidence from a natural experiment in China. *China Economic Review*, 72, 101755.

Chen, J., Shi, X., Zhang, M. A. & Zhang, S. (2022). *Centralization of Environmental Administration and Air Pollution: Evidence from China*. Available at SSRN 4092137.

Chen, S., Sun, Z., Tang, S., & Wu, D. (2011). Government intervention and investment efficiency: Evidence from China. *Journal of Corporate Finance*, 17(2), 259-271.

Chen, X., Cheng, Q., Hao, Y., & Liu, Q. (2020). GDP growth incentives and earnings management: evidence from China. *Review of Accounting Studies*, 25(3), 1002-1039.

Chen, Y. C., Hung, M., & Wang, Y. (2018). The effect of mandatory CSR disclosure on firm profitability and social externalities: Evidence from China. *Journal of Accounting and Economics*, 65(1), 169-190.

Chen, Y. C., Hung, M., & Wang, Y. (2018). The effect of mandatory CSR disclosure on firm profitability and social externalities: Evidence from China. *Journal of Accounting and Economics*, 65(1), 169-190.

Chen, Y., Li, T., Zeng, Q., & Zhu, B. (2023). Effect of ESG performance on the cost of equity capital: Evidence from China. *International Review of Economics & Finance*, 83, 348-364.

Chen, Z., Kahn, M. E., Liu, Y., & Wang, Z. (2018). The consequences of spatially differentiated water pollution regulation in China. *Journal of Environmental Economics and Management*, 88, 468-485.

Davis, L. W. (2008). The effect of driving restrictions on air quality in Mexico City. *Journal of Political Economy*, *116*(1), 38-81.

Davis, L. W., Fuchs, A., & Gertler, P. (2014). Cash for coolers: evaluating a large-scale appliance replacement program in Mexico. *American Economic Journal: Economic Policy*, *6*(4), 207-38.

de Chaisemartin, C., & D'Haultfoeuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9), 2964-96.

Deng, Y., Wu, Y., & Xu, H. (2019). Political turnover and firm pollution discharges: An empirical study. *China Economic Review*, *58*, 101363.

Duflo, E., Greenstone, M., Pande, R., & Ryan, N. (2018). The value of regulatory discretion: Estimates from environmental inspections in India. *Econometrica*, *86*(6), 2123-2160.

Dyck, A., Lins, K. V., Roth, L., & Wagner, H. F. (2019). Do institutional investors drive corporate social responsibility? International evidence. *Journal of Financial Economics*, 131(3), 693-714.

Eaton, S., & Kostka, G. (2017). Central protectionism in China: The “central SOE problem” in environmental governance. *The China Quarterly*, 231, 685-704.

Fan, C. S., Lin, C., & Treisman, D. (2009). Political decentralization and corruption: Evidence from around the world. *Journal of Public Economics*, *93*(1-2), 14-34.

Fan, K., Hui, E., & Shen, J. (2022). *Does integrating environmental protection in cadre evaluation system mitigate the race-to-the-bottom competition? Evidence from industrial land conveyance in China*. The Hong Kong Polytechnic University Working Paper.

Ferrell, A., Liang, H., & Renneboog, L. (2016). Socially responsible firms. *Journal of Financial Economics*, 122(3), 585-606.

Foster, A., Gutierrez, E., & Kumar, N. (2009). Voluntary compliance, pollution levels, and infant mortality in Mexico. *American Economic Review*, *99*(2), 191-97.

Gardner, J. (2021). *Two-stage differences in differences*. University of Mississippi Working Paper.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. *Journal of Econometrics*, 225(2), 254-277.

Grossman, G., & Lewis, J. I. (2014). Administrative unit proliferation. *American Political Science Review*, *108*(1), 196-217.

Grossman, G., Pierskalla, J. H., & Boswell Dean, E. (2017). Government fragmentation and public goods provision. *The Journal of Politics*, *79*(3), 823-840.

Hayek, F.A. (1945). The use of knowledge in society. *American Economic Review*, *35*(4), 519–530.

He, G., Wang, S., & Zhang, B. (2020). Watering down environmental regulation in China. *The Quarterly Journal of Economics*, *135*(4), 2135-2185.

Houston, J. F., & Shan, H. (2022). Corporate ESG profiles and banking relationships. *The Review of Financial Studies*, 35(7), 3373-3417.

Hsu, P. H., Liang, H., & Matos, P. (2021). Leviathan Inc. and corporate environmental engagement. *Management Science*. https://doi.org/10.1287/mnsc.2021.4064

Huang, Z., Li, L., Ma, G., & Xu, L. C. (2017). Hayek, local information, and commanding heights: Decentralizing state-owned enterprises in China. *American Economic Review*, 107(8), 2455-78.

Jia, J., Liang, X., & Ma, G. (2021). Political hierarchy and regional economic development: Evidence from a spatial discontinuity in China. *Journal of Public Economics*, *194*, 104352.

Kahn, M. E., Li, P., & Zhao, D. (2015). Water pollution progress at borders: the role of changes in China's political promotion incentives. *American Economic Journal: Economic Policy*, *7*(4), 223-42.

Kostka, G., & Nahm, J. (2017). Central–local relations: Recentralization and environmental governance in China. *The China Quarterly*, *231*, 567-582.

Krüger, P. (2015). Corporate goodness and shareholder wealth. *Journal of Financial Economics*, 115(2), 304-329.

Li, G., & Masui, T. (2019). Assessing the impacts of China's environmental tax using a dynamic computable general equilibrium model. *Journal of Cleaner Production*, 208, 316-324.

Li, H., & Zhou, L. A. (2005). Political turnover and economic performance: the incentive role of personnel control in China. *Journal of Public Economics*, *89*(9-10), 1743-1762.

Li, J., & Wu, D. (2020). Do corporate social responsibility engagements lead to real environmental, social, and governance impact? *Management Science*, 66(6), 2564-2588.

Li, X., Liu, C., Weng, X., & Zhou, L. A. (2019). Target setting in tournaments: theory and evidence from China. *The Economic Journal*, *129*(623), 2888-2915.

Liang, S., Li, Z., Chen, D., & Chen, S. (2015). Political ranks, incentives and firm performance. *China Journal of Accounting Studies*, *3*(2), 87-108.

Lipscomb, M., & Mobarak, A. M. (2016). Decentralization and pollution spillovers: evidence from the re-drawing of county borders in Brazil. *The Review of Economic Studies*, *84*(1), 464-502.

Liu, C. (2018). Are women greener? Corporate gender diversity and environmental violations. *Journal of Corporate Finance*, 52, 118-142.

Liu, J., & Diamond, J. (2005). China's environment in a globalizing world. *Nature*, *435*(7046), 1179-1186.

Markevich, A., & Zhuravskaya, E. (2011). M-form hierarchy with poorly-diversified divisions: A case of Khrushchev's reform in Soviet Russia. *Journal of Public Economics*, *95*(11-12), 1550-1560.

Nunn, N., & Qian, N. (2011). The potato's contribution to population and urbanization: evidence from a historical experiment. *The Quarterly Journal of Economics*, 126(2), 593-650.

Qian, Y., & Roland, G. (1998). Federalism and the soft budget constraint. *American Economic Review*, *88* (5), 1143-1162.

Ren, S., Wei, W., Sun, H., Xu, Q., Hu, Y., & Chen, X. (2020). Can mandatory environmental information disclosure achieve a win-win for a firm's environmental and economic performance? *Journal of Cleaner Production*, 250, 119530.

Shen, J., Peng, D., Hui, E., & Fan, K. (2022). *Performance Measurability and Air Pollution Control: Evidence from a Quasi-experiment in China*. The Hong Kong Polytechnic University Working Paper.

Sigman, H. (2005). Transboundary spillovers and decentralization of environmental policies. *Journal of Environmental Economics and Management*, *50*(1), 82-101.

Sun, L., & Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, *225*(2), 175-199.

Tan, Y., & Mao, X. (2021). Assessment of the policy effectiveness of central inspections of environmental protection on improving air quality in China. *Journal of Cleaner Production*, 288, 125100.

Tiebout, C. M. (1956). A pure theory of local expenditures. *Journal of Political Economy*, *64*(5), 416-424.

Wang, H., & Jin, Y. (2007). Industrial ownership and environmental performance: evidence from China. *Environmental and Resource Economics*, 36(3), 255-273.

Wang, J., Xiao, X., & Tang, Y. (2008). *Zhongguo longduanxing hangye guanzhi jigou de sheli yu yunxing jizhi* (The establishment and operation of regulatory agencies in China's monopoly industries). Beijing: Commercial Press.

Wang, Q., Liu, M., & Zhang, B. (2022). *Do state-owned enterprises really have better environmental performance in China? Environmental regulation and corporate environmental strategies*. Nanjing University Working paper. https://doi.org/10.21203/rs.3.rs-1658200/v1

Wang, Q., Wong, T. J., & Xia, L. (2008). State ownership, the institutional environment, and auditor choice: Evidence from China. *Journal of Accounting and Economics*, 46(1), 112-134.

Wang, W., Sun, X., & Zhang, M. (2021). Does the central environmental inspection effectively improve air pollution?-An empirical study of 290 prefecture-level cities in China. *Journal of Environmental Management*, 286, 112274.

Wang, X., Wu, W., Yin, C., & Zhou, S. (2019). Trade credit, ownership and informal financing in China. *Pacific-Basin Finance Journal*, 57, 101177.

Wu, J. (2005). *Understanding and interpreting Chinese economic reform*. Thomson/South-Western, Singapore.

Wu, J., Deng, Y., Huang, J., Morck, R., & Yeung, B. (2013). *Incentives and Outcomes: China's Environmental Policy* (No. w18754). National Bureau of Economic Research.

Xu, C. (2011). The fundamental institutions of China's reforms and development. *Journal of Economic Literature*, *49*(4), 1076-1151.

Yang, Z., & Shi, D. (2022). The impacts of political hierarchy on corporate pollution emissions: Evidence from a spatial discontinuity in China. *Journal of Environmental Management*, *302*, 113988.

Yuan, X., Li, Z., Xu, J., & Shang, L. (2022). ESG disclosure and corporate financial irregularities–Evidence from Chinese listed firms. *Journal of Cleaner Production*, 332, 129992.

Zhang, B., Chen, X., & Guo, H. (2018). Does central supervision enhance local environmental enforcement? Quasi-experimental evidence from China. *Journal of Public Economics*, *164*, 70-90.

Zhang, C. (2017). Political connections and corporate environmental responsibility: Adopting or escaping? *Energy Economics*, 68, 539-547.

Zhang, C., Liu, Q., Ge, G., Hao, Y., & Hao, H. (2021). The impact of government intervention on corporate environmental performance: Evidence from China's national civilized city award. *Finance Research Letters*, 39, 101624.

Zhang, Q., Yu, Z., & Kong, D. (2019). The real effect of legal institutions: Environmental courts and firm environmental protection expenditure. *Journal of Environmental Economics and Management*, 98, 102254.

4.A Appendices

Appendix A4.1. Verticalization Reform across Provinces

Province	Reform Time	Verticalization Year
Chongqing	November 2016	2017
Hebei	December 2016	2017
Jiangsu	July 2017	2018
Shandong	September 2017	2018
Qinghai	November 2017	2018
Jiangxi	December 2017	2018
Fujian	December 2017	2018
Hubei	December 2017	2018
Tianjin	January 2018	2018
Shanghai	January 2018	2018
Shanxi	March 2018	2018
Guangxi	December 2018	2019
Xinjiang	December 2018	2019
Guangdong	January 2019	2019
Inner Mongolia	January 2019	2019
Ningxia	January 2019	2019
Jilin	February 2019	2019
Henan	February 2019	2019
Guizhou	February 2019	2019
Yunnan	February 2019	2019
Gansu	March 2019	2019
Zhejiang	March 2019	2019
Anhui	March 2019	2019
Sichuan	March 2019	2019
Beijing	March 2019	2019
Heilongjiang	April 2019	2019
Tibet	April 2019	2019
Shanxi	April 2019	2019
Liaoning	April 2019	2019
Hunan	April 2019	2019
Hainan	July 2019	2020

Appendix A4.2. Variable definition

	Definition	Source
Dependent variables		
ENV	Environmental ratings from Sino-Securities Index (SSNI)	Chindices
SOC	Social ratings from Sino-Securities Index (SSNI)	Chindices
GOV	Corporate governance ratings from Sino-Securities Index (SSNI)	Chindices
REPENV	Number of environmental reputational incidents	RepRisk
REPSOC	Number of social reputational incidents	RepRisk
REPGOV	Number of corporate governance reputational incidents	RepRisk
ABATE1	The proportion of abatement investment to total asset in percentage	CSMAR
ABATE2	The proportion of abatement investment to total revenue in percentage	CSMAR
Independent variables		
Vertical	A dummy variable equal to one if a province adopt vertical reform	Government websites
Distance	The logarithm of geographical distance (km) of company's city to the corresponding cities with Supervision Centers for Environmental Protection (SCEP).	Calculation
NDistance	The institutional distance of company's city (Appendix A4.8).	Calculation
RouteDistance	The logarithm of route distance (km) of company's city to the corresponding cities with Supervision Centers for Environmental Protection (SCEP).	Calculation
Control variables		
LNAT	The logarithm of total assets	CSMAR
ROA	Returns on assets	CSMAR
TANG	Net-fixed asset to total asset ratio	CSMAR
LEV	Leverage ratio	CSMAR
CASH	Cash holdings to total asset ratio	CSMAR
BP	Book-to-price ratio	CSMAR
DUALITY	Duality of CEO	CSMAR
DIRNUM	The logarithm of director number	CSMAR
INDIR	Proportion of independent directors	CSMAR
FEMDIR	Proportion of female directors	CSMAR
INSNUM	The logarithm of institutional investors	CSMAR
IO	The proportion of institutional holdings	CSMAR
ANALYST	The logarithm of analyst following the company	CSMAR
MandatoryDisc	A dummy variable equal to one if a firm mandatory disclose CSR report.	CSMAR
Inspect	Environmental inspection of a province	Government websites

Appendix A4.3. Stacked difference-in-differences analysis

VARIABLES	(1) LSOE ENV	(2) CSOE ENV	(3) POE ENV
DistancexVertical	0.251**	-0.045	-0.081
	(2.06)	(-0.26)	(-0.85)
Vertical	-0.342	1.022***	0.151
	(-1.50)	(3.89)	(1.44)
Observations	5,680	2,105	11,186
R-squared	0.697	0.742	0.708
Control	YES	YES	YES
Firm#Stack FE	YES	YES	YES
Year#Stack FE	YES	YES	YES
City FE	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A4.4. Placebos: social and corporate governance ratings

VARIABLES	(1) LSOE SOC	(2) CSOE SOC	(3) POE SOC	(4) LSOE GOV	(5) CSOE GOV	(6) POE GOV
DistancexVertical	0.096	-0.084	0.034	0.075	0.005	0.042
	(0.59)	(-0.41)	(0.31)	(0.54)	(0.03)	(0.34)
Vertical	-0.086	0.158	0.012	0.078	0.050	-0.013
	(-0.65)	(0.91)	(0.13)	(0.71)	(0.30)	(-0.14)
Observations	7,189	2,647	14,196	7,189	2,647	14,196
R-squared	0.714	0.710	0.664	0.577	0.537	0.567
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A4.5. Staggered difference-in-differences: environmental incidents

VARIABLES	(1) LSOEs REPENV	(2) CSOEs REPENV	(3) POE REPENV
Second-stage regression			
DistancexVertical	-0.031*	0.011	-0.005
	(-1.72)	(0.27)	(-0.48)
Vertical	0.009	0.022	0.017**
	(0.89)	(0.83)	(2.53)
Observations	7,214	2,651	14,342
R-squared	0.001	0.002	0.002
First-stage regression			
Control	YES	YES	YES
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
City FE	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A4.6. Placebos: social and corporate governance incidents

VARIABLES	(1) LSOE REPSOC	(2) CSOE REPSOC	(3) POE REPSOC	(4) LSOE REPGOV	(5) CSOE REPGOV	(6) POE REPGOV
DistancexVertical	-0.006	-0.061	0.019	-0.025	0.139**	0.056***
	(-0.35)	(-1.03)	(1.35)	(-0.66)	(2.03)	(2.62)
Vertical	-0.006	0.038	-0.006	0.045	-0.184***	-0.022
	(-0.33)	(0.79)	(-0.43)	(1.15)	(-3.24)	(-1.00)
Observations	7,214	2,651	14,342	7,214	2,651	14,342
R-squared	0.367	0.609	0.352	0.314	0.604	0.331
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A4.7. Alternative explanations: polluting industries and environmental incidents

Panel A. Vertical reforms and polluting firms

VARIABLES	(1) Polluting firms REPENV	(2) Polluting firms REPENV	(3) Other firms REPENV	(4) Other firms REPENV
DistancexVertical		-0.037		-0.007
		(-1.34)		(-0.59)
Vertical	0.052**	0.076***	0.014	0.019
	(2.45)	(2.65)	(1.47)	(1.47)
Observations	9,202	9,202	15,005	15,005
R-squared	0.405	0.405	0.405	0.405
Control	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
City FE	YES	YES	YES	YES

Panel B. Vertical reforms, polluting firms and state ownership

VARIABLES	(1) LSOE REPENV	(2) CSOE REPENV	(3) POE REPENV	(4) LSOE REPENV	(5) CSOE REPENV	(6) POE REPENV
DistancexVertical	-0.102**	-0.035	0.008	-0.007	0.014	0.004
	(-2.06)	(-0.39)	(0.33)	(-0.39)	(0.26)	(0.34)
Vertical	0.128**	0.203**	0.017	0.001	0.084	0.008
	(2.01)	(2.29)	(0.57)	(0.04)	(1.22)	(0.62)
Observations	2,826	981	5,395	4,388	1,670	8,947
R-squared	0.406	0.605	0.247	0.200	0.561	0.287
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix A4.8. Environmental Inspection

Batch	Inspection Period	Inspection Year	Provinces
Pilot	01/01/2016 – 01/31/2016	2016	Hebei
1	07/12/2016 – 08/19/2016	2017	Inner Mongolia, Heilongjiang, Jiangsu, Jiangxi, Henan, Guangxi, Yunnan, Ningxia
2	11/24/2016 – 12/30/2016	2017	Beijing, Shanghai, Hubei, Guangdong, Chongqing, Shanxi, Gansu
3	04/24/2017 – 05/28/2017	2017	Shanxi, Anhui, Tianjin, Hunan, Fujian, Liaoning, Guizhou
4	08/07/2017 – 09/04/2017	2018	Jilin, Zhejiang, Shandong, Hainan, Sichuan, Tibet, Qinghai, Xinjiang

Appendix A4.9. Confounding events: environmental incidents

VARIABLES	(1) LSOE REPENV	(2) LSOE REPENV	(3) LSOE REPENV	(4) LSOE REPENV	(5) LSOE REPENV	(6) LSOE REPENV
DistancexVertical	-0.041**	-0.068***	-0.030	-0.073***	-0.039**	-0.037*
	(-2.10)	(-2.90)	(-1.57)	(-2.59)	(-2.02)	(-1.90)
Vertical	0.049*	0.063**	0.011	0.066***	0.047*	0.045*
	(1.95)	(2.50)	(0.71)	(2.95)	(1.87)	(1.79)
DistancexInspect		0.048**				
		(2.41)				
Inspect	0.022	-0.005				
	(1.34)	(-0.30)				
Post18			-0.004			
			(-0.31)			
DistancexPost18				0.040		
				(1.56)		
MandatoryDisc					0.012	0.001
					(0.79)	(0.04)
DistancexMandatoryDisc						0.021
						(0.58)
Observations	7,214	7,214	7,214	7,214	7,214	7,214
R-squared	0.379	0.379	0.379	0.379	0.379	0.379
Control	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	NO	YES	YES	YES
City FE	YES	YES	YES	YES	YES	YES

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 5 Lobbying and Fossil Fuel Investment[58]

5.1 Introduction

Global warming is one of the most pressing issues facing modern society: it is causing sea levels to rise dangerously and poses a threat to food production, and consequently affects the lives of billions of people (IPCC, 2021). Oil and gas (fossil fuel) companies are major contributors to global warming; since 1965, the top 20 fossil fuel companies have been responsible for 480 billion tons of carbon dioxide (CO_2) and methane as a result of the combustion of their products, which represents approximately 35% of all energy-related CO_2 and methane emissions worldwide (Climate Accountability Institute, 2019). Fossil fuel companies have earned $1 trillion in profits per year on average for the last five decades (Carrington, 2022); however, they have shown little interest in investing in low-carbon technologies to reduce greenhouse gas emissions.[59] Oil and gas companies have instead actively engaged in lobbying to obtain favorable industry policies, such as increased financial support for fossil fuel production and the removal of environmental regulations (Greenhouse, 2020). According to data from the Center for Responsive Politics, lobbying expenditures by U.S. fossil fuel companies increased from around $20 million in 2000 to more than $100 million in 2009[60], and then plateaued at more than $50 million per year between 2010 and 2019.[61] Figure 5.1 also shows that lobbying expenditure from fossil fuel companies now represents a large amount of total lobbying expenditure, increasing from 25% to 45%. Although lobbying expenditure from oil and gas companies is substantial, studies of the real impacts of fossil fuel lobbying remain scant.[62]

[58] This chapter is co-authored with Eddie C. M. Hui and Jianfu Shen.

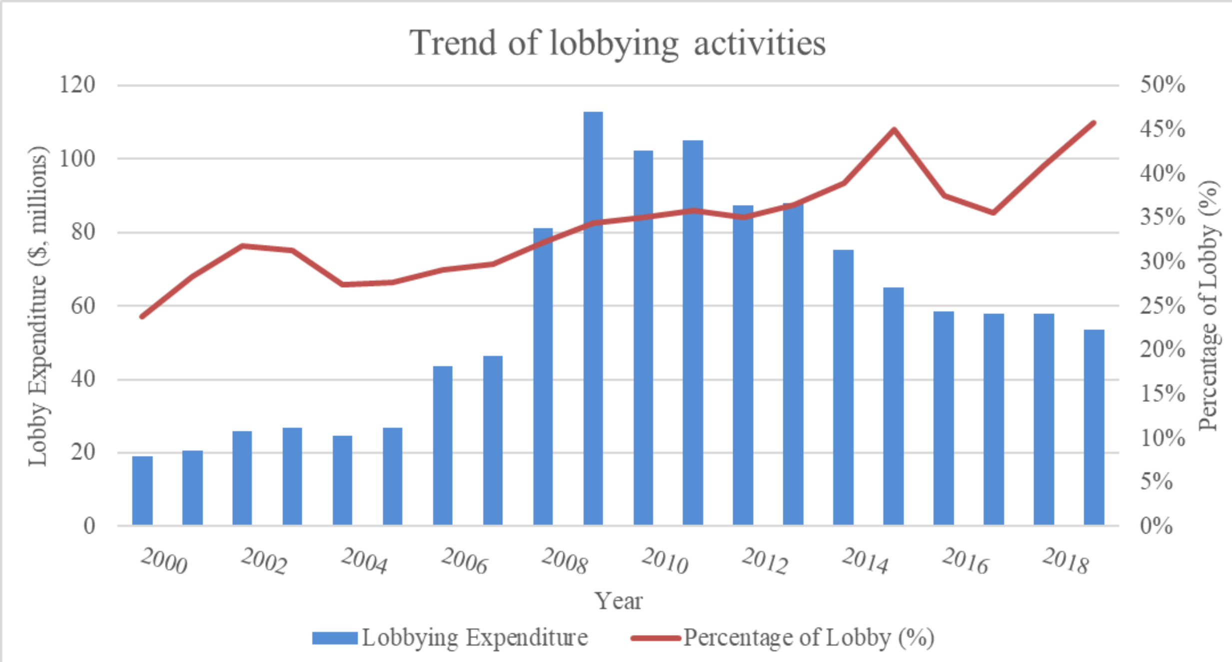
[59] For instance, ExxonMobil spent just 0.22% of its total investment on carbon reduction projects between 2010 and 2018 (House Committee on Oversight and Reform, 2021).

[60] The annual lobbying expenditures by U.S. fossil fuel companies peaked in year 2009 because of the the Waxman–Markey bill.

[61] According to a report released by the House Committee on Oversight and Reform (2021), the four major fossil fuel companies, namely ExxonMobil, Chevron, Shell, and BP, spent a combined $452.6 million lobbying the federal government between 2011 and 2020.

[62] Very few studies have explored lobbying and its consequences in the fossil fuel sector. Kang (2016) estimates that the average return from lobbying expenses in the energy sector is more than 130%. Meng and Rode (2019) find that lobbying diminished the probability of the Waxman–Markey bill being enacted by 13%, which is equivalent to an expected social cost of $60 billion.

Figure 5.1. Trend of lobbying activities in the fossil fuel sector.



Note: This figure shows the lobbying expenditures of oil and gas companies as well as the percentage of lobbying expenditures by oil and gas companies in the total lobbying expenditures of all companies between 2000 and 2018.

This study aims to fill this research gap by examining the effect of fossil fuel lobbying on oil and gas companies' corporate investment decisions. Anecdotal evidence suggests that fossil fuel firms spend a great deal of capital to increase their oil and gas reserves, even after the Paris Agreement (Oil Change International, 2020).[63] It is not clear whether lobbying increases capital expenditure in the fossil fuel sector. Lobbying is viewed as a process of favor exchange between politicians and interest groups (Grossman and Helpman, 1995; 1996), or an information transmission process (Austen-Smith and Wright, 1992; Austen-Smith, 1994; Hegde and Sampat, 2015). If oil and gas companies can obtain benefits from lobbying, e.g., tax breaks,[64] they would increase their capital spending and purchase more oil and gas reserves. The

[63] Chevron planned to increase its oil production by 11% from 2019 to 2030. ExxonMobil announced that it would invest $210 billion in increasing oil and gas production in the next seven years, resulting in 17% more emissions of CO_2 (Crowley and Rathi, 2020).

[64] In an analysis of lobbying by the fossil fuel industry issued by House Committee on Oversight and Reform, Chairwoman Maloney said that big oil companies "pay lip service to climate reforms, but behind the scenes they spend far more time lobbying to preserve their lucrative tax breaks" (House Committee on Oversight and Reform, 2021). Former Exxon lobbyists interviewed by Greenpeace Unearthed revealed that Exxon lobbied against tax hikes under Biden's administration and won billions in tax reductions under Trump's administration (Carter et al., 2021).

transmission of information about policies, especially climate change–related policies, from policymakers to lobbying firms during the lobbying process reduces those firms' political/policy uncertainty. As such, they are better informed than non-lobbying firms about the progress of policies that could affect the fossil fuel sector, and may even be able to block unfavorable bills. Lobbying firms' corporate investment may then increase after lobbying because of the reduction in policy uncertainty (Fried et al., 2022; Choi et al, 2022).[65] Following these arguments, I predict that lobbying firms in the fossil fuel sector increase their capital expenditure and oil and gas reserves more than non-lobbying firms.

Using a firm-year sample of 214 oil and gas companies from 2000 to 2019 in the U.S., this study finds that lobbying significantly increases corporate investment in the fossil fuel sector. In particular, lobbying firms have a 6.2% increase in capital expenditure ratio and a 16.4% increase in the growth of oil and gas reserves compared with non-lobbying firms in the subsequent year, in comparison with non-lobbying firms. The results remain robust when lobbying activity is measured by lobbying expenditure as an alternative key independent variable (Hegde and Sampat, 2015). To address potential endogeneity issues, this study uses two methods: first, an instrumental variable approach, in which the instrumental variable is constructed from the change in membership of congressional committees (Huneeus and Kim, 2021), as such a change could affect the probability of fossil fuel company's lobbying but is exogenous to its investment decisions; and second, an entropy balancing approach in which non-lobbying firms are matched with lobbying firms (Hainmueller, 2012). The results remain robust.

My plant-level analysis investigate whether lobbying promotes responsible environmental practices in tandem with increased fossil fuel investments or exacerbates climate-related issues. This study shows no evidence that lobbying activities lead to a significant improvement in abatement investment or production efficiency for fossil

[65] According to real option theory (e.g., Bernanke, 1983; Dixit and Pindyck, 1994), firms postpone irreversible investments when facing greater uncertainty. Recent studies (Gulen and Ion, 2016; Jens, 2017) find that policy uncertainty is negatively associated with corporate investment. Fried et al. (2022) argue that climate change policy uncertainty depresses irreversible investments in fossil fuel capital. This negative relationship can be mitigated if lobbying reduces policy uncertainty (Choi et al., 2022).

fuel plants. However, I do observe a significant increase in pollution emissions as a result of lobbying.

I further explore whether the positive effect of lobbying on fossil fuel investment can be attributed to favor exchange or to information transmission between lobbying firms and politicians. If fossil fuel investment increases due to favors obtained through lobbying, I should observe that lobbying improves the financial performance of oil and gas companies (e.g., Kang, 2016). However, if increased fossil fuel investment is caused by a reduction in policy uncertainty due to information transmission, firms' risk exposure to policy uncertainty should be reduced after the lobbying. My analysis indicates that lobbying activities significantly improve the financial performance of fossil fuel companies, as measured by return on assets following Lambert (2019) and Zhou (2022). However, firm-level political risks, particularly those associated with climate change policy uncertainty, are not reduced but rather increased following lobbying activities. Taken together, my findings support the favor exchange view and suggest that oil and gas companies increase their fossil fuel investment due to the favors obtained from lobbying.

This study adds to the literature on lobbying and on the impacts of corporate political activity on corporate outcomes. It is the first paper to explore the real impacts of fossil fuel lobbying and empirically test two competing views on lobbying in the literature.[66] Prior studies find that firms can benefit from corporate political activities (Hill et al., 2013; Chen et al., 2015; Kang, 2016; Cao et al., 2018). This study further demonstrates that the returns from corporate lobbying have real impacts on corporate investment decisions. Finally, it sheds light on the influence of political activities on efforts to deal with climate change. It yields implications for policymakers who wish to regulate lobbying in the fossil fuel sector and investors who are interested in promoting responsible lobbying behaviors in the firms in which they invest.[67]

[66] In the lobbying literature, studies have shown that lobbying activities can significantly affect trade policy (e.g., Goldberg and Maggi, 1999; Kim, 2017), financial support and regulations (e.g., Igan et al., 2012; Adelino and Dinc, 2014; Lambert, 2019), mergers and acquisitions (Igan et al., 2022), accounting standards (e.g., Friedman and Heinle, 2016; Monsen, 2022; Zhou, 2022), and federal funding allocation (e.g., de Figueiredo and Silverman, 2006; Best, 2012; Hegde and Sampat, 2015; Goldstein and You, 2017). This study adds to this literature by examining corporate investment decisions.

[67] Fossil fuel lobbying has attracted much media attention in recent years (e.g., Carter et al., 2021;

5.2 Literature Review

Prior research primarily concentrates on two theories concerning the motivations behind political lobbying: (1) the exchange of favors between politicians and interest groups, and (2) the transmission of information. The favor exchange theory proposes that lobbying constitutes a transactional process wherein interest groups offer valuable resources to politicians in return for policy influence (Austen-Smith, 1995; Stigler, 1971). This viewpoint underscores the reciprocal relationship between interest groups and policymakers and aims to comprehend the circumstances that render this exchange mutually advantageous. Stigler (1971) presents an early exploration of interest groups' roles in shaping regulatory outcomes, accentuating the possibility of regulatory capture. This phenomenon occurs when regulators are co-opted by the industries they should regulate, resulting in policy outcomes that benefit these industries at the expense of competitors or consumers. Austen-Smith (1995) devises a model of campaign contributions and access, discovering that exchanging contributions for access can amplify interest groups' influence on policy outcomes and potentially distort the democratic process. Grossman and Helpman (1995) further introduce a model of trade policy and political competition, demonstrating that protection and political influence's equilibrium levels depend on interest groups' contributions to politicians. The exchange theory emphasizes the significance of resources, such as campaign contributions, in obtaining policymakers' access and suggests that resource exchanges can yield mutually beneficial results for both parties (Grossman and Helpman, 1996). However, critics contend that this perspective is overly focused on lobbying's transactional aspects, potentially neglecting information and expertise's roles in shaping policy outcomes (Hall & Deardorff, 2006).

The informational transmission theory underscores information's role in the lobbying process, positing that interest groups can impact policy outcomes by supplying valuable information to policymakers (Bouwen, 2004). This viewpoint

Rowling, 2022) and has been criticized as a major obstacle to climate action. Responsible investors have submitted shareholder proposals for lobbying in favor of climate action and advocated that firms fully disclose their lobbying activities and positions (Reuters, 2022). In 2022, eight U.S. senators wrote a letter to the chair of the Securities and Exchange Commission, urging that it finalize disclosure regulations about corporate lobbying on climate action; such regulations could reduce the negative effect of fossil fuel lobbying on the transition to a green economy (United States Senate, 2022).

highlights the need to understand the dynamics of information exchange in lobbying and its repercussions on policy outcomes. Lohmann (1995) constructs a signaling model of lobbying, illustrating that interest groups can influence policy outcomes by providing credible information to politicians, with the signal's strength contingent on the interest group's reputation and the information transmission cost. Austen-Smith (1993) and Hall and Deardorff (2006) both stress the importance of selective information disclosure and valuable resource provision, such as expertise and support, in assisting legislators in attaining their policy objectives. Kroszner and Stratmann (2005) emphasize political experience's role in shaping firms' lobbying strategies, positing that firms tailor their political activities based on their knowledge of legislators' positions and dependability.

The existing literature explores the impact of political activities on corporate benefits. Hillman et al. (2004) argue that managers participate in political activities to enhance their firm's value. Faccio (2006) supports this view, showing that politically connected firms have a higher likelihood of securing government contracts and financial aid, which leads to increased investment opportunities. Additionally, these firms often receive preferential treatment in regulatory enforcement, thus reducing costs and investment-related risks. Goldman et al. (2009) observe that firms with politically connected directors experience positive stock price reactions following political events. Hill et al. (2013) and Chen et al. (2015) document empirical evidence that corporate lobbying practices improve financial performance and results in higher market returns. Kang (2016) also reveals a positive association between corporate lobbying and firm valuation. Ridge et al. (2017) extend their studies and examine the relationship between political connections and lobbying benefits, revealing that a firm's political connections can enhance the advantages derived from lobbying practices. Abdurakhmonov et al. (2022) suggest that lobbying breadth serves as a risk management strategy, providing political protection against government regulation. These findings indicate that firms in this sector can reap benefits from political lobbying, such as access to financing, investment rates, and market value. However, as pointed out by Hadani et al. (2015), these benefits should be weighed against the potential risks of suboptimal investment decisions and reduced firm value.

Several scholars, including Porter and Kramer (2011), contend that businesses can leverage their political influence to advocate for environmental protection. However, Borisov et al. (2016) suggest that the positive correlation between corporate lobbying and firm valuation may stem from unethical practices, such as bribing politicians, rather than simply informing them. Hadani et al. (2019) further explore the potential adverse effects of politically active firms, revealing an increased tendency to oppose socially responsible regulation and challenge shareholder proposals with a social focus, compared to less politically active firms. Additionally, Acemoglu et al. (2013) assert that lobbying can result in resource misallocation by favoring politically connected firms over more efficient competitors, ultimately leading to a decrease in economic growth and welfare.

Although numerous studies have explored the relationship between corporate lobbying and companies' financial performance, the impact of corporate lobbying on environmental outcomes remains insufficiently examined. Betsill and Corell (2007) investigate the role of non-state actors, such as environmental NGOs, in influencing international environmental policy. Vachon and Menz (2006) support this view, identifying a positive correlation between interest group lobbying and the stringency of environmental policies. This finding suggests that lobbying activities can lead to more rigorous environmental regulations, depending on the goals of interest groups and their ability to establish influential coalitions.

Oil and gas companies, which are major contributors to global warming, actively participate in lobbying to obtain favorable industry policies. As a result, it is essential to examine the effects of corporate lobbying by these firms on their fossil fuel investments and the subsequent environmental implications. Gaining a deeper understanding of the interplay between lobbying and environmental outcomes in the oil and gas sector is crucial for formulating effective policies that promote sustainable development and mitigate the negative impacts of climate change.

5.3 Hypothesis Development

Corporate lobbying may result in favorable policies and tax breaks for fossil fuel companies, encouraging increased capital spending in the sector. Furthermore, the reduction in policy uncertainty, due to information transmission during the lobbying process, can also lead to heightened investment. Consequently, I expect firms engaging in lobbying activities to demonstrate higher capital expenditure compared to their non-lobbying counterparts within the fossil fuel sector. Benefits obtained through lobbying may also incentivize oil and gas companies to augment their spending on acquiring and developing new reserves. Additionally, the diminished policy uncertainty resulting from information transmission during lobbying can encourage companies to expand their reserves. Thus, I propose the first hypothesis of this study as follows:

H1: Corporate lobbying is positively associated with capital expenditure and the growth of oil and gas reserves in the fossil fuel sector.

While lobbying may increase investment in the fossil fuel sector, its impact on promoting responsible environmental practices or exacerbating climate-related issues remains unclear. If fossil fuel companies lobby to receive information from regulators, they may utilize advanced knowledge of environmental regulations to increase abatement investment in response to such regulations. However, if these companies primarily aim to maximize returns through lobbying activities without considering the environment, their lobbying efforts will yield no significant improvement in abatement investment and production efficiency, but rather increase pollution. Therefore, I propose the second hypothesis as follows:

H2: Corporate lobbying does not lead to significant improvements in environmental practices, but significantly increase pollution emissions.

If the positive effect of lobbying on fossil fuel investment can be attributed to favor exchange, it is expected that lobbying will improve the financial performance of oil and gas companies. As a result, I hypothesize that firms engaging in lobbying activities will exhibit superior financial performance, as measured by return on assets, compared to non-lobbying firms in the sector.

H3: Corporate lobbying is positively associated with financial performance in the fossil fuel sector.

The information transmission hypothesis posits that lobbying practices could serve as insurance, as companies use advanced regulatory information to reduce political uncertainty and exposure to climate regulations. Consequently, I hypothesize that lobbying activities will lead to a significant reduction in firm-level political risks associated with climate change policy uncertainty.

H4: Corporate lobbying results in a reduction in firm-level political risks and risks associated with climate change policy uncertainty.

5.4 Sample, data, and variables

Sample and Data

The sample of fossil fuel companies in this study includes all available U.S. oil and gas firms traded on the three main exchanges in the U.S. (NYSE, AMEX, and NASDAQ). Fossil fuel companies are defined as publicly listed firms in the Oil, Gas & Consumable Fuels industry under the Global Industry Classification Standard, following Atanasova and Schwartz (2020). Only firms with U.S. headquarters are included in my sample. Penny stocks and firms with negative book equity are excluded to avoid the impact of outliers. The final sample consists of 214 firms spanning the period 2000 to 2019.

The financial statement data used in this study come from Compustat; the total proved oil and gas reserves data come from the Compustat supplementary Industry Specific database; stock market data come from the Centre for Research in Security Prices (CRSP); and detailed information on lobbying activities is taken from the LobbyView database (Kim, 2018). LobbyView compiles lobbying reports from the Senate Office of Public Records and maps corporate clients to firms in Compustat (Kim, 2017). Further, my study analyzes the abatement investment and pollution emissions associated with fossil fuel facilities using the Toxic Release Inventory (TRI) (Akey and Appel, 2021).

Variable Construction

The key independent variable *LOBDUM* is a dummy variable that equals one if a firm engages in lobbying activities in a year and zero otherwise. To measure lobbying expenditure, an alternative variable *LOBAMT* is used, which is equal to the log of one plus a firm's lobbying expenditure. Two variables are constructed to measure corporate investment decisions: capital expenditure ratio (*CAPEX*) and growth in oil and gas reserves (*ΔRESERVE*). *CAPEX* is calculated by dividing capital expenditures by the net value of property, plant, and equipment in the previous year (Gulen and Ion, 2016). *ΔRESERVE* is measured as the growth in total proved oil reserves in barrels from the previous year to the current year (Atanasova and Schwartz, 2020). Return on assets (*ROA*) is used to measure the financial performance of fossil fuel companies (Cao et al., 2018; Lambert, 2019; Zhou, 2022). My study has constructed three variables to evaluate the following aspects at the plant level: abatement investment, production efficiency in the utilization of toxic chemicals, and pollution emissions. Drawing from the methodology used by Xiong and Png (2019), this study combines data from the Compustat and TRI databases by matching the parent names of TRI companies. Additionally, this paper considers the subsidiaries of listed companies, which I retrieve from their respective 10-K reports, when matching with the TRI database. Abatement investment (ABATE) is a dummy variable that takes the value of one if a plant reports at least one pollution reduction activity (Akey and Appel, 2021; Fang et al., 2023). Production efficiency in the utilization of toxic chemicals (PRODRATIO) measures changes in output or outcome of processes that involve toxic chemicals. It indicates the productivity change for one unit of chemical input in the current year, as compared to the previous year. Following Akey and Appel (2021), my study retains only the ratios ranging between zero and three to eliminate potential errors in the data. Pollution emissions are represented by the natural logarithm of the total weight (in pounds) of toxic releases across all chemicals (Xu and Kim, 2022; Fang et al., 2023). Two variables are used to measure a firm's exposure to political/policy uncertainty. The first variable (LNPRISK) is the log of the average value of the quarterly firm-level political risk index of a firm in a year (Jiao et al., 2022; Das and Yaghoubi, 2023). Two variables are used to measure a firm's exposure to political/policy uncertainty. The first variable (*LNPRISK*) is the log of the average value of the quarterly firm-level political risk index of a firm in a year (Jiao et al., 2022; Das and Yaghoubi, 2023). The political risk index is taken from Hassan et al. (2019), and measures firm-level political risk based on conversations related to politics on conference calls. The second variable (*CPUBETA*) is the beta coefficient of climate change policy uncertainty in an augmented Fama–

French three-factor model using a firm's daily stock returns over a year (Bali et al., 2017; Nagar et al., 2019; Bouri et al., 2022; Tian et al., 2022; Azimli, 2023; Peng et al., 2023). The climate change policy uncertainty index is taken from Gavriilidis (2021). I run a regression of daily excess returns in a firm on the climate policy uncertainty index (measured in natural logarithm terms) and the Fama-French three factors in a year. As Gavriilidis (2021) only provides monthly climate change policy index, I assign a monthly index to each trading day in the month. The coefficient on the climate policy uncertainty captures the sensitivity of a firm's stock return to the climate policy uncertainty index.

A series of firm-level control variables are considered in my study, including the log of total revenue (*SALE*), revenue growth (*ΔSALE*), total assets (*LNAT*), asset growth (*ΔAT*), leverage ratio (*LEV*), change in leverage ratio (*ΔLEV*), profitability (*EBITDA*), cash-flow ratio (*CFR*), turnover ratio (*TURNOVER*) and Tobin's Q (*TOBINQ*) following the previous studies (Atanasova and Schwartz, 2020; Doshi et al., 2018; Jacob, Wentland and Wentland, 2022). All variables are winsorised at 1% and 99%. The details of all variables used are provided in Appendix A5.1.

Table 5.1 presents the summary statistics. Across my firm-year sample, 33.7% of fossil fuel firms engage in lobbying activities on an annual basis. Untabulated results show that the average amount spent on lobbying per firm across my sample is US$686,705. The maximum lobbying expenditure is US$31.39 million, which was spent by ConocoPhillips in 2011.[68] On average, capital expenditures account for 32.9% of the net amount of fixed assets investment. Total proved oil reserves increase on average by 22.4% per year, which is comparable to capital expenditures. The average ratio of ROA is 1.9%. The mean value of the log of the firm-level political risk index is 4.353. The average exposure to climate change policy uncertainty estimated from the augmented Fama–French three-factor model is -0.082. The statistics of the control variables are also reported. In examining the plant-level data, my summary statistics reveal that a mere 5.1% of facilities engage in abatement investments on an annual basis. I observe an average production ratio of 1.005, suggesting that the production efficiency

[68] The maximum lobbying expenditure can be calculated as: exp(17.262) − 1 = 31.39 million. ConocoPhillips was the third largest greenhouse gas emitter in the U.S. in 2020 (Curry et al., 2022), and accounted for 0.91% of global industrial greenhouse gas emissions from 1988 to 2015 (Griffin, 2017).

remains relatively stable, with only a marginal increase when processing each unit of chemical input as compared to the previous year. Furthermore, the logarithm of pollution emissions registers at 10.762, which aligns closely with the magnitude reported by Akey and Appel (2021).

Table 5.1. Summary Statistics

Variable	Observations	Mean	Std. Dev.	5%	95%
Dependent variables					
CAPEX	1,716	0.329	0.315	0.052	0.953
ΔRESERVE	1,249	0.224	1.038	-0.400	1.262
ROA	1,716	0.019	0.116	-0.168	0.140
LNPRISK	1,222	4.353	0.882	2.744	5.689
CPUBETA	1,588	-0.082	8.351	-1.074	1.162
Explanatory variables and instrument					
LOBDUM	1,716	0.337	0.473	0	1
LOBAMT	1,716	4.455	6.338	0	15.148
IVLOBDUM	1,716	0.306	0.461	0	1
Control variables					
SALE	1,716	6.857	2.394	2.762	10.959
ΔSALE	1,716	0.344	0.871	-0.404	1.469
LNAT	1,716	7.773	2.047	4.080	10.855
ΔAT	1,716	0.278	0.566	-0.195	1.229
LEV	1,716	0.282	0.175	0.000	0.579
ΔLEV	1,716	0.080	0.540	-0.391	0.713
EBITDA	1,716	0.162	0.157	-0.084	0.396
CFR	1,716	0.099	0.113	-0.071	0.244
TURNOVER	1,716	0.778	0.996	0.144	3.211
TOBINQ	1,716	1.506	0.763	0.798	2.858

Note: This table presents the summary statistics. The variable definitions are provided in Appendix A5.1.

Table 5.2 shows the top 10 lobbying issues for fossil fuel companies and the top 10 listed fossil fuel companies that engage in lobbying.[69] Similar to general firms, as reported by Kerr et al. (2014), fossil fuel companies spend the most on lobbying related to taxation, which amounts to US$945 million. The fossil fuel industry engages in a significant amount of lobbying in the areas of energy, fuel, and natural resources, which are related to the acquisition of raw materials for their production. Furthermore, the industry spends a considerable amount of money on lobbying over issues of international trade and foreign relations, which have a significant impact on the global supply of fossil fuels.

Table 5.2. Top 10 lobbying issues and fossil fuels firms

Issue	Lobby Expenditure ($mil)	N of lobby Activities	Percentage
Taxation	945.13	2,791	9.63%
Energy/Nuclear	903.94	3,402	9.21%
Environmental	825.19	1,713	8.41%
Fuel/Gas/Oil	696.92	1,492	7.10%
Trade	618.36	864	6.30%
Natural Resources	563.12	1,032	5.74%
Foreign Relations	483.28	533	4.92%
Clean Air & Water	435.88	811	4.44%
Budget/Appropriations	423.86	654	4.32%
Transportation	358.49	448	3.65%

Note: This table presents a list of the top 10 lobbying issues in terms of associated lobbying expenditures conducted by oil and gas companies.

[69] A lobbying activity may pertain to several issues at the same time. Consequently, the aggregate expenditures on the top 10 lobbying issues could exceed the total lobbying expenditures.

5.5 Empirical results

Baseline Estimates

To examine whether lobbying activities might affect the investment decisions of fossil fuel companies, the following model is applied (Cao et al., 2018; Lambert, 2019):

$$INVEST_{i,t+1} = \alpha + \beta_1 LOBDUM_{i,t} + \beta_2 CONTROLS_{i,t} + FIRM_i + YEAR_t + \varepsilon_{i,t} \tag{5.1}$$

where *INVEST* represents the dependent variables of capital expenditure (*CAPEX*) and change in total proved oil reserves (*ΔRESERVE*) for firm *i* in year *t*+1. The key independent variable *LOBDUM* is a dummy variable equal to one if any lobbying activity is conducted in year *t*. *CONTROLS* are a series of firm-level control variables in year *t*. Firm fixed effects (*FIRM*) and year fixed effects (*YEAR*) are included in the model to control for unobservable firm-level characteristics and aggregate market/macroeconomic factors. It is expected that the coefficient on *LOBDUM* would be positive in the regressions of *CAPEX* and *ΔRESERVE*, indicating that fossil fuel companies increase corporate investment subsequent to lobbying activities.

Table 5.3 gives the results of the regressions from Equation (5.1). Column (1) indicates a positive correlation between lobbying activities and capital expenditures. The capital expenditure ratio of a fossil fuel company that conducts lobbying activities increases by 6.2% in the subsequent year, which is significant at the 1% level. The results in column (2) indicate that lobbying activities contribute significantly to the growth of oil and gas reserves by 16.4%. I also use an alternative variable *LOBAMT* to measure lobbying intensity (Hedge and Sampat, 2015); it equals the logarithm of one plus a firm's lobbying expenditure in a year. The coefficients of *LOBAMT* are positive and significant in the regressions of capital expenditure and growth in oil and gas reserves. As shown in column (3), a one-standard-deviation increase in lobbying expenditure translates into a 3.8% increase in capital expenditures.[70] Column (4) shows that the coefficient of lobbying expenditure in the regression of growth in oil and gas

[70] The increase in capital expenditure is calculated as the standard deviation of lobbying expenditure multiplied by the coefficient on capital expenditure: 6.338 × 0.006 = 3.8%. The same calculation method is also applied to the growth in total proved oil reserves.

reserves is 0.016, which indicates that a one-standard-deviation increase in lobbying spending results in a 10.1% increase in the growth rate of oil and gas reserves. Overall, my results suggest that in comparison with non-lobbying firms, fossil fuel companies that engage in lobbying significantly increase their investments in the year after their lobbying activities.[71]

Table 5.3. Lobbying and subsequent corporate investment in fossil fuel companies

	(1)	(2)	(3)	(4)
	CAPEX	ΔRESERVE	CAPEX	ΔRESERVE
LOBDUM	0.062***	0.164*		
	(2.68)	(1.96)		
LOBAMT			0.006***	0.016**
			(2.71)	(2.07)
SALE	-0.166***	-0.712*	-0.167***	-0.713*
	(-4.42)	(-1.83)	(-4.43)	(-1.83)
ΔSALE	0.020	0.063	0.020	0.063
	(1.36)	(0.57)	(1.36)	(0.56)
LNAT	0.059*	0.509	0.058*	0.509
	(1.68)	(1.41)	(1.67)	(1.41)
ΔAT	-0.039	-0.080	-0.039	-0.080
	(-1.31)	(-0.30)	(-1.31)	(-0.31)
LEV	-0.216*	-0.161	-0.212*	-0.151
	(-1.85)	(-0.60)	(-1.82)	(-0.56)
ΔLEV	0.037*	0.232	0.036*	0.232
	(1.88)	(1.42)	(1.87)	(1.42)
EBITDA	-0.046	-0.390	-0.046	-0.387
	(-0.33)	(-0.70)	(-0.33)	(-0.69)
CFR	0.049	0.640	0.050	0.643
	(0.37)	(1.18)	(0.39)	(1.19)
TURNOVER	0.070***	0.692	0.071***	0.695
	(2.91)	(1.51)	(2.95)	(1.51)
TOBINQ	0.141***	0.050	0.142***	0.050
	(4.93)	(0.60)	(4.94)	(0.60)
Firm F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
N	1,716	1,249	1,716	1,249
R-squared	0.6189	0.2918	0.6191	0.2921

Note: This table presents the results of OLS regressions of corporate investment using Equation (5.1). Dependent variables are capital expenditure ratio (CAPEX) and change in total proved oil reserves (ΔRESERVE). The key independent variables are lobbying activity dummy (LOBDUM) and the logarithm of lobbying expenditure (LOBAMT). Control variables including the log of total revenue (SALE), revenue growth (ΔSALE), total assets (LNAT), asset growth (ΔAT), leverage ratio (LEV), change in leverage ratio (ΔLEV), profitability (EBITDA), cash-flow ratio (CFR), turnover ratio (TURNOVER) and Tobin's Q (TOBINQ) have been added to the model. Firm fixed effects and year fixed effects are included in the regressions. The *t-statistics* calculated from robust standard errors clustered at firm level are reported in parentheses. ***1%, **5%, and *10%.

[71] With respect to the control variables, the capital expenditure ratio and the growth in oil and gas reserves are significantly negatively associated with total revenue and leverage ratios, but positively correlated with turnover ratios and Tobin's Q, which is consistent with previous studies (Coles et al., 2006; Coles et al., 2014).

Robustness Tests

Endogeneity problems could result from unobservable variables that influence both lobbying and corporate investment decisions. Reverse causality may also arise if fossil fuel companies that plan to increase their oil and gas reserves participate more actively in lobbying. An instrumental variable approach is used to address these endogeneity issues (Hedge and Sampat, 2015; Lambert, 2019). This study follows Huneeus and Kim (2021) and constructs an instrumental variable from the exogenous change in U.S. politicians' membership in Congress committees to control for potential measurement errors. To construct the instrumental variable, the following three factors are examined: (1) whether committee membership in the House of Representatives and the Senate has changed; (2) whether a politician represents the state where a firm is located; and (3) whether lobbying issues have been discussed at the firm.

The instrumental variable is valid if it is related to a firm's lobbying status but exogenous to its corporate investment. It is likely that a firm that has been engaged in political activities in the past, as shown by its lobbying activity in the previous year, would lobby on the same issue in the following year. Corporate lobbyists are likely to approach local politicians who can represent their interests and who are willing to accept financial support in return for their services. However, only politicians on the relevant committees can have a significant impact in addressing the issues of concern to a firm.[72] Hence, the instrumental variable is a dummy variable (*IVLOBDUM*) that equals one if the co-located politician (representing the state of a firm's headquarters) is a member of a committee that the firm has lobbied about relevant issues in the previous year. Such an instrumental variable would be affected by changes in committee membership in Congress and changes in the representing politicians, which are exogenous to oil and gas firms. This variable should be correlated with a firm's lobbying decisions but unable to influence corporate investment decisions through channels other than lobbying.

[72] Following Bertrand, Bombardini, and Trebbi (2014), this study maps lobbying issues to committees a priori. For instance, the following lobbying issues are mapped to the Senate Committee on Energy and Natural Resources: Energy/Nuclear, Natural Resources, Fuel/Gas/Oil, Waste (hazardous/solid/interstate/nuclear), Commodities (Big Ticket), and Utilities.

Table 5.4 provides the results of the instrumental variable approach. In the first-stage regressions, the coefficients of the instrumental variable *IVLOBDUM* on the lobbying dummy variable *LOBDUM* are 0.765 for the regression of capital expenditure and 0.788 for the regression of growth of oil and gas reserves, which are significant at the 1% confidence level. The Kleibergen–Paap F-statistics of the weak instrument test are significantly larger than the Stock–Yogo 10% critical value of 16.38 (Stock and Yogo, 2005). For the under-identification test, the p-values are significantly less than 0.001. Overall, the instrumental variable meets the relevance condition and thus is considered valid.

Table 5.4. Lobbying and corporate investment: instrumental variable approach

Instrumental approach: second-stage regression	(1)	(2)
	CAPEX	ΔRESERVE
LOBDUM	0.098***	0.338*
	(2.91)	(1.94)
SALE	-0.167***	-0.718*
	(-4.43)	(-1.84)
ΔSALE	0.020	0.060
	(1.32)	(0.53)
LNAT	0.057	0.503
	(1.61)	(1.38)
ΔAT	-0.039	-0.084
	(-1.32)	(-0.32)
LEV	-0.213*	-0.148
	(-1.84)	(-0.56)
ΔLEV	0.036*	0.230
	(1.88)	(1.41)
EBITDA	-0.044	-0.367
	(-0.31)	(-0.66)
CFR	0.052	0.644
	(0.40)	(1.20)
TURNOVER	0.071***	0.703
	(2.94)	(1.53)
TOBINQ	0.141***	0.046
	(4.92)	(0.54)
Firm F.E.	Yes	Yes
Year F.E.	Yes	Yes
Instrumental approach: first-stage regression		
IVLOBDUM	0.765***	0.788***
	(17.63)	(14.87)
Kleibergen-Paap Weak IV Test (F-stat)	310.643	220.670
Kleibergen-Paap Under-identification Test (p-value)	(0.000)	(0.000)
N	1,716	1,249
R-squared	0.2313	0.0739

Note: This table presents the results of instrumental variable analysis of corporate investment following lobbying activities. Dependent variables are capital expenditure ratio (CAPEX) and change in total proved oil reserves (ΔRESERVE). The instrumental variable IVLOBDUM is a dummy variable equal to one if the co-located politician is a member of a committee in which the firm has conducted a corresponding lobbying issue in the previous year. The key independent variables are lobbying activity dummy (LOBDUM). Control variables are the same as Table 5.3. Firm fixed effects and year fixed effects are included in the regressions. The *t-statistics* calculated from robust standard errors clustered at firm level are reported in parentheses. ***1%, **5%, and *10%.

In the second-stage regressions, the coefficients of the lobbying dummy are 0.098 in the regression of capital expenditure and 0.338 in the regression of growth in oil and gas reserves, which indicates that fossil fuel companies increase their capital expenditures by 9.8% and the growth of oil and gas reserves by 33.8% following lobbying activities. The magnitudes of the coefficients from the instrumental variable approach are larger than the coefficients of the OLS regressions in Table 5.3, which implies that my baseline estimates may underestimate the impact of lobbying activities on corporate investment decisions. In sum, my findings that oil and gas companies increase fossil fuel investment after lobbying are still robust when I use the instrumental variable approach.

This study further uses an entropy balancing method to conduct a second robustness test, following previous studies (Chapman et al., 2019; Hainmueller, 2012; McMullin et al., 2019). The entropy balancing approach assigns weights to observable covariates in a control group (non-lobbying firms) on a continuous scale so as to achieve an almost identical distribution of covariates as in the treatment group (lobbying firms). The entropy balancing is run each year to achieve a covariate balance between lobbying firms and non-lobbying firms. The firm characteristics that are selected to achieve covariate balance are revenue growth, asset growth, leverage ratio, change in leverage ratio, profitability, cash-flow ratio, turnover ratio and Tobin's Q. My main results remain robust from the entropy-balanced sample, and are given in the Appendix A5.2.

The lobbying expenses of the 10 oil and gas firms that spent the most on lobbying account for more than 50% of the total lobbying expenditures in the fossil fuel sector. To mitigate the possibility that my results are driven by these outliers, I exclude these lobbying firms (or alternatively the top 20 oil and gas firms that engage in lobbying) from the sample and conduct the analysis again. The results (untabulated) remain similar.

Abatement investment and pollution emissions

The previous section reveals a potential role of political lobbying by fossil fuel companies in promoting investment in conventional energy sources. However, the actual impact of political lobbying on the environment remains to be determined. On the one hand, lobbying may lead these companies to proactively invest in abatement measures, as they anticipate future regulations. By strategically investing in abatement activities, companies could be better prepared to adhere to stricter environmental standards, thus offsetting the environmental consequences of an increased scale of conventional energy investment. On the other hand, lobbying efforts could also be directed towards hindering or weakening regulatory measures, allowing fossil fuel companies to prioritize higher production and revenue despite increased pollution levels. Considering these divergent possibilities, it is difficult to ascertain the true impact of political lobbying on the environmental conduct of fossil fuel corporations. Therefore, understanding whether lobbying ultimately encourages responsible environmental practices or exacerbates climate-related issues is a crucial aspect of this study.

In order to assess the true environmental consequences of political lobbying, this paper utilizes the Toxics Release Inventory (TRI) provided by the U.S. Environmental Protection Agency (EPA). The TRI database offers comprehensive information on pollution emissions from individual plants, along with details on abatement activities undertaken and production efficiency improved. To gain deeper insights into the relationship between political lobbying and the environmental impact of fossil fuel firms, my study merges detailed plant-level data with the records of their respective parent companies. By doing so, I can analyze how the lobbying efforts of these corporations influence their environmental conduct. Specifically, my study will conduct the following instrumental variable estimation to examine whether lobbying activities might affect abatement investment and pollution emissions:

$$ABATE_{j,i,t+1}/PRODRATIO_{j,i,t+1}/EMISSIONS_{j,i,t+1} = \alpha + \beta_1 LOBDUM_{i,t} + \beta_2 CONTROLS_{i,t} + PLANT_{j,i} + YEAR_t + \varepsilon_{j,i,t} \tag{5.2}$$

where *ABATE* represents a dummy variable equal to one if plant j of parent firm i conduct at least one abatement activity in year t. *PRODRATIO* is the production efficiency ratio indicating the ratio of current-year chemical productivity over the previous-year chemical productivity, and *EMISSIONS* is the logarithm of the total weight (in pounds) of toxic releases across all chemicals.

Table 5.5 presents the findings from my analysis. In the first-stage regressions, the instrumental variable passes the weak instrument test and under-identification test, with the p-values significantly less than 0.001. Hence, the instrumental variable is also considered valid in the plant level analysis. For the second-stage regressions, column (1) demonstrates that there is no significant association between a plant's abatement investment in the subsequent year and its parent company's political lobbying activities. Additionally, Column (2) reveals that the efficiency of toxic chemical usage remains unchanged after lobbying. Taken together, these results provide no evidence to support the idea that lobbying efforts lead to improvements in responsible environmental practices or abatement investments by fossil fuel firms. Conversely, Column (3) reveals a significant increase in pollution emissions following political lobbying. The coefficient of 0.589 for the lobbying dummy variable suggests that the volume of emissions rises by 80.2% after the parent company engages in political lobbying. My findings indicate that political lobbying exacerbates climate-related issues and contributes to environmental problems.

Table 5.5. Lobbying, abatement investment and pollution emissions

Instrumental approach: second-stage regression	(1)	(2)	(3)
	ABATE	PRODRATIO	EMISSION
LOBDUM	0.023	-0.002	0.589***
	(1.39)	(-0.12)	(2.73)
SALE	0.054	-0.031	-0.041
	(1.03)	(-0.88)	(-0.15)
ΔSALE	-0.000	0.024	-0.162
	(-0.03)	(0.82)	(-1.17)
LNAT	-0.055	0.049	-0.146
	(-0.96)	(1.19)	(-0.43)
ΔAT	0.006	-0.058**	0.248
	(0.24)	(-2.25)	(1.25)
LEV	0.016	-0.026	-0.762
	(0.22)	(-0.30)	(-0.96)
ΔLEV	-0.005	0.014	0.403*
	(-0.29)	(0.50)	(1.80)
EBITDA	0.199	0.195	1.042
	(1.49)	(1.26)	(0.82)
CFR	-0.428***	-0.239	1.089
	(-2.60)	(-1.23)	(0.71)
TURNOVER	-0.002	0.006	0.020
	(-0.09)	(0.39)	(0.15)
TOBINQ	0.014	0.014	-0.697**
	(0.66)	(0.62)	(-2.33)
Plant F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
Instrumental approach: first-stage regression			
IVLOBDUM	0.749***	0.749***	0.749***
	(33.48)	(33.48)	(33.48)
Kleibergen-Paap Weak IV Test (F-stat)	6913.719	6913.719	6913.719
Kleibergen-Paap Under-identification Test (p-value)	(0.000)	(0.000)	(0.000)
N	3,775	3,775	3,775
R-squared	0.0092	0.0039	0.0116

Note: This table presents the results of instrumental variable analysis of abatement investment and pollution emissions following lobbying activities. Dependent variables are abatement investment (ABATE), production efficiency ratio (PRODRATIO) and pollution emissions (EMISSIONS). The instrumental variable IVLOBDUM is a dummy variable equal to one if the co-located politician is a member of a committee in which the firm has conducted a corresponding lobbying issue in the previous year. The key independent variables are lobbying activity dummy (LOBDUM). Control variables are the same as Table 3. Firm fixed effects and year fixed effects are included in the regressions. The t-statistics calculated from robust standard errors clustered at firm level are reported in parentheses. ***1%, **5%, and *10%.

Favor Exchange or Information Transmission

I further investigate whether the positive impacts of lobbying on fossil fuel investment can be attributed to the benefits received by lobbying firms (the favour exchange view) or the reduction of lobbying firms' policy uncertainty (the information transmission view) (Hedge and Sampat, 2015). To differentiate the arguments, I run regressions using Equation (5.1) after replacing the development variables with corporate financial performance and firm-level political uncertainty/climate risk exposure. I report the results of the instrumental variable approach in Table 5.6. The results from OLS regressions are similar.

Column (1) of Table 5.6 shows that the ROA of fossil fuel firms increases by 2.8% following their lobbying activities. This implies that lobbying activities do improve the financial performance of fossil fuel firms, probably because they can receive tax breaks or other benefits from lobbying. The results are consistent with anecdotal evidence that oil firms obtain tax breaks from lobbying (House Committee on Oversight and Reform, 2021; Carter et al., 2021) and the findings in prior studies that the return on fossil fuel lobbying is surprisingly high (Kang, 2016) and hence lobbying leads to improved financial performance (Cao et al., 2018). Combining this evidence with the findings above, I conjecture that oil and gas companies increase their fossil fuel investments after lobbying because of the favors they receive from lobbying.

My results do not support the argument that increased corporate investment in oil and gas companies is caused by the resolution of political/policy uncertainty due to lobbying (Fried et al., 2022). The coefficients of the lobbying dummy variable are positive in the regressions of the political risk index and climate risk exposure after controlling for firm characteristics. Column (2) indicates that lobbying activities lead to a significant increase in subsequent firm-level political risks. Column (3) shows that lobbying activities increase fossil fuel companies' risk exposure to climate change policy uncertainty. These findings do not support the view that lobbying facilitates information transmission from politicians to lobbying firms and thereby reduces lobbying firms' political/policy uncertainty.[73]

Table 5.6. Favour exchange or information transmission

	(1)	(2)	(2)
	ROA	LNPRISK	CPUBETA
LOBDUM	0.028**	0.314**	0.155*
	(2.28)	(2.55)	(1.78)
CAPEX	0.011	0.138	0.163*
	(0.84)	(0.96)	(1.66)
SALE	0.035***	0.054	-0.201
	(3.58)	(0.47)	(-1.45)
ΔSALE	-0.006	-0.036	-0.012
	(-1.34)	(-0.59)	(-0.30)
LNAT	-0.061***	-0.009	0.171
	(-4.58)	(-0.07)	(1.13)
ΔAT	0.007	0.005	-0.173
	(0.82)	(0.05)	(-1.57)
LEV	0.043	0.146	0.122
	(1.30)	(0.59)	(0.47)
ΔLEV	-0.007	0.062	0.044
	(-1.04)	(1.11)	(0.96)
EBITDA	0.107**	0.309	0.783*
	(2.23)	(0.84)	(1.86)
CFR	-0.048	0.005	-0.135
	(-0.77)	(0.01)	(-0.31)
TURNOVER	-0.004	-0.102	0.092
	(-0.53)	(-0.92)	(1.12)
TOBINQ	0.032***	0.035	0.037
	(3.60)	(0.46)	(0.94)
Firm F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
N	1,399	1,196	1,552

Note: This table presents the results of instrumental variable analysis of financial performance and the exposure on policy/political uncertainty following lobbying activities. Dependent variables are returns on assets (ROA), political risk index (LNPRISK) and exposure on climate risk uncertainty (CPUBETA). The instrumental variable is a dummy variable equal to one if the co-located politician is a member of a committee in which the firm has conducted a corresponding lobbying issue in the previous year. The key independent variables are lobbying activity dummy (LOBDUM). Control variables are the same as Table 5.3. Firm fixed effects and year fixed effects are included in the regressions. The *t-statistics* calculated from robust standard errors clustered at firm level are reported in parentheses. ***1%, **5%, and *10%.

[73] As lobbying firms in the fossil fuel sector can receive benefits from lobbying and expand their fossil fuel activities, their political risk or exposure to climate change policy uncertainty could be increased.

5.6 Conclusion

This study examines the real impact of fossil fuel lobbying on oil and gas companies. My results show that capital expenditures and growth of oil and gas reserves significantly increase following lobbying in fossil fuel companies. To ensure that my estimations do not suffer from possible endogeneity issues, an instrumental variable based on the exogenous shift of congressional committee politicians and an entropy balancing approach are used, and my results remain robust. Fossil fuel companies expand their investment in conventional energy without devoting resources to abatement activities, leading to increased pollution emissions. These companies benefit from lobbying activities in terms of their financial performance, which is consistent with the favor exchange view proposed in previous studies of lobbying (Grossman and Helpman, 1995; 1996; Borisov et al., 2016). My findings, however, do not support the argument that lobbying firms can reduce their political risk or exposure to climate change policy uncertainty by obtaining information via lobbying (Austen-Smith and Wright, 1992; Austen-Smith, 1994). Overall, my findings suggest that oil and gas companies receive benefits from lobbying and in turn expand their fossil fuel activities.

Over the last 50 years, global temperatures have risen significantly (NASA, 2022). Climate change has exacerbated extreme weather events such as heat waves, droughts, and floods, which signals an urgent need to pause the escalation of carbon emissions to the atmosphere. Nevertheless, fossil fuel companies, which are responsible for the majority of carbon emissions, continue to enlarge the scale of their business and hence accelerate climate change. My study reveals that oil and gas companies' lobbying is positively associated with their fossil fuel investments. To combat climate change, it is necessary to regulate fossil fuel lobbying, e.g., to promote transparency concerning oil and gas companies' lobbying positions, expenditures, and benefits (United States Senate, 2022), and to encourage them to invest in low-carbon activities. Future studies could examine how a firm's political activities impact its carbon footprint, such as greenhouse gas emissions and green technology investment, to assist policymakers in making better decisions in regulating lobbying and developing climate change–related legislation.

References

Abdurakhmonov, M., Ridge, J. W., Hill, A. D., & Loncarich, H. (2022). Strategic Risk and Lobbying: Investigating Lobbying Breadth as Risk Management. *Journal of Management*, *48*(5), 1103–1130. https://doi.org/10.1177/01492063211011762

Acemoglu, D., Robinson, J. A., & Torvik, R. (2013). Why Do Voters Dismantle Checks and Balances? *The Review of Economic Studies*, *80*(3), 845–875. https://doi.org/10.1093/restud/rdt007

Adelino, M., & Dinc, I. S. (2014). Corporate distress and lobbying: Evidence from the Stimulus Act. *Journal of Financial Economics*, *114*(2), 256-272.

Akey, P., & Appel, I. (2021). The Limits of Limited Liability: Evidence from Industrial Pollution. *The Journal of Finance*, *76*(1), 5–55. https://doi.org/10.1111/jofi.12978

Atanasova, C., & Schwartz, E. S. (2020). *Stranded fossil fuel reserves and firm value*. NBER working paper.

Austen-Smith, D. (1993). Information and Influence: Lobbying for Agendas and Votes. *American Journal of Political Science*, *37*(3), 799. https://doi.org/10.2307/2111575

Austen-Smith, D. (1994). Strategic transmission of costly information. *Econometrica*, 62(4), 955-963.

Austen-Smith, D. (1995). Campaign Contributions and Access. *American Political Science Review*, *89*(3), 566–581. https://doi.org/10.2307/2082974

Austen-Smith, D., & Wright, J. R. (1992). Competitive lobbying for a legislator's vote. *Social choice and Welfare*, *9*(3), 229-257.

Azimli, A. (2023). The impact of climate policy uncertainty on firm value: Does corporate social responsibility engagement matter? *Finance Research Letters*, *51*, 103456.

Bali, T. G., Brown, S. J., & Tang, Y. (2017). Is economic uncertainty priced in the cross-section of stock returns? *Journal of Financial Economics*, *126*(3), 471-489.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, *98*(1), 85-106.

Bertrand, M., Bombardini, M., & Trebbi, F. (2014). Is it whom you know or what you know? An empirical assessment of the lobbying process. *American Economic Review*, *104*(12), 3885-3920.

Best, R. K. (2012). Disease politics and medical research funding: three ways advocacy shapes policy. *American Sociological Review*, *77*(5), 780-803.

Betsill, M. M., & Corell, E. (Eds.). (2007). *NGO Diplomacy: The Influence of Nongovernmental Organizations in International Environmental Negotiations*. The MIT Press. https://doi.org/10.7551/mitpress/7512.003.0005

Borisov, A., Goldman, E., & Gupta, N. (2016). The corporate value of (corrupt) lobbying. *The Review of Financial Studies*, *29*(4), 1039-1071.

Bouri, E., Iqbal, N., & Klein, T. (2022). Climate policy uncertainty and the price dynamics of green and brown energy stocks. *Finance Research Letters*, *47*, 102740.

Bouwen, P. (2004). Exchanging access goods for access: A comparative study of business lobbying in the European Union institutions. *European Journal of Political Research*, *43*(3), 337–369. https://doi.org/10.1111/j.1475-6765.2004.00157.x

Cao, Z., Fernando, G. D., Tripathy, A., & Upadhyay, A. (2018). The economics of corporate lobbying. *Journal of Corporate Finance*, *49*, 54-80.

Carrington, D. (2022). Revealed: oil sector's 'staggering' $3bn-a-day profits for last 50 years. The Guardian, Available at: https://www.theguardian.com/environment/2022/jul/21/revealed-oil-sectors-staggering-profits-last-50-years [Accessed 25 September 2022].

Carrington, D., 2022. Revealed: oil sector's 'staggering' $3bn-a-day profits for last 50 years. *The Guardian*, Available at: https://www.theguardian.com/environment/2022/jul/21/revealed-oil-sectors-staggering-profits-last-50-years [Accessed 25 September 2022].

Carter, L., Boren, Z. and Kaufman, A. (2021) *Revealed: BP and Shell Back anti-climate lobby groups despite pledges*. Unearthed. Available at https://unearthed.greenpeace.org/2020/09/28/bp-shell-climate-lobby-groups/ [Accessed: February 3, 2023].

Chapman, K. L., Reiter, N., White, H. D., & Williams, C. D. (2019). Information overload and dis-closure smoothing. *Review of Accounting Studies*, *24*(4), 1486–1522. https://doi.org/10.1007/ s11142-019-09500-4.

Chen, H., Parsley, D., & Yang, Y. W. (2015). Corporate lobbying and firm performance. *Journal of Business Finance & Accounting*, *42*(3-4), 444-481.

Choi, W., Chung, C. Y., & Wang, K. (2022). Firm-level political risk and corporate investment. *Finance Research Letters*, *46*, 102307.

Climate Accountability Institute, 2019. *Carbon Majors: Update of Top Twenty companies 1965-2017*. Available at: https://climateaccountability.org/wp-content/uploads/2020/12/CAI-PressRelease-Top20-Oct19.pdf [Accessed 25 September 2022].

Coles, J. L., Daniel, N. D., & Naveen, L. (2006). Managerial incentives and risk-taking. *Journal of Financial Economics*, *79*(2), 431-468.

Coles, J. L., Daniel, N. D., & Naveen, L. (2014). Co-opted boards. *The Review of Financial Studies*, *27*(6), 1751-1796.

Crowley, K. and Rathi, A., 2020. *Exxon's Plan for Surging Carbon Emissions Revealed in Leaked Documents*. Bloomberg. Available at: https://www.bloomberg.com/news/articles/2020-10-05/exxon-carbon-emissions-and-climate-leaked-plans-reveal-rising-co2-output [Accessed 26 September 2022].

Curry, T., Hellgren, L., Russell, P. and Fraioli, S., 2022. *Benchmarking Methane and Other GHG Emissions of Oil & Natural Gas Production in the United States*. Clean Air Task Force. Available at https://cdn.catf.us/wp-content/uploads/2022/07/14094726/oilandgas_benchmarkingreport2022.pdf [Accessed 19 September 2022].

Das, K. K., & Yaghoubi, M. (2023). Stock liquidity and firm-level political risk. *Finance Research Letters*, *51*, 103419.

de Figueiredo, J. M., & Silverman, B. S. (2006). Academic earmarks and the returns to lobbying. *The Journal of Law and Economics*, *49*(2), 597-625.

Dixit, A. K., & Pindyck, R. S. (1994). *Investment under uncertainty*. Princeton University Press.

Doshi, H., Kumar, P., & Yerramilli, V. (2018). Uncertainty, capital investment, and risk management. *Management Science*, 64(12), 5769-5786.

Faccio, M., Masulis, R. W., & McCONNELL, J. J. (2006). Political Connections and Corporate Bailouts. *The Journal of Finance*, *61*(6), 2597–2635. https://doi.org/10.1111/j.1540-6261.2006.01000.x

Fang, M., Hsu, P.-H., & Tsou, C.-Y. (2023). Pollution Abatement Investment under Financial Frictions and Policy Uncertainty. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4390975

Fried, S., Novan, K., & Peterman, W. B. (2022). Climate policy transition risk and the macroeconomy. *European Economic Review*, *147*, 104174.

Friedman, H. L., & Heinle, M. S. (2016). Lobbying and uniform disclosure regulation. *Journal of Accounting Research*, *54*(3), 863-893.

Gavriilidis, K. (2021). *Measuring climate policy uncertainty*. Available at SSRN: https://ssrn.com/abstract=3847388.

Goldberg, P. K., & Maggi, G. (1999). Protection for sale: An empirical investigation. *American Economic Review*, *89*(5), 1135-1155.

Goldman, E., Rocholl, J., & So, J. (2009). Do Politically Connected Boards Affect Firm Value? *Review of Financial Studies*, *22*(6), 2331–2360. https://doi.org/10.1093/rfs/hhn088

Goldstein, R., & You, H. Y. (2017). Cities as lobbyists. *American Journal of Political Science*, *61*(4), 864-876.

Greenhouse. 2020. *Why fossil fuel lobbyists are dominating climate policy during Covid-19*. at: https://www.greenhouse.agency/blog/fossil-fuel-lobbyists-during-covid-19/ [Accessed 25 September 2022].

Griffin, P., 2017. *CDP Carbon Majors Report 2017*. Carbon Disclosure Project. Available at: https://cdn.cdp.net/cdp-production/cms/reports/documents/000/002/327/original/Carbon-Majors-Report-2017.pdf [Accessed 19 September 2022].

Grossman, G. M., & Helpman, E. (1995). Trade wars and trade talks. *Journal of Political Economy*, *103*(4), 675-708.

Grossman, G. M., & Helpman, E. (1996). Electoral competition and special interest politics. *The Review of Economic Studies*, *63*(2), 265-286.

Gulen, H., & Ion, M. (2016). Policy uncertainty and corporate investment. *The Review of Financial Studies*, *29*(3), 523-564.

Hadani, M., Dahan, N. M., & Doh, J. P. (2015). The CEO as chief political officer: Managerial discretion and corporate political activity. *Journal of Business Research*, *68*(11), 2330–2337. https://doi.org/10.1016/j.jbusres.2015.03.046

Hadani, M., Doh, J. P., & Schneider, M. (2019). Social movements and corporate political activity: Managerial responses to socially oriented shareholder activism. *Journal of Business Research*, *95*, 156–170. https://doi.org/10.1016/j.jbusres.2018.10.031

Hainmueller, J. (2012). Entropy balancing for causal effects: A multivariate reweighting method to pro-duce balanced samples in observational studies. *Political Analysis*, *20*(1), 25–46. https://doi.org/10.1093/pan/mpr025.

Hall, R. L., & Deardorff, A. V. (2006). Lobbying as Legislative Subsidy. *American Political Science Review*, *100*(1), 69–84. https://doi.org/10.1017/S0003055406062010

Hassan, T. A., Hollander, S., Van Lent, L., & Tahoun, A. (2019). Firm-level political risk: Measurement and effects. *The Quarterly Journal of Economics*, *134*(4), 2135-2202.

Hegde, D., & Sampat, B. (2015). Can private money buy public science? Disease group lobbying and federal funding for biomedical research. *Management Science, 61*(10), 2281-2298.

Hill, M. D., Kelly, G. W., Lockhart, G. B., & Van Ness, R. A. (2013). Determinants and effects of corporate lobbying. *Financial Management, 42*(4), 931-957.

Hillman, A. J., Keim, G. D., & Schuler, D. (2004). Corporate Political Activity: A Review and Research Agenda. *Journal of Management*, *30*(6), 837–857. https://doi.org/10.1016/j.jm.2004.06.003

House Committee on Oversight and Reform, 2021. *Analysis of the Fossil Fuel Industry's Legislative Lobbying and Capital Expenditures Related to Climate Change*. Available at https://oversight.house.gov/sites/democrats.oversight.house.gov/files/Analysis%20of%20the%20Fossil%20Fuel%20Industrys%20Legislative%20Lobbying%20and%20Capital%20Expenditures%20Related%20to%20Climate%20Change%20-%20Staff%20Memo%20%2810.28.21%29.pdf [Accessed 16 September 2022].

Huneeus, F., & Kim, I. S. (2021). *The effects of firms' lobbying on resource misallocation*. Working paper.

Igan, D., Lambert, T., Wagner, W., & Zhang, E. Q. (2022). Winning connections? Special interests and the sale of failed banks. *Journal of Banking & Finance*, *140*, 106496.

Igan, D., Mishra, P., & Tressel, T. (2012). A fistful of dollars: Lobbying and the financial crisis. *NBER Macroeconomics Annual*, *26*(1), 195-230.

IPCC, 2021. Summary for Policymakers. In: Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O.

Yelekçi, R. Yu, and B. Zhou (Eds.), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate* (pp. 3−32). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. doi:10.1017/9781009157896.001.

Jacob, M., Wentland, K., & Wentland, S. A. (2022). Real effects of tax uncertainty: Evidence from firm capital investments. *Management Science*, 68(6), 4065-4089.

Jens, C. E. (2017). Political uncertainty and investment: Causal evidence from U.S. gubernatorial elections. *Journal of Financial Economics*, *124*(3), 563-579.

Jiao, A., Ma, H., & Ren, H. (2022). Political catastrophe and firm strategies: Evidence from the capitol riot. *Finance Research Letters*, *48*, 102948.

Kang, K. (2016). Policy influence and private returns from lobbying in the energy sector. *The Review of Economic Studies*, *83*(1), 269-305.

Kerr, W. R., Lincoln, W. F., & Mishra, P. (2014). The dynamics of firm lobbying. *American Economic Journal: Economic Policy*, *6*(4), 343-379.

Kim, I. S. (2017). Political cleavages within industry: Firm-level lobbying for trade liberalization. *American Political Science Review*, *111*(1), 1-20.

Kim, I. S. (2018). *Lobbyview: Firm-level lobbying & congressional bills database*. Working paper.

Kroszner, R. S., & Stratmann, T. (2005). Corporate Campaign Contributions, Repeat Giving, and the Rewards to Legislator Reputation. *The Journal of Law and Economics*, *48*(1), 41–71. https://doi.org/10.1086/429114

Lambert, T. (2019). Lobbying on regulatory enforcement actions: Evidence from U.S. commercial and savings banks. *Management Science*, *65*(6), 2545-2572.

Lohmann, S. (1995). Information, access, and contributions: A signaling model of lobbying. *Public Choice*, *85*(3–4), 267–284. https://doi.org/10.1007/BF01048199

McMullin, J. L., Miller, B. P., & Twedt, B. J. (2019). Increased mandated disclosure frequency and price formation: Evidence from the 8-K expansion regulation. *Review of Accounting Studies*, *24*(1), 1–33. https://doi.org/10.1007/s11142-018-9462-2.

Meng, K. C., & Rode, A. (2019). The social cost of lobbying over climate policy. *Nature Climate Change*, *9*(6), 472-476.

Monsen, B. R. (2022). The determinants and consequences of big 4 lobbying positions on proposed financial accounting standards. *The Accounting Review*, *97*(3), 309-341.

Nagar, V., Schoenfeld, J., & Wellman, L. (2019). The effect of economic policy uncertainty on investor information asymmetry and management disclosures. *Journal of Accounting and Economics*, *67*(1), 36-57.

NASA, 2022. World of Change: Global Temperatures. Available at: https://earthobservatory.nasa.gov/world-of-change/global-temperatures [Accessed 26 September 2022].

Oil Change International, 2020. Big Oil Reality Check: Assessing Oil and Gas Company Climate Plans. Available at: http://priceofoil.org/content/uploads/2020/09/OCI-Big-Oil-Reality-Check-vF.pdf [Accessed 26 September 2022].

Peng, D., Colak, G., & Shen, J., (2023). Lean against the wind: The effect of policy uncertainty on a firm's corporate social responsibility performance. *Journal of Corporate Finance*, Forthcoming.

Porter, M. E., & Kramer, M. R. (2011). Creating Shared Value. *Harvard Business Review*, *17*.

Reuters (2022) *Volkswagen rejects shareholder push for climate lobbying disclosures*. Thomson Reuters. Available at https://www.reuters.com/business/autos-transportation/volkswagen-rejects-shareholder-push-climate-lobbying-disclosures-2022-04-09/ [Accessed: February 3, 2023].

Ridge, J. W., Ingram, A., & Hill, A. D. (2017). Beyond Lobbying Expenditures: How Lobbying Breadth and Political Connectedness Affect Firm Outcomes. *Academy of Management Journal*, *60*(3), 1138–1163. https://doi.org/10.5465/amj.2015.0584

Rowling, M. (2022) *Analysis: COP27 fossil fuel lobbyists criticised as Africa Energy Debate simmers*. Thomson Reuters. Available at https://www.reuters.com/business/cop/cop27-fossil-fuel-lobbyists-criticised-africa-energy-debate-simmers-2022-11-10/ [Accessed: February 3, 2023].

Stigler, G. J. (1971). The Theory of Economic Regulation. *The Bell Journal of Economics and Management Science*, *2*(1), 3. https://doi.org/10.2307/3003160

Stock, J. H., & Yogo, M. (2005). Testing for weak instruments in linear IV regression. In: D. W. K. Andrews & J. H. Stock (Eds.), *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg* (pp. 80–108). Cambridge University Press, Cambridge, United Kingdom.

Tian, H., Long, S., & Li, Z. (2022). Asymmetric effects of climate policy uncertainty, infectious diseases-related uncertainty, crude oil volatility, and geopolitical risks on green bond prices. *Finance Research Letters*, *48*, 103008.

United States Senate, 2022. *Letter to SEC on climate disclosure*. Available at https://www.whitehouse.senate.gov/imo/media/doc/Letter%20to%20SEC%20on%20Climate%20Disclosure%20Final.pdf [Accessed 16 September 2022].

Vachon, S., & Menz, F. C. (2006). The role of social, political, and economic interests in promoting state green electricity policies. *Environmental Science & Policy*, *9*(7–8), 652–662. https://doi.org/10.1016/j.envsci.2006.07.005

Xiong, X., & Png, I. P. L. (2019). Location of U.S. Manufacturing, 1987-2014: A New Dataset. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3401582

Xu, Q., & Kim, T. (2022). Financial Constraints and Corporate Environmental Policies. *The Review of Financial Studies*, *35*(2), 576–635. https://doi.org/10.1093/rfs/hhab056

Zhou, Y. (2022). Proprietary Costs and Corporate Lobbying Against Changes in Mandatory Disclosure. *Management Science*, *68*(11), 8483-8505.

5.A Appendices

Appendix A5.1. Variable definition

Variable	Definition
Key independent variables	
LOBDUM	A dummy variable equal to one if firm *i* conduct lobbying activities in year *t* (LobbyView).
LOBAMT	The log of one plus the dollar amount of lobbying spending by firm *i* in year *t* (LobbyView).
Dependent variables	
CAPEX	Capital expenditures of firm *i* in year *t* scaled by its net value of property, plant and equipment in the previous year *t-1* (Compustat).
ΔRESERVE	The growth in total proved oil reserves (in barrels) of firm *i* in year *t* (Compustat).
ABATE	A dummy variable equal to one if plant *j* conduct at least one abatement activity in year t (TRI).
PRODRATIO	The production efficiency ratio indicates the ratio of current-year chemical productivity over the previous-year chemical productivity across all chemicals for plant *j* at year *t* (TRI).
EMISSION	The log of pounds of total toxic releases across all chemicals for plant *j* at year *t* (TRI).
ROA	Returns on asset ratio (Compustat)
LNPRISK	The log of firm level political risk index (firmlevelrisk.com)
CPUBETA	The beta on climate policy uncertainty index (in log) from the augmented Fama-French three-factor model based on a daily return sample (policyuncertainty.com)
Control variables	
SALE	The log of total revenue of firm *i* in year *t* (Compustat).
ΔSALE	The growth in total revenue of firm *i* in year *t* (Compustat).
LNAT	The log of the book value of total assets of firm *i* in year *t* (Compustat).
ΔAT	The growth in total assets of firm *i* in year *t* (Compustat).
LEV	Total debt scaled by the book value of total assets of firm *i* in year *t* (Compustat).
ΔLEV	The percentage change in leverage ratio of firm *i* in year *t* (Compustat).
EBITDA	Earnings before interest, taxes, depreciation and amortization scaled of firm *i* in year *t* scaled by total assets in year *t-1* (Compustat).
CFR	Cash flow of firm *i* in year *t* scaled by the book value of assets in previous year *t-1* (Compustat).
TURNOVER	Total revenue scaled by the book value of total asset ratio of firm *i* in year *t* (Compustat).
TOBINQ	Tobin's Q ratio, which is calculated by the sum of total debt and market capitalization of firm *i*, scaled by the book value of total assets in year *t* (Compustat).

Instruments	
IVLOBDUM	A dummy variable equal to one if a co-located politician in Congressional committees in which firm *i* conducted corresponding lobbying issues in the previous year *t-1* (LobbyView & Charles Stewart's Congressional Data).

Appendix A5.2. Lobbying and corporate investment: entropy-balanced sample

	(1)	(2)	(3)	(4)
	CAPEX	ΔRESERVE	CAPEX	ΔRESERVE
LOBDUM	0.067***	0.150*		
	(2.84)	(1.75)		
LOBAMT			0.006***	0.014**
			(2.80)	(1.97)
SALE	-0.082**	-0.117	-0.082**	-0.121
	(-2.45)	(-0.38)	(-2.45)	(-0.40)
ΔSALE	0.015	-0.093	0.015	-0.094
	(1.11)	(-0.99)	(1.11)	(-1.00)
LNAT	-0.021	-0.137	-0.022	-0.137
	(-0.55)	(-0.45)	(-0.57)	(-0.45)
ΔAT	0.021	0.142	0.022	0.142
	(0.85)	(0.69)	(0.87)	(0.69)
LEV	-0.275***	-0.225	-0.270***	-0.212
	(-3.64)	(-0.60)	(-3.56)	(-0.56)
ΔLEV	0.050*	0.806**	0.049*	0.803**
	(1.91)	(2.44)	(1.88)	(2.43)
EBITDA	-0.220	-0.484	-0.219	-0.477
	(-1.63)	(-0.87)	(-1.63)	(-0.85)
CFR	0.252**	1.340*	0.252**	1.340*
	(2.10)	(1.92)	(2.09)	(1.92)
TURNOVER	0.025	0.200	0.026	0.205
	(1.17)	(0.59)	(1.18)	(0.61)
TOBINQ	0.116***	-0.080	0.117***	-0.080
	(6.45)	(-0.72)	(6.52)	(-0.72)
Firm F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
N	1,650	1,205	1,650	1,205
R-squared	0.6398	0.4179	0.6397	0.4183

Note: This table presents the results of regressions of corporate investment using entropy balance. Dependent variables are capital expenditure ratio (CAPEX) and change in total proved oil reserves (ΔRESERVE). The key independent variables are lobbying activity dummy (LOBDUM) and the logarithm of lobbying expenditure (LOBAMT). Control variables including the log of total revenue (SALE), revenue growth (ΔSALE), total assets (LNAT), asset growth (ΔAT), leverage ratio (LEV), change in leverage ratio (ΔLEV), profitability (EBITDA), cash-flow ratio (CFR), turnover ratio (TURNOVER) and Tobin's Q (TOBINQ) have been added to the model. Firm fixed effects and year fixed effects are included in the regressions. The *t-statistics* calculated from robust standard errors clustered at firm level are reported in parentheses. ***1%, **5%, and *10%.

Chapter 6 ESG Washing, Materiality and Pillar-mix Strategy: A REIT Perspective[74]

6.1 Introduction

In recent years, ESG practices have gained prominence in corporate and investor consciousness due to increasing evidence demonstrating their importance to financial performance and long-term valuations. The research area of greenwashing has been extensively explored in previous studies. Nevertheless, ESG washing in the context of materiality manipulation, in which firms selectively engage in ESG efforts, has yet to be examined. For instance, the Sustainability Accounting Standards Board (SASB), defines "Material ESG Issues" in the environmental pillar that can impact on firm value in the real-estate sector, include energy management and water & wastewater management.[75] However, real estate companies that focus on these environmental issues require a higher level of investment than those that focus on social and governance issues, posing a challenge to the added costs and financial performance of companies (Dwaikat and Ali, 2016; Vyas and Jha, 2018). On the other hand, the costs incurred to improve the performance of less material ESG pillars (i.e. social and governance) for the real-estate sector may not be as significant as REITs.[76]

Consequently, it is reasonable for REITs to evaluate the economic returns of various ESG pillars and to weigh the cost-benefit of investing in each one. In other words, companies are motivated to be strategic in their ESG practices to ensure they are achieving desired outcomes. It may be possible for companies to implement ESG pillar-mix strategies and engage in ESG washing, which involves analysing and comparing the economic returns of various ESG components to invest in those practices that will offer the greatest value. Companies must strike a balance between the need to maintain the value of their stocks through high overall ESG ratings and the need to achieve greater financial performance through ESG pillar-mix strategies. Companies that invest in strategic ESG practices find ways to do so without sacrificing profitability. Therefore,

[74] This chapter is co-authored with Jianfu Shen, Eddie C. M. Hui, Louis T.W. Cheng and Kalok Chan.

[75] For more details see: https://www.sasb.org/standards/materiality-finder/find/?industry[]=IF-RE&lang=en-us

[76] Some studies (e.g. Campbell et al., 2011; Hartzell et al., 2006; Cashman et al., 2016; Peng et al., 2022) have indeed found that corporate governance in REITs enhances firm value, indicating that the benefit from improving governance quality outweighs the cost.

companies can ensure that their ESG practices benefit both the company and its shareholders.

The financial impact of ESG practices in the real-estate industry differs significantly in terms of their cost and benefits. When evaluating the environmental performance of the real-estate industry, green buildings are considered to be the most important factor. These buildings are expensive to construct and maintain. For instance, companies may have to invest considerable resources to construct green buildings and obtain certifications such as LEED, but their return on investment may be negatively affected (Uğur and Leblebici, 2018; Dwaikat and Ali, 2016). Furthermore, maintenance costs for green buildings can also be high, since they require specialised equipment and expertise to ensure buildings are operating efficiently and in compliance with environmental regulations (Scofield and Doane, 2018; Reichardt, 2014). Since the benefits of environmental performance may not be immediately apparent, and the costs may be high, it remains uncertain whether environmental performance has a positive or negative impact on market valuations in the real-estate industry (Coën et al., 2018; Devine and Yonder, 2021).

Meanwhile, some other ESG practices may be less expensive and beneficial to corporate fundamentals. Studies have shown that improvements to corporate governance can enhance corporate fundamentals and market valuations in the real-estate sector (Bauer et al., 2010; Hartzell et al., 2008; Peng et al., 2022). In addition, a recent study indicated that REITs with better social practices, such as human resources development, often perform better on corporate fundamentals (Fan et al., 2023). Therefore, it is reasonable to expect that RETIs will implement ESG pillar-mix strategies by improving social and governance practices while neglecting environmental performance to improve their corporate fundamentals.

Some unique features of REITs make the sector suitable for studying the impact of materiality on possible ESG washing. As I know, capital expenses for the real-estate sector are significantly related to buildings' environmental performance (i.e. the so-called green building practice). Therefore, such an uneven distribution of material issues among the three ESG pillars makes them suitable for pillar-mix analysis. Following a methodology developed for evaluating greenwashing in previous literature

(Lyon and Maxwell, 2011; Kim and Lyon, 2015), my study develops a measure known as strategic ESG score for evaluating the ESG pillar-mix strategies adopted by REITs. A strategic ESG score is calculated by subtracting the environmental score from the sum of the social and governance scores and scaling it by the overall ESG score. My study empirically demonstrates that REITs have less diverse practices in environmental performance and less desire to raise their environmental scores once they have reached a certain level. Social and governance scores, however, tend to skew upwards, suggesting that some REITs are likely to engage in ESG pillar-mix strategies. Next, this study examines the impact of strategic ESG practices on corporate fundamentals. According to my instrumental variable approach with two-stage least square estimations, an increase of one standard deviation in strategic ESG scores results in a 5.26% increase in rental income, a 17% reduction in operating expenses and a 9.15% increase in gross profit margin. Strategic ESG practices also result in greater subsequent capital expansion. For a one-standard-deviation increase in strategic ESG score, asset growth rates increase by 11.22% and periodic investments by 10.32%. On the other hand, overall ESG scores do not predict the corporate fundamentals of REITs. My results indicate that ESG pillar-mix strategies conducted by REITs are beneficial to their subsequent corporate fundamentals.

My study further evaluates the impact of ESG pillar-mix strategies on market valuations. My event study shows that an increase in strategic ESG scores yields cumulative abnormal returns of 0.316% in a 7-day window and 0.414% in a 10-day window. An improvement in overall ESG score, however, does not lead to significant returns. A decline in strategic ESG score is associated with negative abnormal returns. My study further shows that ESG pillar-mix ESG strategies lead to higher subsequent stock returns. Via long REITs with high strategic ESG scores and short REITs with low strategic ESG scores, long-short portfolios generate positive risk-adjusted returns of 0.558% per month under an equal-weighted scheme and 0.821% under a value-weighted scheme, respectively. The Fama-MacBeth model is further considered to assess the predictability of strategic ESG practices in subsequent returns after considering overall ESG scores and other common asset-pricing factors, and my results remain robust. My study further demonstrates that strategic ESG scores are positively associated with long-term market values, as measured by Tobin's Q ratio and buy-and-hold returns over the next 12 months. Taken together, the results indicate that ESG pillar-mix strategies can enhance the subsequent fundamentals and market valuations of REITs.

My study further indicates that ESG pillar-mix strategies result in larger growth in greenhouse gas emissions. Specifically, an increase of one standard deviation in strategic ESG score results in an increase of 2.98% in direct greenhouse gas emissions, 1.67% in indirect emissions due to energy consumption and 1.27% in indirect emissions due to upstream business activities. Furthermore, a standard deviation increase in ESG score results in a 9.38% increase in environmental damage costs. My study indicates that ESG pillar-mix strategies result in higher carbon emissions and environmental costs. Further analysis shows that a one-standard-deviation increase in strategic ESG score results in a 5.16% increase in institutional ownership and around a 10.18% increase in the number of institutional investors. My results indicate that ESG pillar-mix strategies have negative environmental consequences; however, institutional investors, which represent an influential force in capital markets, do not correct the pitfalls of strategic ESG practices. In fact, they welcome negative environmental impacts and tend to be more interested in REITs that engage in such practices.

This study contributes to the current literature in three ways. First, this paper illustrates that improving less material ESG practices and underplaying more material ESG practices may also result in positive effects on corporate fundamentals. There are some differences in ESG practices. Previous studies have argued that only material ESG practices lead to better accounting performance and stock returns, while immaterial ESG practices do not (Khan et al., 2016). Serafeim and Yoon (2022) add that investors are more concerned with material ESG incidents rather than immaterial ESG incidents. Therefore, Serafeim (2020) argues that companies should deploy their ESG practices strategically, depending on their financial importance to their operation, to gain a competitive advantage. However, my study provides empirical results that contradict previous studies. In the real-estate sector, environmental (social and governance) practices play a material (less material) role. My study indicates that REITs may adopt strategic ESG practices by underplaying their material ESG practices and inflating their immaterial ESG ones. These strategic practices enhance the corporate performance and market value of REITs.

Second, this study highlights the significant flaws and limitations associated with using ESG as an institutional design for improving environmental governance. Because firms are concerned with increasing their value, they game the system in terms of their ESG efforts. My study documents that strategic ESG practices are negatively associated with environmental performance, resulting in increased greenhouse gas emissions and higher environmental costs. However, the material environmental consequences of strategic practices are neither detected nor even welcomed by institutional investors. Certainly, my study indicates that both firms and institutional investors may engage in ESG washing to boost their own financial benefits. In this regard, institutional ownership, which is a major force in capital markets, is not interested in correcting this ESG washing.

Third, my study contributes to the formulation of political advice regarding climate-risk mitigation. The construction and maintenance of green buildings can be costly, which can be a major barrier to their adoption (Uğur and Leblebici, 2018; Dwaikat and Ali, 2016). On the other hand, social and governance policies can contribute to the long-term success of a company and increase shareholder value (Peng et al., 2022; Fan et al., 2023). The real-estate sector is incentivised to make strategic ESG efforts, which contribute significantly to greenhouse gas emissions, with the markets benefiting from strategic efforts and unable to correct any negative consequences. My study advocates that policymakers should introduce regulations that make green investments more attractive and economical. They should offer incentives that encourage the real-estate sector to invest in green buildings and sustainability initiatives. This will reduce emissions and lead to long-term success. Furthermore, real-estate companies should improve transparency by reporting their carbon emissions. This will allow investors to make more informed decisions and acknowledge negative externalities.

This study is organised as follows: a literature review is conducted in the next section, followed by hypotheses development. Then, the sample, data and variables used in this study will be discussed. Empirical results will be presented in the following section, and conclusions will be drawn in the final section.

6.2 Literature review

Greenwashing and ESG washing

Over the past decade, companies have been under increasing pressure to provide more information about their ESG practices. Several studies have revealed the economic consequences of selective ESG practices of firms. Companies that disclose CSR issues voluntarily are more likely to access equity capital at lower prices (Dhaliwal et al., 2011) and improve stock liquidity (Barth et al., 2017; Krueger et al., 2023). Lu et al. (2017) add that the issuance of sustainability reports increases their cash holdings, especially in firms with more information opacity and weaker external monitoring. The quality of voluntary ESG disclosure is positively associated with firm value (Plumlee et al., 2015). Stock returns are positively affected by the release of good ESG news and negatively affected by bad ESG news (Flammer, 2013; Krüger, 2015). However, some companies may engage in selective ESG activities by making false or exaggerated claims about their ESG activities, rather than fully disclosing both the negative and positive aspects of their environmental performance or remaining silent (Lyon and Maxwell 2011; Lyon and Montgomery, 2015).

There is no doubt that the disclosure of ESG information is valuable to firms and important to stakeholders. The disclosure of ESG information, however, does not guarantee that firms will make authentic efforts in their ESG practices or if they simply wish to align with legitimacy requirements and social expectations. For instance, Ramus and Montiel (2005) found that selective efforts and unfulfilled promises tend to be more prevalent in service industries than in manufacturing ones. Members of the United Nations Global Compact (UNGC), usually regarded as a sustainable organisation, sometimes downplay their environmental commitments and continue to pursue poor environmental practices (Berliner and Prakash, 2012). Many studies have examined the reasons for the decoupling of ESG disclosure from practice. For instance, companies are incentivised to engage in greenwashing in order to improve their public image and attract customers and investors who prioritise sustainability (Delmas and Burbano, 2011). Philippe and Durand (2011) add that the release of a corporate sustainability report can enhance its overall reputation, even without taking any actions to improve the company's environmental performance. Companies with a poor reputation may be able to mitigate their stock-market risk by making public statements regarding their commitment to society, implying that investors have indeed been influenced by cheap talk (Bansal and Clelland, 2004). Symbolic ESG disclosures and actions may fulfil government requirements (Berrone et al., 2017). In addition, recent studies have also examined the consequences of decoupling talk from action. For instance, decoupling may be perceived as irresponsible and lead to a loss of confidence among consumers, investors and nongovernmental organisations (NGOs) (Berrone et al., 2017; Jahdi and Acikdilli, 2009; Guo et al., 2017; Lyon and Montgomery, 2015). Investors will be less likely to invest in companies with considerable discrepancies between responsible words and irresponsible walks (Pizzetti et al., 2021). Firms that falsify claims and manipulate ESG practices are less likely to attract investors than those that selectively report ESG information (Gatti et al., 2021). Such discrepancies may also result in poor financial performance, while actual ESG practices are not detrimental to corporate fundamentals (Walker and Wan, 2012).

Despite previous studies focusing on the decoupling of talk and action, few studies have compared different ESG efforts. Recent studies have argued that the materiality of ESG practices plays an important role in creating shareholder value and advancing product innovation (Eccles & Serafeim, 2013). Using the classification of ESG practices by the Sustainability Accounting Standards Board (SASB), Khan et al. (2016) show that companies with significant improvements in their material ESG ratings outperform those with declines in ratings. However, changes in immaterial ESG ratings do not accurately predict future returns. Companies with significant improvements in their material ESG ratings experience higher returns on sales than those with declines in ratings. However, changes in immaterial ESG ratings do not have any corresponding effects. For instance, materially good news has substantial positive returns but materially bad news has a large negative impact on stock price. Investors, meanwhile, are unconcerned about immaterial ESG incidents. Furthermore, Grewal et al. (2021) document that public companies that voluntarily disclose more financially material ESG information exhibit an increase in stock-price informativeness. Moreover, Serafeim and Yoon (2022) find that investors are more concerned with material ESG news rather than immaterial ESG events. Grewal et al. (2021) show that companies that disclose more financially material ESG information exhibit an increase in stock-price informativeness. These findings indicate that in addition to selective disclosures on ESG issues, companies may also make selective efforts to implement authentic ESG practices.

ESG practices among REITs

Real estate accounts for nearly 40% of global carbon dioxide emissions, with building operations accounting for approximately 70% and construction 30% (Carlin, 2022). In addition, the real-estate industry is responsible for approximately 75% of energy consumption in the United States (Eichholtz et al., 2012). Therefore, ESG practices, especially the environmental pillar, are imperative in the real-estate sector for the sustainable development of my society. A number of previous studies have shown that ESG practices contribute positively to equity valuations in the real-estate sector. For instance, REITs with high ESG ratings operate more efficiently and outperform those with poor scores in the stock market (Aroul et al., 2022; Hebb et al., 2010). REITs that disclose their ESG information in accordance with the Global Real Estate Sustainability Benchmark (GRESB) earn significant cross-sectional returns (Devine et al., 2022). Some studies link the market performance of REITs to green buildings. REITs with a greater proportion of green properties have higher rental revenue and operating profit, which leads to higher market valuations, less risk and lower interest costs (Devine and Yonder, 2021). As green buildings enjoy a better reputation and tenant satisfaction, they can charge higher rents, have higher occupancy rates and offer fewer rent concessions than non-green buildings (Devine and Kok, 2015). Green buildings command higher rents and sell for higher prices than conventional buildings, especially in underdeveloped regions (Eichholtz et al., 2010). This increase in rents and valuations can be attributed to the reduction in energy consumption (Eichholtz et al., 2013). Other studies add that certified commercial green properties generate higher rental incomes and sales prices (Fuerst and McAllister, 2011; Wiley et al., 2010; Miller et al., 2008). And loans for green buildings have a lower default rate (An and Pivo, 2020).

However, some studies show contradictory results regarding the impact of ESG performance on the equity valuations of REITs. Coën et al. (2018) reveal that REITs with green buildings underperform their non-green counterparts, and this poor performance is attributed to both peer pressure and excess investment in green buildings. During the Covid-19 period, REITs with higher ESG ratings had lower financial performance and lower operating cash flows but higher stock volatility (Chacon et al., 2022). Furthermore, Eichholtz, Kok, and Yonder (2012) conclude that there is no obvious relationship between green buildings and abnormal returns in the REIT market, as investors have already factored in the costs of green buildings into their stock valuations. The initial cost of building green is often higher than for traditional buildings due to the use of energy-efficient and sustainable materials (Dwaikat and Ali, 2016), as well as specialised labour and maintenance costs (Scofield and Doane, 2018; Reichardt, 2014). Furthermore, it cannot be disputed that obtaining green building certification is an expensive process (Uğur and Leblebici, 2018). Therefore, the costs associated with the construction of green buildings may outweigh their benefits in the short term (Deng and Wu, 2014).

6.3 Hypotheses development

This paper examines whether companies engage in strategic ESG efforts to maintain strong fundamentals while simultaneously taking advantage of capital markets. Strategic ESG initiatives do not constitute greenwashing, since companies do not engage in dishonest behaviour such as concealing their unethical actions or exaggerating their responsible efforts. As companies have limited resources, they may be unable to invest in all ESG initiatives, but instead may prioritise those that are most likely to have positive financial outcomes. Companies engage in strategic ESG initiatives that are most likely to lead to tangible financial returns, while at the same time avoiding initiatives that are unlikely to generate positive financial returns. Furthermore, ESG initiatives have become increasingly important for companies in the capital market. Investors have increasingly high expectations regarding the overall ESG performance of companies, and companies must ensure that their ESG initiatives align with those expectations.

In the real-estate sector, improving environmental performance can incur significant expenses, which are not seen in other industries. RESITs typically invest in green buildings as a means of increasing their environmental resilience (NAREIT, 2022). Thus, ESG rating agencies, such as MSCI, focus most of their attention on Opportunities in Green Building when evaluating the environmental pillar of a REIT's ESG performance (MSCI, 2022). Compared to conventional building construction, green-building construction is more expensive (Uğur and Leblebici, 2018; Dwaikat and Ali, 2016). This can be attributed to the additional costs associated with the use of renewable materials, energy-efficient technologies and the certification process. Furthermore, green-building renovations may result in a reduction in revenue or concessions in rental income. Some studies even find that green buildings involve higher operating costs than conventional buildings (Scofield and Doane, 2018; Reichardt, 2014). Thus, REIT managers should consider the additional costs and risks when developing green buildings to improve their environmental ratings.

On the other hand, REITs may benefit from the improvement in social and governance ratings. A REIT is subject to strict regulatory requirements, which require them to distribute at least 90% of their income as dividends to investors. Additionally, managers are restricted in their ability to allocate retained capital other than to invest in the real-estate sector (Bianco et al., 2007). Hence, improvements in corporate governance may not lead to improvements in the fundamentals of REITs. However, recent studies have revealed that managers of REITs overinvest in value-destroying projects to maximise their own personal interests (Xu and Ooi, 2018; Ling et al., 2019). Thus, internal governance mechanisms such as clawback provisions, which allow REITs to recover executive compensation and prevent irresponsible or unethical behaviour by executives, are beneficial to REIT shareholders' interests and corporate efficiency (Peng et al., 2022). REITs are also beneficial for social initiatives, such as the development of human capital, which can in turn improve the fundamentals of the company and increase the stock price (Fan et al., 2023).

To maintain a high overall ESG rating, REITs should undertake strategic ESG efforts which allot limited resources to environmental initiatives but substantially improve their social and governance performance to meet the expectations of capital markets without letting corporate fundamentals deteriorate. Nevertheless, it remains unclear how ESG practices affect the market valuation and environmental performance of REITs. It is also unclear whether an important force in capital markets, institutional ownership, will welcome the strategic implementation of ESG practices. Therefore, this paper considers the following hypotheses:

H1: Strategic ESG efforts are positively associated with the corporate fundamentals of REITs.

H2: Strategic ESG efforts are positively associated with market valuations and predicted stock returns of REITs.

H3: Strategic ESG efforts are positively associated with growth in greenhouse gas emissions.

H4: Strategic ESG efforts are positively associated with institutional investment.

6.4 Sample, data and variables

The CRSP/Ziman database is used to extract all REITs traded on the three primary exchanges in the U.S. (NYSE, AMX and NASDAQ).[77] This database contains information regarding the market capitalisation and monthly returns of all listed REITs.

My study combines the REIT sample with stock-level ESG performance from MSCI ESG ratings data, which is the successor to MSCI KLD data. My study chose MSCI ESG data for the following reasons. First, MSCI is the leading ESG ratings provider listed on the NYSE, with a market capitalisation of approximately $42.9 billion, and approximately 3,300 employees. The company has provided ESG rating services to more than 1,700 investors.[78] Second, MSCI ESG ratings cover a broader range of companies and longer time periods than other ESG rating agencies, such as Thomson Reuters ASSET4, RobescoSAM and Sustainalytics (Khan et al., 2016; Berg et al.,

[77] The Ziman database has been widely used in previous studies on REITs; see Ro and Ziobrowski (2011), Glascock and Lu-Andrews (2015), Ling and Naranjo (2015), Ling et al. (2020), Shen et al. (2021a & 2021b) etc.

[78] See: https://www.msci.com/our-solutions/esg-investing, as of January 2023.

2022a). Moreover, MSCI updates its ESG ratings at least once per year, which is more frequently than other rating agencies. Third, MSCI ESG ratings have better data quality than other agencies. A variety of data sources are utilised by MSCI to make a determination of each company's ESG performance, such as company disclosures, media reports and NGO reports. It has been shown by Berg et al. (2021b) that MSCI is the least noisy ESG data vendor in the U.S. Lastly, MSCI provides ESG data that are unadjusted for industry. REITs are generally involved in one or more industries, such as residential, retail, hotel & resort and industrial. Using industry-unadjusted ESG data, it is possible to evaluate the strategic ESG efforts made in different industries (Pastor et al., 2022).

In Table 6.1, my study provides a summary of the number of REITs in my sample containing ESG information. In 2007, MSCI ESG ratings covered 18 REITs. As of 2021, 134 REITs are covered by MSCI ESG ratings. An MSCI ESG rating is assigned to 189 REITs in total. The change in ESG ratings is presented in the righthand column. The number of changes is comparable to the number of REITs covered, which corresponds to an annual update of ESG ratings. Since some REITs receive two or more ESG ratings updates in a given year, the number of changes is greater than the extent of coverage in some years.

Table 6.1. Number of equity REITs covered by MSCI ESG ratings

Year	N of REITs	N of Rating Changes
2007	18	0
2008	23	11
2009	22	14
2010	17	0
2011	15	15
2012	98	54
2013	116	91
2014	130	120
2015	136	135
2016	141	141
2017	142	152
2018	145	151
2019	147	155
2020	140	145
2021	134	143

Note: This table presents the number of REITs covered by MSCI ESG ratings and the number of REITs experienced a change in ESG ratings by year from 2007 to 2021.

The key independent variables in this study are the strategic ESG efforts of REITs. As discussed in my hypotheses development, the environmental performance of REITs is financially costly and may adversely affect the company's fundamentals. On the other hand, social and governance performance may benefit the company's performance. The paper decomposes the performance into two components: environmental performance and governance performance, following the methodology of Pástor et al. (2022). Specifically, the environmental performance of a REIT is estimated as:

$$ENV_{i,t} = EnvScore_{i,t} \times EnvWeight_{i,t} \tag{6.1}$$

where *ENV* is the overall environmental score of a REIT. *EnvScore* is *Environmental Pillar Score* and *EnvWeight* is *Environmental Pillar Weight* in the MSCI database.

EnvScore is the weighted average score of four major themes, including Climate Change, Natural Capital, Pollution & Waste and Environmental Opportunities. *EnvSocre* ranges from 0 to 10 and is designed to measure the material environmental risks and opportunities for firms within the same industry. *EnvWeight* ranges from 0 to 100 and measures the importance of environmental materiality of the corresponding industry in comparison to other industries.

Similarly, the social and governance performance of a REIT is calculated as:

$$SOC_{i,t} = SocScore_{i,t} \times SocWeight_{i,t}$$

$$GOV_{i,t} = GovScore_{i,t} \times GovWeight_{i,t}$$

(6.2)

where *SOC* is the overall social score and *GOV* is the overall governance score of a REIT. *SocScore* is the *Social Pillar Score*, *SocWeight* is the *Social Pillar Weight*, *GovScore* is the *Governance Pillar Score* and *GovWeight* is the *Governance Pillar Weight.*

Similar to the calculation of MSCI, overall ESG scores are calculated as the sum of the environmental, social and governance scores:

$$ESG_{i,t} = ENV_{i,t} + SOC_{i,t} + GOV_{i,t}$$

(6.3)

Strategic ESG scores are defined as the difference between environmental score and the sum of social and governance scores, then divided by overall ESG score to standardise scores within the interval of -1 to 1. Specifically, strategic ESG score is estimated as:

$$STRATEGIC_{i,t} = \frac{(SOC_{i,t} + GOV_{i,t}) - ENV_{i,t}}{ESG_{i,t}}$$

(6.4)

where *STRATEGIC* is the strategic ESG score of a REIT.

Table 6.2 Panel A shows statistics sorted by strategic ESG scores. Average strategic ESG scores are -0.185 in the lowest quintile and 0.551 in the highest one, with a difference of 0.736. In the lowest quintile of strategic ESG scores, overall ESG score is 4.869, which is significantly higher than that in the highest quintile, 4.229. Statistics indicate that REITs that engage in more balanced ESG efforts are more likely to obtain higher overall ESG scores. Companies that engage in strategic ESG efforts receive significantly lower environmental scores and significantly higher social and governance scores. Panel B shows statistics sorted by overall ESG scores. REITs with a low ESG score are more likely to engage in strategic ESG initiatives. However, selective ESG efforts do not decrease monotonically when REITs improve their ESG scores. In conjunction with overall ESG score, environmental scores as well as social and governance scores increase monotonically.

Table 6.2. ESG pillar-mix strategies and ESG scores

Panel A. Sorted by strategic ESG scores

Strategic ESG score	STRATEGIC	ESG	ENV	SOCGOV
1 (Lowest)	-0.185	4.869	2.905	1.963
2	-0.012	4.801	2.438	2.362
3	0.100	4.689	2.113	2.576
4	0.232	4.590	1.786	2.804
5 (Highest)	0.551	4.229	0.954	3.276
Highest - Lowest	0.736	-0.639	-1.952	1.312
t-stat	(36.49)***	(-8.49)***	(-29.85)***	(20.77)***

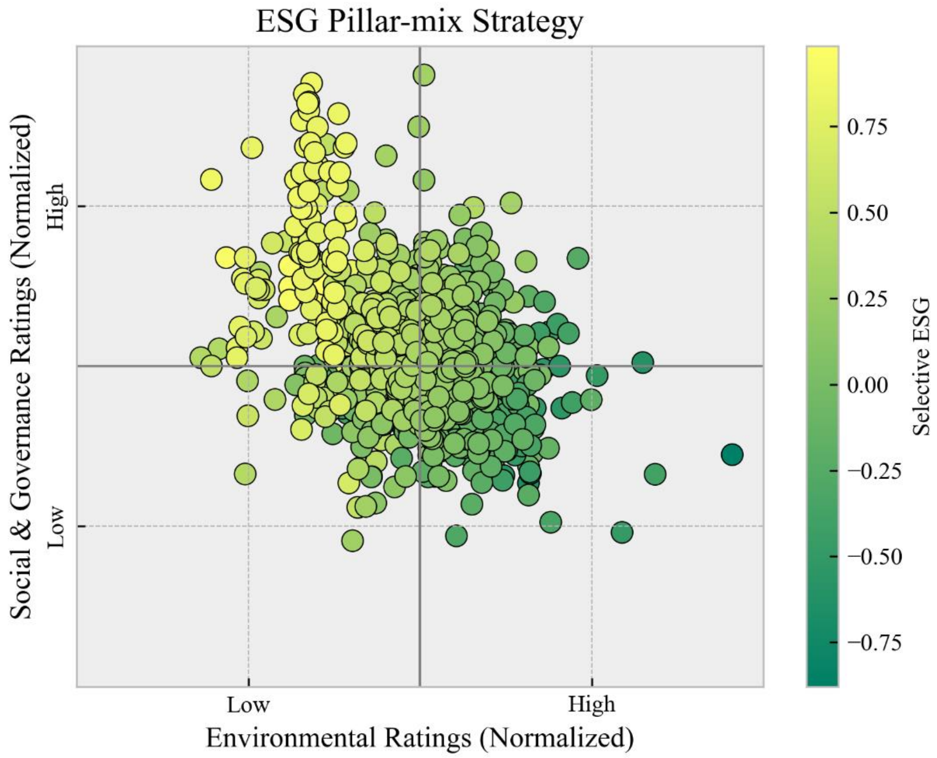
Panel B. Sorted by overall ESG scores

Overall ESG score	STRATEGIC	ESG	ENV	SOCGOV
1 (Lowest)	0.246	3.598	1.382	2.217
2	0.166	4.232	1.784	2.448
3	0.090	4.577	2.104	2.473
4	0.068	4.995	2.341	2.654
5 (Highest)	0.099	5.830	2.649	3.181
Highest - Lowest	-0.148	2.231	1.267	0.964
t-stat	(-5.32)***	(41.72)***	(16.34)***	(14.08)***

Note: this table presents the summary statistics of ESG scores, including strategic ESG scores (*STRATEGIC*), overall ESG scores (*ESG*), environmental scores (*ENV*) as well as social and governance scores (*SOCGOV*). The table reports the mean of ESG scores in the quintile portfolios sorted by strategic ESG scores in Panel A and overall ESG scores in Panel B. The differences of average values between the top quintile and the bottom quintile are also reported, and t-statistics is reported in parentheses. ***1%, **5%, and *10%.

Figure 6.1 illustrates the distribution of strategic ESG scores within the matrix of environmental, social and governance scores. The X-axis (Y-axis) categorises environmental scores (social and governance scores) into high and low groups based on their medians each year. As shown in the figure, while some REITs have performed above the median in terms of environmental scores as well as social and governance scores, many REITs choose to have above-median social and governance scores, but below-median environmental scores. The northwest quadrant shows that REITs that are more likely to engage in ESG washing also have significantly larger strategic ESG scores. If REITs do not game their ESG efforts and choose to improve all E/S/G dimensions, they have above-median environmental scores and above-median social and governance scores, and they also have strategic ESG scores close to zero (as shown in the northeast quadrant). REITs that allocate more effort to the environment rather than to social and governance have above-median environmental scores but below-median social and governance scores (as shown in the southeast quadrant), and their strategic ESG scores are negative. Overall, strategic ESG scores can capture the strategic efforts that REITs allocate to environment and social & government dimensions.

Figure 6.1. ESG Pillar-mix Strategies



Note: This figure shows the distribution of the strategic ESG scores. Environmental scores (X-axis) and social & governance scores (Y-axis) are divided into low and high groups based on the median of the scores. The strategic ESG scores are colored according to their values.

This study considers several variables to measure the corporate fundamentals of REITs, including rental income growth (RENTGROW), cost of goods sold (COGS), gross profit margin (GPMAGIN), asset growth (ASSETGROW) and periodic investment (INVESTMENT), according to previous studies regarding the operational efficiency of REITs (Ambrose et al., 2000; An et al., 2016; Ghosh et al., 2013; Deng and Ong, 2018; Ambrose and Linneman, 2001; Feng et al., 2007; Ott et al., 2005; Bond et al., 2019). The study also collected monthly stock return data and conducted an event study to determine the impact of ESG initiatives on valuations. Tobin's Q (TOBINQ) and buy-and-hold returns (BHR) over the next 12 months were also considered to assess the long-term valuation effects. The above variables are constructed using data obtained from Compustat and the CRSP/Ziman database. Institutional ownership data are extracted from the Refinitiv Institutional Holdings (13F) database. The institutional ownership (IO) of a REIT is calculated as the percentage of stocks held by institutional investors in a given quarter. The number of institutional investors (INSNUM) who hold a REIT is also considered. Following previous studies, my study retrieves greenhouse gas emissions data from Trucost. Four different sources of emissions are considered in my study. Scope 1 emissions are those resulting from the direct operation of the company itself. Scope 2 emissions arise from the company's consumption of purchased heat, steam and electricity. Scope 3 emissions are divided into two categories. Scope 3 Upstream emissions result from all indirect activities used in the operation of the company, such as business travel and resources used by suppliers. Scope 3 Downstream emissions are all the indirect activities associated with the use of products or services by customers. This study also retrieves the environmental damage cost associated with greenhouse gas emissions estimated from the database. For the purpose of comparing changes in greenhouse gas emissions and environmental costs between REITs, my study calculates percentage changes for greenhouse gas emission indicators. Furthermore, my study also considers the following control variables: book-to-market ratio (*BM*), market capitalization (*SIZE*), asset turnover (*TURNOVER*), return on equity (*ROE*), dividend to total asset ratio (*DIV*), leverage ratio (*LEV*), momentum factor (*MOM*) and idiosyncratic volatility (*IVOL*). The above variables are constructed using data obtained from Compustat and the CRSP/Ziman database. They are winsorised between 1% and 99% except for ESG scores. Appendix A6.1 contains details of the variables' construction and definitions mentioned above.

Table 6.3 presents summary statistics for the variables. Panel A shows statistics for variables in the firm-year sample from 2007 to 2021. In general, the average score for strategic ESG efforts is 0.134, and scores range from -0.878 to 0.984. The average overall ESG score is 4.638. Average rental income growth is 0.080, whereas average gross profit margin is 0.357. The average asset growth of REITs is 0.084, and average periodic investment is 0.100. For valuation variables, Tobin's Q ratio is 1.524 and buy-and-hold returns are 0.099 on average. Panel B illustrates the event study sample, showing a change of 0.028, on average, in strategic ESG scores and 0.014 in overall ESG scores. Average cumulative abnormal returns in the windows [-3, 3] and [-5, 5] are 0.138% and 0.236%, respectively. As shown in Panel C, the average monthly returns in the firm-month sample are 0.928%. Panel D shows that the institutional ownership of REITs is 0.863 and the logarithm of the number of institutional investors is 5.643 on average.

Table 6.3. Summary statistics

Panel A. Firm-year sample

	Obs.	Mean	Std. Dev.	Min	Max
STRATEGIC	1,424	0.134	0.335	-.0878	0.984
ESG	1,424	4.638	0.906	1.357	8.726
RENTGROW	895	0.080	0.164	-0.376	0.639
COGS	1,237	6.003	1.063	3.473	8.452
GPMARGIN	1,236	0.357	0.191	-0.402	0.769
ASSETGROW	1,238	0.084	0.195	-0.201	1.153
INVESTMENT	1,164	0.100	0.144	-0.155	0.723
TOBINQ	1,237	1.524	0.493	0.856	3.454
BHR	1,258	0.099	0.260	-0.566	0.941
BM	1,424	0.603	0.360	0.088	2.403
SIZE	1,424	8.164	1.130	5.892	10.943
TURNOVER	1,424	0.170	0.102	0.057	0.600
ROE	1,424	0.060	0.094	-0.262	0.398
DIV	1,424	0.037	0.021	0.000	0.134
LEV	1,424	0.484	0.129	0.063	0.782
IVSTRATEGIC	1,367	0.124	0.246	-0.559	0.886

Panel B. Event study sample

	Obs.	Mean	Std. Dev.	Min	Max
ΔSTRATEGIC	1,272	0.028	0.273	-1.216	1.182
ΔESG	1,272	0.014	0.630	-3.343	3.966
CAR (-3, 3)	1,272	0.138	3.896	-12.974	11.697
CAR (-5, 5)	1,272	0.236	4.711	-14.167	13.607

Panel C. Firm-month sample

	Obs.	Mean	Std. Dev.	Min	Max
STRATEGIC	13,047	0.194	0.308	-0.670	0.984
ESG	13,047	4.491	0.803	1.357	8.557
RET	13,047	0.928	7.194	-21.450	24.090
BM	13,047	0.601	0.328	0.091	2.092
SIZE	13,047	8.077	1.122	5.840	10.886
TURNOVER	13,047	0.175	0.107	0.059	0.622
ROE	13,047	0.063	0.091	-0.250	0.431
DIV	13,047	0.038	0.021	0.000	0.140
LEV	13,047	0.478	0.127	0.078	0.771
MON	13,047	0.090	0.267	-0.571	1.001
IVOL	13,047	0.014	0.006	0.008	0.042

Panel D. Firm-quarter sample

	Obs.	Mean	Std. Dev.	Min	Max
STRATEGIC	3,962	0.132	0.320	-0.673	0.984
ESG	3,962	4.655	0.877	1.357	8.726
IO	3,962	0.863	0.149	0.144	1.000
INSNUM	3,962	5.643	0.479	4.277	7.476
BM	3,962	0.544	0.262	0.091	1.453
SIZE	3,962	8.218	1.100	5.857	10.886
TURNOVER	3,962	0.178	0.106	0.072	0.629
ROE	3,962	0.080	0.073	0.002	0.399
DIV	3,962	0.040	0.020	0.000	0.134
LEV	3,962	0.474	0.128	0.053	0.764

Note: This table presents the summary statistics. Panel A presents the statistics in firm-year sample. Panel B provides the statistics of event study sample. Panel C shows the statistics in analyzing monthly returns. Panel D presents the statistics in firm-quarter sample. The variable definitions are provided in Appendix A1.

6.5 Empirical results

ESG pillar-mixed strategies and corporate fundamentals

This section examines the effect of strategic ESG initiatives on subsequent firm fundamentals of REITs. Based on hypothesis H1, if environmental responsibility practices increase the cost of REITs while social and governance practices improve their operational efficiency, then REITs adopting pillar-mix ESG strategies are expected to have better corporate performance and fundamentals. Four aspects of firm fundamentals are examined in my study: revenue growth, operating expenditure, profitability and capital growth. The following model is employed to test whether ESG can predict future firm fundamentals:

$$
\begin{aligned}
Fundamentals_{i,t+1} \\
&= \alpha + \beta_1 Strategic_{i,t} + \beta_2 ESG_{i,t} + \beta_3 Controls_{i,t} + PropertyType_i \\
&+ Year_t + \varepsilon_{i,t}
\end{aligned}
\tag{6.5}
$$

where *Fundamentals* indicates the corporate fundamentals of REIT *i* in year *t+1*, including rental income growth (*RENTGROW*), cost of goods sold (*COGS*), gross profit margin (*GPMAGIN*), asset growth (*ASSETGROW*) and periodic investment (*INVESTMENT*). Strategic ESG score (*Strategic*) is the key independent variable. To control for the variance in my results from overall ESG practices, my study adds overall ESG score (ESG). *Controls* are a series of controlling variables in previous asset-pricing studies, including book-to-market ratio (*BM*), market capitalization (*SIZE*), asset turnover (*TURNOVER*), return on equity (*ROE*), dividend to total asset ratio (*DIV*) and leverage ratio (*LEV*).

Table 6.4. ESG pillar-mix strategies and fundamental performance

	RENTGROW	COGS	GPMARGIN	ASSETGROW	INVESTMENT
	(1)	(2)	(3)	(4)	(5)
STRATEGIC	0.076	-0.158	0.059	0.080	0.078
	(2.56)**	(-2.35)**	(2.17)**	(3.69)***	(4.46)***
ESG	-0.000	0.044	-0.019	0.003	-0.001
	(-0.01)	(1.91)*	(-2.36)**	(0.35)	(-0.23)
BM	-0.076	0.920	-0.134	-0.151	-0.122
	(-2.26)**	(8.84)***	(-3.40)***	(-5.94)***	(-5.68)***
SIZE	-0.024	0.863	0.008	-0.031	-0.026
	(-3.05)***	(31.33)***	(0.87)	(-3.70)***	(-3.84)***
TURNOVER	-0.011	4.953	-0.852	0.025	0.014
	(-0.08)	(9.84)***	(-8.02)***	(0.23)	(0.13)
ROE	0.006	-1.981	0.645	0.156	0.141
	(0.05)	(-6.28)***	(5.56)***	(1.73)*	(1.66)*
DIV	-1.531	-0.291	0.015	-1.131	-1.024
	(-3.87)***	(-0.24)	(0.04)	(-3.14)***	(-3.10)***
LEV	-0.272	1.612	-0.117	-0.272	-0.228
	(-2.92)***	(6.61)***	(-1.98)**	(-3.45)***	(-3.49)***
Property type F.E.	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes
N of obs.	895	1,237	1,236	1,238	1,164
R-squared	0.159	0.843	0.421	0.116	0.167

Note: This table presents the results of the OLS regression using equation (6.5) based on a firm-year sample in the REITs from 2007 to 2021. The dependent variables in Panel A are growth in rental income (RENTGROW), operating expenditure (COGS), gross profit margin (GPMARGIN), asset growth ratio (ASSETGROW) and periodic investment (INVESTMENT) in year t+1. The independent variables are strategic ESG scores (STRATEGIC) and overall ESG scores (ESG) in year t. The dependent variables in Panel B are the equity issuance to market capitalization ratio (EQTISSU) and long-term debt ratio (LTDBT) in year t+1. Control variables are measured in year t and defined in Appendix A6.1. Property type and year-fixed effects are included in the regressions. The t-statistics calculated based on robust standard errors clustered by firm level are reported in parentheses. ***1%, **5%, and *10%.

Table 6.4 presents the relationship between ESG pillar-mixed strategies and subsequent corporate fundamentals of REITs. Column (1) indicates that a standard deviation increase in strategic ESG practices results in rental income growth of 2.55%,[79] which is significant at a 5% level. Overall ESG scores, however, do not significantly affect rental income growth. Column (2) shows that a one-standard-deviation increase in strategic ESG practices results in a significant reduction in operational expenditure of 5.29%. On the other hand, there is a significant positive correlation between overall ESG scores and expenditure. A one-standard-deviation increase in ESG scores results in a 3.99% increase in operational expenditure, which indicates that improving ESG performance is expensive. As for profitability, Column (3) shows that a one-standard-deviation increase in strategic ESG score results in a 1.98% increase in gross profit margin, which is significant at a 5% level. Overall ESG scores, however, are significantly negatively correlated with gross profit margin. Columns (4) and (5) show that an increase of one standard deviation in strategic practices leads to an increase in asset growth rate of 2.68%, and in periodic investment of 2.61%, which are both significant at a 1% level. Overall ESG scores, however, do not significantly affect capital growth. The above findings indicate that strategic ESG practices can benefit the capital expansion of REITs. In terms of control variables, book-to-market and leverage ratios are negatively correlated with corporate fundamentals, while returns on equity are positively associated. To sum up, ESG pillar-mix strategies improve the corporate fundamentals of REITs, while overall ESG scores are not significantly linked to corporate fundamentals or linked in a negative manner[80].

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[79] Based on the coefficient multiplied by the standard deviation of strategic ESG score, the increase in rental income is calculated as 0.076*0.335 = 2.55%. In the subsequent analysis, the same calculation processes are applied.

[80] The analysis in Appendix A6.2 reveals important insights into the relationship between E/S/G scores and corporate fundamentals for REITs. The results indicate an inverse relationship between environmental scores and certain financial metrics - specifically, REITs with higher environmental scores tended to have lower rental income growth, higher operational expenditures, and weaker gross profit margins. This suggests that initiatives to improve environmental sustainability require significant upfront investments by REITs, which can pressure financial performance in the short-term. However, the positive association between governance scores and rental income growth points to the benefits of strategic ESG practices. These findings highlight the complex interplay between sustainability efforts and financial fundamentals in the REIT industry. Environmental initiatives may dampen subsequent profitability due to investment costs. Yet good governance seems beneficial for revenue growth. Thus, REITs are incentivized to promote social and governance scores but ignore the environmental practices to boost the overall ESG ratings. This analysis provides empirical evidence to illustrate the motivation of strategic ESG practices for REITs.

The results of this study may be affected by endogeneity issues, such as spurious correlations with unobservable factors and reverse causality. To mitigate endogeneity concerns, my study considers an instrumental variable approach with two-stage least square estimations (IV-2SLS), following previous studies (Devine and Yonder, 2021; Peng et al., 2022). A valid instrument variable should have a strong correlation with the strategic ESG practices of REITs, but it should not be influenced by other mechanisms that might affect the outcome variable. Previous studies document that peer companies often imitate the ESG practices of their competitors, particularly in highly competitive industries (Cao et al., 2019; Liu and Wu, 2016). The real-estate assets held by REITs are similar, and their operations are relatively transparent (Eichholtz and Kok, 2008). REITs are highly competitive, resulting in strong peer effects (Mulherin and Womack, 2015). Therefore, REITs are expected to emulate the ESG practices of their peers, particularly those operating in similar geographic regions and in similar industries. Due to the fact that the ESG practices of their peers do not directly affect the corporate fundamentals of a REIT, the strategic ESG practices of their peers are an ideal instrument variable. Based on an instrumental variable approach, the following equation is used to estimate first-stage regression:

$$Strategic_{i,t} = \alpha + \beta_1 IVStrategic_{i,t} + \beta_2 ESG_{i,t} + \beta_3 Controls_{i,t} + PropertyType_i + Year_t + \varepsilon_{i,t} \tag{6.6}$$

where $IVStrategic$ is the instrumental variable of strategic ESG scores, which represents the average strategic ESG scores of other REITs operating in the same state and with the same property type.

Table 6.5 Panel A shows the results of first-stage regressions. My instrumental variables have a coefficient of 0.804 and a t-statistic of 15.89, with a Kleibergen-Paap rk LM statistic of 64.762 and pass the tests of under-identification. The Cragg-Donald Wald F-statistic is 269.581, which exceeds Stock and Yogo (2005)'s critical value of 16.38. My results indicate that average strategic ESG scores of peer companies can be used as an instrumental variable.

Table 6.5. ESG pillar-mix strategies and fundamental performance: instrumental variable estimation

Panel A. the first stage of 2SLS regressions

	(1)
Dep. Var. =	STRATEGIC
IVSTRATEGIC	0.804
	(15.89)***
Control variables	Yes
Property type F.E.	Yes
Year F.E.	Yes
N of obs.	1,188
R-squared	0.481
Underidentification test	
Kleibergen-Paap rk LM statistic	64.762***
Weak identification test	
Cragg–Donald Wald F-statistic	269.581
Stock-Yogo (2005) critical value at 10% level	16.38

Panel B. the second stage of 2SLS regressions

	RENTGROW	COGS	GPMARGIN	ASSETGROW	INVESTMENT
	(1)	(2)	(3)	(4)	(5)
STRATEGIC	0.157	-0.517	0.273	0.335	0.308
	(2.28)**	(-2.62)***	(3.73)***	(3.83)***	(5.00)***
ESG	0.003	0.039	-0.018	0.002	-0.003
	(0.34)	(2.39)**	(-3.58)***	(0.30)	(-0.51)
BM	-0.080	0.995	-0.140	-0.160	-0.129
	(-3.09)***	(15.13)***	(-6.05)***	(-7.63)***	(-7.65)***
SIZE	-0.025	0.882	0.002	-0.039	-0.033
	(-4.56)***	(59.69)***	(0.33)	(-5.69)***	(-6.08)***
TURNOVER	-0.028	4.961	-0.829	0.027	0.018
	(-0.22)	(12.11)***	(-9.58)***	(0.26)	(0.20)
ROE	0.031	-2.025	0.608	0.163	0.133
	(0.31)	(-7.43)***	(7.34)***	(1.86)*	(1.85)*
DIV	-1.734	0.145	0.007	-1.195	-1.046
	(-4.53)***	(0.16)	(0.03)	(-3.35)***	(-3.28)***
LEV	-0.303	1.903	-0.200	-0.360	-0.289
	(-4.75)***	(13.92)***	(-4.68)***	(-5.89)***	(-6.11)***
Property type F.E.	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes
N of obs.	870	1,186	1,185	1,187	1,119
R-squared	0.078	0.817	0.235	0.031	0.043

Note: This table presents the results of the instrumental variable approach based on a firm-year sample in the REITs from 2007 to 2021. Panel A shows the first stage regression of the instrumental variable approach in equation (6.6). The instrumental variable IVSTRATEGIC is the average of strategic ESG scores for other REITs operating in the same region and with the same property type. Panel B shows the result of the second stage regression. Control variables are measured in year t and defined in Appendix A6.1. Property type and year-fixed effects are included in the regressions. The t-statistics calculated from robust standard errors are reported in parentheses. ***1%, **5%, and *10%.

Panel B gives the results of second-stage regressions. In line with the results obtained from OLS regressions, ESG practices implemented by REITs have significantly enhanced rental-income growth, gross profit margins, asset growth and periodic investments, while reducing operating expenses. The magnitudes of the coefficients, however, are much greater than those of OLS regressions. Specifically, a one-standard-deviation increase in strategic ESG score results in a 5.26% increase in rental income growth, as well as a 17% reduction in operating expenses. Gross profit margin increases by 9.15% as well. When strategic ESG scores are raised by one standard deviation, the asset growth rate increases by 11.22% and periodic investment increases by 10.32%. All coefficients are statistically significant at a 1% level. My results indicate that OLS regressions underestimate the impact of strategic ESG practices on corporate fundamentals.

ESG pillar-mixed strategies and corporate valuation

An event study is implemented to evaluate the market reaction to a change in strategic ESG practices. Also, my study takes overall ESG scores into account as a comparison. Table 6.6 summarizes the cumulative abnormal returns (CARs) resulting from the improvement and reduction in scores. CARs are estimated using the Fama-French three-factor model. Two event windows [-3, +3] and [-5, +5] are considered in my study.[81] REITs with improved strategic ESG scores experience a significant and positive CAR of 0.316% in a 7-day window and 0.414% in an 11-day window. Positive returns are also experienced in the upgrading of overall ESG scores, but the magnitude of the returns is small and insignificant.

A downgrade of strategic ESG scores, however, results in a negative CAR of -0.131% in a 7-day window and -0.033% in an 11-day window, indicating that investors do not welcome any deterioration in material ESG practices, although the results are insignificant. In contrast, a decline in overall ESG scores leads to positive returns of 0.199% in a 7-day window and 0.386% in an 11-day window. Market reaction to a downgrade of overall ESG score is positive and significant in an 11-day period following a downgrade. In conclusion, improving ESG practices boosts market valuations, whereas reducing ESG practices reduces them. An improvement in overall ESG score does not significantly affect market value, but a reduction in overall ESG score leads to a higher market valuation.

[81] Fama-French factor returns were retrieved from Kenneth French's website. The results remain consistent with my findings if the market model and the Carhart four-factor model are used in estimating CARs.

Table 6.6 ESG pillar-mix strategies and market reactions

	Strategic ESG	Overall ESG
Upgrade		
CAR (-3, 3)	0.316	0.085
	(2.31)**	(0.56)
CAR (-5, 5)	0.414	0.103
	(2.44)**	(0.57)
N of obs.	766	692
Downgrade		
CAR (-3, 3)	-0.131	0.199
	(-0.73)	(1.26)
CAR (-5, 5)	-0.033	0.386
	(-0.16)	(2.00)**
N of obs.	506	578

Note: This table presents the cumulative abnormal returns (CARs) on the update of ESG ratings among the REITs from 2008 to 2021. CARs are calculated from the Fama-French three-factor model in different event windows. The t-statistics are reported in parentheses. ***1%, **5%, and *10%.

My next step is to examine the relationship between ESG pillar-mix strategies and subsequent stock performance. Following traditional asset pricing literature, my study REITs are sorted into quintile portfolios based on their strategic ESG scores in the previous month (Fama and French, 1993; Cohen and Frazzini, 2008). Long-short portfolios are constructed by longing REITs in the top quintile and shorting REITs in the bottom quintile. My study considers an equal-weighted scheme as well as a value-weighted scheme, which takes the market capitalisation of REITs into account. Further, risk-adjusted returns obtained from the Fama-French three-factor model are also provided. As a precaution against quintile portfolios being over-weighted to specific REITs, my sample begins in 2014 so that the sample contains a sufficient number of REITs (over 20) for each quintile. To address potential heteroskedasticity and autocorrelation between lagged residuals, t-statistics are estimated from Newey and West (1987) standard errors for a six-month period.

Table 6.7 reports the returns in quintile portfolios. Using equal-weighted quintile portfolios based on strategic ESG scores, column (1) indicates that subsequent returns diminish monotonically from the bottom quintile to the fourth one. Excess returns increase from 0.578% to 1.220%. Excess returns in the top quintile decrease slightly to 1.109%. The long-short portfolio constructed by longing the top quintile and shorting the bottom quintile generates monthly returns of 0.532%, which is significant at a 5%

level. Column (2) provides the returns of portfolios constructed under a value-weighted scheme. Excess monthly returns for the bottom quintile are 0.621% while those for the top quintile are 1.267%. The long-short portfolio generates monthly returns of 0.646%, which is greater than the return of an equal-weighted portfolio, though the returns are not statistically significant.

Columns (3) and (4) present the portfolio returns after considering the Fama-French three-factor model. Column (3) indicates portfolios constructed under an equal-weighted scheme. Investing in REITs with less strategic ESG practices yields a negative alpha, as indicated by the bottom quintile's alpha of -0.287%. As REITs adopt more strategic ESG practices, their alpha increases, reaching 0.360% in the fourth quintile. The top quintile yields an alpha of 0.271%, and the long-short portfolio generates an alpha of 0.558%, which is significant at a 1% level. As shown in column (4), the bottom quintile yields a -0.341% alpha and the top quintile yields a 0.480% alpha for the value-weighted scheme. The monthly alpha of the long-short portfolio is 0.821%, which is significant at a 5% level. The results indicate that strategic ESG practices are associated with positive results in the future.

Table 6.7. ESG pillar-mix strategies and future stock returns: long-short portfolios

	Excess return		Alpha	
	EW	VW	EW	VW
Strategic ESG	(1)	(2)	(3)	(4)
1 (Lowest)	0.578	0.621	-0.287	-0.341
2	0.902	1.002	0.028	0.197
3	0.991	1.134	0.130	0.301
4	1.220	1.089	0.360	0.297
5 (Highest)	1.109	1.267	0.271	0.480
Highest - Lowest	0.532	0.646	0.558	0.821
t-stat	(2.04)**	(1.43)	(2.68)***	(2.50)**

Note: This table presents the portfolio returns sorted by strategic ESG scores. The sample contains listed equity REITs in the US market with MSCI ESG ratings information from 2014 to 2021. This table presents excess returns and alphas of equal-weighted (EW) portfolios and value-weighted (VW) portfolios separately. The alphas of portfolios are estimated from the Fama-French three-factor model. The t-statistics reported in parentheses are adjusted by Newey-West standard errors with 6- month lag. ***1%, **5%, and *10%.

In addition, the Fama-MacBeth regression model is employed to explore the relationship between strategic ESG practices and the subsequent stock returns of REITs (Fama and MacBeth, 1973). As shown in Shen et al. (2021a), a cross-sectional equation is established as follows:

$$RET_{i,t} = \alpha_t + \gamma_{1,t}Strategic_{i,t} + \gamma_{2,t}ESG_{i,t} + \gamma_{3,t}Controls_{i,t} + \varepsilon_{i,t} \tag{6.7}$$

where *RET* is the excess return of REIT *i* in month *t. Controls* are a series of variables that are used as controlling variables in previous asset-pricing studies, including book-to-market ratio (*BM*), market capitalization (*SIZE*), asset turnover (*TURNOVER*), return on equity (*ROE*), dividend to total asset ratio (*DIV*), leverage ratio (*LEV*), momentum (*MOM*) and idiosyncratic volatility (*IVOL*) (Fama and French, 1992; Fama and French, 1993; Jegadeesh and Titman, 1993; Carhart, 1997; Ang et al., 2009; George and Hwang, 2010; Giacomini et al., 2015; Hou et al., 2015; Bond and Xue, 2017).

Table 6.8 details the results of a Fama-MacBeth regression. Column (1) shows that the coefficient for strategic ESG scores is positive, 0.882, and significant at a 5% level. By increasing strategic ESG scores by one standard deviation, subsequent monthly returns will increase by 0.272%[82]. Column (2), however, indicates that ESG scores are not significantly associated with future returns. Column (3) incorporates both strategic ESG scores and overall ESG scores in a Fama-MacBeth regression model. The coefficient for strategic ESG scores remains positive, 0.916, and significant at a 1% level. The result indicates that the positive association between strategic ESG practices and future returns cannot be explained by overall ESG performance.

[82] The standard deviation of strategic ESG scores in the firm-month sample is 0.308. A one-standard-deviation increase in strategic ESG scores is calculated as 0.308*0.882 = 0.272%.

Table 6.8. ESG pillar-mix strategies and future stock returns: Fama-MacBeth regressions

	(1)	(2)	(3)
STRATEGIC	0.882**		0.916***
	(2.53)		(2.69)
ESG		0.052	0.077
		(0.68)	(1.05)
BM	-0.672***	-0.772***	-0.683***
	(-2.84)	(-3.25)	(-2.93)
SIZE	-0.023	-0.014	-0.046
	(-0.31)	(-0.15)	(-0.56)
TURNOVER	-0.598	-0.438	-0.634
	(-0.58)	(-0.44)	(-0.62)
ROE	-0.373	-0.535	-0.217
	(-0.46)	(-0.65)	(-0.27)
DIV	-2.396	-0.829	-2.252
	(-0.69)	(-0.25)	(-0.65)
LEV	-1.036**	-0.849	-1.080**
	(-2.00)	(-1.65)	(-2.05)
MOM	1.055*	1.180**	1.089**
	(1.88)	(2.00)	(1.99)
IVOL	-45.337	-30.504	-39.577
	(-1.29)	(-0.87)	(-1.11)
Constant	2.176*	1.761	1.960
	(1.87)	(1.45)	(1.64)
N of obs.	13,047	13,047	13,047
R-squared	0.2462	0.2367	0.2569

Note: This table presents the results of the Fama-MacBeth regressions of REITs returns on strategic ESG scores (STRATEGIC) and overall ESG scores (ESG) using equation (6.7). The definition of control variables are shown in Appendix A6.1. The t-statistics reported in parentheses are adjusted by Newey-West standard errors with 6-month lag. ***1%, **5%, and *10%.

Lastly, my study examines the long-term valuation effects of strategic ESG practices. Using firm-year panel data, the following model is developed based on an instrumental variable approach with two-stage least square estimations (IV-2SLS) (Fan et al., 2023):

$$TOBINQ_{i,t+1}/BHR_{i,t+1} = \alpha + \beta_1 Strategic_{i,t} + \beta_2 ESG_{i,t} + \beta_3 Controls_{i,t} + PropertyType_i + Year_t + \varepsilon_{i,t} \tag{6.8}$$

where *TOBINQ* is Tobin's Q in year *t+1*, and *BHR* is buy-and-hold returns over the subsequent 12 months.

Table 6.9 shows that strategic ESG practices are positively associated with Tobin's Q ratio. The coefficient is 0.573, which is statistically significant at a 1% level. A unit increase in standard deviation in strategic ESG scores is associated with an increase of 0.192 in Tobin's Q in the following year. However, overall ESG scores are not significantly correlated with Tobin's Q ratio83. Column (2) indicates that ESG pillar-mix strategies are also beneficial to buy-and-hold returns over the next 12 months. The coefficient for strategic ESG score is 0.400, which indicates that an increase in strategic ESG scores of one standard deviation will result in an increase in buy-and-hold returns of 13.4%. This result is statistically significant at a 1% level. Overall ESG scores do not significantly predict buy-and-hold returns. In summary, my results suggest that strategic ESG practices significantly improve the market valuations of REITs. My results do not support previous studies that green buildings have higher market valuations than non-green buildings (Eichholtz et al., 2010; Eichholtz et al., 2013; Bruegge et al., 2016; Kholodilin et al., 2017). My findings, however, are in line with previous literature that states that green buildings underperform their non-green counterparts because environmental investments are too expensive in the real-estate

[83] For control variables, my results indicate that Tobin's Q is negatively correlated with book-to-market ratio in the previous year, and positively correlated with market size, return on equity and dividend ratios. My result is in line with the findings of previous research (Bauer et al., 2010; Cheung et al., 2015; Hartzell et al., 2014).

sector (Uğur and Leblebici, 2018; Dwaikat and Ali, 2016) and result in lower market values (Coën et al., 2018; Chacon et al., 2022).

Table 6.9. ESG pillar-mix strategies and valuation: the second stage of 2SLS regressions

	TOBINQ	BHR
	(1)	(2)
STRATEGIC	0.573	0.400
	(3.56)***	(4.21)***
ESG	0.013	0.007
	(1.06)	(0.92)
BM	-0.630	-0.079
	(-9.01)***	(-2.35)**
SIZE	0.059	-0.021
	(4.61)***	(-2.66)***
TURNOVER	0.180	-0.174
	(1.07)	(-1.86)*
ROE	0.978	0.178
	(6.24)***	(1.77)*
DIV	1.862	-1.044
	(2.59)***	(-2.75)***
LEV	-0.249	-0.221
	(-2.22)**	(-3.26)***
Property type F.E.	Yes	Yes
Year F.E.	Yes	Yes
N of obs.	1,186	1,206
R-squared	0.465	-0.026

Note: This table presents the results of the second-stage regression of the instrumental variable approach using equation (6.8) based on a firm-year sample in the REITs from 2007 to 2021. The dependent variables are Tobin's Q (TOBINQ) in year t+1 and buy-and-hold returns (BHR) over the next 12 months. The independent variables are strategic ESG scores (STRATEGIC) and overall ESG scores (ESG) in year t. Control variables are measured in year t and defined in Appendix A6.1. Property and year-fixed effects are included in the regressions. The t-statistics calculated from robust standard errors are reported in parentheses. ***1%, **5%, and *10%.

ESG pillar-mixed strategies and greenhouse gas emissions

The real-estate sector makes a significant contribution to greenhouse gas emissions. This is due to the energy consumed during the construction of new buildings as well as the operation of existing buildings. ESG pillar-mixed strategies focus on social and governance performance over environmental investment. This may result in an increase in greenhouse gas emissions by companies, contributing to global warming. The following model is used to evaluate this hypothesis:

$$\begin{aligned} \Delta GHGEMISSIONS_{i,t+1}/\Delta GHGCOST_{i,t+1} \\ = \alpha + \beta_1 Strategic_{i,t} + \beta_2 ESG_{i,t} + \beta_3 Controls_{i,t} + PropertyType_i \\ + Year_t + \varepsilon_{i,t} \end{aligned} \tag{6.9}$$

where *ΔGHGEMISSIONS* refers to a series of variables that reflect the change in greenhouse gas emissions, including the change in direct emissions (*ΔSCOPE1*), the change in indirect greenhouse gas emissions from energy consumption (*ΔSCOPE2*), the change in indirect greenhouse gas emissions from upstream business activities (*ΔSCOPE3UP*) and the change in indirect greenhouse gas emissions from downstream business activities (*ΔSCOPE3DOWN*). Furthermore, *ΔGHGCOST* refers to the change in total damage costs associated with greenhouse gas emissions.

Table 6.10 demonstrates the results of two-stage least squares estimation (IV-2SLS). Column (1) indicates that strategic ESG practices are significantly associated with an increase in direct greenhouse gas emissions. A standard deviation increase in strategic ESG score results in an increase in direct greenhouse gas emissions of 2.98%, which is significant at a 1% level. This result implies that strategic ESG practices are associated with higher carbon emissions as a result of the construction and operation of buildings. Columns (2) and (3) add that strategic ESG practices also significantly increase indirect carbon emissions. An increase of one standard deviation in strategic ESG score results in an increase of 1.67% in indirect greenhouse gas emissions caused by energy consumption and 1.27% in emissions caused by upstream activities, such as the transportation of building construction materials. Column (4), however, indicates that strategic ESG practices do not influence the emissions caused by downstream activities.

This result is reasonable given that the strategic ESG practices of REITs are less likely to be linked to the carbon emissions of their clients. Column (5) indicates the impact of ESG pillar-mixed strategies on environmental damage costs driven by greenhouse gas emissions. An increase of one standard deviation in ESG score causes environmental damage costs to increase by 9.38%, which is significant at a 1% level. In contrast, there is no significant association between overall ESG scores and greenhouse gas emissions. My study suggests that while strategic ESG practices may be beneficial to the company, they can also lead to an increase in emissions, thus exacerbating the effects of climate change.

Table 6.10. ESG pillar-mix strategies and greenhouse gas emissions: the second stage of 2SLS regressions

	ΔSCOPE1	ΔSCOPE2	ΔSCOPE3UP	ΔSCOPE3DOWN	ΔGHGCOST
	(1)	(2)	(3)	(4)	(5)
STRATEGIC	0.089	0.050	0.038	0.012	0.280
	(3.72)***	(2.55)**	(3.22)***	(0.30)	(3.39)***
ESG	0.002	0.001	0.001	0.003	0.008
	(1.38)	(0.38)	(0.78)	(0.39)	(1.00)
BM	-0.021	-0.023	-0.021	-0.034	-0.129
	(-3.38)***	(-5.10)***	(-5.38)***	(-2.88)***	(-6.07)***
SIZE	-0.006	-0.006	-0.004	-0.001	-0.036
	(-3.21)***	(-4.07)***	(-3.76)***	(-0.17)	(-5.11)***
TURNOVER	0.000	0.017	-0.010	-0.089	-0.020
	(0.00)	(0.90)	(-0.65)	(-1.60)	(-0.26)
ROE	-0.012	-0.029	0.001	0.010	-0.036
	(-0.60)	(-1.77)*	(0.11)	(0.23)	(-0.54)
DIV	-0.202	-0.201	-0.212	-0.301	-1.313
	(-2.02)**	(-2.74)***	(-3.92)***	(-1.08)	(-3.87)***
LEV	-0.034	-0.027	-0.037	-0.016	-0.214
	(-2.14)**	(-2.28)**	(-4.36)***	(-0.49)	(-3.71)***
Property type F.E.	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes
N of obs.	707	707	707	354	707
R-squared	-0.043	0.009	0.014	0.025	-0.015

Note: This table presents the results of the second-stage regression of the instrumental variable approach using equation (6.9) based on a firm-year sample in the REITs from 2007 to 2021. The dependent variables are the growth in direct greenhouse gas emissions (Δ SCOPE1), the growth in indirect greenhouse gas emissions from energy consumption (Δ SCOPE2), the growth in indirect greenhouse gas emissions from upstream business activities (Δ SCOPE3UP), the growth in indirect greenhouse gas emissions from downstream business activities (Δ SCOPE3DOWN) and the growth in the total damage costs associated with greenhouse gas emissions (Δ GHGCOST) in year *t+1*. The independent variables are strategic ESG scores (STRATEGIC) and overall ESG scores (ESG) in year *t*. Control variables are measured in year *t* and defined in Appendix A6.1. Property and year-fixed effects are included in the regressions. The *t-statistics* calculated from robust standard errors are reported in parentheses. ***1%, **5%, and *10%.

ESG pillar-mixed strategies and institutional investment

ESG pillar-mixed strategies enhance corporate fundamentals and also result in higher returns for investors. Institutional investors may be more attracted to REITs that participate in ESG pillar-mixed strategies since they can both benefit portfolio returns and meet the requirements of their clients with respect to ESG performance. The result could be an increase in institutional investors and an influx of institutional capital for companies engaging in strategic ESG initiatives. Considering that institutional investor data are updated quarterly, the following model is proposed based on a firm-quarter sample:

$$\begin{aligned} IO_{i,q+1}/INSNUM_{i,q+1} \\ &= \alpha + \beta_1 Strategic_{i,q} + \beta_2 ESG_{i,q} + \beta_3 Controls_{i,q} + PropertyType_i \\ &+ YearQuarter_q + \varepsilon_{i,q} \end{aligned} \tag{6.10}$$

where *IO* is total institutional ownership divided by the outstanding share of REIT *i* in quarter *q*+1, and *INSNUM* is the logarithm of the number of institutional investors. The independent variables are strategic ESG scores (*STRATEGIC*) and overall ESG scores (*ESG*) in year-end quarter *q*. Control variables are also measured in year-end quarter *q*. The model replaces year fixed effects by year-quarter fixed effects (*YearQuarter*).

In Table 6.11, the results of two-stage least squares estimation (IV-2SLS) are presented. The results of my study indicate that strategic ESG practices are positively associated with both institutional capital inflows and institutional investor numbers. Column (1) shows the results regarding institutional ownership. The coefficient for strategic ESG score is 0.158, which indicates that a one-standard-deviation increase in strategic ESG score results in a 5.16% increase in institutional ownership. The coefficient is statistically significant at a 1% level. Column (2) displays the results for the number of institutional investors. The coefficient for strategic ESG score is 0.303, which indicates that for a one-standard-deviation increase in strategic ESG score, the number of institutional investors increases by about 10.18%.[84] The coefficient is also statistically significant at a 1% level. My results indicate that strategic ESG practices attract professional investors. In addition, my results demonstrate that overall ESG scores are positively correlated with both the proportion of institutional ownership as well as the number of institutional investors, which is consistent with Dimson et al. (2015), Kim et al. (2019) and Pedersen et al. (2021). In untabulated results, my findings remain robust in a firm-year sample. My results indicate that the negative social consequences of strategic ESG practices may not be detected by institutional investors. Moreover, these professional investors even welcome REITs that have adopted ESG pillar-mixed strategies. My research indicates that the important force of the capital market does not help to correct this ESG blunder.

[84] The percentage increase in the number of institutional investors is calculated as exp(0.320*0.303) – 1 = 10.18%.

Table 6.11. ESG pillar-mix strategies and institutional ownership: the second stage of 2SLS regressions

	IO	INSNUM
	(1)	(2)
STRATEGIC	0.158	0.303
	(5.38)***	(6.10)***
ESG	0.025	0.025
	(9.02)***	(6.20)***
BM	-0.037	0.080
	(-2.70)***	(4.30)***
SIZE	0.036	0.382
	(13.65)***	(97.29)***
TURNOVER	0.210	0.177
	(7.18)***	(3.93)***
ROE	-0.336	-0.077
	(-8.57)***	(-1.39)
DIV	-1.689	0.813
	(-10.18)***	(3.56)***
LEV	-0.120	-0.044
	(-5.10)***	(-1.09)
Property type F.E.	Yes	Yes
Year-Quarter F.E.	Yes	Yes
N of obs.	3,962	3,962
R-squared	0.221	0.839

Note: This table presents the results of the second-stage regression of the instrumental variable approach using equation (6.10) based on a firm-year sample in the REITs from 2007 to 2021. The dependent variables are institutional ownership (IO) and the logarithm of institutional owners (INSNUM) in quarter q+1. The independent variables are strategic ESG scores (*STRATEGIC*) and overall ESG scores (*ESG*) in year-end quarter *q*. Control variables are measured in year-end quarter *q* and defined in Appendix A6.1. Property and year-quarter fixed effects are included in the regressions. The *t-statistics* calculated from robust standard errors are reported in parentheses. ***1%, **5%, and *10%.

6.6 Conclusion

This paper has examined the impact of ESG pillar-mix strategies on corporate fundamentals and market valuations of REITs. Environmental investments are typically viewed as more of a cost than a potential benefit by REITs. REITs may devise ESG pillar-mix strategies that emphasise social and governance practices over environmental investments to meet the expectations of capital markets without diminishing corporate fundamentals. My empirical results reveal that ESG pillar-mix strategies can significantly improve corporate fundamentals. Specifically, these strategies can increase rental income growth, reduce operating expenditure and improve profitability and capital expansion. My results remain robust after using instrumental variable estimations to address potential endogeneity concerns.

This paper further shows how capital markets respond to ESG pillar-mix strategies conducted by REITs. My event study indicates that improvements in strategic ESG scores result in positive cumulative abnormal returns of 0.414% over a 10-day period, while improvements in overall ESG scores are not associated with significant returns. Furthermore, the long-short portfolios constructed using strategic ESG scores earn significant monthly returns (alphas) ranging from 0.532% to 0.821% under equal-weighted schemes and value-weighted schemes. In addition, ESG pillar-mix strategies lead to higher long-term market valuations, as measured by Tobin's Q in the subsequent year and buy-and-hold returns over the next 12 months.

The real-estate sector contributes approximately 40% of global emissions of carbon dioxide. REITs that adopt ESG pillar-mix strategies may neglect their environmental practices if they are given incentives to prioritise social and governance practices. My study reveals that REITs that adopt ESG pillar-mix strategies produce more greenhouse gas emissions. Furthermore, these strategies result in higher costs associated with environmental damage. However, my results indicate that implementing ESG pillar-mix strategies attracts more institutional investors and see an influx of institutional capital. This implies that the negative environmental consequences driven by strategic ESG efforts are not detected or even welcomed by institutional investors.

It is essential to address the environmental impact of the real-estate sector in order to tackle climate change. Without proper incentives to prioritise environmental practices, REITs may not be able to make meaningful progress in reducing their carbon emissions. As investors, it is important to recognise that potential distortions of ESG practices may not be able to adequately address environmental concerns. Investors should therefore ensure that REITs are given the necessary incentives to prioritise environmental practices, so that meaningful progress can be made in reducing global emissions of carbon dioxide. In addition, my study suggests that policymakers should ensure that REITs are given the necessary incentives to prioritise environmental practices, such as tax rebates for green investors, green bonds for green buildings and real estate cap-and-trade programmes. Furthermore, they should implement more stringent emission regulations that hold REITs accountable for their environmental practices, and ensure they are making meaningful progress in reducing global emissions of carbon dioxide.

References

Ambrose, B., & Linneman, P. (2001). REIT Organizational Structure and Operating Characteristics. *Journal of Real Estate Research*, *21*(3), 141–162. https://doi.org/10.1080/10835547.2001.12091049

Ambrose, B. W., Ehrlich, S. R., Hughes, W. T., & Wachter, S. M. (2000). REIT Economies of Scale: Fact or Fiction? *The Journal of Real Estate Finance and Economics*, *20*(2), 211–224. https://doi.org/10.1023/A:1007881422383

An, X., Deng, Y., Fisher, J. D., & Hu, M. R. (2016). Commercial Real Estate Rental Index: A Dynamic Panel Data Model Estimation: Commercial Real Estate Rental Index. *Real Estate Economics*, *44*(2), 378–410. https://doi.org/10.1111/1540-6229.12101

Ang, A., Hodrick, R. J., Xing, Y., & Zhang, X. (2009). High idiosyncratic volatility and low returns: International and further U.S. evidence. *Journal of Financial Economics*, *91*(1), 1–23. https://doi.org/10.1016/j.jfineco.2007.12.005

Aroul, R. R., Sabherwal, S., & Villupuram, S. V. (2022). ESG, operational efficiency and operational performance: Evidence from Real Estate Investment Trusts. *Managerial Finance*, *48*(8), 1206–1220. https://doi.org/10.1108/MF-12-2021-0593

Bansal, P., & Clelland, I. (2004). Talking Trash: Legitimacy, Impression Management, and Unsystematic Risk in the Context of the Natural Environment. *Academy of Management Journal*, *47*(1), 93–103. https://doi.org/10.2307/20159562

Barth, M. E., Cahan, S. F., Chen, L., & Venter, E. R. (2017). The economic consequences associated with integrated report quality: Capital market and real effects. *Accounting, Organizations and Society*, *62*, 43–64. https://doi.org/10.1016/j.aos.2017.08.005

Bauer, R., Eichholtz, P., & Kok, N. (2010). Corporate Governance and Performance: The REIT Effect. *Real Estate Economics*, *38*(1), 1–29. https://doi.org/10.1111/j.1540-6229.2009.00252.x

Berg, F., Koelbel, J., Pavlova, A., & Rigobon, R. (2022). *ESG Confusion and Stock Returns: Tackling the Problem of Noise* (No. w30562; p. w30562). National Bureau of Economic Research. https://doi.org/10.3386/w30562

Berg, F., Kölbel, J. F., & Rigobon, R. (2022). Aggregate Confusion: The Divergence of ESG Ratings. *Review of Finance*, *26*(6), 1315–1344. https://doi.org/10.1093/rof/rfac033

Berliner, D., & Prakash, A. (2012). From norms to programs: The United Nations Global Compact and global governance: The UN Global Compact and global governance. *Regulation & Governance*, *6*(2), 149–166. https://doi.org/10.1111/j.1748-5991.2012.01130.x

Berrone, P., Fosfuri, A., & Gelabert, L. (2017). Does Greenwashing Pay Off? Understanding the Relationship Between Environmental Actions and Environmental Legitimacy. *Journal of Business Ethics*, *144*(2), 363–379. https://doi.org/10.1007/s10551-015-2816-9

Bianco, C., Ghosh, C., & Sirmans, C. F. (2007). The Impact of Corporate Governance on the Performance of REITs. *The Journal of Portfolio Management*, *33*(5), 175–191. https://doi.org/10.3905/jpm.2007.699613

Bond, S. A., Pai, Y.-J., Wang, P., & Zheng, S. (2019). The Impact of Dividend Reinvestment Plans on Firm Payout Choices-Evidence from Real Estate Investment Trusts: Impact of Dividend Reinvestment Plans on Firm Payout Choices. *Real Estate Economics*, *47*(1), 178–213. https://doi.org/10.1111/1540-6229.12248

Bond, S., & Xue, C. (2017). The Cross Section of Expected Real Estate Returns: Insights from Investment-Based Asset Pricing. *The Journal of Real Estate Finance and Economics*, *54*(3), 403–428. https://doi.org/10.1007/s11146-016-9573-0

Cao, J., Liang, H., & Zhan, X. (2019). Peer Effects of Corporate Social Responsibility. *Management Science*, *65*(12), 5487–5503. https://doi.org/10.1287/mnsc.2018.3100

Carhart, M. M. (1997). On Persistence in Mutual Fund Performance. *The Journal of Finance*, *52*(1), 57–82. https://doi.org/10.1111/j.1540-6261.1997.tb03808.x

Carlin, D. (2022). 40% of emissions come from real estate; here's how the sector can decarbonize. *Forbes*.

Chacon, R., Feng, Z., & Wu, Z. (2022). Does investing in ESG pay off? Evidence from REITs around the COVID-19 pandemic. *Evidence from REITs around the COVID-19 Pandemic (June 27, 2022)*.

Cheung, W. M., Chung, R., & Fung, S. (2015). The effects of stock liquidity on firm value and corporate governance: Endogeneity and the REIT experiment. *Journal of Corporate Finance*, *35*, 211–231. https://doi.org/10.1016/j.jcorpfin.2015.09.001

Coën, A., Lecomte, P., & Abdelmoula, D. (2018). The Financial Performance of Green Reits Revisited. *Journal of Real Estate Portfolio Management*, *24*(1), 95–105. https://doi.org/10.1080/10835547.2018.12090009

Cohen, L., & Frazzini, A. (2008). Economic Links and Predictable Returns. *The Journal of Finance*, *63*(4), 1977–2011. https://doi.org/10.1111/j.1540-6261.2008.01379.x

Delmas, M. A., & Burbano, V. C. (2011). The Drivers of Greenwashing. *California Management Review*, *54*(1), 64–87. https://doi.org/10.1525/cmr.2011.54.1.64

Deng, X., & Ong, S. E. (2018). Real Earnings Management, Liquidity Risk and REITs SEO Dynamics. *The Journal of Real Estate Finance and Economics*, *56*(3), 410–

442. https://doi.org/10.1007/s11146-017-9649-5

Deng, Y., & Wu, J. (2014). Economic returns to residential green building investment: The developers' perspective. *Regional Science and Urban Economics*, *47*, 35–44. https://doi.org/10.1016/j.regsciurbeco.2013.09.015

Devine, A., & Kok, N. (2015). Green Certification and Building Performance: *Implications for Tangibles and Intangibles*. *The Journal of Portfolio Management*, *41*(6), 151–163. https://doi.org/10.3905/jpm.2015.41.6.151

Devine, A., Sanderford, A., & Wang, C. (2022). Sustainability and Private Equity Real Estate Returns. *The Journal of Real Estate Finance and Economics*. https://doi.org/10.1007/s11146-022-09914-z

Devine, A., & Yönder, E. (2021). Impact of Environmental Investments on Corporate Financial Performance: Decomposing Valuation and Cash Flow Effects. *The Journal of Real Estate Finance and Economics*. https://doi.org/10.1007/s11146-021-09872-y

Dhaliwal, D. S., Li, O. Z., Tsang, A., & Yang, Y. G. (2011). Voluntary Nonfinancial Disclosure and the Cost of Equity Capital: The Initiation of Corporate Social Responsibility Reporting. *The Accounting Review*, *86*(1), 59–100. https://doi.org/10.2308/accr.00000005

Dimson, E., Karakaş, O., & Li, X. (2015). Active Ownership. *Review of Financial Studies*, *28*(12), 3225–3268. https://doi.org/10.1093/rfs/hhv044

Dwaikat, L. N., & Ali, K. N. (2016). Green buildings cost premium: A review of empirical evidence. *Energy and Buildings*, *110*, 396–403. https://doi.org/10.1016/j.enbuild.2015.11.021

Eccles, R. G., & Serafeim, G. (2013). The performance frontier. *Harvard Business Review*, *91*(5), 50–60.

Eichholtz, P., Kok, N., & Quigley, J. M. (2010). Doing Well by Doing Good? Green Office Buildings. *American Economic Review*, *100*(5), 2492–2509. https://doi.org/10.1257/aer.100.5.2492

Eichholtz, P., Kok, N., & Quigley, J. M. (2013). The Economics of Green Building. *Review of Economics and Statistics*, *95*(1), 50–63. https://doi.org/10.1162/REST_a_00291

Eichholtz, P., Kok, N., & Yonder, E. (2012). Portfolio greenness and the financial performance of REITs. *Journal of International Money and Finance*, *31*(7), 1911–1929. https://doi.org/10.1016/j.jimonfin.2012.05.014

Eichholtz, P. M. A., & Kok, N. (2008). How Does the Market for Corporate Control Function for Property Companies? *The Journal of Real Estate Finance and Economics*, *36*(2), 141–163. https://doi.org/10.1007/s11146-007-9061-7

Fama, E. F., & French, K. R. (1992). The Cross-Section of Expected Stock Returns.

The Journal of Finance, *47*(2), 427–465. https://doi.org/10.1111/j.1540-6261.1992.tb04398.x

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, *33*(1), 3–56. https://doi.org/10.1016/0304-405X(93)90023-5

Fama, E. F., & MacBeth, J. D. (1973). Risk, Return, and Equilibrium: Empirical Tests. *Journal of Political Economy*, *81*(3), 607–636. https://doi.org/10.1086/260061

Fan, K. Y., Shen, J., Hui, E. C., & Cheng, L. T. W. (2023). Responsible Investing in the Real Estate Investment Trusts. *Working Paper*.

Feng, Z., Ghosh, C., & Sirmans, C. F. (2007). On the Capital Structure of Real Estate Investment Trusts (REITs). *The Journal of Real Estate Finance and Economics*, *34*(1), 81–105. https://doi.org/10.1007/s11146-007-9005-2

Flammer, C. (2013). Corporate Social Responsibility and Shareholder Reaction: The Environmental Awareness of Investors. *Academy of Management Journal*, *56*(3), 758–781. https://doi.org/10.5465/amj.2011.0744

Fuerst, F., & McAllister, P. (2011). Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values: Green Noise or Green Value? *Real Estate Economics*, *39*(1), 45–69. https://doi.org/10.1111/j.1540-6229.2010.00286.x

Gatti, L., Pizzetti, M., & Seele, P. (2021). Green lies and their effect on intention to invest. *Journal of Business Research*, *127*, 228–240. https://doi.org/10.1016/j.jbusres.2021.01.028

George, T. J., & Hwang, C.-Y. (2010). A resolution of the distress risk and leverage puzzles in the cross section of stock returns. *Journal of Financial Economics*, *96*(1), 56–79. https://doi.org/10.1016/j.jfineco.2009.11.003

Ghosh, C., Roark, S., & Sirmans, C. F. (2013). On The Operating Performance of REITs Following Seasoned Equity Offerings: Anomaly Revisited. *The Journal of Real Estate Finance and Economics*, *46*(4), 633–663. https://doi.org/10.1007/s11146-011-9344-x

Giacomini, E., Ling, D. C., & Naranjo, A. (2015). Leverage and Returns: A Cross-Country Analysis of Public Real Estate Markets. *The Journal of Real Estate Finance and Economics*, *51*(2), 125–159. https://doi.org/10.1007/s11146-014-9489-5

Glascock, J. L., & Lu-Andrews, R. (2015). The Price Behavior of REITs Surrounding Extreme Market-Related Events. *The Journal of Real Estate Finance and Economics*, *51*(4), 441–479. https://doi.org/10.1007/s11146-015-9495-2

Grewal, J., Hauptmann, C., & Serafeim, G. (2021). Material Sustainability Information and Stock Price Informativeness. *Journal of Business Ethics*, *171*(3), 513–544.

https://doi.org/10.1007/s10551-020-04451-2

Guo, R., Tao, L., Li, C. B., & Wang, T. (2017). A Path Analysis of Greenwashing in a Trust Crisis Among Chinese Energy Companies: The Role of Brand Legitimacy and Brand Loyalty. *Journal of Business Ethics*, *140*(3), 523–536. https://doi.org/10.1007/s10551-015-2672-7

Hartzell, J. C., Kallberg, J. G., & Liu, C. H. (2008). The Role of Corporate Governance in Initial Public Offerings: Evidence from Real Estate Investment Trusts. *The Journal of Law and Economics*, *51*(3), 539–562. https://doi.org/10.1086/589701

Hebb, T., Hamilton, A., & Hachigian, H. (2010). Responsible Property Investing in Canada: Factoring Both Environmental and Social Impacts in the Canadian Real Estate Market. *Journal of Business Ethics*, *92*(S1), 99–115. https://doi.org/10.1007/s10551-010-0636-5

Hou, K., Xue, C., & Zhang, L. (2015). Digesting Anomalies: An Investment Approach. *Review of Financial Studies*, *28*(3), 650–705. https://doi.org/10.1093/rfs/hhu068

Jahdi, K. S., & Acikdilli, G. (2009). Marketing Communications and Corporate Social Responsibility (CSR): Marriage of Convenience or Shotgun Wedding? *Journal of Business Ethics*, *88*(1), 103–113. https://doi.org/10.1007/s10551-009-0113-1

Jegadeesh, N., & Titman, S. (1993). Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency. *The Journal of Finance*, *48*(1), 65–91. https://doi.org/10.1111/j.1540-6261.1993.tb04702.x

Khan, M., Serafeim, G., & Yoon, A. (2016). Corporate Sustainability: First Evidence on Materiality. *The Accounting Review*, *91*(6), 1697–1724. https://doi.org/10.2308/accr-51383

Kim, E.-H., & Lyon, T. P. (2015). Greenwash vs. Brownwash: Exaggeration and Undue Modesty in Corporate Sustainability Disclosure. *Organization Science*, *26*(3), 705–723. https://doi.org/10.1287/orsc.2014.0949

Kim, I., Wan, H., Wang, B., & Yang, T. (2019). Institutional Investors and Corporate Environmental, Social, and Governance Policies: Evidence from Toxics Release Data. *Management Science*, *65*(10), 4901–4926. https://doi.org/10.1287/mnsc.2018.3055

Krueger, P., Sautner, Z., Tang, D. Y., & Zhong, R. (2023). The Effects of Mandatory ESG Disclosure around the World. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3832745

Krüger, P. (2015). Corporate goodness and shareholder wealth. *Journal of Financial Economics*, *115*(2), 304–329. https://doi.org/10.1016/j.jfineco.2014.09.008

Ling, D. C., & Naranjo, A. (2015). Returns and Information Transmission Dynamics in Public and Private Real Estate Markets: Returns and Information Transmission Dynamics. *Real Estate Economics*, *43*(1), 163–208. https://doi.org/10.1111/1540-

6229.12069

Ling, D. C., Ooi, J. T. L., & Xu, R. (2019). Asset Growth and Stock Performance: Evidence from REITs. *Real Estate Economics*, *47*(3), 884–927. https://doi.org/10.1111/1540-6229.12186

Ling, D. C., Wang, C., & Zhou, T. (2021). Institutional common ownership and firm value: Evidence from real estate investment trusts. *Real Estate Economics*, *49*(1), 187–223. https://doi.org/10.1111/1540-6229.12312

Liu, S., & Wu, D. (2016). Competing by conducting good deeds: The peer effect of corporate social responsibility. *Finance Research Letters*, *16*, 47–54. https://doi.org/10.1016/j.frl.2015.10.013

Lu, L. Y., Shailer, G., & Yu, Y. (2017). Corporate Social Responsibility Disclosure and the Value of Cash Holdings. *European Accounting Review*, *26*(4), 729–753. https://doi.org/10.1080/09638180.2016.1187074

Lyon, T. P., & Maxwell, J. W. (2011). Greenwash: Corporate Environmental Disclosure under Threat of Audit. *Journal of Economics & Management Strategy*, *20*(1), 3–41. https://doi.org/10.1111/j.1530-9134.2010.00282.x

Lyon, T. P., & Montgomery, A. W. (2015). The Means and End of Greenwash. *Organization & Environment*, *28*(2), 223–249. https://doi.org/10.1177/1086026615575332

Miller, N., Spivey, J., & Florance, A. (2008). Does Green Pay Off? *Journal of Real Estate Portfolio Management*, *14*(4), 385–400. https://doi.org/10.1080/10835547.2008.12089822

MSCI. (2022). *ESG Industry Materiality Map*. https://www.msci.com/our-solutions/esg-investing/esg-industry-materiality-map

Mulherin, J. H., & Womack, K. S. (2015). Competition, Auctions & Negotiations in REIT Takeovers. *The Journal of Real Estate Finance and Economics*, *50*(2), 151–180. https://doi.org/10.1007/s11146-013-9447-7

NAREIT. (2022). *Nareit's REIT Industry ESG Report 2022*. https://www.reit.com/investing/reits-sustainability/2022-reit-esg-report

Newey, W. K., & West, K. D. (1987). A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. *Econometrica*, *55*(3), 703. https://doi.org/10.2307/1913610

Ott, S. H., Riddiough, T. J., & Yi, H.-C. (2005). Finance, Investment and Investment Performance: Evidence from the REIT Sector. *Real Estate Economics*, *33*(1), 203–235. https://doi.org/10.1111/j.1080-8620.2005.00117.x

Pástor, Ľ., Stambaugh, R. F., & Taylor, L. A. (2022). Dissecting green returns. *Journal of Financial Economics*, *146*(2), 403–424. https://doi.org/10.1016/j.jfineco.2022.07.007

Pedersen, L. H., Fitzgibbons, S., & Pomorski, L. (2021). Responsible investing: The ESG-efficient frontier. *Journal of Financial Economics*, *142*(2), 572–597. https://doi.org/10.1016/j.jfineco.2020.11.001

Peng, D., Shen, J., Fung, S. Y. K., Hui, E. C. M., & Fan, K. (2022). The Valuation Effect and Consequences of Clawback Adoption in Real Estate Investment Trusts. *The Journal of Real Estate Finance and Economics*. https://doi.org/10.1007/s11146-022-09909-w

Philippe, D., & Durand, R. (2011). The impact of norm-conforming behaviors on firm reputation. *Strategic Management Journal*, *32*(9), 969–993. https://doi.org/10.1002/smj.919

Pizzetti, M., Gatti, L., & Seele, P. (2021). Firms Talk, Suppliers Walk: Analyzing the Locus of Greenwashing in the Blame Game and Introducing 'Vicarious Greenwashing.' *Journal of Business Ethics*, *170*(1), 21–38. https://doi.org/10.1007/s10551-019-04406-2

Plumlee, M., Brown, D., Hayes, R. M., & Marshall, R. S. (2015). Voluntary environmental disclosure quality and firm value: Further evidence. *Journal of Accounting and Public Policy*, *34*(4), 336–361. https://doi.org/10.1016/j.jaccpubpol.2015.04.004

Ramus, C. A., & Montiel, I. (2005). When Are Corporate Environmental Policies a Form of Greenwashing? *Business & Society*, *44*(4), 377–414. https://doi.org/10.1177/0007650305278120

Reichardt, A. (2014). Operating Expenses and the Rent Premium of Energy Star and LEED Certified Buildings in the Central and Eastern U.S. *The Journal of Real Estate Finance and Economics*, *49*(3), 413–433. https://doi.org/10.1007/s11146-013-9442-z

Ro, S., & Ziobrowski, A. J. (2011). Does Focus Really Matter? Specialized vs. Diversified REITs. *The Journal of Real Estate Finance and Economics*, *42*(1), 68–83. https://doi.org/10.1007/s11146-009-9189-8

Scofield, J. H., & Doane, J. (2018). Energy performance of LEED-certified buildings from 2015 Chicago benchmarking data. *Energy and Buildings*, *174*, 402–413. https://doi.org/10.1016/j.enbuild.2018.06.019

Serafeim, G. (2020). Social-impact efforts that create real value. *Harvard Business Review*, *98*(5), 38–48.

Serafeim, G., & Yoon, A. (2022). Which Corporate ESG News Does the Market React To? *Financial Analysts Journal*, *78*(1), 59–78. https://doi.org/10.1080/0015198X.2021.1973879

Shen, J., Hui, E. C. M., & Fan, K. (2021a). Did Real Estate Professionals Anticipate the 2007-2008 Financial Crisis? Evidence from Insider Trading in the REITs. *The Journal of Real Estate Finance and Economics*, *63*(1), 122–142.

https://doi.org/10.1007/s11146-020-09763-8

Shen, J., Hui, E. C. M., & Fan, K. (2021b). The Beta Anomaly in the REIT Market. *The Journal of Real Estate Finance and Economics*, *63*(3), 414–436. https://doi.org/10.1007/s11146-020-09784-3

Stock, J., & Yogo, M. (2005). Testing for Weak Instruments in Linear IV Regression. In *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg* (pp. 80–108). Cambridge University Press.

Uğur, L. O., & Leblebici, N. (2018). An examination of the LEED green building certification system in terms of construction costs. *Renewable and Sustainable Energy Reviews*, *81*, 1476–1483. https://doi.org/10.1016/j.rser.2017.05.210

Walker, K., & Wan, F. (2012). The Harm of Symbolic Actions and Green-Washing: Corporate Actions and Communications on Environmental Performance and Their Financial Implications. *Journal of Business Ethics*, *109*(2), 227–242. https://doi.org/10.1007/s10551-011-1122-4

Wiley, J. A., Benefield, J. D., & Johnson, K. H. (2010). Green Design and the Market for Commercial Office Space. *The Journal of Real Estate Finance and Economics*, *41*(2), 228–243. https://doi.org/10.1007/s11146-008-9142-2

Xu, R., & Ooi, J. T. L. (2018). Good Growth, Bad Growth: How Effective are REITs' Corporate Watchdogs? *The Journal of Real Estate Finance and Economics*, *57*(1), 64–86. https://doi.org/10.1007/s11146-017-9640-1

6.A Appendices

Appendix A6.1. Variable definition

Variable	Definition
Key independent variables	
STRATEGIC	The measure of strategic ESG practices. It is calculated by the sum of the social and governance scores minus the environmental score, then divided by the overall ESG score: (SOC+GOV-ENV)/ESG.
ESG	The overall environmental social and governance scores.
ENV	The environmental scores.
SOCGOV	The sum of the social scores and governance scores.
IVSTRATEGIC	The instrument variable of STRATEGIC. It is the average weighted of STRATEGIC of other companies with the same property type, operating in the same industry and the same country.
Dependent variables	
RENTGROW	The growth of rental income of a REIT, which is calculated by the difference between the rental income in the current year and the last year, and scaled by the rental income in the last year.
COGS	The operating expenditure of a REIT, which is equal to the log of cost of goods sold.
GPMAGIN	The gross profit margin ratio, which is equal to the gross profit divided by the total revenue of a REIT.
ASSETGROW	The growth of total assets of a REIT, which is calculated by the difference between the total assets in the current year and the last year, and scaled by the total assets in the last year.
INVESTMENT	The periodic investment of a REIT, which is calculated by the retained capital earnings plus the net new issuance of financial claims, and scaled by the total assets in the last year (Ott et al., 2005; Peng et al., 2022).
TOBINQ	Tobin’s Q ratio, which is calculated by the sum of total debt and market capitalization of a REIT in a year, divided by total assets.
BHR	The buy-and-hold returns of a REIT over the next 12 months.
IO	The total institutional ownership over the share outstanding of a REIT.
INSNUM	The logarithm of the number of institutional investors of a REIT.
ΔSCOPE1	The percentage change in direct greenhouse gas emissions (scope 1), which is calculated by the difference between direct greenhouse gas emissions (scope 1) in the current year and the last year, and scaled by the direct greenhouse gas emissions (scope 1) in the last year.

ΔSCOPE2	The percentage change in indirect greenhouse gas emissions from energy consumption (scope 2), which is calculated by the difference between indirect greenhouse gas emissions from energy consumption (scope 2) in the current year and the last year, and scaled by the indirect greenhouse gas emissions from energy consumption (scope 2) in the last year.
ΔSCOPE3UP	The percentage change in indirect greenhouse gas emissions from upstream business activities (scope 3 upstream), which is calculated by the difference between indirect greenhouse gas emissions from upstream business activities (scope 3 upstream) in the current year and the last year, and scaled by the indirect greenhouse gas emissions from upstream business activities (scope 3 upstream) in the last year.
ΔSCOPE3DOWN	The percentage change in indirect greenhouse gas emissions from downstream business activities (scope 3 downstream), which is calculated by the difference between indirect greenhouse gas emissions from downstream business activities (scope 3 downstream) in the current year and the last year, and scaled by the indirect greenhouse gas emissions from downstream business activities (scope 3 downstream) in the last year.
ΔGHGCOST	The percentage change in the total damage costs associated with greenhouse gas emissions, which is calculated by the difference between the total damage costs associated with greenhouse gas emissions in the current year and the last year, and scaled by the total damage costs associated with greenhouse gas emissions in the last year.
Controlling variables	
BM	The book-to-market ratio of a REIT.
SIZE	The market capitalization of a REIT.
TURNOVER	The revenue to total asset ratio of a REIT.
ROE	The return on equity ratio of a REIT.
DIV	The dividend to total asset ratio of a REIT.
LEV	The leverage ratio of a REIT.
MOM	The cumulative returns of a REIT over the past 12 months.
IVOL	The idiosyncratic volatility estimated by the daily returns of a REIT based on the Fama-French three-factor model over the past 12 months.

Appendix A6.2. Environmental, social, and governance (ESG) scores and fundamental performance

Panel A. ESG scores and rental income growth

	(1)	(2)	(3)
	RENTGROW	RENTGROW	RENTGROW
ENV	-0.023***		
	(-2.65)		
SOC		0.013	
		(0.99)	
GOV			0.032*
			(1.68)
BM	-0.077**	-0.082**	-0.078**
	(-2.23)	(-2.37)	(-2.29)
SIZE	-0.022***	-0.026***	-0.025***
	(-2.96)	(-3.27)	(-3.43)
TURNOVER	-0.004	0.011	0.015
	(-0.03)	(0.08)	(0.10)
ROE	-0.004	-0.012	-0.002
	(-0.04)	(-0.10)	(-0.01)
DIV	-1.510***	-1.514***	-1.463***
	(-3.83)	(-3.75)	(-3.62)
LEV	-0.267***	-0.281***	-0.271***
	(-2.82)	(-2.98)	(-2.85)
Property type F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
N of obs.	895	895	895
R-squared	0.1563	0.1480	0.1512

Panel B. ESG scores and operating expenditures

	(1)	(2)	(3)
	COGS	COGS	COGS
ENV	0.077***		
	(3.70)		
SOC		-0.002	
		(-0.07)	
GOV			-0.076
			(-1.39)
BM	0.917***	0.923***	0.910***
	(8.80)	(8.70)	(8.53)
SIZE	0.867***	0.873***	0.875***
	(31.20)	(30.14)	(30.76)
TURNOVER	4.915***	4.890***	4.841***
	(9.89)	(9.95)	(9.91)
ROE	-1.985***	-1.947***	-1.975***
	(-6.28)	(-5.97)	(-6.17)
DIV	-0.295	-0.586	-0.595
	(-0.24)	(-0.49)	(-0.50)
LEV	1.620***	1.577***	1.571***
	(6.63)	(6.35)	(6.43)
Property type F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
N of obs.	1,237	1,237	1,237
R-squared	0.8429	0.8396	0.8404

Panel C. ESG scores and corporate profitability

	(1)	(2)	(3)
	GPMARGIN	GPMARGIN	GPMARGIN
ENV	-0.030***		
	(-4.18)		
SOC		0.006	
		(0.53)	
GOV			0.015
			(0.86)
BM	-0.132***	-0.135***	-0.133***
	(-3.36)	(-3.43)	(-3.37)
SIZE	0.007	0.003	0.004
	(0.71)	(0.35)	(0.41)
TURNOVER	-0.836***	-0.827***	-0.817***
	(-7.95)	(-7.60)	(-7.41)
ROE	0.648***	0.636***	0.638***
	(5.55)	(5.33)	(5.37)
DIV	0.012	0.108	0.130
	(0.03)	(0.29)	(0.35)
LEV	-0.122**	-0.109*	-0.103*
	(-2.06)	(-1.80)	(-1.70)
Property type F.E.	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes
N of obs.	1,236	1,236	1,236
R-squared	0.4201	0.4045	0.4050

Chapter 7 Conclusions

7.1 Revisiting the research objectives

This thesis addresses two major research objectives. The first major one is to evaluate how institutional designs affect environmental governance in China. Chapters 2–4 examine the first objective by exploring how institutional designs, including the cadre evaluation system, incentive-orientated performance contracts and the political hierarchy of government environmental regulation agencies, have contributed to successful environmental governance in China over the past decade. I provide evidence demonstrating how institutional designs affect stakeholders' motivations for improving environmental governance. Specific research objectives derived from the major objectives can be stated as follows:

1. To examine the impact of the reform of the cadre evaluation system on the political motivation of local officials in responding to environmental protection issues.
2. To determine the impact of the coverage of automated air quality monitoring stations on air pollution.
3. To investigate the interplay between political hierarchy and corporate environmental governance.

To address the first research objective, Chapter 2 examines how political incentives affect public resources allocation by local officials. When local officials face prominent political promotion reviews, they reduce industrial land prices to attract investment from pollution-intensive industries. This can lead to short-term economic growth but damage the environment in the long run. Following the inclusion of environmental quality into the cadre evaluation system in 2013, local officials have been less likely to distort industrial land prices. A reduction in industrial land prices can no longer contribute to economic growth. This chapter indicates that the reform of the cadre evaluation system may motivate local officials to be more concerned about pollution problems.

The second research objective is addressed in Chapter 3, by examining whether incentive-orientated performance contracts linked to measurable environmental performance can contribute to improvements in air quality. By exploiting the Air Pollution Prevention and Control Action Plan launched in China in 2013, I find that cities with strong performance measurability experience significantly more reductions in PM2.5 concentrations than cities with weak performance measurability. This implies that improvements in performance measurement can reduce the tendency of local officials to "game the system". The findings show that more extensive coverage of automated air quality monitoring stations can result in greater improvements in air quality.

The third research objective is explored in Chapter 4, by examining how the environmental verticalization reform affects corporate environmental governance. China implemented a reform that enabled provincial environmental protection bureaus to directly manage lower-level bureaus in 2016. I find that the corporate environmental governance of local SOEs has improved significantly following the reform, as local environmental protection bureaus no longer have conflicts of interest with local governments. However, the reform has not resulted in improvements in corporate environmental governance in central SOEs, whose executives are in higher positions than provincial environmental protection bureaus leaders, nor in POEs, which were already managed before the reform. This study indicates that the political hierarchy plays an important role in the effectiveness of corporate environmental governance in China.

The second major objective of my thesis is to explore what distorts incentives to reduce greenhouse gas emissions in the United States. Some institutional designs, however, may impede effective environmental governance, even in developed countries with strict environmental regulations and policies. These institutional designs may hinder the implementation of environmental policies and distort incentives for improvements to environmental quality. My thesis investigates the pitfalls of institutional designs in two carbon-intensive industries, namely, the fossil-fuel sector and the real-estate sector. Specifically, my thesis addresses the following research objectives:

4. To assess the effect of political lobbying of fossil fuel firms on oil and gas investment.

5. To evaluate the impact of strategic ESG practices on the corporate fundamentals, market valuations and carbon emissions of real estate investment trusts (REITs).

Chapter 5 explores the fourth research objective, by analysing the impact of political lobbying on the oil and gas reserves of fossil-fuel firms. The chapter provides evidence that political lobbying contributes to the expansion of fossil-fuel investment. I further find that lobbying activities significantly increase the financial performance of fossil-fuel companies, but do not decrease their political risk or exposure to climate change policy uncertainty. The findings highlight the need for stronger regulation and increased transparency regarding political affiliations to ensure more sustainable energy policies.

The fifth research objective is addressed in Chapter 6, which illustrates the corporate and social consequences of strategic ESG practices. This chapter examines how ESG-pillar-mixed strategies impact on the future corporate fundamentals, market valuations, institutional ownership and environmental consequences of REITs in the United States. My empirical findings show that the fundamentals of REITs improve when they adopt ESG pillar-mixed strategies, which emphasise social and governance investments but overlook environmental investments. In addition, these strategies result in higher stock returns and market values in the future. Additional results indicate that strategic ESG practices can degrade environmental performance; however, these practices are not detected or even welcomed by institutional investors. This chapter discusses the major limitations and flaws associated with utilising ESG as one of the institutional designs for improving environmental governance. Firms strive to maximise their value and therefore engage in ESG activities that are in their own best interests. The important force of the capital market, institutional investors, does not assist in the correction of this ESG washing.

7.2 Significance of the findings

The significance of the research findings is threefold. First, this thesis highlights the importance of institutional designs, such as governance reforms and the political system, in addressing environmental problems in countries at different stages of development. Specifically, for developing countries like China that are experiencing rapid industrialisation, previous studies argue that the Chinese government's efforts to address environmental problems are hindered by the weak enforcement of environmental regulations and the lack of incentives for local officials to prioritise environmental protection (He, 2006; Wang et al., 2008; Jia, 2017). My thesis reveals that institutional designs such as promotion reviews and the cadre evaluation system are essential for incentivising local officials to prioritise environmental protection over economic growth. The introduction of automated air quality monitoring systems can also greatly improve the effectiveness of environmental policies in developing nations by providing accurate and real-time pollution data, reducing the ability of local officials to distort or hide information. Furthermore, environmental verticalization reforms that consolidate authority over pollution monitoring and enforcement in dedicated environmental bureaus can help improve corporate environmental governance of local state-owned enterprises in industrialising economies. However, as evidenced in the more developed United States, increased corporate lobbying of politicians based on ideological ties and strategic corporate ESG practices can lead to critical oversights of environmental investments needed to truly mitigate climate change. This indicates that a heavy reliance on political affiliation and capital market for environmental progress may be less effective in advanced economies.

Secondly, this thesis thoroughly examines appropriate institutional designs for environmental governance based on a country's stage of economic development. For rapidly industrialising developing countries like China, governance reforms that incentivise officials through performance reviews and promotions tied to environmental metrics, along with accurate automated monitoring systems, are vital to implement effective environmental policies during this high-pollution stage. However, the comprehensive research on the United States suggests that as countries become more economically developed, increased corporate lobbying and strategic ESG practices may significantly hinder environmental progress even as they benefit company profits and public image. This signifies that policymakers in mature economies should consider the limitations and motivations behind corporate environmental governance and use regulation to incentivise meaningful sustainability investments from industries. They should not rely heavily on social pressure and capital market alone to produce the transformative change needed to combat urgent climate challenges.

Lastly, this thesis provides an important contribution by conducting a comparative analysis of environmental governance challenges and institutional policy responses between developing and developed economies. The contrast between China and the United States illustrates that while developing nations may face issues of poor regulatory enforcement and information asymmetry, advanced economies encounter greenwashing and ideological lobbying as barriers to sustainability. The cross-country analysis in this research allows for identifying stage-specific institutional weaknesses in environmental governance, as well as best practices that may be shared across development levels. For instance, China could learn from the U.S. experience by proactively closing loopholes to corporate greenwashing as its economy matures. Meanwhile, the U.S. could borrow from China's governance reforms that prioritise environmental metrics in official performance reviews. By highlighting commonalities and differences in environmental governance trajectory.

In conclusion, this extensive research aims to provide nuanced, evidence-based insights to aid policymakers in understanding the underlying institutional causes of environmental issues at different development stages, in order to devise tailored and impactful solutions that enhance environmental quality as an economy evolves. This pragmatic approach can deliver new perspectives for academics and officials seeking to address environmental challenges in countries at varying points of industrialisation and growth.

7.3 Policy implications

My research has policy implications for improving the effectiveness of environmental protection policies and regulations, as well as for designing better institutional arrangements that can help to ensure compliance with those policies and regulations. Specifically, my research suggests that such policy improvements and institutional arrangements based on a country's stage of development:

1. In developing countries that utilise a top-down personnel management approach for appointing officials, there is a risk that economic growth and development goals will be prioritised over environmental protection. To mitigate unsustainable race-to-the-bottom competition between local officials, policymakers should consider integrating environmental protection and sustainability targets into the cadre evaluation system for assessing and promoting officials. The inclusion of environmental metrics into personnel evaluations can provide much-needed incentives for officials in developing countries to make meaningful efforts towards sustainability. However, relying solely on these types of top-down political incentives has proven to have very limited effectiveness for achieving sustainability without systemic reforms that fundamentally realign incentives and enhance accountability through rigorous performance measurement. Therefore, in addition to incorporating sustainability factors into their personnel management processes, policymakers must also focus their efforts on implementing systemic changes that rebuild the incentive structures and accountability mechanisms affecting officials through utilising transparency requirements and binding performance contracts.
2. Policymakers should focus their efforts on implementing enhanced transparency requirements that mandate the documentation and public disclosure of the specific political affiliations and greenhouse gases emissions levels of all companies operating within their jurisdictions. Equipping the general public with detailed information on the precise political connections and environmental consequences of key businesses will significantly aid accountability and enable the central government and citizens to make much more informed regarding which political candidates to support based on their commitments and track records on sustainability. Furthermore, policymakers should strongly consider

utilising written performance contracts that directly link measurable sustainability outcomes, such as pollution reduction targets, renewable energy generation levels or habitat conservation acreage, to incentives, salaries, job security and promotion opportunities for both public sector officials and private sector firms. As evidenced by past situations of local officials in China gaming air quality metrics when environmental targets conflicted with economic growth goals, the measurability of sustainability performance must be matched by a fundamental realignment of incentives towards environmental protection and sustainability rather than unfettered economic growth. The utilisation of binding contracts predicated on quantitative environmental metrics has been demonstrated to be one of the most effective motivators for securing compliance from both public sector officials and private sector firms. Rigorous performance measurability enables direct accountability for sustainability results.

3. Robust political independence and stringent transparency requirements for environmental regulatory agencies are essential institutional prerequisites for effective environmental governance, regardless of a country's development status. To prevent conflicts of interest, developing country policymakers should consider legally mandating the environmental regulation function under apolitical agencies or ministries isolated from growth-oriented departments. However, centralising authority within apolitical agencies risks resistance from vested interests benefitting from the status quo, such as China. As reforming institutions requires gradually building widespread public support for change, policymakers must take a long-term approach to fundamentally transform the system. This involves consistently advocating and implementing incremental reforms that demonstrate the benefits of independent governance. Developed countries should maintain the political independence of environmental regulators that has already been achieved. Regulatory procedures and decision-making should remain open and accessible to the public across all contexts, so that probity can be maintained and both businesses and citizens can continue to trust in due process.
4. Mandatory disclosure laws for political affiliations, campaign contributions, and lobbying activities by oil, gas and other industrial corporations can mitigate risks of regulatory capture, misuse of public funds, and negative externalities. Such

private sector transparency requirements should be considered by policymakers in both developing and developed countries to ensure the integrity of public spending and environmental decision-making. While specific disclosure rules must be tailored to local norms and regulations, the underlying principle of increasing accountability through private sector transparency applies broadly. Policymakers have a responsibility to continuously assess and update disclosure policies as a preventative measure against collusion and corruption.

5. Market mechanisms alone are insufficient to address environmental issues effectively, as companies rationally prioritise maximising financial returns over minimising environmental externalities that do not directly affect their bottom line. Even with policy reforms aimed at incentivising better environmental performance, such as tax breaks or performance-based subsidies, firms may find ways to circumvent full compliance if they face significant economic costs or competitive disadvantages. Thus, some level of government intervention and regulation is necessary to realign private incentives with the broader public interest and social welfare. Beyond reforms to bureaucratic incentives and performance evaluations for public officials like China, governments could consider implementing more stringent command-and-control policies such as hard limits on emissions or mandates to adopt certain technologies. Market-based policies like carbon pricing, taxes on negative environmental externalities, and tradable permit systems can also play an important role in helping bridge the gap between private costs and social costs. However, these will likely need to be combined with thoughtful regulations and institutional reforms in a hybrid policy approach in order to effectively motivate the full range of stakeholders across both public and private spheres to take action to improve environmental quality and mitigate climate change. Policymakers cannot rely wholly on voluntary corporate social responsibility initiatives; governments have a crucial role to play in establishing the necessary incentives, guidelines, and enforcement mechanisms needed to drive environmental progress.
6. Incentives, regulations, and policy initiatives aimed at encouraging more sustainable business practices, such as tax rebates or subsidies for green investors, tradable permit systems for carbon emissions, and credits for voluntary environmental stewardship initiatives, should be carefully designed

and implemented in a manner that accounts for each country's current stage of economic development and institutional capability. Developing countries may need to focus first on establishing and enforcing a set of basic environmental regulations and guidelines before attempting to implement more sophisticated market-based mechanisms. Policymakers in more economically advanced developed countries should aim to conduct rigorous contextual cost-benefit analyses to tailor incentives and regulations appropriately to local institutional environments and business conditions, rather than taking a one-size-fits-all approach. They should also consider phasing in new policies incrementally and continually evaluating their impacts over time. Understanding the strengths and limitations of existing institutions will be key to successfully crafting incentives and regulations that achieve environmental goals without imposing excessive costs or administrative burdens.

7.4 Limitation and suggestions for future research

This research empirically examines how institutional design plays a significant role in environmental governance. Aside from the conclusions of the thesis, some implications may also be derived from this thesis that may advance future research.

Environmental governance in international contexts

This research focuses on successful institutional designs in China, a developing country, and the limitation aspects of environmental governance in the United States, a developed country. Both countries contribute significantly to global economic growth and pollution levels. However, the thesis is limited in scope by only comparing two countries at different stages of development. Other developing countries such as Brazil and developed countries like Germany also have unique institutional designs and environmental policies that are worthy of exploration. Their successes and shortcomings can provide valuable insights into the strengths and weaknesses of environmental governance strategies tailored to a country's development stage. For example, Germany, an industrialised developed country, has a well-known progressive approach to environmental protection with strong institutional designs (Popp, 2006; Frondel et al., 2008; Kammerer, 2009; Dechezleprêtre et al., 2011). In contrast, Brazil, an emerging developing country, has a decentralised environmental policy where local governments take the lead (Cunha et al., 2016; Lipscomb and Mobarak, 2017; Machado et al., 2017). Comparing institutional designs across more countries at different development stages could reveal more generalised insights into effective environmental governance based on level of development. The successes and limitations of different institutional designs in developed versus developing countries can provide more comprehensive understanding into strategies that balance environmental and economic objectives given a country's resources and growth needs.

Environmental governance from a bottom-up perspective

This thesis only examines institutional designs from a top-down perspective. To gain a deeper understanding of how environmental governance functions, it would be interesting to examine the effects of bottom-up approaches, such as citizen organisations and grassroots advocacy groups. Investigating the interactions between different levels of governance, from grassroots to the international, could provide a more comprehensive understanding of the field. For instance, this could include an analysis of how NGOs and civil society organisations use their influence to shape environmental policy and regulations from the bottom-up. It is possible to conduct these studies in an event-based manner. Previous studies of the Deepwater Horizon oil spill in the Gulf of Mexico could narrate an environmental shock on how different stakeholders, including NGOs, investors and consumers, interacted to shape the response to the crisis and subsequent regulations that were adopted (Dyck et al., 2019; Wang et al., 2018; Barrage et al., 2020). A similar analysis could be applied to environmental incidents in China (Cao et al., 2018) or to the recent train derailment and toxic spill in Ohio (Bassler, 2023). Examining such events and their aftermath could reveal insights into the relative influence and interactions between top-down institutional designs and bottom-up advocacy in driving environmental governance. Furthermore, this could involve examining how different countries' environmental policies intersect, or how global agreements such as the Paris Agreement are implemented at the national and local levels. Future studies could examine how institutional designs, such as the incorporation of different stakeholders' participation, have been used to address environmental problems from both top-down and bottom-up perspectives. This more comprehensive approach could provide greater insights into effective environmental governance.

Environmental governance and informal institutional design

This thesis primarily focuses on the formal aspects of institutional design, such as rules, regulations and political structures. However, this research has not considered how informal institutional designs, such as social networks, cultures and norms, may affect environmental governance. For example, recent studies have shown that informal norms of reciprocity and trust can influence the effectiveness of collective action (Knack and Keefer, 1997; Fehr and Schmidt, 2006; Farrow et al., 2017; Nyborg, 2018; Hoffmann et al., 2021), although there is limited empirical evidence on how social norms influence environmental governance specifically (Owen and Videras, 2007; Torgler et al., 2009). Furthermore, social networks can have significant impacts on environmental governance by influencing the formation of informal norms and the dissemination of information (Borgatti and Cross, 2003; Ryan et al., 2008). By focusing only on formal institutional designs, this thesis provides an incomplete picture of the factors shaping environmental governance. Informal institutions such as social norms and networks likely also play an important role. Future research should examine how these informal designs may be leveraged to promote sustainable practices, either on their own or in conjunction with formal rules and regulations. Studying the interactions between formal and informal institutions could provide valuable insights into a more comprehensive approach to environmental governance.

References

Barrage, L., Chyn, E., & Hastings, J. (2020). Advertising and Environmental Stewardship: Evidence from the BP Oil Spill. *American Economic Journal: Economic Policy*, *12*(1), 33–61. https://doi.org/10.1257/pol.20160555

Bassler, R. (2023). East Palestine Train Derailment. *United States Environmental Protection Agency*. https://response.epa.gov/EastPalestineTrainDerailment

Borgatti, S. P., & Cross, R. (2003). A Relational View of Information Seeking and Learning in Social Networks. *Management Science*, *49*(4), 432–445. https://doi.org/10.1287/mnsc.49.4.432.14428

Cao, G., Yang, L., Liu, L., Ma, Z., Wang, J., & Bi, J. (2018). Environmental incidents in China: Lessons from 2006 to 2015. *Science of The Total Environment*, *633*, 1165–1172. https://doi.org/10.1016/j.scitotenv.2018.03.271

Cunha, F. A. F. de S., Börner, J., Wunder, S., Cosenza, C. A. N., & Lucena, A. F. P. (2016). The implementation costs of forest conservation policies in Brazil. *Ecological Economics*, *130*, 209–220. https://doi.org/10.1016/j.ecolecon.2016.07.007

Dechezleprêtre, A., Glachant, M., Haščič, I., Johnstone, N., & Ménière, Y. (2011). Invention and Transfer of Climate Change–Mitigation Technologies: A Global Analysis. *Review of Environmental Economics and Policy*, *5*(1), 109–130. https://doi.org/10.1093/reep/req023

Dyck, A., Lins, K. V., Roth, L., & Wagner, H. F. (2019). Do institutional investors drive corporate social responsibility? International evidence. *Journal of Financial Economics*, *131*(3), 693–714. https://doi.org/10.1016/j.jfineco.2018.08.013

Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social Norms and Pro-environmental Behavior: A Review of the Evidence. *Ecological Economics*, *140*, 1–13. https://doi.org/10.1016/j.ecolecon.2017.04.017

Fehr, E., & Schmidt, K. M. (2006). Chapter 8 The Economics of Fairness, Reciprocity and Altruism – Experimental Evidence and New Theories. In *Handbook of the Economics of Giving, Altruism and Reciprocity* (Vol. 1, pp. 615–691). Elsevier. https://doi.org/10.1016/S1574-0714(06)01008-6

Frondel, M., Horbach, J., & Rennings, K. (2008). What triggers environmental management and innovation? Empirical evidence for Germany. *Ecological Economics*, *66*(1), 153–160. https://doi.org/10.1016/j.ecolecon.2007.08.016

He, J. (2006). Pollution haven hypothesis and environmental impacts of foreign direct investment: The case of industrial emission of sulfur dioxide (SO2) in Chinese provinces. *Ecological Economics*, *60*(1), 228–245. https://doi.org/10.1016/j.ecolecon.2005.12.008

Hoffmann, B. L., Scartascini, C., & Cafferata, F. G. (2022). How can we improve air pollution? Try increasing trust first. *Environment and Development Economics*, *27*(5), 393–413. https://doi.org/10.1017/S1355770X2100036X

Jia, R. (2017). Pollution for Promotion. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3029046

Kammerer, D. (2009). The effects of customer benefit and regulation on environmental product innovation. *Ecological Economics*, *68*(8–9), 2285–2295. https://doi.org/10.1016/j.ecolecon.2009.02.016

Knack, S., & Keefer, P. (1997). Does Social Capital Have an Economic Payoff? A Cross-Country Investigation. *The Quarterly Journal of Economics*, *112*(4), 1251–1288. https://doi.org/10.1162/003355300555475

Lipscomb, M., & Mobarak, A. M. (2017). Decentralization and Pollution Spillovers: Evidence from the Re-drawing of County Borders in Brazil. *The Review of Economic Studies*, *84*(1), 464–502. https://doi.org/10.1093/restud/rdw023

Machado, A. I., Beretta, M., Fragoso, R., & Duarte, E. (2017). Overview of the state of the art of constructed wetlands for decentralized wastewater management in Brazil. *Journal of Environmental Management*, *187*, 560–570. https://doi.org/10.1016/j.jenvman.2016.11.015

Nyborg, K. (2018). Social Norms and the Environment. *Annual Review of Resource Economics*, *10*(1), 405–423. https://doi.org/10.1146/annurev-resource-100517-023232

Owen, A. L., & Videras, J. R. (2007). Culture and public goods: The case of religion and the voluntary provision of environmental quality. *Journal of Environmental Economics and Management*, *54*(2), 162–180. https://doi.org/10.1016/j.jeem.2007.04.001

Popp, D. (2006). International innovation and diffusion of air pollution control technologies: The effects of NOX and SO2 regulation in the US, Japan, and Germany. *Journal of Environmental Economics and Management*, *51*(1), 46–71. https://doi.org/10.1016/j.jeem.2005.04.006

Ryan, L., Sales, R., Tilki, M., & Siara, B. (2008). Social Networks, Social Support and Social Capital: The Experiences of Recent Polish Migrants in London. *Sociology*, *42*(4), 672–690. https://doi.org/10.1177/0038038508091622

Torgler, B., Frey, B. S., & Wilson, C. (2009). Environmental and Pro-Social Norms: Evidence on Littering. *The B.E. Journal of Economic Analysis & Policy*, *9*(1). https://doi.org/10.2202/1935-1682.1929

Wang, M., Webber, M., Finlayson, B., & Barnett, J. (2008). Rural industries and water pollution in China. *Journal of Environmental Management*, *86*(4), 648–659. https://doi.org/10.1016/j.jenvman.2006.12.019

Wang, Z., Lee, A., & Polonsky, M. (2018). Egregiousness and Boycott Intensity: Evidence from the BP *Deepwater Horizon* Oil Spill. *Management Science*, *64*(1), 149–163. https://doi.org/10.1287/mnsc.2016.2577