When the Cat is Away the Mice Will not Play: How Carbon Markets Stabilize Emissions Amid Political Uncertainty

Abstract

This study examines how the Carbon Emission Trading System (ETS) mitigates the emission instability caused by political shocks. We document a phenomenon in Chinese cities where carbon emissions increase during local leadership turnovers ("the cat is away"), contrasting with the emission reductions during central inspections ("the cat is around"). However, the introduction of an ETS effectively moderates these fluctuations. The stabilizing effect of the ETS operates through two mechanisms: it reinforces consistent government regulation and curbs firms' opportunistic behavior. Additionally, we find that a higher carbon price improves emission control while simultaneously cushioning the impact of political shocks.

Keywords: Carbon emissions control; Pilot ETS in China; Political uncertainty; Climate policy

JEL: D78; H70; Q50; R11

1. Introduction

Carbon emissions control is an ongoing cat-and-mouse game between regulators and polluters. While conventional instruments—ranging from emission standards, feebates to the carbon tax —aim to internalize the social costs of carbon, their efficacy is frequently compromised by inconsistent governance (Goulder and Schein, 2013; Adamou et al., 2014). Among these tools, the Emissions Trading System (ETS) is distinguished by its capacity to utilize market-based price signals to enhance regulatory efficiency. (Parry and Williams III, 2012). By aligning economic incentives with environmental goals, the ETS has become a key instrument in global climate policy.

However, the efficacy of climate governance is increasingly threatened by rising political uncertainty. Geopolitical conflicts, unexpected election outcomes, and wavering policy commitments—create significant discontinuities in climate initiatives, undermining the credibility of long-term reduction targets (Monastersky and Sousanis, 2015; Yu et al., 2021). This volatility raises a fundamental question for institutional design: Can climate policies be engineered to withstand the disruptions of political shocks? China, the world's largest carbon emitter since 2006 (Gregg et al., 2008), provides a unique laboratory for this inquiry. To meet its 2060 carbon neutrality goal, China has launched the world's largest ETS in terms of covered emissions[1] in 2021. Before that, pilot programs across multiple cities have created a staggered natural

[1] According to the International Carbon Action Partnership, China's national ETS is the world's largest in terms of covered emissions, estimated to cover around 8 billion tCO2 – or more than 60% of the country's CO2 emissions.

laboratory for assessing the performance of market-based instruments across diverse geographic, industrial, and political landscapes.

The vigorous expansion of these pilots, combined with identifiable political shocks, provides a unique empirical window to estimate the interaction between ETS and political uncertainty. In this paper, we explore the role of the Carbon ETS under political uncertainty. Using a daily panel of 270 Chinese cities from 2013 to 2019, we document a robust "cat and mouse game" driven by two symmetric shocks to regulatory intensity: unannounced central inspections and municipal leadership turnovers. We find that emissions (proxied by the Air Quality Index, or AQI) increase by 2.2% during local government leader turnovers. Regression Discontinuity in Time (RDIT) estimates further confirm the discontinuity in turnovers' effects on AQI. While existing literature has examined the positive impact of inspections on air quality——"the cat is around" (Zheng and Na, 2020), we provide the first analysis of a symmetric situation, "the cat is away".

The observed symmetric volatility maps directly to the broader challenges of global climate policy, where leadership transitions often jeopardize long-term environmental commitments. In this context, we identify the Carbon ETS as a critical institutional stabilizer. Specifically, our results show that the implementation of the ETS reduces the AQI spike during leadership turnovers by 5% and hedges the AQI drop during inspections by 5.5%. Cities integrated into the ETS consistently show lower susceptibility to political shocks post-implementation. These effects are robust to Propensity Score Matching (PSM), Synthetic Difference-in-Differences (SDID) and alternative subsample strategies. The findings hold even when excluding non-ETS cities, ensuring that our findings are not driven by sample selection.

We identify two primary channels through which the ETS exerts its stabilizing influence: the improvement of government regulatory consistency and the disciplining of firm-level opportunistic behavior. We find that environmental fines fall during political turnovers, suggesting a temporary decline in enforcement. Simultaneously, listed firms in polluting industries increase merger and acquisition (M&A) activity, consistent with opportunistic behavior in production and operations. After the ETS is introduced, both fines and M&A activity stabilize, implying that the ETS enhances enforcement consistency and curbs strategic gaming by firms. Thus, the presence of a carbon market mitigates the impact of regulatory policy uncertainty on emissions control efforts. These results remain robust under alternative event windows and estimation methods. Furthermore, our theoretical model, detailed in the online appendix, predicts that cities with the ETS are less responsive to political events than those without, as the ETS regulates firms' behavior and reduces incentives for gaming the system. The model also highlights the importance of a sufficiently high carbon price. We find that a higher carbon price amplifies the moderating effect on regulatory intensity and improves air quality. Since price reflects market operation efficiency, our analysis reinforces the conclusion that the ETS stabilizes emissions control efforts amid political uncertainty.

Our research unveils the systematic opportunistic emissions induced by political uncertainty, underscoring the imperative for a nuanced understanding of the interplay between political economy factors and climate policy (Fredriksson and Svensson, 2003). Also, our study offers one of the first resolutions for mitigating the political uncertainty effect on climate policy by carbon ETS. Furthermore, our study provides some of the first evidence of how the ETS addresses both government and market failures in carbon emission control (Stern, 2022; Stern et al., 2022). The findings suggest that, even when the cat is away, the mice will not play because the ETS is in place to discourage opportunistic behavior. This has significant implications for the development of the ETS, as well as other market-based instruments initiated by governments, particularly in China and other developing countries, where political factors can profoundly influence the effectiveness of environmental policies (Tang and Bao, 2024). Finally, our study emphasizes the essentiality of adequate carbon price which grants the efficiency of the carbon market (Rozenberg et al., 2020). By addressing these issues, our study comprehensively evaluates the importance of carbon ETS on both emission reduction and moderating effect on government failures. It contributes to the ongoing debate on the optimal design and implementation of the climate policy, ultimately informing the global effort to mitigate climate change.

2. Literature Review and Hypothesis

2.1. Political Uncertainty in Climate Change Mitigation

The political economy of climate change mitigation involves balancing global cooperation with national interests (Keohane and Victor, 2011; Goldthau and Sovacool, 2012). While agreements like the Paris Accord set global goals, domestic politics and economic pressures shape their implementation. Countries face trade-offs between environmental protection, economic growth, and social equity (Meckling, 2011). Geopolitical shocks—such as the Ukraine war—have changed carbon mitigation: for example, the conflict increased emissions globally but also pushed the EU toward energy independence inducing climate policy changes. Similarly, local political events affect local environmental outcomes. In China, unannounced central inspections reduce emissions (Zheng and Na, 2020), while tensions between decentralized and centralized imperatives cause regulatory cycles (Alkon and Wong, 2020). Therefore, as an urgent concern, political uncertainty induce instability in carbon emission and climate policies in nearly level of government, from a village to the COP26. With great determination in emission reduction, human beings will have to stabilize emission plan in a political turbulent age.

2.2.Efficacy of Carbon Emission Systems

While various instruments applied for emission reduction in last century, the flexibility, adaptability, and innovation-driven nature of the ETS, coupled with its potential to foster international cooperation, make it a powerful tool for achieving emission reduction goals in an efficient and equitable manner (Munnings et al., 2016), fostering innovation and investments in low-carbon technologies (Zhu et al., 2019; Chen and Lin, 2021; Ren et al., 2022).

Moreover, the ETS can be adapted over time to reflect changing policy goals, market conditions, or scientific knowledge, ensuring that the policy remains relevant and effective in addressing the evolving challenge of climate change (Ellerman et al., 2016). The ETS has the potential to facilitate international cooperation and policy harmonisation, helping to address the global nature of climate change. The EU ETS, for example, has inspired the development of carbon markets in other regions and provided a model for international policy coordination (Tuerk et al., 2009). By linking carbon markets across different jurisdictions, the ETS can help to achieve global emission reduction targets in a more cost-effective and equitable manner (Hintermann, 2016). Calel and Dechezleprêtre (2016) analyse the impact of the EU ETS on technological innovation, demonstrating that the policy stimulated patenting activity in low-carbon technologies. Marin et al. (2018) examine the role of the EU ETS in shaping corporate investment behavior, finding evidence of increased investments in energy efficiency and low-carbon technologies.

Several studies have compared different carbon markets and drawing lessons for future policy development (Tuerk et al., 2009; Xiong et al., 2017; Narassimhan et al., 2018). The Regional Greenhouse Gas Initiative (RGGI), a cap-and-trade program in the Northeastern United States, has been successful in reducing emissions (Murray and Maniloff, 2015). The California Cap-and-Trade Program has also played a significant role in reducing the state's greenhouse gas emissions (Woo et al., 2017; Cushing et al., 2018). Meanwhile, in China, the pilot schemes have provided a foundational "policy laboratory" for China's national carbon market (Cao et al., 2019; Gao et al., 2020).

2.3.Carbon Market: Market Failure and Government Failures

The perennial debate on the balance between government intervention and free markets lies at the heart of economic growth considerations. Scholars have long identified the intricacies of market failure, particularly in developing countries where the absence of non-market institutions exacerbates issues related to capital formation and investment decisions (Stiglitz, 1989; Datta-Chaudhuri, 1990). However, government interventions are prone to government failure, often misjudging technological possibilities or resulting in inefficient public enterprises and excessive controls over the private sector (Krueger, 1990).

Addressing climate change requires navigating this "institutional mismatch" (Furton and Martin, 2019) between these two modes of failure. On one hand, greenhouse gas emissions represent the "ultimate" market failure (Stern and Stiglitz, 2021). On the other hand, the implementation of climate policies is frequently disrupted by manifestations of government failure, ranging from political capture by special interests (O'neill and Nicholson-Cole, 2009) to the unreliability of administrative planning during political transitions.

By establishing a price for carbon, the ETS aims to rectify the market failure that allowed for free emissions for over two centuries (Andrew, 2008). However, early programs were plagued by suboptimal design, such as rigid constant emissions rules and inability to execute cost-effective trades (Atkinson and Tietenberg, 1991). Even the EU ETS faced internal market failures due to generous allocations that undermined carbon prices and information gaps that facilitated fraud (Newell et al., 2012). Despite these hurdles, the standard rationale remains that market forces, when properly channelled, are more efficient than administrative command-and-control measures in driving investment/profit cycles toward a low-carbon trajectory (Paterson, 2012).

2.4.Gaps in the literature & Development of Hypotheses

Existing research has extensively validated the efficacy of Carbon ETS in internalizing externalities under stable institutional conditions (Ellerman et al., 2016) and emphasized the threaten of political shocks on climate policy (Keohane and Victor, 2011). However, as discussed in Section 2.3, the performance of ETS under "institutional mismatch" remains largely unexplored. While we understand that carbon emissions represent the "ultimate market failure", we have yet to fully comprehend how market-based instruments perform when the very institution tasked with their oversight—the local government—undergoes a "failure" of its own due to political shocks. This paper fills this urgent gap by examining the role of carbon market in the face of those shocks.

The long-standing tradition in political economics suggests that political cycles induce systematic fluctuations in economic outcomes (Nordhaus, 1975). In the Chinese context, the "promotion tournament" framework (Li and Zhou, 2005) provides a specific mechanism for this volatility. As local officials prioritize short-term economic performance or social stability during leadership transitions, a "regulatory vacuum" often emerges. This vacuum constitutes a significant form of government failure. When the administrative "Command-and-Control" (C&C) oversight is temporarily weakened due to the reshuffling of leadership priorities, firms encounter a window of low-cost non-compliance. Therefore, we propose our first hypothesis:

Hypothesis 1: Local leadership turnovers induce a significant increase in industrial emissions due to a temporary "government failure" in administrative environmental oversight. And travelling inspections induce a significant decrease in industrial emissions.

If leadership turnover represents a government failure that exacerbates market failure (emissions), the crucial policy question is whether market-based instruments can "immunize" environmental goals against these political shocks. As argued in Section 2.3, the ETS was conceived to rectify the negative externalities of pollution through a price-based approach. We argue that this market logic provides institutional resilience against the political instability described in Hypothesis 1 through two channels:

Reducing firms' opportunistic behaviors: Unlike administrative monitoring, which fluctuates with an official's "attention span" or career path (Stavins, 2003), the market price for carbon is a persistent and algorithmic signal. Even if a local leader is in transition, the financial liability of holding permits for every ton of CO2 emitted remains a hard budget constraint for the firm. Therefore, firms in the ETS market need not to opt for opportunistic emissions.

Reinforcing Regulatory Consistency: Market instruments reduce the "political cost" of enforcement by delegating it to a market-clearing mechanism rather than discretionary bureaucratic inspections. As Gulen and Ion (2016) suggest, market-based frameworks can mitigate policy-induced uncertainty by providing a predictable hedge for firm behavior.

By synthesizing the theoretical interplay between market-based discipline and the risks of government failure, we propose:

Hypothesis 2: The introduction of the ETS serves as a moderating mechanism that mitigates the impact of political uncertainty, making industrial emissions less responsive to leadership turnovers and inspections.

By identifying this "stabilizing effect" of carbon markets, this paper moves beyond documenting pollution turbulence. Our contribution is to show that beyond mere static efficiency, the ETS provides a governance benefit by smoothing the shocks of political transitions—effectively serving as a corrective mechanism for both market failure and the "institutional mismatch" inherent in political governance.

3. Method and Data

3.1.Empirical Model and Estimation Techniques

Our main model based on panel data and city level fix effects.

$$LnAQI_{it} = \alpha_i + \gamma_t + \beta_1 Turnover_{it} + \beta_2 Inspection_{it} + \theta Holiday_t + \delta W_{it} + \varepsilon_{it} \quad (1)$$

The benchmark model examines the relationship between air quality and political uncertainty and central travelling inspection. The dependent variable, $LnAQI_{it}$, is the natural logarithm of the AQI in the city i on day t. We also consider other air pollutant measures, including PM2.5, PM10, SO2, NO2, CO, and O3, in the logarithmic form. The model includes city and monthly fixed effects, denoted by α_i and γ_t, respectively, to control for unobserved, time-invariant city-specific characteristics and time effects within a month. $Turnover_{it}$ is 1 for days in a week before the turnover of senior officials in the city i. β_1 is the coefficient describing the effect of political uncertainty on local air quality. $Inspection_{it}$ is 1 if the central travelling inspection is inspecting the province of the city i. β_2 describe the inspection effect on air quality. $Holiday_t$ is 1 for official holidays. And W_{it} includes weather controls, namely the level of sunshine, wind speed, precipitation, humidity and temperature for the city I on day t. ε_{it} is the error term.

3.2.Data Sources and Sample

A central challenge in evaluating the daily impacts of the Carbon ETS is the discrepancy between the carbon emission and the availability of high-frequency data. While the ETS explicitly regulates carbon dioxide, city-level CO2 emissions in China are currently unavailable at a daily resolution, as Continuous Emission Monitoring Systems (CEMS) for carbon are not yet universally accessible for academic research. To address this, we employ the Air Quality Index (AQI) as a high-frequency proxy for industrial carbon-intensive activities.

This measurement strategy is substantiated by three considerations. Firstly, our approach follows the recent environmental economics literature that utilizes air quality indicators to evaluate carbon-related policies when direct carbon data is absent or lacks sufficient granularity (Tang et al., 2022). Scholars have increasingly leveraged the "synergistic effect" or "co-pollutant" relationship between CO2 and criteria air pollutants to identify the footprints of industrial production. These studies demonstrate that because greenhouse gases and local air pollutants—such as SO2 and NOx—originate predominantly from the same source (fossil fuel combustion in the power and manufacturing sectors), air quality serves as a reliable, high-frequency mirror of underlying carbon-intensive operations. Also, the high-frequency nature of our study requires a metric that captures immediate behavioral responses to political shocks. AQI provides a daily, real-time reflection of local industrial output and regulatory enforcement intensity. Additionally, we explicitly address the potential divergence between air quality trends and carbon emissions through a pollutant-decomposition analysis provided in the Online Appendix (Table A1-4). We theoretically contend that if the carbon emissions are truly influenced by the carbon-stabilizing channel of the ETS, the effect should be concentrated in pollutants directly tied to fossil fuel combustion (Zheng and Kahn, 2013). Our empirical results validate this: when AQI is decomposed, primary pollutants most closely associated with carbon emission activity yield regression coefficients and significance levels that are highly consistent with our baseline AQI findings. Conversely, secondary pollutants with more complex, non-combustion-related formation processes exhibit markedly different and often insignificant results. This "placebo-style" decomposition confirms that our reliance on AQI is theoretically sound and empirically focused on the carbon-mitigation mechanisms targeted by the ETS.

Air Quality is measured by a wide range of indicators in the literature, such as air quality index, PM2.5, CO2, etc (Davis, 2008; Chen and Whalley, 2012; Zhong et al., 2017; Zhang et al., 2019). In 2012, China updated its air quality index (AQI) to include six pollutants, namely SO2, NO2, PM10, PM2.5, O3, and CO, in order to better evaluate the air pollution level according to Technical Regulation on Ambient Air Quality Index. This new AQI is a more comprehensive indicator than the previous air pollution index (API) as it incorporates three additional pollutants (PM2.5, O3, and CO) and reflects a higher value when the air pollution is more severe (Greenstone et al., 2022). Consequently, recent studies have adopted AQI as the core indicator of air pollution levels (Tan et al., 2021). Therefore, we focus on daily AQI in our research and also cover alternative measures in the robustness check.

Besides, weather conditions play a crucial role in determining the level of air pollution and emission. For example, precipitation and wind can reduce the concentration of pollutants such as PM10 (Rost et al., 2009), while humidity, temperature, and sunshine are related to other pollutants such as ozone (Lu et al., 2019). Therefore, we included the main weather condition variables as controls in our analysis, such as time of sunshine, average wind speed, 24-hour precipitation, average humidity, and average temperature.

[Insert Figure 1 about here]

The sample periods started from October 28th 2013, to December 31st 2019, covering 270 cities from 31 provinces in China. The variables are the AQI (higher index implies lower air quality), pollutants' density (μg/m3), time of sunshine (0.1 hours), precipitation in 24 hours (0.1 mm), average wind speed (0.1m/s), average humidity (1%), average temperature (0.1°C), turnover of municipal leaders (1 for days in the week before the announcement of turnover), holiday dummy, inspection (1 during inspection). Air quality data is collected from the aqistudy.cn based on the data by China National Environment Monitoring Center. Weather data is based on the China Meteorological Daily Dataset (v3.0) provided by National Meteorological Information Center. Turnover, inspection and holiday data are collected from official websites manually. The final dataset was constructed by merging the air quality, meteorological, and political shock variables by city and date. We excluded observations with missing weather or AQI information to ensure the internal validity of our estimates. For pollutant-specific decomposition analyses (e.g., PM2.5, SO2), we utilized samples where specific pollutant data were available. The consolidated primary dataset comprises 511,772 city-day observations, providing sufficient power for the high-dimensional fixed-effects models employed in our empirical analysis.

3.3.Unannounced Inspections

Travelling inspection represents a highly efficient and well-known approach for the Ministry of Ecology and Environment (MEE) to fulfil its mission in daily work. In fact, since 2012, the inspection teams have played a vital role in the anti-corruption campaign under the leadership of Chairman Xi. Typically, these inspection teams are led by powerful government officials who previously held provincial leadership roles, and they conduct unannounced visits to provinces or state-owned enterprises (SOEs) to assess compliance with regulations and rules. As addressing climate change is a top priority for MEE, carbon emissions have always been a critical area of inspection.

Local government takes the visits by inspection teams exceptionally seriously due to the political status of the team leader and the severe consequences that could result from any wrongdoing detected. According to the MEE website, the travelling inspection teams report their arrival in the provincial capital on the website and typically spend one month in the province. Table 1 shows the schedule of MEE inspections from 2016 to 2019, covering all 31 regions in our sample. Specifically, the dummy variable takes a value of 1 when the inspection team is currently inspecting the province or city, which is consistent with existing literature (Zheng and Na, 2020).

[Insert Table 1 about here]

3.4.Turnovers of Senior Local Government Officials

We focus our attention on high-ranking officials in a given city, specifically the mayor and head secretary. We manually collected information on their turnover from official websites, such as ce.cn and local government websites. While some turnovers may be unpredictable prior to their announcement, most turnovers have information leakage beforehand. Consequently, political uncertainty in the short period ([-7,0] in the baseline model) before the announcement of turnover is extremely high for firms and other agents in the city. The choice of the [-7, 0] window specifically targets the period of peak political uncertainty and the 'regulatory vacuum' that emerges during leadership transitions. Unlike other policy domains (e.g., education or fiscal management) where performance outcomes are opaque, air quality is a highly visible performance indicator. The announcement (Day 0) typically signals the imminent arrival of new leadership. This shift creates an immediate 'political image risk' for firms; while administrative enforcement may still be in transition, firms are incentivized to curtail visible emissions instantaneously to avoid creating a negative 'first impression' for the incoming leader.

To maximize the turnover effect during this short period, we exclude turnovers that occurred 14 days before the next turnover shock. These methods also help us to keep the consistency of data in event study research and the RDiT model in Online Appendix. Our sample consists of 1282 turnovers for 270 cities during the sampling period, while one city had no turnovers during the sampling period. Table 2 shows the distribution of turnovers among different regions. Most regions had over 40 turnovers during the period, while minority autonomous regions like Tibet, Guangxi, and Xinjiang had fewer turnovers. To capture the effect of officials' turnover, we constructed dummies that take a value of 1 for days within one week before the turnover and 0 for other dates. We also applied alternative windows as a robustness check in Online Appendix.

[Insert Table 2 about here]

3.5.Other Control Variables

To account for the holiday effect which caused the possible traffic condition change (Fu and Gu, 2017) in daily-level analysis, we introduce a holiday dummy variable that takes a value of 1 on official holidays, such as New Year, Spring Festival, Tomb-Sweeping Day, Labor Day, Dragon Boat Festival, Mid-Autumn Festival, and National Day. By incorporating this variable, we aim to account for any variations in traffic patterns that may be attributed to the occurrence of holidays.

While broader factors such as industrial restructuring or energy supply dynamics may influence local air quality, these are largely absorbed by our high-dimensional fixed-effects framework. Specifically, our baseline specification includes City Fixed Effects to control for time-invariant local institutional quality and geographic characteristics, alongside Month Fixed Effects to account for national-level seasonal trends and macro-environmental policy shifts. Furthermore, to address the possibility of city-specific annual trajectories—such as localized industrial upgrades or shifts in energy consumption—we provide a robustness check in the Appendix utilizing City *

Year Fixed Effects. This saturated specification ensures that our identification is driven solely by the high-frequency daily variation relative to the political event.

[Insert Table 3 about here]

4. Empirical Findings and Discussions

4.1. Political Uncertainty Effect of Turnovers and Inspections

Table 4 presents the empirical findings of our first hypothesis, using the Staggered Difference-in-Differences (DID) model and panel data. We examine seven different measures of air pollution in this table, controlling for city fixed effects, monthly fixed effects, holiday effects, and weather conditions. The first column of Table 4 presents our main result, revealing that both turnovers and inspections significantly affect local air quality, albeit in opposite directions. Specifically, during the turnover window, the air quality deteriorates by 2.2% with a 1% level of significance. In contrast, during the inspection period, air quality improves by 5%, which aligns with our hypothesis and prior research. Importantly, turnover effects remain significant in Columns 2, 3, and 5, while inspection effects remain significant across all seven columns. Furthermore, turnover has a higher impact on PM10 and PM2.5, exceeding 2.5%. In contrast, inspection has the highest impact on SO2, with a 9.9% decrease. In Online Appendix Table A1-4 shows that pollutants which are highly related to carbon emission and fossil fuels including PM10, PM2.5, SO2 and NO2, all have significant turnover effect while other pollutants are not. Therefore, the decomposition of performance by pollutants supports that using AQI as proxy for carbon emission is feasible in this research.

[Insert Table 4 about here]

4.2.The Stabilizing Effect of ETS

Chinese cities vary dramatically in many aspects. Therefore, to further explore the turnover effect and inspection effect based on the heterogeneity among cities, we first decompose the city sample according to our Hypothesis 2. By deriving the effect in different groups, we show how cities react to turnover and inspections differently. Considering the settings of ETS, turnovers and inspections, we apply the following staggered Difference-in-Difference-in-Difference (DDD) mode to test the moderating effect. This allows us to compare the turnover-induced AQI fluctuations in pilot cities vs. non-pilot cities, before and after the staggered implementation of the ETS.

$$\begin{aligned} LnAQI_{it} = {} & \alpha_i + \gamma_t + \beta_1 Turnover_{it} \\ & + \gamma_1 ETS_{it} \times ETS\ Open_{it} \times Turnover_{it} \\ & + \gamma_2 ETS_{it} \times Turnover_{it} + \gamma_3 ETS_{it} \times ETS\ Open_{it} \\ & + \beta_2 Inspection_{it} \\ & + \gamma_4 ETS_{it} \times ETS\ Open_{it} \times Inspection_{it} \times + \theta Holiday_t \\ & + \delta W_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

Besides the similar setting as equation 1， equation 2 includes all interaction terms between ETS_{it} (treatment), $ETS\ Open_{it}$ (post) and political dummies (shock). $\gamma_1$represents the moderating effect of ETS after opening on turnover effect. γ_2 shows the difference in turnover effect by the ETS group comparing with other cities. γ_3 shows emission reduction effect by ETS after opening. Similarly, $\gamma_4$represents the moderating effect of ETS after opening on inspection effect. Since the ETS opening is a staggered shock, $ETS\ Open_{it}$, ETS , $ETS\ Open_{it} \times Inspection_{it}$ and $ETS\ Open_{it} \times$

$Turnover_{it}$ omitted because of collinearity. Also, since all inspection starts after the opening of local ETS, $ETS_{it}\ \times Inspection$is also omitted.

[Insert Table 5 about here]

Table 5 shows the difference and mechanism of the effect. Column 1 uses the subsample of regions covered by the provincial carbon ETS. There are seven regional carbon ETS supported by the Development and Reform Commission since 2013: Beijing, Shanghai, Shenzhen, Guangdong, Hubei, Chongqing and Tianjin. Moreover, on December 22, 2016, Fujian opened a new provincial carbon ETS, the only trading carbon allowance besides the above 7 ETS. These eight carbon ETS mainly focused on firms in the province and were the core of carbon emission transactions before 2021, when the national carbon ETS opened. With the systematic regulation and management of carbon emissions, firms and governments in those provinces and cities were operating the game of cat and mouse differently compared to regions without the carbon ETS. Therefore, we found that the turnover and inspection effect patterns are much different in column 1. The coefficient of Turnover is insignificant, while the coefficient of Inspection is significantly positive. This result is entirely different from the pattern in column 2, using the subsample of regions without the carbon ETS. Such a divergence is likely the result of the carbon ETS, which changes the behavior of firms.

Moreover, we use an DDD term to derive the influence of the carbon ETS on the turnover and inspection effect. In column 3, we use an interaction term of carbon ETS* ETS Open and its interaction terms with turnover and inspection dummies. Carbon ETS (covered)* ETS Open is 1 for cities covered by a provincial carbon ETS. Since all eight carbon ETS opened on different dates, we chose the market opening date as the start of the dummy for the carbon ETS. Air quality deteriorates by 2.7% during the turnover window and improves by 5.9% during inspections. The magnitude of the effect is larger than that in Table 2. And the coefficient of the interaction term of $ETS_{it} \times ETS\ Open_{it} \times Turnover_{it}$ is significantly negative, and that for $ETS_{it} \times ETS\ Open_{it} + \beta_2 Inspection_{it}$ is significantly positive. Opening a carbon ETS seems to form self-regulation that limits the emission during the turnover period by 3.8% (22.9%-18.1%) and induces the emission during inspections by 5.51%. Therefore, the ETS effect hedges abnormal air quality turbulence during turnovers and inspections.

Establishing carbon emissions trading schemes (ETS) in provincial capitals is more likely to impact cities that are already their respective provinces' economic and political centres. To test the effect of carbon ETS, we analyze subsamples consisting only of cities with established carbon ETS in column 4. The results indicate that turnover and inspection effects are insignificant, contrasting those obtained from other cities in column 5. To further assess the influence of the carbon ETS, we utilize a set of interaction terms similar to column 3 in column 6. Here, the coefficient of Carbon ETS (location) remains insignificant, but the coefficient of Carbon ETS (Location)*ETS Open*Turnover is higher than the effect observed in column 3. This implies that the self-regulation of firms in capital cities is more significant than firms in other cities. Conversely, the coefficient of Carbon ETS (Location)*Inspection is insignificant. In Online Appendix A1-10, we further prove that the stabilizing effect works for both capitals and other cities.

While environmental inspections are largely perceived as exogenous, unannounced shocks, a potential concern arises regarding the endogeneity of municipal turnovers. Specifically, leadership changes may be systematically correlated with local economic performance, regional reputation, or other unobserved institutional shifts. To address these concerns and validate the causal interpretation of our results, we implement two primary robustness checks. First, as shown in Column 1 of Appendix Table A1-3, we incorporate City*Year Fixed Effects. This strategy, following the methodology of (Gormley and Matsa, 2014) , effectively absorbs all time-varying local unobservables at the annual level, including annual GDP fluctuations, institutional reforms, and localized economic shocks. Because administrative performance is generally evaluated on an annual or quarterly basis, saturating the model with city-year intercepts ensures that our identification is driven by comparing days within the same city and the same year when a turnover occurred versus when it did not. The discrete, daily-level jump in AQI observed at the moment of the announcement is highly unlikely to be driven by year-long economic trends, thereby isolating the strategic behavioral response to the political shock.

While the combination of City * Year Fixed Effects and RDiT provides a robust framework for identifying daily-level shifts in AQI, we acknowledge a potential limitation regarding the quasi-randomness of turnover timing within a year. Our results identify the average treatment effect of major leadership changes—specifically mayors and head secretaries—across a broad panel of 270 cities. However, political transitions are not monolithic; turnovers triggered by sudden administrative investigations or environmental performance failures might carry different implications than routine, scheduled promotions. Although our sub-sample analyses by economic cycle and city rank confirm the persistence of the turnover effect, we cannot entirely rule out the possibility that the specific timing of certain turnovers is correlated with unobserved local administrative shifts. We encourage future studies to utilize more granular biographical data on officials to further decompose the heterogeneity of these political shocks. Nevertheless, the consistent performance of the Carbon ETS as a moderating mechanism across various specifications suggests that its stabilizing function is a general institutional dividend.

Besides, we conduct a heterogeneity analysis to test whether the identified "turnover effect" is merely a proxy for broader economic slowdowns. We partition the sample into "Growth" and "Depression" periods based on annual GDP fluctuations, defining growth as years with increasing GDP and depression as years with declining GDP. If our estimates were simply reflecting a macroeconomic contraction, we would expect a significant divergence in the coefficients between these two regimes. However, the results in Appendix Table A1-2 Columns 2 and 3 demonstrate that the turnover coefficients remain statistically significant and remarkably consistent across both economic states. The stability of these estimates indicates that the behavioral response to political uncertainty—rather than a broader economic contraction—is the primary driver of emission volatility.

Regarding the net turnover effect in ETS-covered cities after the market opening, the point estimates in the triple-difference (DDD) model (Table 5, Column 3) yield a slightly negative value (-0.021). However, this should be interpreted as a statistical neutralization rather than a genuine reversal of the causal effect. As shown in our sub-sample analysis in Table 6 (Column 4), the coefficient for Turnover in ETS regions post-opening is -0.010 with a t-statistic of -0.63, indicating that the impact of political shocks becomes statistically indistinguishable from zero. Furthermore, the relatively large magnitude of the moderating coefficient (-0.229) is empirically consistent with the pre-existing heterogeneity of the pilot cities. Our results in Table 6 (Column 3) reveal that pilot regions exhibited a significantly higher baseline sensitivity to political shocks before the ETS inauguration, with an AQI spike of 10.9%—substantially higher than the national average. Therefore, a larger moderating effect is necessary to offset this initial volatility. This transition from a high positive impact to a statistical zero, as illustrated in Figure 2, provides robust support for our hypothesis that the ETS serves as an institutional stabilizer that 'immunizes' environmental outcomes against political disruptions.

4.3. Stabilizing Effect and City Selection

While Tables 4 and 5 investigate the impact of the carbon ETS on turnover and inspection effects, differences between cities with and without the carbon ETS may stem from endogeneity. Specifically, pilot cities for Chinese reforms may not have been randomly selected. A key concern is that cities with an ETS might perform better simply because they inherently experience lower political uncertainty, even before the ETS was established.

To address potential selection bias, we employ three strategies: (1) limiting the subsample to cities covered by the carbon ETS, (2) using propensity score matching (PSM) to match these cities with comparable ones and (3) using a SDID method. Although pilot regions may face selection bias, focusing on them helps mitigate this concern. Since all regions eventually established an ETS but at different times, the staggered openings allow regions without an ETS to serve as a control group.

[Insert Table 6 about here]

[Insert Figure 2 about here]

Therefore, in Table 6, Columns 1 to 4, we first compare the turnover effect between different groups. Since there is no inspection before the opening of the last ETS, we drop the inspection variable and its interaction term in Columns 1 to 5 for clearer expression. In Columns 1 and 2, we divide the sample of regions never covered by ETS by December 2016, when the last ETS in the sample finally opened. For these columns, we find that the turnover effect increased slightly over time. However, in Columns 3 and 4, we find that the turnover effect for regions with ETS dropped significantly after the opening of ETS.

In Column 5, the DDD term is significant, suggesting that even without concerns about city selection, the moderating effect still applies in these cities.

We also apply PSM to draw the concern of city selection in Column 6 and 7. In the first stage of PSM matching, we estimate a logit model with an ETS-covered dummy variable as the dependent variable and determinants such as average local pollution levels, demographic, economic, and environmental protection indicators from the five years preceding the pilot scheme announcement in 2011 as independent variables. We then use this regression to calculate the predicted probabilities of being an ETS-covered city for each observation. Employing a nearest-neighbourhood matching strategy within calliper radius of 0.1 in column 1 and 0.05 in column 2 without replacement, we identify comparable cities for each ETS-covered city based on their propensity scores.

Results in columns 6 and 7 demonstrate that employing PSM-DID strengthens the moderating effect of carbon ETS compared to Table 5. The moderation effect on Turnover increases from approximately 5% to 6%, and the moderation effect on Inspection increases from 5% to 7%.

While the PSM-DID framework accounts for selection on observables, it may not fully eliminate concerns regarding the non-random assignment of the ETS pilot status, especially if the pre-treatment Carbon ETS * Turnover interaction remains statistically significant. One potential critique is that the observed mitigating effect is merely a byproduct of superior governmental capacity in pilot regions. However, the significantly positive coefficient on the interaction term in the pre-reform period directly contradicts this "capacity hypothesis." If pilot cities were inherently better governed or more resilient to political shocks, they should not have exhibited a more pronounced government failure (i.e., a larger emission spike) during turnovers prior to the policy's introduction. Furthermore, the mitigation of the turnover effect was not a primary design objective of the pilot scheme; rather, it appears as an institutional "dividend" of the market-based reform.

In reality, pilot schemes in China have long been subject to city-selection problems, with the central government often prioritizing regions with higher administrative readiness (Wang and Yang, 2025). To systematically address the divergent turnover-induced trends between the treatment and control groups, we employ the Synthetic Difference-in-Differences (SDID) estimator. This method re-equilibrates the control group by assigning unit and time weights, thereby constructing a more accurate counterfactual that mirrors the treatment group's performance prior to the ETS inauguration. The results of the SDID estimation, presented in Column 8, indicate that after the synthetic procedure, the pre-treatment Carbon ETS * Turnover interaction becomes statistically insignificant. This confirms that the reweighted control group effectively eliminates the baseline difference in turnover susceptibility between the two groups. Crucially, the coefficients for the turnover effect, inspection effect, and the mitigating effect remain statistically significant and economically substantial under this more rigorous specification. Finally, our event study plot (Online Appendix A1.2) provides visual confirmation of the dynamic treatment effect, demonstrating that the parallel trends assumption holds prior to the ETS opening, with the stabilizing effect emerging only after the policy implementation.

While air quality in cities with the carbon ETS does not change significantly during inspections, other regions experience worse air quality. One possible explanation is that when inspection teams arrive in provincial capitals, other cities are informed about the inspection but not its schedule. The traveling inspection team does not inspect every city daily but moves around the province. As a result, cities outside the capitals have time to prepare. To perform well during inspections, firms in these cities may accelerate short-term emissions before the team arrives or over-emit afterward to compensate for their "good performance" during inspections. Such behavior is highly risky for cities without an ETS, as they face penalties if caught. However, cities covered by the carbon ETS can purchase additional allowances if caught, with the only cost being future allowance purchases. This risky behavior leads to increased emissions in non-inspected cities, consistent with the insignificant coefficient in Column 4.

Further empirical evidence is presented in Table A1-3 of the Online Appendix. In Column 5, regions covered by the ETS exhibit a statistically significant positive effect during the first week of inspections. A granular decomposition of this effect reveals a distinct spatial heterogeneity: in Column 6, the coefficient for provincial capitals is statistically insignificant, a result consistent with the logistical protocols of traveling inspection teams, which typically begin their administrative initialization at the provincial capital. Conversely, Column 7 demonstrates that non-capital cities experience a significant surge in emissions during this initial week. This contrast provides robust evidence for anticipatory over-emission behavior; while inspection teams are occupied with administrative briefings in the capital, firms in outlying jurisdictions utilize this "regulatory window" to accelerate carbon-intensive production before the team descends to their specific locales.

4.4.Channels for The Stabilizing Effect of ETS

The stabilizing effect reflects a shift in equilibrium following the establishment of an emissions trading system (ETS), driven by changes in firm and government behaviors that existed prior to the ETS. Controlling for weather conditions, changes in air quality or carbon emissions largely depend on two factors: the regulatory intensity of governments and the strength of opportunistic emissions by firms.

Government regulatory intensity varies over time, influenced by political factors such as economic growth goals or fiscal planning, often aligned with the political business cycle. As shown in the baseline analysis, the turnover and inspection effects suggest two distinct states of emissions or regulatory intensity. Following the existing literature in environmental economics and political economy, we utilize the frequency of environmental administrative fines as a proxy for regulatory enforcement stringency (Blundell et al., 2020; Salimgarieva and Blundell, 2025). Environmental fines have long been recognized as the "visible hand" of the state, representing the actualized output of monitoring and oversight efforts.

While fine counts could be influenced by administrative delays or reporting lags, such idiosyncratic noise is effectively mitigated in our high-dimensional fixed-effects framework. Specifically, the inclusion of City Fixed Effects controls for time-invariant local institutional quality and reporting infrastructure, while Monthly Fixed Effects absorb any national-level shifts in environmental regulations, institutional reforms, or administrative reporting cycles. Furthermore, any systematic delay in reporting would likely be uniform across the panel, which is captured by our time fixed effects, leaving the city-specific, event-driven variation as the primary identifier of enforcement intensity.

[Insert Table 7 about here]

[Insert Figure 3 about here]

Table 7 presents the results. Columns 1 to 4 examine how regulatory intensity evolves and contributes to the ETS's moderating effect. To maintain consistency in comparison, we exclude inspection indicators since inspections were absent in regions prior to the establishment of their ETS. Column 1 indicates that before the ETS's implementation, pilot regions had fewer fines during periods of local government turnover. In contrast, Column 2 shows an insignificant coefficient for fine counts. Column 3 reveals that the introduction of the ETS leads to an increase in fines during turnovers, suggesting that turnover effects previously weakened regulatory intensity due to heightened political uncertainty. However, after the ETS's establishment, automated monitoring systems reduced regulatory costs and enhanced regulatory intensity. In Column 4 when all regions are included, the mitigating impact of inspections is also clear. This suggests that while traveling inspections enhance regulatory intensity consistency, the ETS reduces fines by integrating market operations.

On the firm side, political uncertainty encourages opportunistic behaviors. Chinese firms tend to opportunistically operate M&A during periods with high political uncertainty. High-polluting industries typically face stringent regulation, but during times of uncertainty, firms exploit the situation to adjust their operations. To capture this, we analyze the number of mergers and acquisitions (M&A) by local listed firms in high-pollution industries. Regarding firm-level responses, we employ the volume of Mergers and Acquisitions (M&A) by industrial firms to capture opportunistic behavior and operational expansion under political uncertainty. In the corporate finance literature, M&A is regarded as one of the most significant strategic decisions a firm makes, sensitive to both regulatory costs and policy stability (Bonaime et al., 2018). During periods of political turnover, when administrative oversight is temporarily weakened—a phenomenon we define as "regulatory vacuum"—firms may engage in "regulatory gaming" by accelerating M&A to consolidate carbon-intensive assets or expand production capacity while the "shadow of the state" is less imposing.

Our model with Monthly Fixed Effects is specifically designed to purge the influence of macroeconomic cycles, capital market liquidity, and industrial trends. National-level capital market conditions, energy price shocks, and industry-wide technological shifts are common to all cities and are thus absorbed by the time-specific intercepts. Consequently, the observed spike in M&A during local turnovers is a city-specific phenomenon, reflecting a strategic "window of opportunity" exploited by local firms. The robustness of this mechanism is further supported by the fact that such opportunistic expansions are significantly dampened in ETS-covered regions. This suggests that the ETS, by establishing a market-based, non-discretionary compliance cost, raises the "future regulatory risk" associated with these acquisitions, thereby disciplining firm behavior even when local political oversight is in flux. The systematic nature of these findings across over 200 cities suggests that our results capture a meaningful institutional shift in the government-firm nexus rather than accidental market fluctuations.

Columns 5 to 8 in Table 7 present these results. Before the ETS's implementation, firms exhibited increased M&A activity during local government turnovers, as shown in Column 5. Columns 5 and 6 demonstrate that the ETS significantly mitigates this opportunistic effect. These findings suggest that while political uncertainty amplifies firms' opportunistic behaviors, the ETS reduces such behaviors by enforcing consistent monitoring and reporting systems. The concentration of M&A activity during turnovers implies opportunistic operations and production practices by firms, which are curtailed by the ETS and its automated monitoring mechanisms.

In summary, the ETS moderates the impact of political uncertainty through two key channels. First, it stabilizes regulatory intensity, reducing the time-varying patterns of local government regulators. Second, it curtails firms' opportunistic behaviors by providing a consistent monitoring and reporting framework. These effects collectively contribute to a more predictable and stable regulatory environment, enhancing the effectiveness of environmental governance.

5. Conclusions and Policy Implications

The findings of this paper provide empirical support for the effectiveness of the Emission Trading System (ETS) in addressing both market and government failures in carbon emission control. Our quantitative synthesis reveals that in the absence of market-based constraints, local leadership turnovers induce a statistically significant deterioration in air quality by approximately 2.2 %, while central inspections trigger a temporary but substantial improvement of approximately 5%. The central contribution of this study is the discovery of the "stabilizing dividend" of the Carbon ETS. We find that the introduction of an ETS serves as a robust institutional hedge, effectively neutralizing the volatility induced by political shocks. This suggests that the ETS helps mitigate the impact of political uncertainty on emission control efforts. Furthermore, the ETS moderates the "regulatory gaming" behavior of firms during inspections—particularly the anticipatory over-emissions observed in non-capital cities—by establishing a persistent, non-discretionary carbon price that serves as a "cost floor" regardless of the local administrative attention span. Its flexibility, adaptability, and innovation-driven nature, along with its potential to foster international cooperation, make it a powerful tool for achieving emission reduction goals in an efficient and equitable manner.

While traditional administrative command-and-control tools remain inherently vulnerable to the "regulatory vacuum" and the shifting priorities of political cycles, the Carbon ETS provides a resilient institutional platform that aggregates multi-party consensus and aligns the long-term interests of firms and regulators through a persistent carbon price. By shifting the burden of enforcement from high-frequency human-led management to a self-reinforcing and transparent market mechanism, policy-makers can secure a "stabilizing dividend" that ensures climate goals remain "immunized" against political shocks. This approach effectively addresses both the ultimate market failure of greenhouse gas externalities and the government failure inherent in political uncertainty, transforming climate regulation into a sustainable, long-term, and predictable institutional arrangement.

References

1. Adamou, A., Clerides, S., Zachariadis, T., 2014. Welfare implications of car feebates: A simulation analysis. The Economic Journal 124, F420-F443.
2. Alkon, M., Wong, A., 2020. Authoritarian energy transitions undermined? Environmental governance cycles in China's power sector. Energy Research & Social Science 68, 101531.
3. Andrew, B., 2008. Market failure, government failure and externalities in climate change mitigation: The case for a carbon tax. Public Administration and Development: The International Journal of Management Research and Practice 28, 393-401.
4. Atkinson, S., Tietenberg, T., 1991. Market failure in incentive-based regulation: the case of emissions trading. Journal of Environmental Economics and management 21, 17-31.
5. Blundell, W., Gowrisankaran, G., Langer, A., 2020. Escalation of scrutiny: The gains from dynamic enforcement of environmental regulations. American Economic Review 110, 2558-2585.
6. Bonaime, A., Gulen, H., Ion, M., 2018. Does policy uncertainty affect mergers and acquisitions? Journal of financial economics 129, 531-558.
7. Calel, R., Dechezleprêtre, A., 2016. Environmental policy and directed technological change: evidence from the European carbon market. Review of economics and statistics 98, 173-191.
8. Cao, J., Ho, M.S., Jorgenson, D.W., Nielsen, C.P., 2019. China's emissions trading system and an ETS-carbon tax hybrid. Energy Economics 81, 741-753.
9. Chen, X., Lin, B., 2021. Towards carbon neutrality by implementing carbon emissions trading scheme: Policy evaluation in China. Energy Policy 157, 112510.
10. Chen, Y., Whalley, A., 2012. Green infrastructure: The effects of urban rail transit on air quality. American Economic Journal: Economic Policy 4, 58-97.
11. Cushing, L., Blaustein-Rejto, D., Wander, M., Pastor, M., Sadd, J., Zhu, A., Morello-Frosch, R., 2018. Carbon trading, co-pollutants, and environmental equity: Evidence from California's cap-and-trade program (2011–2015). PLoS medicine 15, e1002604.
12. Datta-Chaudhuri, M., 1990. Market failure and government failure. Journal of Economic Perspectives 4, 25-39.
13. Davis, L.W., 2008. The effect of driving restrictions on air quality in Mexico City. Journal of Political Economy 116, 38-81.
14. Ellerman, A.D., Marcantonini, C., Zaklan, A., 2016. The European Union emissions trading system: ten years and counting. Review of Environmental Economics and Policy.
15. Fredriksson, P.G., Svensson, J., 2003. Political instability, corruption and policy formation: the case of environmental policy. Journal of public economics 87, 1383-1405.
16. Fu, S., Gu, Y., 2017. Highway toll and air pollution: Evidence from Chinese cities. Journal of environmental Economics and Management 83, 32-49.
17. Furton, G., Martin, A., 2019. Beyond market failure and government failure. Public Choice 178, 197-216.
18. Gao, Y., Li, M., Xue, J., Liu, Y., 2020. Evaluation of effectiveness of China's carbon emissions trading scheme in carbon mitigation. Energy economics 90, 104872.
19. Goldthau, A., Sovacool, B.K., 2012. The uniqueness of the energy security, justice, and governance problem. Energy policy 41, 232-240.

20. Gormley, T.A., Matsa, D.A., 2014. Common errors: How to (and not to) control for unobserved heterogeneity. The Review of Financial Studies 27, 617-661.
21. Goulder, L.H., Schein, A.R., 2013. Carbon taxes versus cap and trade: a critical review. Climate Change Economics 4, 1350010.
22. 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 4, 54-70.
23. Gregg, J.S., Andres, R.J., Marland, G., 2008. China: Emissions pattern of the world leader in CO2 emissions from fossil fuel consumption and cement production. Geophysical Research Letters 35.
24. Gulen, H., Ion, M., 2016. Policy uncertainty and corporate investment. The Review of financial studies 29, 523-564.
25. Hintermann, B., 2016. Pass-through of CO2 emission costs to hourly electricity prices in Germany. Journal of the Association of Environmental and Resource Economists 3, 857-891.
26. Keohane, R.O., Victor, D.G., 2011. The regime complex for climate change. Perspectives on politics 9, 7-23.
27. Krueger, A.O., 1990. Government failures in development. Journal of Economic perspectives 4, 9-23.
28. Li, H., Zhou, L.-A., 2005. Political turnover and economic performance: the incentive role of personnel control in China. Journal of public economics 89, 1743-1762.
29. Lu, X., Zhang, L., Chen, Y., Zhou, M., Zheng, B., Li, K., Liu, Y., Lin, J., Fu, T.-M., Zhang, Q., 2019. Exploring 2016–2017 surface ozone pollution over China: source contributions and meteorological influences. Atmospheric Chemistry and Physics 19, 8339-8361.
30. Marin, G., Marino, M., Pellegrin, C., 2018. The impact of the European Emission Trading Scheme on multiple measures of economic performance. Environmental and Resource Economics 71, 551-582.
31. Meckling, J., 2011. Carbon coalitions: Business, climate politics, and the rise of emissions trading. MIT Press.
32. Monastersky, R., Sousanis, N., 2015. The fragile framework: can nations unite to save Earth's climate? Nature 527, S1-S1.
33. Munnings, C., Morgenstern, R.D., Wang, Z., Liu, X., 2016. Assessing the design of three carbon trading pilot programs in China. Energy Policy 96, 688-699.
34. Murray, B.C., Maniloff, P.T., 2015. Why have greenhouse emissions in RGGI states declined? An econometric attribution to economic, energy market, and policy factors. Energy Economics 51, 581-589.
35. Narassimhan, E., Gallagher, K.S., Koester, S., Alejo, J.R., 2018. Carbon pricing in practice: A review of existing emissions trading systems. Climate Policy 18, 967-991.
36. Newell, P., Pattberg, P., Schroeder, H., 2012. Multiactor governance and the environment. Annual review of environment and resources 37, 365-387.
37. Nordhaus, W.D., 1975. The political business cycle. The review of economic studies 42, 169-190.
38. O'neill, S., Nicholson-Cole, S., 2009. "Fear won't do it" promoting positive engagement with climate change through visual and iconic representations. Science communication 30,

355-379.
39. Parry, I., Williams III, R.C., 2012. Moving US climate policy forward: Are carbon taxes the only good alternative. Oxford University Press. Available at: http://www. oxfordscholarship. com ….
40. Paterson, M., 2012. Who and what are carbon markets for? Politics and the development of climate policy. Climate Policy 12, 82-97.
41. Ren, X., Li, Y., Wen, F., Lu, Z., 2022. The interrelationship between the carbon market and the green bonds market: Evidence from wavelet quantile-on-quantile method. Technological Forecasting and Social Change 179, 121611.
42. Rost, J., Holst, T., Sahn, E., Klingner, M., Anke, K., Ahrens, D., Mayer, H., 2009. Variability of PM10 concentrations dependent on meteorological conditions. International Journal of Environment and Pollution 36, 3-18.
43. Rozenberg, J., Vogt-Schilb, A., Hallegatte, S., 2020. Instrument choice and stranded assets in the transition to clean capital. Journal of Environmental Economics and Management 100, 102183.
44. Salimgarieva, A., Blundell, W., 2025. Enforcing Regulation When Violations Are Heterogeneous: Empirical Evidence from US Stationary Emissions Policy. Journal of the Association of Environmental and Resource Economists 12, 663-699.
45. Stavins, R.N., 2003. Experience with market-based environmental policy instruments, Handbook of environmental economics. Elsevier, pp. 355-435.
46. Stern, N., 2022. A time for action on climate change and a time for change in economics. The Economic Journal 132, 1259-1289.
47. Stern, N., Stiglitz, J., Taylor, C., 2022. The economics of immense risk, urgent action and radical change: towards new approaches to the economics of climate change. Journal of Economic Methodology 29, 181-216.
48. Stern, N., Stiglitz, J.E., 2021. The social cost of carbon, risk, distribution, market failures: An alternative approach. National Bureau of Economic Research Cambridge, MA, USA.
49. Stiglitz, J.E., 1989. Markets, market failures, and development. The American economic review 79, 197-203.
50. Tan, X., Han, L., Zhang, X., Zhou, W., Li, W., Qian, Y., 2021. A review of current air quality indexes and improvements under the multi-contaminant air pollution exposure. Journal of environmental management 279, 111681.
51. Tang, R., Zhao, J., Liu, Y., Huang, X., Zhang, Y., Zhou, D., Ding, A., Nielsen, C.P., Wang, H., 2022. Air quality and health co-benefits of China's carbon dioxide emissions peaking before 2030. Nature communications 13, 1008.
52. Tang, T.H., Bao, H.X., 2024. Political uncertainty and carbon emission trading: Evidence from China. Cities 145, 104713.
53. Tuerk, A., Mehling, M., Flachsland, C., Sterk, W., 2009. Linking carbon markets: concepts, case studies and pathways. Climate Policy 9, 341-357.
54. Wang, S., Yang, D.Y., 2025. Policy experimentation in China: The political economy of policy learning. Journal of Political Economy 133, 000-000.
55. Woo, C.K., Olson, A., Chen, Y., Moore, J., Schlag, N., Ong, A., Ho, T., 2017. Does California's CO2 price affect wholesale electricity prices in the Western USA? Energy Policy 110, 9-19.

56. Xiong, L., Shen, B., Qi, S., Price, L., Ye, B., 2017. The allowance mechanism of China's carbon trading pilots: A comparative analysis with schemes in EU and California. Applied Energy 185, 1849-1859.
57. Yu, B., Zhao, Q., Wei, Y.-M., 2021. Review of carbon leakage under regionally differentiated climate policies. Science of The Total Environment 782, 146765.
58. Zhang, Y., Vu, T.V., Sun, J., He, J., Shen, X., Lin, W., Zhang, X., Zhong, J., Gao, W., Wang, Y., 2019. Significant changes in chemistry of fine particles in wintertime Beijing from 2007 to 2017: impact of clean air actions. Environmental Science & Technology 54, 1344-1352.
59. 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.
60. Zheng, S., Kahn, M.E., 2013. Understanding China's urban pollution dynamics. Journal of economic literature 51, 731-772.
61. 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, 821-856.
62. Zhu, J., Fan, Y., Deng, X., Xue, L., 2019. Low-carbon innovation induced by emissions trading in China. Nature communications 10, 4088.

Figure 1. Sample Cities, Pilot Carbon ETS Cities and Pilot Carbon ETS Regions

The Figure shows the distribution of 270 cities in our sample. Cities covered by dark green are cities with Pilot Carbon ETS. Regions colored by light green are cities covered by provincial Carbon ETS. Gray regions are other cities in our sample.

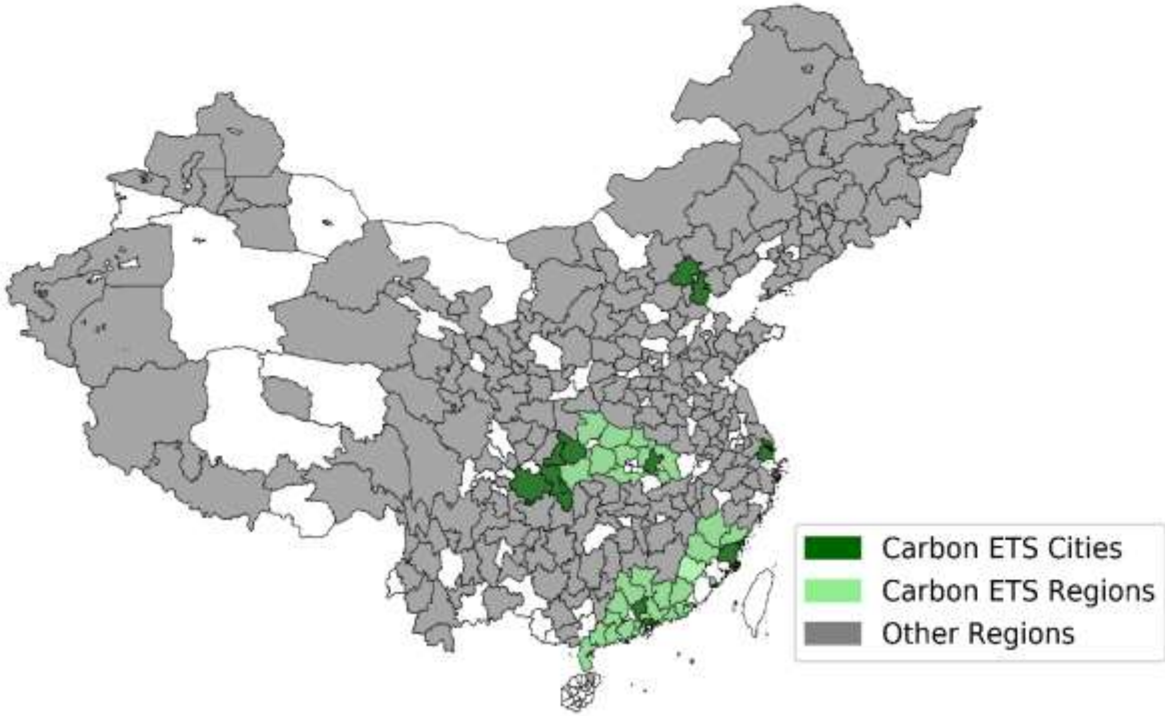

Figure 2. Why the Moderating Effect Is Not Due to City Selection

This figure illustrates the turnover effects reported in Table 6, comparing Columns 1 vs. 2 and Columns 3 vs. 4. As shown in the two sets of comparisons below, regions without ETS consistently exhibit positive and significant turnover effects across different periods. In contrast, regions with ETS experience a notable reduction in the turnover effect after the ETS is implemented. Therefore, the observed moderating effect is not driven by pre-existing differences in cities selected for ETS coverage—regions with ETS do not simply have weaker turnover effects from the outset.

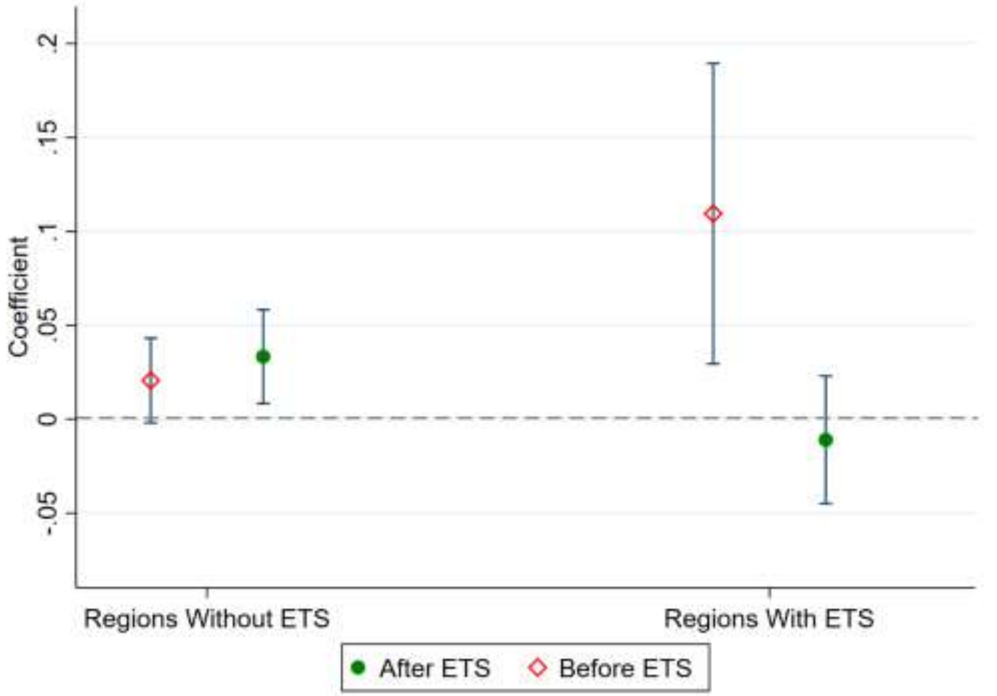

Figure 3. How the Moderating Effect Operates

This figure presents findings from Table 7, comparing turnover effects between Columns 1 vs. 2 and Columns 5 vs. 6. The comparisons show that in regions covered by the ETS, both government regulatory responses and firms' opportunistic behaviors are stabilized to statistically insignificant levels following the introduction of the ETS

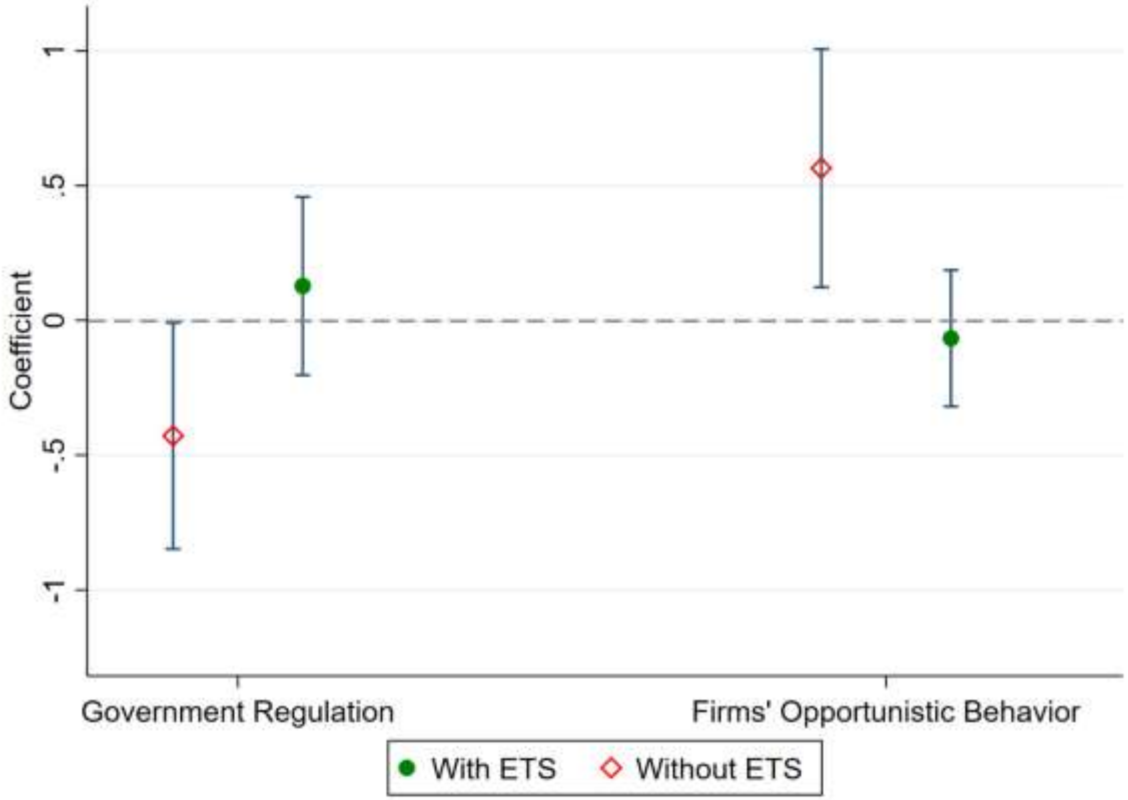

Table 1: Unannounced inspections

Date	Province	Date	Province	Date	Province
2016/1/4	Hebei	2017/4/27	Anhui	2018/6/6	Jiangsu
2016/7/12	Ningxia	2017/4/28	Tianjin	2018/6/6	Yunnan
2016/7/14	Guangxi	2017/4/29	Shanxi	2018/6/7	Guangxi
2016/7/14	Inner Mongolia	2017/7/19	Heilongjiang	2018/10/30	Hunan
2016/7/14	Jiangxi	2017/8/7	Sichuan	2018/10/31	Anhui
2016/7/15	Yunnan	2017/8/8	Qinghai	2018/10/31	Hubei
2016/7/16	Henan	2017/8/10	Shandong	2018/11/1	Shandong
2016/11/24	Chongqing	2017/8/11	Hainan	2018/11/3	Shaanxi
2016/11/26	Hubei	2017/8/11	Jilin	2018/11/3	Sichuan
2016/11/28	Guangdong	2017/8/11	Xinjiang	2018/11/4	Guizhou
2016/11/28	Shaanxi	2017/8/12	Zhejiang	2018/11/4	Liaoning
2016/11/28	Shanghai	2017/8/15	Tibet	2018/11/5	Jilin
2016/11/29	Beijing	2018/5/30	Heilongjiang	2019/7/8	Beijing
2016/11/30	Gansu	2018/5/31	Hebei	2019/7/9	Shanghai
2017/4/24	Fujian	2018/6/1	Henan	2019/7/12	Chongqing
2017/4/25	Hunan	2018/6/2	Ningxia	2019/7/12	Gansu
2017/4/25	Liaoning	2018/6/3	Jiangxi	2019/7/14	Hainan
2017/4/26	Guizhou	2018/6/5	Guangdong	2019/7/14	Qinghai
		2018/6/6	Inner Mongolia	2019/7/15	Fujian

Table 2: Turnovers

Table 2 shows how many city-level leaders' turnovers were in a province during the from October 28th 2013 to December 31th 2019.

Province	Turnovers	Province	Turnovers
Anhui	44	Jiangsu	44
Beijing	4	Jiangxi	43
Chongqing	5	Jilin	59
Fujian	30	Liaoning	88
Gansu	41	Ningxia	15
Guangdong	100	Qinghai	16
Guangxi	36	Shaanxi	30
Guizhou	43	Shandong	65
Hainan	4	Shanghai	2
Hebei	42	Shanxi	58
Heilongjiang	73	Sichuan	56
Henan	61	Tianjin	3
Hubei	54	Tibet	16
Hunan	57	Xinjiang	35
Inner Mongolia	51	Yunnan	51
		Zhejiang	56

Table 3. Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
AQI (Air Quality Index)	511,772	74.22	47.50	0	500
PM2.5 (µg/m3)	511,772	44.29	39.57	0	1787
PM10 (µg/m3)	511,772	79.89	77.54	0	8818
SO2 (µg/m3)	511,772	19.32	23.12	0	800
NO2 (µg/m3)	511,772	29.10	17.37	0	471
O3 (µg/m3)	511,772	58.77	29.60	0	435
CO (µg/m3)	511,772	0.98	0.57	0	25.69
Sunshine (0.1 hour)	511,772	56.45	41.57	0	155
Precipitation (0.1mm)	511,772	27.79	96.90	0	4552
Wind Speed (0.1m/s)	511,772	21.72	12.24	0	205
Humidity (1%)	511,772	67.38	19.05	3	100
Temperature (0.1°C)	511,772	139.55	112.33	-388	423
Turnover	511,772	0.02	0.12	0	1
Holiday	511,772	0.07	0.25	0	1
Inspection	511,772	0.03	0.16	0	1

Table 4. Political Uncertainty and Local Air Quality

The table reports the results of DID regressing log air quality indicators against dummies for political uncertainty (*Turnover, Inspection*) and a series of controls. *Turnover* is 1 for days in the week before local leaders' turnover. *Inspection* is 1 for days in the period of MEE travelling inspections. City fixed effects, monthly fixed effects and holiday dummy are included. Standard errors are clustered at the city level. Robust t-statistics are in parenthesis. ***, **, and * correspond to statistical significance at 1%,5% and 10% levels respectively.

	(1) Log (AQI)	(2) Log (PM2.5)	(3) Log (PM10)	(4) Log (SO2)	(5) Log (NO2)	(6) Log (CO)	(7) Log (O3)
Turnover	0.022***	0.024**	0.025***	0.015	0.015**	-0.006	-0.009
	(2.94)	(2.31)	(2.64)	(1.28)	(2.19)	(-0.76)	(-1.07)
Inspection	-0.050***	-0.078***	-0.070***	-0.099***	-0.032***	-0.022**	-0.039***
	(-6.69)	(-7.41)	(-7.12)	(-6.02)	(-3.04)	(-2.32)	(-3.27)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Holiday	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	511,760	511,704	511,602	511,725	511,710	511,690	511,689
R2	0.49	0.52	0.54	0.62	0.65	0.53	0.51

Table 5. Political Uncertainty, air pollution and Carbon ETS

The table reports the results of DDD regressing log air quality indicators against a dummy for political uncertainty (*Turnover*), an interaction term between *Turnover* and *Carbon ETS * ETS Open*. *Turnover* is 1 for days in the week before local leaders' turnover. *Inspection* is 1 for days in the period of MEE travelling inspections. Carbon ETS *(Covered)* is one if the city has been covered by one of the eight provincial Carbon ETS. *Carbon ETS (location)* is one if the city has a provincial Carbon ETS. *ETS Open* is one if the related ETS opened. Column 1 uses the subsample of only regions finally covered by eight provincial carbon ETS. Column 4 uses the subsample of cities with Carbon ETS finally. Standard errors are clustered at the city level. Robust t-statistics are in parenthesis. ***, **, and * correspond to statistical significance at 1%,5% and 10% levels respectively.

	(1) Regions Covered by Carbon ETS	(2) Other	(3) All	(4) Cities with Carbon ETS	(5) Other	(6) All
Turnover	-0.003	0.025***	0.027***	-0.021	0.024***	0.024***
	(-0.19)	(3.06)	(3.38)	(-0.88)	(3.12)	(3.17)
Inspection	0.03**	-0.056***	-0.059***	-0.01	-0.051***	-0.052***
	(2.05)	(-7.04)	(-7.36)	(-0.20)	(-6.68)	(-6.79)
Carbon ETS (Covered) ETS Open*			0.004			
			(0.19)			
*Carbon ETS (Covered) * ETS Open *Turnover*			-0.229**			
			(-4.40)			
*Carbon ETS (Covered) * ETS Open *Inspection*			0.055***			
			(3.56)			
*Carbon ETS * Turnover*			0.181***			0.189***
			(3.58)			(7.99)
Carbon ETS (location)						-0.016
						(-0.39)
*Carbon ETS (Location) * ETS Open *Turnover*						-0.282***
						(-6.29)
*Carbon ETS (Location) * ETS Open *Inspection*						0.046
						(1.09)
Control	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Holiday	Yes	Yes	Yes	Yes	Yes	Yes
N	78,817	432,943	511,760	16,794	494,966	511,760

R2	0.48	0.49	0.49	0.44	0.49	0.49

Table 6. Stabilizing Effect and City Selection

To address concerns regarding city selection in the adoption of carbon ETS, the table presents results using PSM, SDID and other subsamples. Columns 1 to 2 presents results using only regions without ETS while columns 3 to 5 uses only regions with ETS. Columns 6 and 7 present results from PSM sample matching. Column 6 utilizes a nearest neighbourhood matching strategy within a 0.1 calliper radius without replacement, while Column 7 employs a similar strategy within a 0.05 calliper radius without replacement. Column 7 employs a SDID strategy. *Turnover* is 1 for days in the week before local leaders' turnover. *Inspection* is 1 for days in the period of MEE travelling inspections. *Carbon ETS* is one if the city has been covered by one of the eight provincial Carbon ETS. Column 7 employs a SDID strategy. Standard errors are clustered at the city level. Robust t-statistics are in parenthesis. ***, **, and * correspond to statistical significance at 1%,5% and 10% levels respectively.

	Regions Without ETS		Regions With ETS			PSM		SDID
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Before the Last ETS	After the Last ETS	Before Opening	After Opening	All	Without Replacement Radius=0.1	Without Replacement Radius=0.05	All
Turnover	0.021*	0.033***	0.109***	-0.010	0.103*	0.057***	0.072***	0.041***
	(1.80)	(2.63)	(2.83)	(-0.63)	(2.01)	(3.50)	(3.74)	(4.10)
Carbon ETS* ETS Open					-0.024	-0.013	-0.013	-0.021
					(-1.04)	(-0.42)	(-0.42)	(-0.97)
Carbon ETS*ETS Open*Turnover					-0.113**	-0.214***	-0.215***	-0.115**
					(-2.14)	(-3.18)	(-3.19)	(-2.21)
*Carbon ETS *Turnover*						0.159**	0.158**	0.067
						(2.42)	(2.39)	(1.30)
Inspection						0.062***	0.057***	0.059***
						(-3.52)	(-3.32)	(-3.89)
Carbon ETS* ETS Open*Inspection						0.077***	0.072***	0.093***
						(3.88)	(3.74)	(5.61)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Holiday	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	190,863	242,080	6,016	72,801	78.817	120,140	114,510	509,692
R2	0.49	0.49	0.63	0.48	0.49	0.51	0.51	0.48

Table 7. Mechanism

The table reports the results of DID regressing log air quality indicators against dummies for political uncertainty (*Turnover, Inspection),* an interaction term between *Turnover* and *Carbon ETS*. *Turnover* is 1 for days in the week before local leaders' turnover. *Inspection* is 1 for days in the period of MEE travelling inspections. Carbon ETS*(Covered)* is one if the city has been covered by one of the eight provincial Carbon ETS. *Carbon ETS (location)* is one if the city has a provincial Carbon ETS. Column 1 uses the subsample of only regions finally covered by eight provincial carbon ETS. Column 4 uses the subsample of cities with Carbon ETS finally. Standard errors are clustered at the city level. Robust t-statistics are in parenthesis. ***, **, and * correspond to statistical significance at 1%,5% and 10% levels respectively.

	Environmental Regulation				Merge and Acquisition			
	Regions Covered by Carbon ETS			All	Regions Covered by Carbon ETS			All
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Before Opening	After Opening	All	All	Before Opening	After Opening	All	All
Turnover	-0.428**	0.128	-0.980***	-0.102	0.565**	-0.066	0.498***	0.257**
	(-2.00)	(0.76)	(-3.09)	(-0.75)	(2.50)	(-0.52)	(3.18)	(2.14)
Inspection		0.274**	0.305**	0.784***		-0.163	-0.132	-0.185**
		(2.34)	(2.56)	(6.63)		(-1.18)	(-0.88)	(-2.12)
*Carbon ETS * ETS Open*			0.002	-0.282			0.155	0.086
			(0.00)	(-1.39)			(0.90)	(0.59)
Carbon ETS ETS Open* Turnover*			1.115***	1.314***			-0.561**	-0.420**
			(3.14)	(3.61)			(-2.57)	(-2.01)
Carbon ETS ETS Open* Inspection*				-0.747***				0.275
				(-4.21)				(1.49)
*Carbon ETS * Turnover*				-0.854***				0.124
				(-2.72)				(0.59)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Holiday	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6,016	72,801	78,817	511,772	6,016	72,801	78,817	511,772
R2	0.35	0.41	0.40	0.24	0.20	0.30	0.29	0.26