Blue Sky Protection and Corporate Financing Decisions

-- Evidence from Ultra-low Emission Standards Policy

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Abstract

In this study, we examine the impact of an investment-oriented environmental policy on corporate financing decisions that linked to sustainable production. Analyzing a large sample of Chinese manufacturing firms between 2009 and 2018, we determine that strengthened environmental protection causes higher financial leverage. Using an exogenous regulatory shock, we show that regulated firms are more likely to increase debt ratios following the introduction of an ultra-low emission standards policy in China. This impact is stronger in firms with lower levels of government ownership, fewer financial constraints, those operating in low-polluting industries, and those with less reliane on trade credit. Channel analysis reveals that China's ultra-low emission standards policy significantly increases firms' capital expenditure, motivating them to issue more debt to meet immediate and short-lived cash needs. Our study offers evidence that investment-oriented legislation leads to higher corporate financial leverage, providing insights for both policymakers and businesses regarding such operational risk.

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Keywords: Ultra-low Emission Standards; Environmental Regulation; Investment-Oriented; Capital Structure; Sustainable Production

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1 Introduction

Environmental concerns have garnered significant attention in the context of sustainable operation management, drawing interest from academia, industry, policymakers, and the public. To address environmental pollution, a variety of regulatory measures have been implemented globally.[3] These regulations pose considerable challenges for firms, particularly manufacturing firms, requiring them to adjust their operational strategies to meet increasingly stringent environmental standards. Much of the existing literature on sustainable operation management has focused on the micro-level effects of cost-oriented environmental policies, such as emissions trading schemes and pollution charges (Krass et al., 2013; Drake et al., 2016; Huang et al. 2021; Dang et al., 2023; Song et al., 2023).[4] However, there is a limited exploration of how investment-oriented environmental regulations—those requiring significant capital expenditures—affect corporate financial strategies. This study aims to fill this gap by examining how manufacturing firms adjust their capital structures in response to China's ultra-low emission standards policy, thus shedding light on the relationship between investment-oriented environmental regulations and financing decisions within the broader framework of sustainable operation management.

Understanding the relationship between strengthened emission standards and financing decisions is vital for the effective management of sustainable operations. When environmental management requires significant capital investment, financial strategies should be closely aligned with sustainability-focused operational processes. For instance, a company transitioning to cleaner production methods might seek additional loans or issue

[3] Notable examples include the Nitrogen Oxides Budget Trading Program in the United States and the Industrial Emissions Directive in the European Union.

[4] Environmental regulation can be classified into two primary categories: cost-oriented and investment-oriented regulation (Ambec et al., 2013; Ye and Wang, 2019). Cost-oriented environmental regulation prioritizes the resolution of environmental issues. These regulations require firms to clean up pollutants or buy pollution emission rights to achieve environmental objectives. Illustrative examples include emissions trading schemes, pollution taxes or charges, and performance standards. Conversely, investment-oriented environmental regulation serves to incentivize and direct capital toward environmentally beneficial projects and technologies. These regulations encourage companies to invest in sustainable practices and technologies, of which the mechanisms include renewable energy investment incentives and energy efficiency standards.

bonds to fund the installation of eco-friendly facilities. However, strict regulations can strain financial resources, restrict access to credit, and potentially lead firms to take compliance shortcuts or engage in riskier behavior (Bartram et al., 2022; Dang et al, 2022 and 2023). Such actions can compromise both regulatory compliance and operational efficiency. Therefore, a thorough analysis is needed to fully grasp the implications of these dynamics on corporations.

Our study leverages China’s ultra-low emission standards policy, which is widely recognized as the most significant contributor to air quality improvements in China (Zhang et al., 2019). Effective from 2014, ultra-low emission standards for the manufacturing sector were enacted in pilot cities experiencing severe air pollution. These standards imposed strict limits on the emissions of the most toxic pollutants, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter (PM). Targets were established to reduce them to levels comparable with those in developed countries. These standards were most effective in reducing key air pollutants, contributing to nationwide reductions of 43%, 60%, and 41% for SO_2, NO_x, and primary $PM_{2.5}$ emissions, respectively (Zhang et al., 2019). However, they also imposed substantial costs on affected firms, which were required to procure pollution abatement equipment and to invest in significant facility upgrades to enhance energy efficiency, For example, in the steel industry, the cost of achieving ultra-low emissions could add approximately \$20 to \$50 per tonne of steel produced, suggesting a compliance cost ranging from \$200 to \$500 million for a steel plant with an annual production capacity of 10 million tonnes, imposing considerable financial responsibilities on manufacturing companies.

To establish a causal relationship, our study employs an identification strategy that utilizes the implementation of the ultra-low emission standards policy as an exogenous regulatory shock. We employ a difference-in-difference approach to investigate the effects of investment-oriented environmental regulations on corporate financing decisions. In our analysis, we classify treated firms as manufacturers headquartered in the pilot cities, which are considered to be significant air pollution zones. Conversely, we use those headquartered in other cities as control firms. Our findings reveal that firms operating in key regulated zones experienced a significant increase in financial leverage, amounting to 1.7 percentage points, which embodies economic significance, since it represents a 9.6% rise relative to the sample mean.

To address potential endogeneity concerns related to pre-trends and reverse causality, we carefully examine the timing of leverage changes before and after the implementation of the emission policy. Our analysis reveals that the increase in financial leverage observed in treated firms, relative to control firms, is evident only after the policy is implemented. Furthermore, to address the possibility of systematic differences between the treated and control firms that may affect our results, we employ propensity score matching (PSM) to define the control group. By matching firms based on similar characteristics, we create a more comparable control group. Our baseline results remain robust when using these matched samples. In addition, we conduct several tests to ensure the robustness of our findings. For example, we control for potentially confounding energy regulations to account for their potential impact on our results. We also conduct placebo tests using pseudo-samples of treated and control firms to assess the validity of our findings. Our main results withstand these additional tests, further supporting the robustness of our findings.

In our subsequent analysis, we analyze the heterogeneity of the treatment effect, presenting additional evidence in respect of the economic mechanisms underlying our findings. First, we examine firms with varying levels of government ownership, finding that non-SOEs experienced a more pronounced effect on their financial leverage following the implementation of the policy. This can be attributed to the relatively higher compliance costs faced by non-SOEs due to the stricter environmental regulations. Additionally, we conduct a test focusing firms' financial constraint. Given that the ultra-low emission standards impact corporate financial decision-making through an increase in capital expenditure, we anticipate a stronger treatment effect for firms with fewer financial constraints, as they are more exposed to this regulatory shock. Our empirical results support this conjecture. We also find that the positive association between air pollution regulations and corporate financial leverage is more pronounced among firms in low-polluting industries, as they have a comparative advantage in securing bank financing (Huang et al., 2021; Chai et al., 2022).

Likewise, we observe a stronger treatment effect for manufacturers with lower levels of trade credit. Acting as a substitute for bank credit, trade credit enables suppliers to serve as liquidity providers, buffering against liquidity shocks triggered by air quality regulations. This, in turn, reduces the sensitivity of financing decisions to the enforcement of emission limits.

Last, we investigate potential channels through which the observed effect is operationalized. Our mechanism analysis reveals that manufacturing firms with headquarters in the affected regions faced increased cash requirements following the introduction of the ultra-low emission standards. This is demonstrated by their higher operating costs, reduced cash reserves, and diminished free cash flows. Additionally, we find that these firms substantially increased their capital expenditure, indicative of a greater investment in pollution abatement. Altogether, our findings suggest that manufacturing firms' response to the emission standards aligns with the pecking order theory, which posits that debt is the preferred source of external financing when they have insufficient funds (Myers, 1984; Myers and Majluf, 1984). Furthermore, our results are consistent with the funding horizon theory (DeAngelo et al., 2011; Huang and Ritter, 2021). Specifically, manufacturers required to undertake immediate and short-term investment spending due to implementation of the policy exhibit a preference for issuing debt rather than equity. This preference for debt issuance contributes to a higher leverage ratio, *ceteris paribus*.

Our analysis lies at the intersection of the literature on sustainable operations management and corporate finance. Primarily, this paper enhances our understanding of the micro-level impacts of environmental management on corporate financial and operational decisions. Prior research has investigated how environmental policies influence corporate technology choices (Krass et al., 2013; Drake et al., 2016), carbon-emitting production practices (Huang et al., 2021), product offerings (Han et al., 2022), and supply chain performance (Song et al., 2023). We extend this body of work by examining the effects of environmental management on firms' financial strategies related to sustainable production, which aims to reduce environmental impact and enhance resource efficiency.

In addition, this paper offers the first causal evidence on how investment-oriented environmental regulations influence corporate financing decisions. To date, research in this domain of inquiry has been scant. Notably, Dang et al. (2023) investigate the U.S. Nitrogen Oxides Budget Trading Program of 2004—a cost-oriented environmental regulation—and report that manufacturing firms decrease their financial leverage in response to heightened distress risk. In contrast, our analysis of China's ultra-low emission standards reveals that investment-related environmental regulations prompt firms to increase capital expenditures, which in turn enhances their financial leverage. This divergence underscores the variability in firms' financial responses based on the nature of the environmental regulation, a dimension that has been largely neglected in previous studies. By elucidating the differential impacts of varied environmental regulations on corporate financial behavior, our findings emphasize the nuanced role of regulatory policies in shaping financial decision-making related to operations management.

Furthermore, we contribute to the literature on the importance of cash needs for financing decisions (DeAngelo et al., 2010; Denis and McKeon, 2012; McLean and Palazzo, 2018). Our findings provide empirical support for the funding-horizon theory on capital structure. From this theoretical perspective, firms with temporary cash shortfalls caused by investing in tangible assets issue debt, and firms with persistent cash shortfalls caused by R&D spending issue equity (DeAngelo et al., 2011; Huang and Ritter, 2021). In our investigation, we find that the short-term capital outlay on pollution abatement equipment required by strengthened air quality regulations engenders higher financial leverage, reinforcing the funding-horizon theory.

The subsequent sections of this paper are organized as follows: Section 2 provides an in-depth exploration of the institutional background, theoretical framework, and the development of hypotheses. Section 3 engages in methodological considerations, encompassing aspects such as sample selection and the identification strategy. Section 4 presents the baseline results, together with the outcomes of robustness tests and cross-sectional analysis. Section 5 undertakes an investigation into the underlying mechanisms. Section 6 offers our concluding remarks.

2 Institutional Background and Hypothesis Development

2.1 Institutional Background

The issue of air pollution in China has attracted significant attention in recent years due to escalating concern. The World Health Organization (WHO) has documented the widespread and persistent haze caused by elevated $PM_{2.5}$ concentrations, particularly in North China, since 2013. Analysis of monitoring data at city-level in 2013 reveals an alarming annual average $PM_{2.5}$ concentration of 72 micrograms per cubic meter, surpassing the WHO's recommended guideline by a multiple of 6.2 (Yu et al., 2022), causing adverse effects on public health, degrading people's quality of life, and incurring substantial economic losses (Greenstone and Hanna, 2014; Tanaka, 2015; Landrigan, 2017; Huang et al., 2018).

In response to severe air pollution and to advance sustainable development, China's Ministry of Environmental Protection promulgated an ultra-low emissions standards policy in 47 pilot cities across 19 provinces in China, effective from 2014. Firms in the manufacturing sector in 47 prefecture-level cities are mandated to adhere to stringent emission limits for atmospheric pollution caused by sulfur dioxide (SO_2), nitrogen oxides (NO_X), and particulate matter (PM). Figure 1 depicts the distribution of these cities, organized into three districts and ten groups, encompassing Beijing-Tianjin-Hebei, the Yangtze River Delta, the Pearl River Delta, central Liaoning, Shandong, Wuhan and its surrounding areas, Chuangzhutan, Chengdu, Chongqing, the economic zone on the west side of the straits, central and northern Shanxi, Shaanxi, Guanzhong, Ganning, and Urumqi. The majority of these pilot cities are coastal or are located in developed regions, which face significant air pollution challenges.

[Insert Figure 1 here]

In comparison to pre-existing standards, the ultra-low emission standards substantially reduced the permissible emission limits. Specifically, the limits for existing industrial boilers were reduced by 47% and 67% for particulate matter and sulfur dioxide, respectively, and the limits for newly built boilers were reduced even more. In general, the standards were aligned with equivalent standards set by countries such as the United Kingdom, France, and Ireland, and were even more stringent than the emission thresholds in countries such as the

United States and Japan. Given the widespread utilization of industrial boilers in the manufacturing sector, manufacturers operating in pilot cities are disproportionately impacted by the implementation of this policy. See Appendix B for more details of the ultra-low emission standards policy.

Compliance with the new emission requirements necessitates significant investments in pollution abatement. This includes the installation of flue gas desulfurization (FGD) units, selective catalytic reduction (SCR) systems, and electrostatic precipitators (ESP) or fabric filters to control particulate emissions. Additionally, firms have to make substantial investments in facility upgrades to enhance energy efficiency and achieve long-term operational and environmental benefits. The cost of fully implementing the ultra-low emission standards nationwide is considerable, estimated at 25 billion US dollars, which represents approximately 0.24% of China's GDP in 2014 (Tang et al., 2019; Tang et al., 2023).

The execution of the standards has, in fact, led to significant enhancements in air quality, especially in the reduction of fine particulate matter concentration, sulfur dioxide and nitrogen oxide emissions within the pilot areas (Karplus et al., 2018; Yu et al., 2022). This policy introduces a valuable source of exogenous variation in a firm's capital expenditure on pollution abatement. Consequently, it provides an opportunity to determine the causal impact of environmental investment regulations on corporate financial outcomes. The first phase of the implementation of emission standards concluded in 2017, followed by the commencement of the second phase. The second phase introduced even stricter limits than the first. To remove the potential impact of this policy change, our study focuses exclusively on the first phase.

2.2 Theoretical framework and Hypothesis Development

Sustainable operation management integrates the profit and efficiency orientation of traditional operation management with broader considerations of the company's internal and external stakeholders and its environmental impact (Kleindorder, 2005). Compliance with environmental regulations is a crucial aspect of sustainable operations management. It reflects how companies meet environmental standards and guidelines, which can include emissions limits, waste disposal, resource conservation, and energy efficiency requirements.

These compliance efforts are integral to both sustainable practices and risk management, as they align corporate behavior with regulatory expectations and mitigate potential legal and financial risks. The research relating environmental management to firm performance is fragmented across the finance, economics and operation management literature (Corbett and Klassen, 2005). Existing research in sustainable operation management has investigated how environmental policies influence corporate technology choices (Perino and Requate, 2012; Krass et al., 2013; Drake et al., 2016; Wang et al., 2021), carbon-emitting production practices (Huang et al., 2021), product offerings (Han et al., 2022), and supply chain performance (Song et al., 2023).

However, what is arguably of greater interest, albeit more difficult to establish, is how such regulations impact corporate financing decision. Financing decisions play a pivotal role in enabling firms to comply with environmental regulations. Adopting new, cleaner technologies and implementing environmentally friendly operational policies often require significant capital investment, which can stretch firms' financial resources. Decisions on how to source this financing — whether through debt, equity, or internal funds — can influence a company's ability to invest in compliance measures effectively. Consequently, corporate financing strategy is an essential part of managing both compliance risks and advancing broader environmental goals. This question has not been explored in the operation research literature, but funding horizon and trade-off theories suggest theoretical frameworks to support studies of the impact of environmental regulations on corporate financing decisions.

2.2.1 Funding horizon theory, environmental regulation and firm leverage

The funding-horizon theory contends that the nature and persistence of cash needs drive corporate financing decisions (DeAngelo et al., 2011). Specifically, firms experiencing sustained cash shortfalls, often due to research and development (R&D) expenditures, are more likely to issue equity. In contrast, firms facing temporary cash shortfalls, such as those caused by investments in tangible assets, tend to favor debt issuance (Huang and Ritter, 2021). For example, Denis and McKeon (2012) argue that firms that increase leverage by raising debt do so primarily in response to operating needs rather than for making substantial equity payouts. Liu et al (2023) supports the funding horizon theory by demonstrating that firms use equity issues to meet persistent cash needs, particularly by launching IPOs.

The implementation of ultra-low emission standards imposes mandatory requirements on manufacturers to integrate clean technologies and upgrade industrial boilers within specified time limits, resulting in transient cash needs. Consistent with the funding-horizon theory, firms may choose debt issuance over equity to satisfy the immediate and short-term cash requirements caused by the imposition of stricter emissions regulations.

Traditional theories of security issuance, such as the pecking order theory (Myers, 1984; Myers and Majluf, 1984), also provide insight into corporate financing behavior. The pecking order theory suggests that firms prefer debt as a source of external financing when internal funds are insufficient, and issue external equity only as a last resort. Empirical evidence provided by Leary and Roberts (2010) indicates that pecking order theory is more likely to explain financial policy when incentive conflicts, rather than information asymmetry, are involved. Furthermore, Fulghieri et al. (2020) augment the pecking order theory by demonstrating that mature firms, with more stable cash flows, tend to prefer debt financing, whereas younger firms, which often have riskier and more valuable growth opportunities, are more inclined to favor equity finance.

In the case of investments driven by environmental regulations, as in China, firms may increase leverage to close the financing gap created by the costs of regulatory compliance. This need arises as firms seek external funding to meet the rising costs of pollution abatement, driven by enhanced emission standards requiring upgrades to industrial dust removal facilities.

In summary, the implementation of the ultra-low emission standards has created the need for firms to employ more aggressive financial policies. Hence, the foregoing rationale leads us to formulate our first hypothesis:

H1a: *The implementation of the ultra-low emission standards causes firms to increase their financial leverage.*

2.2.2 Trade-off theory, environmental regulation and firm leverage

The trade-off theory posits that firms determine their optimal capital structure by balancing the benefits and costs associated with debt financing (Kraus and Litzenberger, 1973; Bradley et al., 1984). Specifically, a firm issuing debt seeks to optimize the value derived from debt tax shields while seeking to mitigate the potential losses that could arise if taking on debt causes financial distress (Graham, 2000; Agrawal and Matsa, 2013).

Stringent environmental regulations impose significant additional costs on firms, compelling them to adopt clean production technologies and implement pollution abatement facilities to comply with emissions targets. When expenditure to reduce pollution increases a firm's fixed costs, it results in elevated operating leverage and, consequently, an increased risk of financial distress (Serfling, 2016). This heightened risk can lead to higher lending spreads (Huang et al., 2021), incentivizing firms to reduce their leverage.

For example, Nguyen and Phan (2020), in their study of Australian firms, find that the Kyoto Protocol, which decrees carbon emissions reductions, increases financial distress risk, prompting firms to reduce financial leverage. Similarly, Dang et al. (2023) provide robust evidence from the Nitrogen Oxides Budget Trading Program (NBP) in the United States, which is a regional initiative aimed at reducing Nitrogen Oxides emissions from power plants. They establish that the implementation of the NBP led to a reduction in financial leverage among manufacturing firms, driven by increased operating leverage and distress risk.

In the context of China's ultra-low emission standards, the policy imposes substantial additional costs on manufacturers by requiring significant investments in pollution abatement technologies, such as scrubbers, catalytic converters, and advanced filtration systems. These costs, which are predominantly fixed, increase the operating leverage of manufacturing firms in affected regions, thereby heightening their financial distress risk. As a result, these firms may opt to deleverage in response to the financial pressures imposed by the high costs of compliance with emissions standards.

Given these contrasting perspectives, an alternative hypothesis emerges:

H1b: *The implementation of the ultra-low emission standards causes firms to decrease their financial leverage.*

3 Methodological issues

3.1 Data and Sample

To examine the impact of the adoption of ultra-low emission standards on corporate financial decisions, we conduct our analysis over a 10-year period, spanning from 2009 to 2018. The choice of 2009 as the starting point for our sample period aims to mitigate the influence of the 2008 global financial crisis, while concluding the period in 2018 extends our study by one year following the cessation of the first phase of ultra-low emission standards in 2017. We restrict our sample to firms in the manufacturing industry, as the policy mainly affects manufacturing firms. To control for the possible impact caused by outliers, all continuous variables are winsorized at the 1% and 99% levels. Following screening, the final sample comprises 17,145 firm-year observations of 2470 manufacturing firms for our empirical analysis.

3.2 Identification Strategy

In analyzing the ramifications of the emission limits on the financial leverage of manufacturing firms domiciled in pilot cities, our analytical approach adopts the tenets of the difference-in-differences (DID) methodology. The model under consideration for estimation is specified as follows:

$$Debt_{it} = \alpha_0 + \alpha_1 ULES_i \times Post_t + \beta X_{it} + \gamma Z_{ct} + \kappa_i + \delta_s + \varphi_t + \varepsilon_{it} \tag{1}$$

where $Debt_{it}$ is the financial leverage of firm i in year t; $ULES_i$ is a dummy variable which equals one if a firm is headquartered in one of the 47 pilot cities and zero otherwise; $Post_t$ is a dummy variable which equals one for observations made during 2014-2018 and zero for those during 2009-2013.[5] X_{it} represents a set of firm-level control variables, and Z_{ct} represents a set of city-level control variables. We also include firm-fixed effect (κ_i), city-fixed effect (δ_s), and year-fixed effect (φ_t) in the regression model. ε_{it} is the error term with standard errors clustered at the firm level.

In our analysis, we employ book leverage as a surrogate for financial leverage, in alignment with antecedent investigations on capital structure (Agrawal and Matsa, 2013; Serfling, 2016; Dang et al., 2023). The computation of book leverage involves the division of the book value of long-term debt plus debt in current liabilities by the book value of total assets. Regarding the inclusion of control variables, we incorporate several pivotal metrics.

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[5] Although the ultra-low emission standards policy was introduced in April 2013, full implementation did not occur until 2014, when the new emission standards were enforced. Consequently, we designate the year 2014 as the commencement of the post-shock period.

In consonance with the methodologies outlined by Frank and Goyal (2009) and Heider and Ljungqvist (2015), we integrate firm total assets (*Size*), profitability (*ROA*), and fixed assets (*Tangibility*). Furthermore, we consider intangible assets (*Intangibles*) due to their potential as collateral for debt (Lim et al., 2020). Cash flow (*Flow*) is included to capture the debt financing motivations of cash-abundant firms (Dasgupta et al., 2011). Additionally, we control for sales growth (*Growth*), given its association with firms' debt borrowing behavior (La Rocca et al., 2011). To account for potential city-level economic and environmental factors that may influence capital structure decisions and regulatory implementation, we include city-level GDP growth and the concentration of $PM_{2.5}$, consistent with Dang et al. (2023). For a detailed overview of our key variables, please refer to Appendix A.

3.3 Endogeneity Concerns

A fundamental assumption underpinning the difference-in-differences (DID) methodology employed in this study is that the implementation of the ultra-low emission standards is exogenous to the capital structure decisions of manufacturing firms. In the ensuing sections, we meticulously explore and contend with potential concerns pertaining to the endogeneity of this policy.

One concern is that the implementation of the policy may be subject to lobbying. However, no firms support the emission limits, as it requires them to comply with pollution control standards and install emission abatement equipment, which would increase their costs. The emission limits in China represents a governmental initiative designed to combat air pollution and enhance overall air quality.

In addition, the manufacturing firms were not expecting the implementation of the emission limits. As we demonstrate in our dynamic analysis, the impact of the emission limits was not observed until after 2014. Therefore, while it is possible that some affected firms made initial adjustments prior to 2014, these responses are unlikely to significantly influence our statistical inferences. Overall, these discussions strengthen our conclusion that the impact of endogeneity on our findings is minimal.

4 Empirical Results and discussions

4.1 Summary Statistics

Table 1 provides a synopsis of the variables employed in our study. To mitigate the potential influence of outliers, all variables, excluding binary and macroeconomic indicators, are winsorized at the 1^{st} and 99^{th} percentiles. Financial leverage metrics are censored at zero and one. Notably, the mean values of book leverage are 17.8%.

4.2 Baseline results

Table 2 presents the baseline regression estimates delineating the impact of the ultra-low emission standards on the financial leverage of manufacturing firms. Columns (1) to (3) report results derived from the full sample. In Column (1), only firm, city, and year fixed effects are included without additional controls. Column (2) introduces firm-level control variables customary in capital structure literature, encompassing firm size (*Size*), profitability (*ROA*), fixed assets (*Tangibility*), intangible assets (*Intangibles*), cash flow (*Flow*), and growth opportunities (*Growth*). In Column (3), the model incorporates city-level GDP growth and the concentration of $PM_{2.5}$. Across all model specifications, the coefficients on *ULES*×*Post* consistently exhibit significance and positivity, signifying a discernible positive impact of the policy's implementation on firms' financial leverage.

In the absence of time-varying firm- and city-level controls, Column (1) in Table 2 reveals that, subsequently to the enactment of the emission limits, book leverage increased by 2.5 percentage points. Upon incorporation of two sets of control variables in Columns (2)-(3), both the economic and statistical significance of the coefficients on *ULES*×*Post* persist. Specifically, in Column (3), which features a comprehensive set of controls, book leverage experiences a substantial increase of 1.7 percentage points, corresponding to 9.6% relative to its sample mean (0.017/0.178). The magnitude of the policy's impact on financial leverage aligns with recent empirical studies on the effects of other policy shocks. Notably, Serfling (2016) observes a 4.5% reduction in book leverage following the state-level implementation of employment protection laws.

In sum, the robustness of the positive effect of the ultra-low emission standards on capital structure holds across diverse model specifications. This outcome aligns with the conjecture that the adoption of the emission limits prompted manufacturers to augment their financial leverage.

4.3 Robustness analysis

4.3.1 Dynamic Effects on Capital Structure

A key concern regarding the difference-in-differences model is that some trend differentials that pre-exist between the control and treated firms may drive our results. Another concern is that there may be lead or lag effects caused by the implementation of the ultra-low emission standards on capital structure. On the one hand, as it took years for China's legislative authority to approve the emission limits, firms may have had expectations regarding its enactment and thus could have adjusted their capital structure before 2013. On the other hand, it may have taken firms some time to respond to the policy and adjust their debt schedules. To eliminate these concerns, we explore the dynamic effects of the emission limits. We adopt an event study method by including lags and leads of the *Post* indicator, as suggested in Jacobson et al. (1993) and Graham et al. (2023). Specifically, we estimate the following specification.

$$Debt_{it} = \alpha_0 + \sum_{t=2009}^{2018} \theta_t ULES_i \times Year_t + \beta X_{it} + \kappa_i + \delta_s + \varphi_t + \varepsilon_{it} \qquad (2)$$

where we set the year 2013 as the baseline year, occurring just before the air quality regulations took effect, and exclude it from the regression. $Year_t$ is an indicator for each year. The remaining terms are the same as those in Equation (1). The time varying coefficient, θ_t, captures the dynamic effects of the regulation on corporate capital structure from 2009 to 2018 relative to the baseline year. If capital structure decisions for control and treated firms follow a similar trend as one before the law was enacted, then θ_t should be insignificant for each year before 2014.

Figure 2 depicts all estimated coefficients of the interaction term *ULES* × *Post*, accompanied by the corresponding 95% confidence intervals. The outcomes indicate that the estimated effects are not significantly divergent from zero during the pretreatment periods. This substantiates the validity of the parallel trend assumption and diminishes concerns regarding reverse causality as a potential driver of our results. Following the year 2014, the coefficients exhibit statistically significant positivity. Collectively, these findings affirm that the air quality regulation significantly elevates financial leverage in treated firms subsequently to the enactment of air quality regulations.

[Insert Figure 2 here]

4.3.2 Debt Maturity Structure

In the previous analyses, we used total book leverage as a proxy for corporate capital structure. Firms either take on short- or long-term debt in their financing decisions. To investigate whether corporate debt maturity changes after implementation of the environmental regulations, we employ long- and short-term leverage as dependent variables, respectively.

The estimation results presented in Table 3 reveal significant changes in firms' debt issuance following the implementation of air quality regulations. When considering short-term leverage as the dependent variable, the data indicate a mean increase of 0.010 in the ratio of short-term debt during the posttreatment period. This translates to an 8.1% (0.010/0.124) rise in the sample mean for the debt ratio, given an average short-term leverage of 0.124. Turning to long-term debt as the dependent variable in Column (2), we observe a mean increase of 0.006 in the ratio of long-term debt following the regulation's enactment. This corresponds to an 11.1% (0.006/0.054) increase in the sample mean for the long-term debt ratio. Notably, these estimated coefficients accord with our baseline findings presented in Table 2, highlighting a consistent pattern of firms increasing both short- and long-term debt issuance in response to air quality regulations.

4.3.3 PSM-DiD

In the light of the established common pre-existing trend evident in our dynamic model analysis, there is a possibility that systematic differences between the treated and control groups might influence the observed outcomes. To allay this concern, we employ a matched difference-in-differences methodology to validate and affirm the robustness of our results. The initial step involves the application of Propensity Score Matching (PSM) to meticulously craft the most comparable treated and control groups, subsequently conducting a difference-in-difference regression based on this matched subsample.

In the implementation of PSM, we begin with a probit estimation, where the binary dependent variable, denoted as *Treated*, assumes a value of one if a firm is headquartered in a pilot city, and zero otherwise. The probit model incorporates all control variables from Equation (1). Utilizing propensity scores derived from the probit model and employing nearest-neighbor matching (ratio=1:15), following the methodology devised by Smith and Todd (2005), we establish matches between treated and control groups.

We then evaluate the success of the matching process by conducting a balance test. Figure C1 of Appendix C presents the propensity score distributions both before and after matching. A visual inspection reveals that PSM significantly reduces the bias between the treatment and control groups. Furthermore, Figure C2 illustrates the differences in covariates pre- and post-matching, showing that deviations across all variables fall to below 7%, thereby confirming that the balance assumption is satisfied.

Subsequently, a difference-in-difference regression is executed, mirroring the structure of Equation (1), to estimate the causal impact of air quality regulations on corporate capital structure. The results, presented in Table 4, robustly reaffirm a positive relationship between exposure to air quality regulations and corporate capital structure. This confirmation serves to underscore that our principal findings are not contingent upon unobserved firm-level factors within the treated and control groups.

4.3.4 A permutation test

It might be argued that firm-level unobservables could drive the results. To alleviate these concerns, we implement a falsification test, as in Chetty et al. (2009) and Mastrobuoni and Pinotti (2015). We randomly assign the treatment variable to the sample firms and construct the false treatment variable *ULES_False*. Then, we re-estimate Equation (1). Given the randomization of our data-generating process, the interaction between the new treatment variable and the policy dummy, *ULES_False*×*Post,* is supposed to have no impact on corporate capital structure. Following Mastrobuoni and Pinotti (2015), we repeat the data-generating process and re-estimate the model 500 times to reduce noise contamination. Figure 3 plots the estimated results. The blue hollow circles are a scatter plot, with each circle showing the point estimate on the x-axis and the associated *p* value on the y-axis. If our baseline results were determined by coincidence or firm-level unobservables, then the estimates from the randomization check should be close to the estimate based on the real data (reflected by the vertical red dashed line). However, most of the estimates from the randomization check are not close to the estimate derived from the true data. In fact, the estimates center around zero, with the majority of their *p*-values being greater than 10%. This suggests that the increase in the debt ratio after the introduction of air quality regulations is not a coincidence. These results verify that our main findings are not determined by firm-level unobserved factors.

[Insert Figure 3 here]

4.3.5 Other regulatory policies

In the presence of additional policies that influence firms' air pollution emissions, the accuracy of our estimates may be compromised. This section explores the potential for these policies to introduce confounding variables that could alter our primary findings. Among these policies, the most significant are the Twelfth Five-Year Plan (FYP) for National Economic and Social Development, a goal-setting initiative of the central government aimed at reducing energy intensity across all provinces from 2011 to 2015 (Mao et al., 2023). The second significant policy is the implementation of carbon emission trading scheme (ETS) pilots on a regional scale. Launched in 2013, this policy seeks to regulate the carbon emissions of participating firms. Prior studies indicate that this policy has led to a reduction in coal consumption and carbon emissions among these firms (Cui et al., 2021).

To ensure that our findings on the ultra-low emission standards are not influenced by these broader policies, we incorporate additional controls related to energy policy in our regression analysis. Furthermore, we exclude firms participating in the ETS from our sample and rerun the regressions. The results presented in Table 5 demonstrate that our statistical inferences remain unchanged, indicating that the policy's impact is robust and not influenced by these additional policies.

4.4 Heterogeneous analysis

Thus far, we have analyzed the impact of air quality regulations on corporate capital structure. In this section, we extend our investigation by examining whether the debt ratios differ with the diverse characteristics of firms. We employ several heterogeneous analyses as follows: (1) government ownership, (2) financial constraints, and (3) industry heterogeneity.

4.4.1 Government ownership

A unique feature of the Chinese capital market is its concentration of government ownership, with state-owned enterprises (SOEs) constituting a large proportion of listed firms in China (Tang, 2020). SOEs are controlled by the government and are likely to have complied with environmental standards even before stringent air quality regulations were promulgated (Clò et al., 2017; Zhang and Zhao, 2022). With enhanced air quality regulations, non-SOEs experience relatively larger rising environmental compliance cost than SOEs; thus, they may have greater motivations for taking on debt to support their operations. Therefore, we expect there to be a larger impact of air quality regulations on corporate capital structure among SOEs as opposed to non-SOEs.

The full sample was stratified into two distinct groups: the SOE group and the non-SOE group. The results of this segmentation are presented in Panel B of Table 6. Notably, the coefficient associated with the interaction term between *ULES* and *Post* exhibits a greater magnitude for non-SOEs in comparison to SOEs. This disparity in coefficients is statistically significant (p-value = 0.015), suggesting a differential impact of air quality regulations on corporate capital structure based on government ownership. The discernible pattern indicates that the influence of air quality regulations is more pronounced among firms with lower government ownership. This finding aligns with the notion that, in order to comply with the emission standards, non-SOEs must invest more substantially in pollution abatement and equipment upgrades than their SOE counterparts. Consequently, non-SOEs exhibit a more assertive posture in the debt market as a strategic response to these regulatory pressures.

4.4.2 Financial constraints

The literature has established that financial constraints are a significant driver of firms' capital structure variations. This is because financially constrained firms face challenges in accessing external credit. This was confirmed by Graham and Leary (2011) and Liu et al. (2021a). In the face of cost shocks, unconstrained firms can borrow more debt to mitigate financial distress. However, financially constrained firms struggle to do so. Given this, we seek to explore how debt ratios vary among firms facing different financial constraints. We predict that unconstrained firms will find it easier to access external finance, making them more responsive to air quality regulations.

We classify firms into two groups based on the extent of their financial difficulties, proxied by the SA index created by Hadlock and Pierce (2010). We calculate the SA index using data at the end of 2013. Larger values of the index indicate a greater level of financial constraint. A firm is placed in the high (low) constrained group if its SA index is above (below) the sample median. We re-estimate the DID Equation (1) for each group of firms. Panel A of Table 6 shows that the impact of the air quality regulations on corporate capital structure is more pronounced in firms with low financial constraints, because the coefficients in column (2) are larger relative to those in column (1). The difference in these coefficients is statistically significant at conventional levels (p-value = 0.011). This indicates that financially unconstrained firms assume more debt as a result of the implementation of the air quality regulation.

4.4.3 High-polluting Industries

Firms operating in high-emission industries exhibit greater sensitivity to the intensification of environmental regulations compared to those in low-emission sectors (Nguyen and Phan, 2020; Mao et al., 2023). Stricter environmental policies, such as the implementation of ultra-low emission standards, impose substantial compliance costs on high-pollution industries, necessitating significant capital expenditures on pollution control technologies and equipment. These investments can deplete financial resources, diminishing the competitiveness of these firms relative to their counterparts in low-pollution industries, and consequently reducing their borrowing capacity from financial institutions. Furthermore, Chinese banks have increasingly incorporated environmental risks into their loan approval processes (Fan et al., 2021).[6] As a result, firms in high-polluting industries, such as steel, cement, and petrochemicals, have encountered higher interest rates and diminished access to bank financing (Huang et al., 2021; Chai et al., 2022). These sectors, which were once pivotal to China's economic growth, now face growing challenges in securing financial

[6] In 2012, China significantly intensified the enforcement of green credit regulations, making firms' environmental performance a critical factor for banks when determining loan amounts and interest rates. As a result, Chinese banks markedly curtailed their lending to heavy-polluting industries.

support. Consequently, we predict that the positive association between air quality regulation and corporate financial leverage will be more pronounced within low-polluting industries.

The full sample was stratified into two distinct groups: the heavy-emitter group and the light-emitter group. The heavy-emitter group consists of six industries that are among the most egregious sources of air pollutants, including thermal power, steel, petrochemicals, cement, non-ferrous metals, and chemicals, while the light-emitter group comprises the remaining industries. The results of this stratification are detailed in Panel C of Table 6. Importantly, the coefficient on the interaction term between *ULES* and *Post* is larger for the light-emitter group compared to the heavy-emitter group. This difference in coefficients is statistically significant (p-value = 0.068), indicating a differential effect of air quality regulations on corporate capital structure across industries. The observed pattern suggests that the positive relationship between investment-oriented regulation and corporate debt ratios is more pronounced among low-pollution firms. This finding suggests that firms in low-polluting industries are better placed to secure financing compared to their counterparts in high-polluting industries.

4.4.4 Trade Credit

Trade credit, extended by sellers to buyers for goods purchases, represents a strategic investment that defines supply chain relationships (Frennea et al., 2019; Astvansh and Jindal, 2022). It enables customers to receive goods or services with deferred payment, rather than requiring payment at the time of sale. As a major source of short-term financing, trade credit serves as a substitute for bank credit (Huang et al., 2011; Lau and Schaede, 2020; Jin et al., 2024) and plays a crucial role in supporting firms during liquidity shocks (Cunat, 2007). Firms relying more heavily on trade credit may be less inclined to seek debt financing when faced with liquidity challenges arising from air quality regulations. Therefore, we hypothesize that the positive relationship between air quality regulations and corporate financial leverage will be stronger for firms with lower reliance on trade credit.

Following Dang et al. (2024), we measure trade credit using the difference between accounts payable and accounts receivable, scaled by total assets. Firms are classified into high and low groups based on whether their trade credit surpasses or falls below the sample median as of the end of 2013. The results, as presented in Panel C of Table 6, emphasize the significance of the interaction term *ULES* × *Post*, especially for firms with lower trade credit reliance, where the coefficient is both significant and larger than for their higher-reliance counterparts. This difference, statistically significant with a *p*-value of 0.065, indicates a stronger response to air quality regulations among firms with lower levels of supply chain financing.

These findings suggest that firms with lower trade credit are more likely to increase debt levels compared to firms with higher trade credit, aligning with previous research showing that trade credit can serve as a substitute for bank credit and buffer against liquidity shock (Huang et al., 2011; Lau and Schaede, 2020; Jin et al., 2024).

5 Mechanism Analysis

In the preceding sections, we established a positive impact of the ultra-low emission standards on corporate debt ratios. Now, we examine potential mechanisms that may elucidate this effect. Drawing from the pecking order theory, debt is considered the preferred source of external financing in the absence of retained earnings (Myers, 1984; Myers and Majluf, 1984). Furthermore, the funding horizon theory posits that firms resort to debt to address transient cash requirements while opting for equity issuance to meet enduring funding needs (DeAngelo et al., 2011; Huang and Ritter, 2021). In this study, we put our hypothesis to the test: following the enactment of the ultra-low emission standards, manufacturing firms exhibit an increased propensity to address cash flow shortages through debt financing, thereby leading to an overall surge in financial leverage.

5.1 Cash Needs Incentives

Initially, we evaluate how the policy influenced the affected firms' cash needs. Given that manufacturers are mandated to enhance pollution control measures and transition to energy efficient technology after adoption of the emission limits, it is expected that these expenditure will result in elevated operating cost and, subsequently, reductions in free cash flow and cash reserves. In columns (1) - (3) of Table 7, we present the estimates derived from the DID models for operating cost, cash holdings, and free cash flow, respectively.

Consistent with our hypotheses, the impact of the policy on production costs is both statistically and economically significant. After the policy implementation, firms witnessed a significant increase in operating costs, amounting to 1.02% relative to the sample means (0.007/0.689). Additionally, the program's effect on cash holdings and free cash flow is negative and statistically significant, indicating an immediate depletion of cash resources. In summary, our analysis suggests that firms grapple with escalating costs and pressing liquidity needs subsequently to the introduction of air quality regulations.

The trade-off theory posits that increased distress risk incentivizes firms to reduce debt financing (Kraus and Litzenberger, 1973; Bradley et al., 1984; Agrawal and Matsa, 2013). We examine whether distress risk influences firms' financing decisions in this context, employing three proxies to measure distress risk. The first proxy is the Altman Z-score (Altman, 1968), where a lower Z-score indicates a higher risk of default. The second is operating leverage, as defined by Chen et al. (2022), calculated as the ratio of fixed costs (comprising depreciation, amortization, and selling, general, and administrative expenses) to lagged assets. Higher operating leverage is associated with greater distress risk (Serfling, 2016; Kahl et al., 2019). The third measure is distance-to-default, following the methodology of Bharath and Shumway (2008). Columns (4) to (6) of Table 7 present the estimates from the DID models for distress risk using these three measures. The results indicate that the coefficients on the interaction term are not statistically significant, suggesting that the distress risk for the affected firms did not increase significantly following the implementation of ultra-low emission standards. Taken together, these findings imply that the cash flow needs of the firms outweighed the incentives to reduce distress risk, thereby leading to higher financial leverage among the affected firms.

5.2 The Nature of Cash Needs

The investigation into the essential nature of cash requirements among manufacturing firms subject to the emission limits reveals specific obligations mandated by the air quality regulation. These obligations include the acquisition of energy-efficient boilers, installation of desulfurization systems, and the upgrading of dust removal facilities. Notably, the cash needs associated with these tangible asset purchases are considered transient compared to those linked to activities such as operating losses, research and development (R&D)

spending or innovation activities. According to the funding horizon theory, firms with immediate and short-term investment requirements tend to prefer raising debt over issuing equity (DeAngelo et al., 2011; Huang and Ritter, 2021).

The research aims to identify the origins of cash requirements, specifically whether they arise from capital expenditure, R&D spending, or operating losses. The summarized findings in columns (1)-(5) of Table 8 indicate that, following the implementation of the air quality regulations, firms experienced a significant increase in capital investment. However, operating profits, R&D spending and innovation activities did not show statistically significant influences attributable to the introduction of air quality regulations.

This observation may be attributed to the fact that expanding capital expenditure on pollution control equipment and upgrading industrial boilers delivers immediate air quality benefits and is often less costly than investing in green innovation. Consequently, many companies opted to acquire energy efficient and environmentally friendly equipment rather than allocating funds to green innovation projects during the implementation of the ultra-low emission standards. These findings shed light on the prioritization of immediate air quality improvements through tangible asset investments over longer-term and potentially costlier green innovation initiatives.

6 Conclusion

In this paper, we undertake an investigation into the influence of environmental policy risk on corporate financing decisions. By utilizing the implementation of China's ultra-low emission standards as a quasi-natural experiment, our findings indicate that more stringent environmental regulations lead to higher financial leverage for corporations. Our cross-sectional analysis suggests that this impact is particularly pronounced for firms with lower levels of government ownership, fewer financial constraints, and those operating in low-polluting industries and those with lower levels of reliance on trade credit.

Furthermore, we have deconstructed the underlying mechanism that links air quality regulations to corporate financing choices. The strengthening of environmental protections mandated by the emission limits has driven firms to increase their capital expenditure on pollution abatement and equipment upgrading. Firms with immediate and short-term cash needs, arising from tangible asset investments, exhibit a preference for debt issuance over equity issuance, aligning with the principles of the funding horizon theory (DeAngelo et al., 2011; Huang and Ritter, 2021).

Our research presents novel evidence of corporate financial behavior in response to environmental regulations. While extant literature predominantly explores cost-centric regulatory frameworks, this study shifts the focus to the impact of enhanced emission standards — an investment-oriented environmental policy that requires significant capital outlays for sustainable operations. The findings demonstrate a positive association between such investment-driven policies and corporate financial leverage, lending empirical support to the funding-horizon theory, which emphasizes the role of firms' cash needs in shaping financing decisions.

This study highlights the operational risks posed by transitioning to stricter environmental regulations, emphasizing the need for firms to adapt their financial and operational strategies. Future research endeavors may explore the causal effects of investment-oriented environmental regulations on various aspects of corporate operations management, including product offering and supply chain strategies. This line of inquiry can provide further insights into the dynamics of corporate responses to evolving environmental policies.

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Figures and Tables

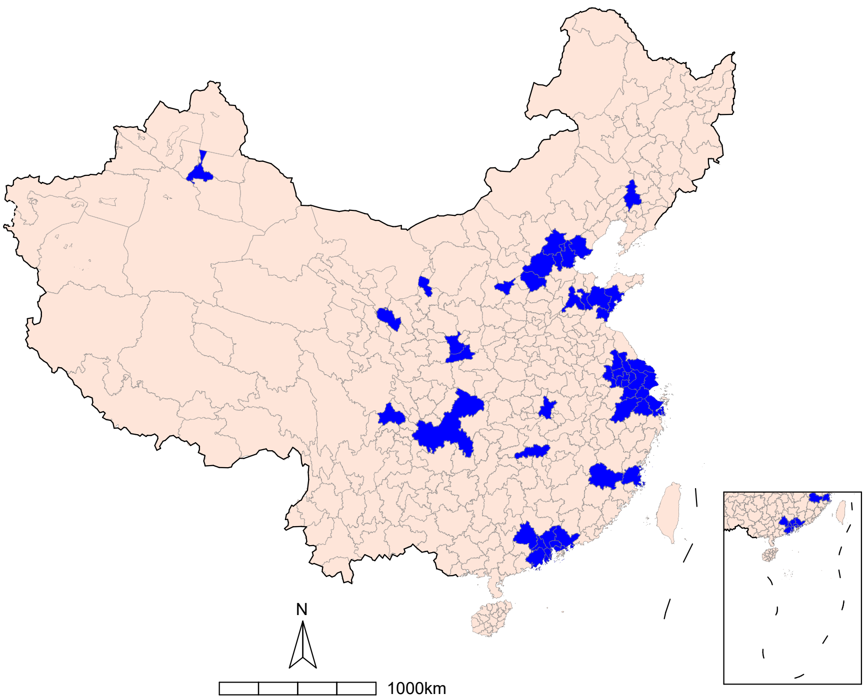

Figure 1　The Pilot Cities

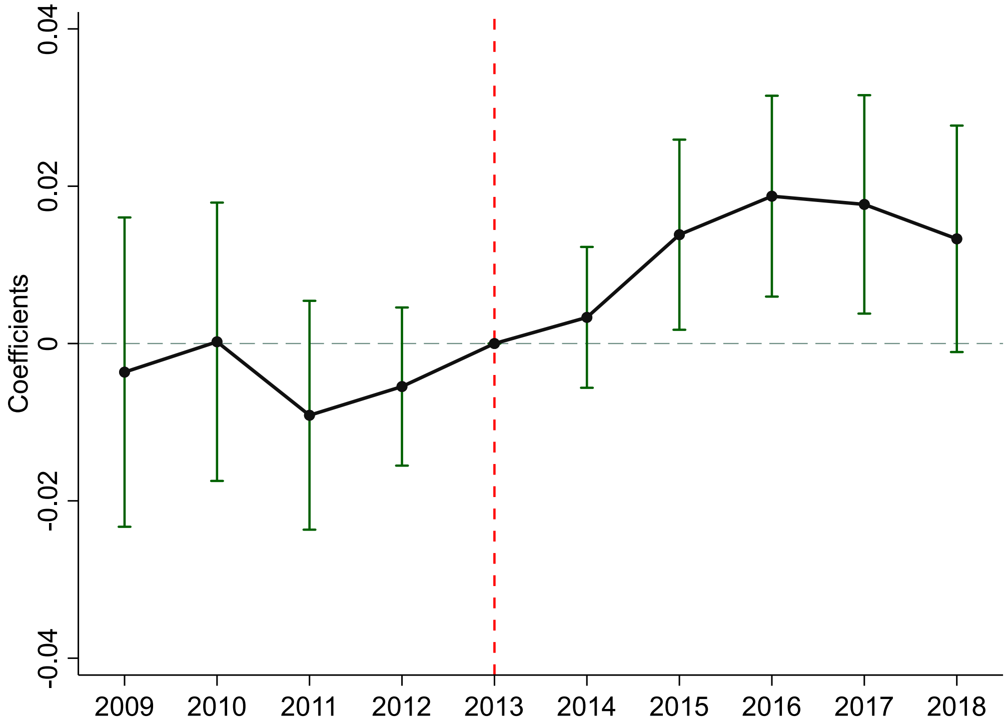

Figure 2 Dynamic effects of the implementation of the China's ultra-low emission standards

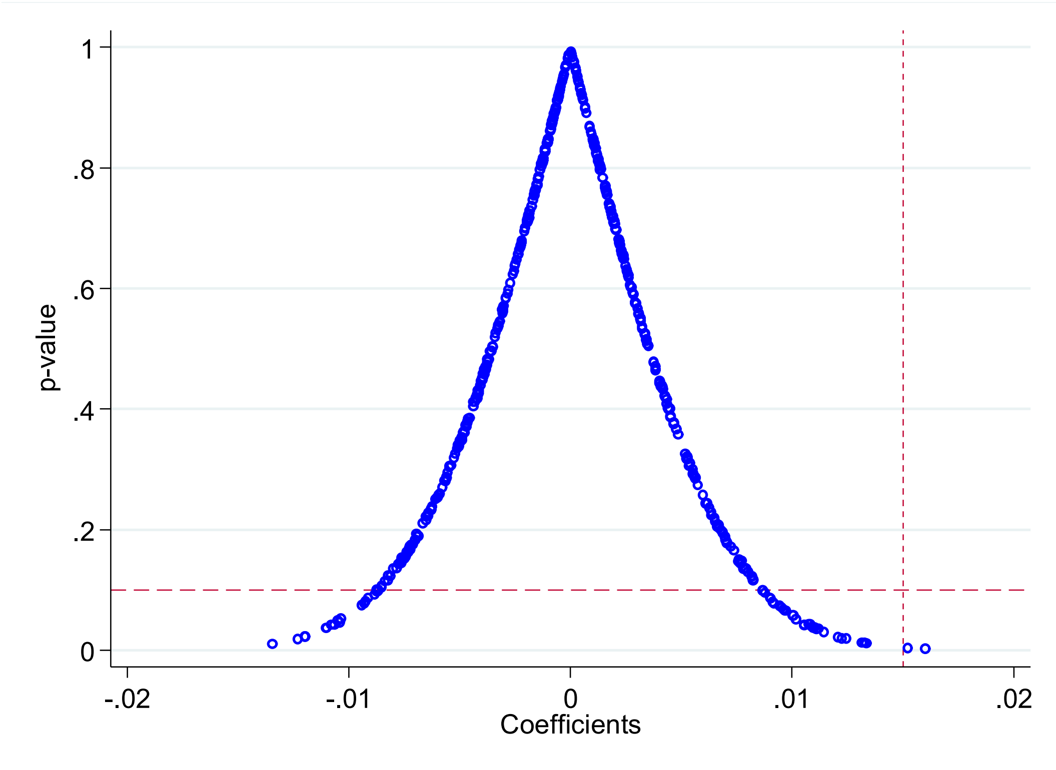

Figure 3 A Permutation Test

Note: This figure shows the results from a permutation test that randomly assigns treated firms and re-estimates Equation (1) 500 times. The blue hollow circles are a scatter plot, with each circle showing the point estimate on the x-axis and the associated *p* value on the y-axis. The solid line plots the density distribution of the point estimates.

Table 1 Summary Statistics

Variables		Mean	SD	P25	Median	P75
Dependent variables						
Book Leverage	17145	0.178	0.173	0.019	0.137	0.288
Control variables						
Firm Size	17145	7.599	1.222	6.728	7.497	8.353
ROA	17145	0.073	0.055	0.031	0.061	0.102
Tangibility	17145	0.229	0.129	0.13	0.209	0.31
Intangibles	17145	0.047	0.033	0.023	0.039	0.061
Cash Flow	17145	0.069	0.074	0.021	0.061	0.111
Revenue Growth	17145	0.176	0.245	0.026	0.139	0.281
GDP Growth	17145	0.107	0.062	0.076	0.1	0.127
$PM_{2.5}$	17145	3.784	0.319	3.575	3.784	3.994
Additional dependent variables						
Short Book Leverage	17145	0.124	0.13	0.004	0.088	0.2
Long Book Leverage	17145	0.054	0.091	0	0.003	0.077
Operating Cost	16808	0.689	0.153	0.609	0.714	0.801
Cash Holding	16802	0.193	0.127	0.1	0.159	0.251
Free Cash Flow	16788	-0.008	0.096	-0.065	-0.002	0.053
Z-score	12039	5.343	4.899	2.394	3.737	6.316
Operating Leverage	12568	0.144	0.086	0.086	0.122	0.173
Distance-to-default	12019	10.479	4.243	7.156	9.618	13.343
Total Investment	16801	0.08	0.069	0.03	0.06	0.11
Operating Profit	16692	0.08	0.059	0.035	0.067	0.114
R&D Expenditure	15837	0.032	0.023	0.017	0.028	0.043
Green Innovation 1	12388	0.327	0.729	0	0	0
Green Innovation 2	12388	0.25	0.596	0	0	0

Notes: This table presents the descriptive statistics of the key variables for the full sample, including the mean and standard deviation, among many others. All variable definitions are shown in Appendix B.

Table 2 Baseline Results

VARIABLES	Book Leverage		
	(1)	(2)	(3)
ULES× *Post*	0.025***	0.017***	0.017***
	(0.006)	(0.005)	(0.005)
Size		0.059***	0.059***
		(0.005)	(0.005)
ROA		-0.040	-0.040
		(0.039)	(0.039)
Tangibility		0.116***	0.116***
		(0.021)	(0.021)
Intangibles		0.547***	0.547***
		(0.061)	(0.061)
Cash Flow		-0.155***	-0.155***
		(0.019)	(0.019)
Revenue Growth		0.071***	0.071***
		(0.005)	(0.005)
GDP Growth			0.026
			(0.020)
$PM_{2.5}$ *Concentration*			0.003
			(0.010)
Constant	0.169***	-0.327***	-0.340***
	(0.002)	(0.039)	(0.054)
Firm FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	17,145	17,145	17,145
Adjusted R-squared	0.633	0.664	0.664

Notes: The dependent variable is *Book Leverage*, measured as the book value of long-term debt plus debt in current liabilities divided by the book value of total assets. *ULES* is an indicator that equals one if a firm is headquartered in a pilot city. *Post* is an indicator that equals zero in 2009-2013 and one in 2014-2018. See Appendix A for more details of the variable constructions. Standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3 Impact on Debt Maturity Structure

VARIABLES	Short-term Book Leverage	Long-term Book Leverage
	(1)	(2)
ULES × Post	0.010**	0.006**
	(0.004)	(0.003)
Controls	Yes	Yes
Firm FE	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
Observations	17,145	17,145
Adjusted R-squared	0.612	0.566

Notes: In Column (1), the dependent variable is *Short-term Book Leverage*, which is measured as the debt in current liabilities divided by the book value of total assets. In Column (2), the dependent variable is *Long-term Book Leverage*, which is measured as the book value of long-term debt divided by the book value of total assets. *ULES* is an indicator that equals one if a firm is headquartered in a pilot city. *Post* is an indicator that equals zero in 2009-2013 and one in 2014-2018. See Appendix A for more details of the variable constructions. Standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4 Results from a matched difference-in-differences model

VARIABLES	Book Leverage		
	(1)	(2)	(3)
ULES × *Post*	0.024***	0.017***	0.016***
	(0.006)	(0.005)	(0.005)
Controls	No	Yes/No	Yes
Firm FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	16,885	16,885	16,885
Adjusted R-squared	0.631	0.662	0.662

Notes: This table reports the result of the difference-in-difference regression on the basis of the propensity score matched subsample. The dependent variable is *Book Leverage*, measured as the book value of long-term debt plus debt in current liabilities divided by the book value of total assets. *ULES* is an indicator that equals one if a firm is headquartered in a pilot city. *Post* is an indicator that equals zero in 2009-2013 and one in 2014-2018. Column (1) has no controls; column (2) includes *Size*, *ROA*, *Tangibility*, *Intangibles*, *Flow*, and *Growth* as controls; column (3) additionally adds city-level GDP growth and the concentration of PM2.5 to the controls. See Appendix A for more details of the variable constructions. Standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5 Excluding Confounding Policies

VARIABLES	Book Leverage	
	(1)	(2)
ULES × Post	0.019***	0.015***
	(0.006)	(0.005)
Goal × Post	0.048	
	(0.034)	
Controls	Yes	Yes
Firm FE	Yes	Yes
City FE	Yes	Yes
Year FE	Yes	Yes
Observations	17,145	16,166
Adjusted R-squared	0.664	0.663

Notes: The dependent variable is *Book Leverage*, measured as the book value of long-term debt plus debt in current liabilities divided by the book value of total assets. *ULES* is an indicator that equals one if a firm is headquartered in a pilot city. *Post* is an indicator that equals zero in 2009-2013 and one in 2014-2018. *Goal* is the provincial reduction goals in energy intensity during Twelfth Five-Year Plan (FYP). In Column (2), firms participating in the ETS are excluded from our sample. See Appendix A for more details of the variable constructions. Standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6 Heterogeneous Impacts

	Panel A: Ownership		Panel B: Financial Constraint		Panel C: High-polluting		Panel D: Trade Credit	
	SOE	Non-SOE	High	Low	Yes	No	High	Low
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ULES× Post	-0.007	0.018***	0.005	0.029***	-0.005	0.018***	0.009	0.023***
	(0.011)	(0.007)	(0.007)	(0.008)	(0.013)	(0.006)	(0.008)	(0.007)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,094	11,671	7,462	9,683	2,820	14,325	5,507	11,638
Adj R-squared	0.724	0.640	0.683	0.631	0.696	0.635	0.690	0.659
P-value	0.015		0.008		0.068		0.065	

Notes: The dependent variable is *Book Leverage*, measured as the book value of long-term debt plus debt in current liabilities divided by the book value of total assets. *ULES* is an indicator that equals one if a firm is headquartered in a pilot city. *Post* is an indicator that equals zero in 2009-2013 and one in 2014-2018. In Panel A, we divide the full sample into two subsamples, namely, an SOE subsample and a non-SOE subsample. In Panel B, we measure financial constraint by using the SA index (Hadlock and Pierce, 2010). A firm is included in the high (low) constrained group if its SA index is above (below) the sample median at the end of 2013. In Panel C, the high-polluting group consists of six industries, namely, thermal power, steel, petrochemicals, cement, non-ferrous metals, and chemicals, while the low-polluting group comprises the remaining industries. In Panel D, we measure trade credit by using the difference between accounts payable and account receivables divided by assets.A firm is included in the high (low) group if its value of trade credit is above (below) the sample median at the end of 2013. See Appendix A for more details of the variable constructions. All standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7 The Impact on Corporate Cash Needs

VARIABLES	Operating Cost (1)	Cash Holding (2)	Free Cash Flow (3)	Z-score (4)	Operating Leverage (5)	Distance-to-default (6)
ULES × Post	0.007**	-0.012***	-0.011***	-0.088	0.003	-0.136
	(0.003)	(0.005)	(0.003)	(0.183)	(0.002)	(0.136)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,798	16,793	16,773	11,954	12,467	11,929
Adjusted R-squared	0.911	0.543	0.172	0.650	0.711	0.460

Notes: This table investigates the impact of China's ultra-low emission standards on firms' cash needs. In Column 1, the dependent variable is operating cost, measured as the cost of goods sold (COGS) divided by sales. In Column 2, the dependent variable is the cash holding, measured as cash and short-term investments divided by lagged assets (Bliss et al. 2015; Amberg et al., 2021). In Column 3, the dependent variable is the free cash flow, measured as operating cash flow minus capital expenditure divided by lagged assets (Richardson, 2006). In Column 4, the dependent variable is Altman *Z-scor*e, in which a lower *Z-score* implies a higher risk of default. In Column 5, the dependent variable is operating leverage, which is proxied by the ratio of fixed costs (measured by depreciation and amortization plus selling, general, and administrative expenses) to the lagged assets. In Column 6, the dependent variable is distance-to-default, constructed following Bharath and Shumway (2008). See Appendix A for more details of the variable constructions. All standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8 The Nature of Cash Needs

VARIABLES	Total Investment	Operating Profit	R&D	Green Innovation 1	Green Innovation 2
	(1)	(2)	(3)	(4)	(5)
ULES × Post	0.007***	-0.001	0.000	-0.031	-0.020
	(0.002)	(0.002)	(0.001)	(0.027)	(0.023)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	16,788	16,673	15,799	12,315	12,315
Adjusted R-squared	0.421	0.706	0.736	0.623	0.619

Notes: In column (1), the dependent variable is *Total Investment*, which is measured as the expenditure on capital and intangible assets divided by lagged assets. In column (2), the dependent variable is *Operating Profit*, which is measured by EBIT (earnings before interest and tax) divided by lagged assets. In column (3), the dependent variable is *R&D*, which is measured by R&D expenditure divided by lagged assets. In column (4), the dependent variable is *Green Innovation 1*, which is calculated as the natural logarithm of one plus the number of green patents application. In column (5), the dependent variable is *Green Innovation 2*, which is calculated as the natural logarithm of one plus the number of green patents granted. See Appendix A for more details of the variable constructions. Standard errors in parentheses are clustered at the firm level. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix A: Description and definition of key variables

Book Leverage = the book value of long-term debt plus debt in current liabilities divided by the book value of total assets.

Short-term Book Leverage = the debt in current liabilities divided by the book value of total assets.

Long-term Book Leverage= the book value of long-term debt divided by the book value of total assets.

Size = logarithm of firm's total asset.

ROA = ratio of net profits over total assets.

Tangibility = fixed assets divided by total assets

Intangibles = intangible asset divided by total assets

Cash Flow = operating cash flow divided by total assets

Sales Growth = growth rate of sales revenue

GDP Growth = city-level GDP growth

$PM_{2.5}$ = the concentration of $PM_{2.5}$ at the city level

Operating Cost = cost of goods sold (COGS) divided by sales

Cash Holding = cash and short-term investments divided by lagged assets

Free Cash Flow = operating cash flow subtracting capital expenditure divided by lagged assets

Z-score= Altman Z-score, in which a lower Z-score implies a higher risk of default

Operating Leverage = the ratio of fixed costs (measured by depreciation and amortization plus selling, general, and administrative expenses) to the lagged assets.

Distance-to-default = distance-to-default measure constructed following Bharath and Shumway (2008).

Total Investment = the expenditure on capital and intangible assets divided by lagged assets

Operating Profit = EBIT (earnings before interest and tax) divided by lagged assets

R&D = research and development expenditure divided by lagged assets

Green Innovation 1 = the natural logarithm of one plus the number of green patent applications

Green Innovation 2 = the natural logarithm of one plus the number of green patents granted.

Appendix B: Additional information on institutional background

The implementation of the ultra-low emission standards policy exerted significant effects on firms within the manufacturing sector. The policy established stringent emission limits for industrial boilers, which are major contributors to air pollution. Traditionally, industrial boilers have been widely utilized in the manufacturing sector due to their cost-effectiveness. For instance, pharmaceutical manufacturers employ coal-fired boilers for heating, steam generation, and various manufacturing processes. Consequently, manufacturers relying on industrial boilers experienced substantial impacts from the emission standards policy. These industrial boilers were extensively equipped with sulfur dioxide and particulate control devices following the enforcement of the new emission standards (Zhang et al., 2019).

The ultra-low emission standards policy also specifies stricter emission limits for several pollution-intensive industries, including thermal power, steel, petrochemicals, cement, non-ferrous metals, and chemicals. Specifically, the allowable emission limits for iron and steel production were reduced by 60%, 67%, and 40% for particulate matter, sulfur dioxide, and nitrogen oxide, respectively (Bo et al., 2021). In the non-ferrous metals industry, such as aluminum, copper, nickel, and cobalt, the ultra-low standards impose a stringent emission limit of 10 mg/m^3 for particulate matter. This new limit represents between 6.7% and 50.0% of the pre-existing emission limits for newly established firms.

To ensure compliance with the emission limits, the Chinese government established a robust monitoring and enforcement mechanism. This involved the implementation of continuous emission monitoring systems (CEMS) at the plant level and the imposition of strict penalties for non-compliance (Karplus et al., 2018; Bo et al., 2021; Yang et al., 2023). Firms found in violation of the standards face severe punishments, including financial penalties, doubled sewage charges, production reductions, and plant suspensions.

The execution of the ultra-low emission standards has, indeed, led to significant enhancements in air quality. Notably, the Beijing-Tianjin-Hebei area emerges as a standout region, experiencing the most substantial decline in $PM_{2.5}$ concentration. Over the time frame spanning 2013 to 2017, the population-weighted average $PM_{2.5}$ concentration in this area decreased by 31%, plummeting from an initial value of 96.2 to 66.4 micrograms per cubic meter.

This favorable trajectory in air quality coincided with a reduction in pollutant emissions from manufacturers, providing an opportunity to determine the causal impact of investment-oriented environmental regulations on corporate financial outcomes. The analysis of the interplay between environmental regulations and firms’ financing decisions contributes to a comprehensive understanding of the broader economic implications associated with such regulatory measures.

Appendix C: Balance test for PSM-DID

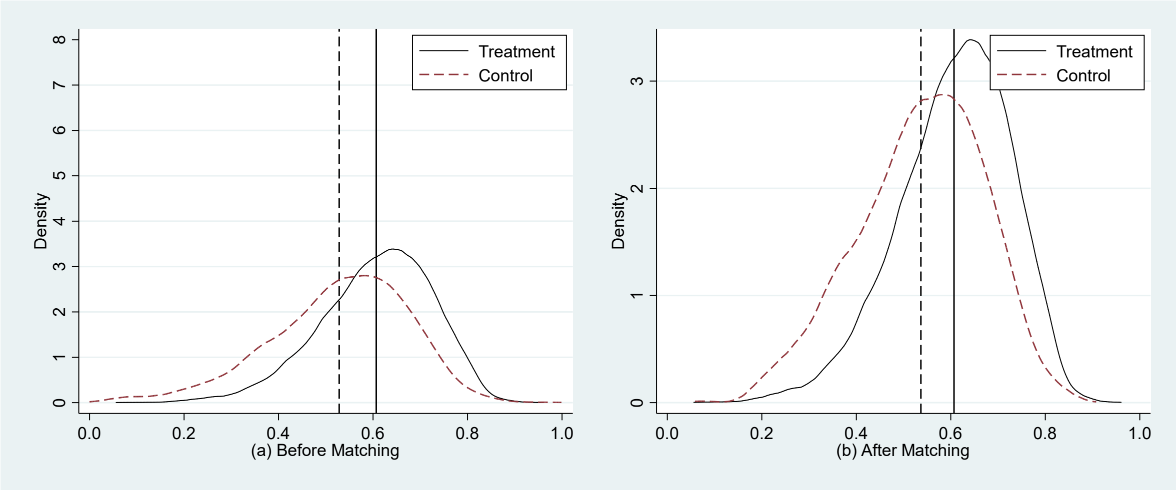

Figure C1 Propensity Score Distribution before and after Matching

Note: The figure on the left illustrates the distribution of propensity scores before the matching process, whereas the figure on the right depicts the distribution after matching. In both figures, the horizontal axis denotes the propensity scores, and the vertical axis shows the kernel density. A solid vertical line indicates the average distribution for the treatment group, while a dashed vertical line signifies the mean distribution for the control group.

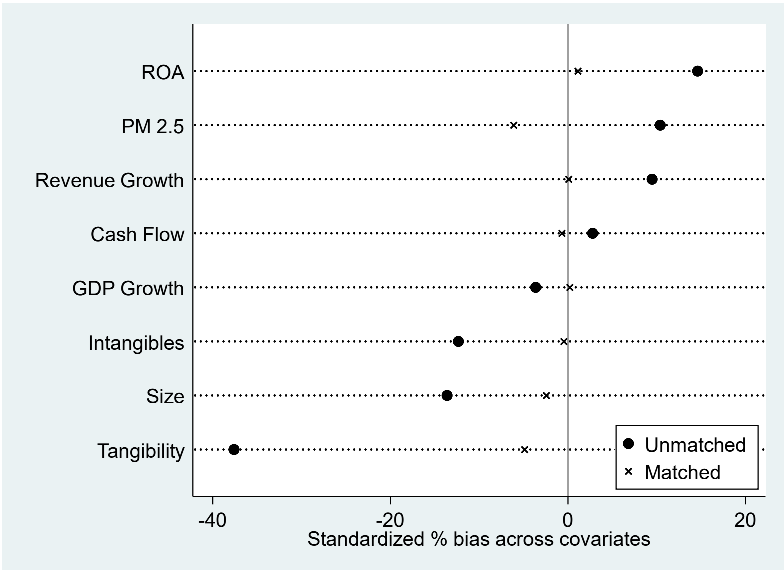

Figure C2 Comparison of Covariate Differences before and after Matching