When Carbon Exposure Becomes Strategic: Issue Activation, Climate-Policy Attention, and Innovation Search under China's Emissions Trading System[1]

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Abstract

Carbon markets price emissions, but firms exposed to the same market do not respond uniformly. We argue that this unevenness reflects issue activation: ETS exposure activates inherited carbon profiles as strategic issues, first observable in climate-policy attention and later reflected in patent-based innovation outcomes. Using China's regional emissions-trading system (ETS) and a panel of A-share listed firms from 2001 to 2024, we show that firms with higher pre-policy CO2 emissions exhibit stronger climate-policy attention after ETS exposure, including when attention is net of report length, general policy language, and uncertainty terms. The same exposure-intensity proxy is associated with higher green patent applications, green invention applications, and broader invention applications. The response is not a narrow green substitution: green innovation rises in absolute terms, while green-relative measures do not. Timing tests indicate that climate-policy attention precedes later green innovation, and this conversion is stronger among firms with higher absorptive capacity and lower financing constraints. The findings show how carbon-market exposure becomes strategic through attention allocation and capability-conditioned technical response.

Keywords: carbon markets; emissions trading; climate-policy attention; innovation search; green innovation; absorptive capacity; financing constraints; China

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1. Introduction

Carbon markets are designed as price-based instruments, yet firms exposed to the same carbon-market regime do not respond in the same way. Some firms treat regulation as background compliance. Others translate it into managerial discussion, technical response, and visible innovation activity. A common incentive cannot by itself explain that gap. The same allowance price becomes a strategic problem only for firms that treat it as one, so carbon pricing acts not only through the cost of compliance but through which firms put that cost on the managerial agenda.

We argue that carbon markets affect corporate environmental strategy by activating inherited carbon exposure as a strategic issue. The mechanism separates the policy trigger, ETS exposure, from the firm attribute it acts on: a firm's pre-policy CO2 emissions, inherited from its production processes, energy use, technology choices, and asset configurations. When these two meet, inherited emissions become tied to allowance needs, compliance risk, regulatory scrutiny, and future climate-policy uncertainty. We call this process issue activation: ETS exposure turns a firm's inherited carbon profile into an issue that managers must notice, interpret, communicate, and search around.

Prior work on carbon markets and environmental innovation has shown that emissions trading can affect technological change, although the size and form of the response vary across firms and policy designs. Borghesi, Cainelli, and Mazzanti (2015) show how emissions trading connects to environmental innovation in manufacturing, while Calel and Dechezlepretre (2016) provide evidence on directed technical change under the European carbon market. Martin, Muuls, and Wagner (2016) emphasize that firm-level evidence after a decade of EU ETS implementation remains conditional on design and exposure. The induced-innovation logic explains why carbon pricing can alter the payoff to cleaner technologies (Popp, 2002; Aghion, Dechezlepretre, Hemous, Martin, & Van Reenen, 2016).

Business-and-environment research explains why this incentive does not enter all firms in the same way. Ecological issues can be sources of constraint and strategic opportunity (Hart, 1995; Berchicci & King, 2007), but firms differ in how they interpret ecological pressures (Bansal & Roth, 2000), organize responses to environmental demands (Delmas & Toffel, 2008), and build environmental strategy under contingent firm and context conditions (Aragón-Correa & Sharma, 2003). Work on greenwashing under local regulation also reminds us that environmental communication can be symbolic rather than operational (Li, Li, Seppanen, & Koivumaki, 2023). We connect these conversations by asking how a policy instrument enters the firm as a salient issue and when that issue becomes innovation search.

The empirical setting is China's regional ETS pilots. Before the national carbon market, China launched pilot carbon markets in Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei, and Shenzhen. The pilots combined regional implementation with sectoral coverage, creating variation in exposure across firms, provinces, industries, and time. We use a listed-firm panel from 2001 to 2024 and operationalize the exposure-intensity proxy as ETS covered exposure interacted with a firm's pre-policy CO2 emissions. The main specification includes firm fixed effects, province-year fixed effects, industry-year fixed effects, and firm controls. The design compares firms within the same local-year and industry-year environments while exploiting whether carbon-market exposure activates inherited emissions as a strategic issue.

The results support the issue-activation account. ETS exposure increases climate-policy attention more strongly among firms with higher pre-policy CO2 emissions. This pattern holds when attention is net of report length, general policy terms, and uncertainty terms, and it also appears in climate-term shares and climate-to-policy term ratios. The effect therefore changes the climate-policy content of firm communication, not merely disclosure volume.

The exposure-intensity proxy is also associated with innovation-search outcomes. In inverse-probability-weighted specifications balanced on pre-treatment attention, patenting, firm fundamentals, and CO2 levels and trends, the same proxy predicts green patent applications, green invention applications, and broader invention applications. These results remain positive in nearest-neighbor matched samples and under alternative trend adjustments based on province-industry trends and pre-outcome trends.

The innovation response is broad and portfolio-expanding. Green application shares, green invention shares, green grant shares, and green-minus-non-green measures are statistically insignificant, while non-green invention applications also rise. We therefore interpret the results as evidence of broader innovation-search outcomes instead of green-only portfolio reallocation. Green innovation is central because it is directly relevant to climate strategy, but it is one observed component of a wider technical response to carbon-market exposure.

We then examine whether the timing of attention and innovation is consistent with the proposed process. Climate-policy attention at time t predicts green applications and green invention applications at t+1 and t+2, even after controlling for current innovation, ETS exposure, the ETS x pre-policy CO2 interaction, firm fixed effects, province-year fixed effects, industry-year fixed effects, and controls. The exposure-intensity association with later green innovation also attenuates once climate-policy attention is included, consistent with attention lying on the path from exposure to innovation.

Finally, we show that the conversion from attention to green innovation depends on firm conditions. The association between climate-policy attention and subsequent green invention applications is stronger among firms with higher absorptive capacity and among firms with lower financing constraints. These patterns are consistent with a strategy account in which

carbon markets activate a salient issue, but firms need technical knowledge and financing flexibility to turn attention into green inventive output.

Our main contribution is to theorize carbon markets as issue-activation mechanisms in addition to incentive mechanisms. Market-based regulation works through prices and compliance burdens, but those pressures become actionable only when they activate firm-specific attributes as issues for attention and search. This argument contributes to environmental strategy by explaining why business responses to the same climate-policy instrument vary across firms. It extends the attention-based view by identifying a contingent activation process: a market-design policy makes a measurable firm attribute, inherited carbon profile, salient through observable climate-policy text. We also refine the green innovation debate by distinguishing absolute increases in green innovation from green-relative reallocation. Carbon markets can expand innovation activity around climate-regulatory problems even when they do not raise the green share of a firm's patent portfolio. Finally, we specify the conversion conditions under which attention becomes green innovation: absorptive capacity and financing flexibility moderate the attention-to-invention link, distinguishing issue recognition from technical execution.

2. Conceptual Framework and Hypothesis Development

2.1 Regulatory activation and climate-policy attention

Carbon markets make emissions economically consequential, but the strategic consequences of that price signal depend on how firms process it. Standard induced-innovation models frame climate regulation as a shift in technological payoffs: carbon prices change the relative returns to clean and dirty technologies (Popp, 2002; Aghion, Dechezlepretre, Hemous, Martin, & Van Reenen, 2016). The Porter tradition adds that well-designed regulation can stimulate innovation that partly offsets compliance burdens (Porter & van der Linde, 1995; Ambec, Cohen, Elgie, & Lanoie, 2013), although empirical magnitudes

remain mixed (Jaffe & Palmer, 1997). A decade of emissions-trading evidence complicates that clean incentive story. Firm responses vary with allowance allocation, enforcement, market design, and exposure, and the innovation effects are uneven across firms and sectors (Borghesi, Cainelli, & Mazzanti, 2015; Calel & Dechezlepretre, 2016; Martin, Muuls, & Wagner, 2016).

This incentive logic is incomplete, because firms do not respond to every regulatory signal with equal intensity. Simon's (1947) bounded-rationality view implies that organizations cannot process all issues with equal priority. Cyert and March (1963) locate search in problems that become salient relative to organizational goals, and Ocasio's (1997) attention-based view explains how issues compete for managerial interpretation and resource allocation. A carbon market may therefore matter because it changes costs and because it changes which issues become salient inside the firm. The same ETS rule can remain a background condition for one firm and become a central strategic problem for another.

Pre-policy carbon emissions are central to this variation, but they are not a cognitive state by themselves. Before ETS implementation, emissions reflect inherited production processes, energy use, technology choices, and asset configurations. Building on the strategic-issue tradition, in which managerial action depends on how managers categorize issues and place them on strategic agendas (Dutton & Jackson, 1987; Dutton, 1988), we treat ETS exposure as the event that reclassifies a firm's dormant emissions profile as a strategic issue. The firm may need to evaluate allowance needs, compliance exposure, energy-saving retrofits, carbon-management systems, cleaner equipment, green R&D projects, supplier adjustments, and future disclosure commitments. Empirically, we proxy this activation with the interaction of ETS exposure and pre-policy CO2 emissions. The interaction measures how strongly exposure should make a firm's emissions salient, not the managerial cognition it sets off.

The question is then not whether ETS raises green innovation on average, but how the regulation enters firm strategy in the first place. Attention-based theory implies that salient issues are more likely to be noticed, interpreted, and encoded in organizational communication and decision routines (Ocasio, 1997; Hoffman & Ocasio, 2001). The first observable response should therefore be greater attention to climate-policy issues, and specifically to climate-policy content rather than longer reports, generic policy language, or broad ESG rhetoric. Annual reports and related corporate texts are not direct observations of boardroom cognition, but they are externally visible traces of which issues firms choose to process and communicate.

Hypothesis 1. ETS exposure will induce larger increases in climate-policy attention among firms with higher inherited carbon profiles than among firms with lower inherited carbon profiles.

2.2 Activated carbon exposure and innovation-search outcomes

Issue activation first shows up in corporate rhetoric, but attention is itself a precursor to action. Once an issue is salient, firms must search for responses. Behavioral theories of the firm treat search as a response to problems that become salient relative to organizational goals and constraints (Cyert & March, 1963; March, 1991). The default prediction in this tradition is often local search: organizations look first near familiar technologies, routines, and problem definitions. For high-emission firms exposed to ETS, however, the problem extends beyond whether to buy allowances or absorb costs. Managers must interpret future allowance prices, identify abatement paths, evaluate process changes, and decide whether technical experimentation is worthwhile under policy uncertainty.

Green patents are the natural margin to examine because they link climate regulation directly to technological change. Yet carbon-market exposure can make local search insufficient. ETS affects allowance planning, production processes, energy systems, supplier

choices, asset configurations, and disclosure commitments at the same time, while future carbon prices and compliance expectations remain uncertain. This combination can broaden patenting activity around the carbon-regulatory issue rather than solve a single narrow abatement problem. Firms may pursue process improvements, efficiency-oriented inventions, general equipment upgrades, energy-management systems, or adjacent technical projects that support adaptation without being classified as green patents. Hart's (1995) natural-resource-based view connects environmental problems to capability development. Bansal and Roth (2000) show that ecological responsiveness can involve multiple motives, while Delmas and Toffel (2008) open the organizational black box of responses to environmental demands. A green-only outcome would miss part of that response portfolio.

ETS is not a single-outcome treatment; it opens several technical margins at once. Firms facing ETS-activated exposure may generate green inventions, but they may also expand adjacent non-green invention as they reconfigure production systems, improve energy efficiency, change equipment, or modify technical routines. The expected response is therefore an expansion of observed innovation activity around the technological implications of carbon regulation.

Accordingly, the theory predicts absolute increases in green innovation outcomes and broader inventive activity. A stronger green share would imply a narrower directed-green-substitution story. The broader-search prediction is more consistent with a setting in which firms explore multiple technical responses to climate regulation. We measure outputs, patent counts, and interpret them as observable traces of innovation search; the internal search process itself is not observed. Green-relative tests therefore bound the claim.

Hypothesis 2a. Following ETS exposure, firms with higher inherited carbon profiles will show larger absolute increases in green innovation outcomes than firms with lower inherited carbon profiles.

Hypothesis 2b. Following ETS exposure, firms with higher inherited carbon profiles will show broader patent-based inventive activity than firms with lower inherited carbon profiles, consistent with search-portfolio expansion rather than green-only reallocation.

2.3 Climate-policy attention and subsequent innovation

If issue activation works through attention, attention should precede at least part of the innovation response. Issues that attract managerial attention are more likely to shape information gathering, project evaluation, and resource allocation. When climate-policy issues become salient, firms have stronger reasons to assess abatement options, learn about regulatory requirements, evaluate cleaner technologies, and initiate technical search. These activities need not produce immediate patents because innovation requires problem definition, experimentation, internal approval, application, and in some cases examination before grants are observed.

We treat climate-policy attention as temporal channel evidence. Attention is a post-treatment firm response and may reflect managerial interpretation, disclosure choices, investor communication, or regulatory signaling. Disclosure-based climate-policy attention therefore traces issue prioritization rather than measuring it directly. If this trace predicts later innovation outcomes after accounting for current innovation and exposure intensity, the sequence is consistent with the idea that carbon-market regulation becomes actionable through attention more than symbolic disclosure alone.

Hypothesis 3. Observable climate-policy attention will precede subsequent green innovation outcomes, consistent with attention serving as an observable trace of issue prioritization that guides technical response.

2.4 Converting attention into green innovation

Attention makes search more likely, but it does not guarantee green innovation. Firms vary in their ability to convert climate-policy attention into technical output. Two conditions are especially relevant: absorptive capacity and financing flexibility.

Absorptive capacity captures a firm's ability to recognize valuable external information, assimilate it, and apply it to commercial or technological ends (Cohen & Levinthal, 1990). In this paper, absorptive capacity is not a generic innovation advantage. It is the ability to decode an unfamiliar climate-policy signal and translate it into specific technological trajectories that can support patentable green invention. Recent research similarly treats green absorptive capacity as a condition that helps firms turn green orientation and innovation into competitive advantage (Shehzad, Zhang, Naveed, Zia, & Sherani, 2024). Firms with stronger R&D routines and technical knowledge should be better able to connect allowance needs, abatement options, and process constraints to patentable green invention. Firms with weaker absorptive capacity may notice the issue but lack the knowledge base needed to transform attention into experimentation.

Financing flexibility shapes the same conversion process from the resource side. Green invention can be costly, uncertain, and slow to pay off. Firms must fund experimentation, absorb failure risk, and sustain projects long enough for applications and grants to emerge. Financial constraints can weaken environmental innovation even when the strategic issue is recognized (Hall, 2002; Brown, Martinsson, & Petersen, 2012). Firms with fewer financing constraints should be better positioned to act on climate-policy attention because they can sustain green-search projects long enough for their option value to be realized instead of abandoning them at early stages.

The conversion from attention to green innovation should therefore be strongest when firms have both the knowledge base and the financial flexibility to act. The moderators are not added because capable and unconstrained firms innovate more in general; they are boundary

conditions for turning attention into funded technical experimentation under climate-policy uncertainty. The contingent natural-resource-based view emphasizes that environmental-strategy outcomes depend on firm and context conditions (Aragón-Correa & Sharma, 2003). We specify the contingency at the attention-conversion stage: capability and financing condition whether climate-policy attention becomes green invention, not whether ETS exposure first becomes noticeable.

Hypothesis 4a. Firms with higher absorptive capacity will show a stronger conversion of climate-policy attention into subsequent green innovation than firms with lower absorptive capacity.

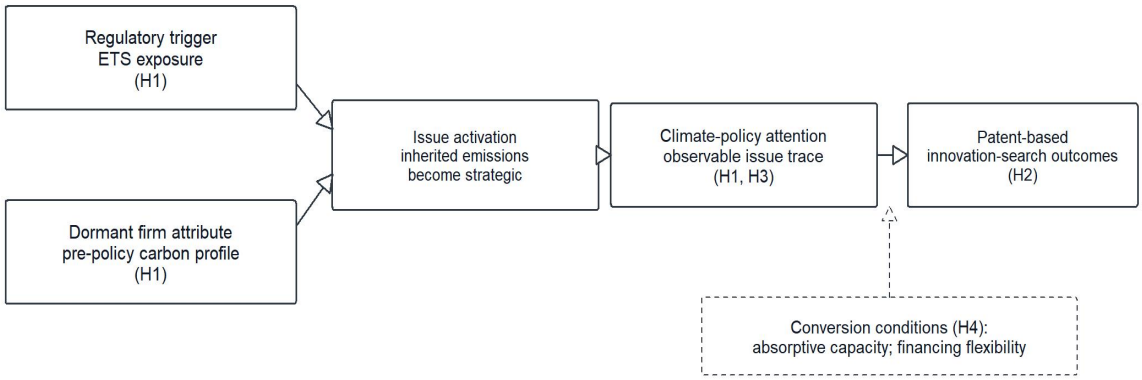
Hypothesis 4b. Firms with lower financing constraints will show a stronger conversion of climate-policy attention into subsequent green innovation than firms with higher financing constraints.

The issue-activation account differs from three rival interpretations. A pure compliance-cost account predicts innovation pressure but does not by itself predict cleaned climate-policy attention after netting out report length, generic policy language, and uncertainty terms. In that account, inherited emissions matter because they raise marginal abatement costs or allowance needs; the account is largely silent about whether the cost shock becomes visible as an organizational issue before innovation occurs. A symbolic-disclosure account predicts climate talk without subsequent innovation, a long-standing concern in the greenwashing literature on selective corporate environmental disclosure (Lyon & Maxwell, 2011; Marquis, Toffel, & Zhou, 2016), with recent firm-level extensions covering climate communication and regulated settings (Coen, Herman, & Pegram, 2022; Xiang, Chen, Zhang, & Sun, 2024). A firm-scale account predicts broad innovation among larger producers but not the attention-to-green-innovation sequence conditional on absorptive capacity and financing flexibility. We do more than ask whether ETS-exposed high-emission firms patent more. We

test whether the response first appears in climate-policy attention and then converts into green innovation under the capability and financing conditions the theory specifies.

Figure 1 summarizes the conceptual framework. ETS exposure is the regulatory trigger; the pre-policy carbon profile is the dormant firm attribute; their interaction is the empirical exposure-intensity proxy. Issue activation becomes visible in climate-policy attention and is followed by innovation-search outcomes. Absorptive capacity and financing flexibility condition whether attention becomes green technological output. The framework does not require green innovation to increase relative to non-green innovation, and it treats disclosure-based attention as an observable trace of attention to that issue.

Figure 1. Conceptual framework: regulatory trigger, dormant carbon profile, issue activation, attention, and innovation-search outcomes.



Note. Solid arrows show the theorized issue-activation sequence. The dashed arrow indicates conversion conditions. ETS exposure x standardized 2010-2012 pre-policy CO2 is the empirical exposure-intensity proxy; issue activation is the conceptual process.

3. Institutional Setting, Data, and Measures

3.1 China's regional emissions-trading pilots

China's regional ETS pilots provide a useful setting for studying how carbon exposure becomes a strategic issue. Before launching the national carbon market, China approved pilot

carbon markets in Beijing, Tianjin, Shanghai, Chongqing, Guangdong, Hubei, and Shenzhen. The pilots began market operation around 2013-2014 and differed in allowance allocation, covered sectors, market design, and compliance rules. Prior research on China's regional carbon markets has documented innovation responses to the pilots (Cui, Zhang, & Zheng, 2018; Zhu, Fan, Deng, & Xue, 2019). More recent firm-level work similarly finds that pilot carbon trading affected corporate innovation and green innovation, with effects varying by price signals, firm scale, and external attention (Lv & Bai, 2021; Liu & Li, 2022). Those studies provide an important boundary because they treat attention largely as external scrutiny or market pressure. We depart from that external-attention logic by examining firms' own climate-policy attention: the observable textual trace that ETS exposure has activated inherited emissions as an issue managers must process, communicate, and search around. Pilot coverage typically combined region and sector: a firm faced ETS exposure when it was in both a pilot region and a locally covered sector, while firms outside either condition did not face the same regional market.

This structure creates variation in whether a listed firm was exposed to a regional carbon market and whether its inherited emissions were likely to be activated by that exposure. High-emission firms in covered settings had more reason to treat ETS as a central issue because their inherited emissions were more directly connected to allowance needs, regulatory expectations, and future compliance costs. Low-emission firms could be exposed to the same institutional setting but face weaker exposure intensity.

The empirical scope is regional ETS exposure embedded in China's broader carbon-market development. The panel also covers the 2020 carbon-neutrality pledge and the 2021 national ETS launch. To address the possibility that late national climate-policy shocks drive the results, we report robustness tests that restrict the panel to years before 2020 and before

2021. The core attention and innovation-search estimates remain positive in these shorter windows.

3.2 Sample and data sources

The sample covers Chinese A-share listed firms from 2001 to 2024. The main panel contains 59,195 firm-year observations for 5,271 firms. The data combine listed-firm financial controls, green patent outcomes, climate-policy attention measures from annual-report text, allocated firm-level carbon emissions, and environmental governance variables. Firm-year financial controls and governance variables are organized at the listed-firm level. Patent variables are firm-year counts of applications and grants, separated into green patents, green invention patents, and broader invention patents. Climate-policy attention variables are constructed from corporate text using term frequencies related to climate-policy uncertainty (CPU), climate policy, and climate attention.

The main estimation sample includes firms with pre-policy CO2 information. This restriction matters because pre-policy emissions are the dormant attribute activated by ETS exposure. To reduce anticipation concerns around 2013 pilot preparation, the main specification uses the 2010-2012 average of log allocated CO2 emissions. The main pre-CO2 sample includes 1,929 firms, of which 423 are ever exposed to ETS in the pre-CO2 sample. We use all available firm-year observations for these firms in the panel regressions after constructing the pre-policy emissions measure. The resulting main regressions contain about 35,000 firm-year observations, depending on outcome availability. Appendix Tables A18-A19 compare retained and excluded firms. Most excluded firms enter the panel later and lack pre-policy carbon records; retained firms are only modestly larger but substantially more patent-active before treatment, so the estimates should be interpreted as evidence for older, observable listed firms with sufficient pre-policy carbon records rather than for all A-share firms.

Table 1. Sample structure and pre-treatment balance.

Panel	Item	Value
A. Sample	Panel rows	59,195
	Unique firms	5,271
	Firms with 2010-2012 pre-policy CO2	1,929
	Ever-ETS firms with pre-policy CO2	423
	Nearest-neighbor matched firms	1,165
B. Pre-treatment balance	Unweighted	Mean abs. SMD = 0.046; max = 0.210
	IPW ATT	Mean abs. SMD = 0.005; max = 0.017
	3-nearest-neighbor	Mean abs. SMD = 0.007; max = 0.025

Note. Panel A reports the identification sample. Panel B summarizes pre-treatment balance after inverse-probability weighting and nearest-neighbor matching. SMD denotes standardized mean difference. Full balance checks are reported in Appendix Table A2. The main exposure-intensity proxy uses standardized 2010-2012 pre-policy CO2.

3.3 Key variables

The main explanatory variable is the exposure-intensity proxy, measured as: ETS covered exposure x standardized pre-policy CO2 emissions. ETS covered exposure equals one when a firm is located in a regional ETS pilot area, observed after the common pilot implementation window, and belongs to an industry covered by the corresponding pilot market. The covered-industry mapping follows pilot-sector descriptions and distinguishes covered sectors such as electricity and heat, iron and steel, petrochemicals, cement, nonferrous metals, paper, aviation, and selected manufacturing or service sectors where applicable. Location is assigned at the listed-firm province level, so the treatment captures listed-firm policy exposure rather than verified facility-level compliance obligations; multi-province production assets and annual covered-entity lists would allow a sharper facility-level design.

The CO2 measure is allocated rather than directly observed at the firm smokestack level. We use a firm-year carbon-emissions file that reports industry CO2 totals, listed-firm operating cost, industry operating cost, and allocated listed-firm CO2. Firm CO2 is allocated as the firm's operating cost divided by industry operating cost multiplied by industry CO2 emissions, then logged. Because the allocation uses operating-cost shares within an industry,

the firm-level CO2 measure shares variation with firm scale; within-industry emissions rank, carbon intensity, and ETS x pre-policy size controls address this scale dimension in Table 6 and the appendix. The main tables use the 2010-2012 average to avoid incorporating 2013 pilot preparation into the pre-policy moderator. Appendix tables report 2010-2013 as the coverage-robust window and 2007-2010 and 2005-2010 as earlier-window checks. The interaction is a proxy for exposure intensity; it is not treated as an independent measure of managerial attention.

Climate-policy attention is measured using firm annual-report text variables related to climate policy and climate-policy uncertainty. Text-based climate measures are increasingly used in finance and strategy-adjacent work. Engle, Giglio, Kelly, Lee, and Stroebel (2020) construct climate-news measures; Krueger, Sautner, and Starks (2020) document investor attention to climate risks; and Sautner, van Lent, Vilkov, and Zhang (2023) estimate firm-level climate change exposure from corporate communication. Sautner et al. (2023) measure broad climate exposure in corporate communication and link it to capital-market and real outcomes. We use that measurement logic for a narrower construct: climate-policy attention in annual reports, tied to a specific regulatory trigger and downstream patent-based innovation outcomes. We use two main measures: a climate-policy attention index and a climate attention measure, both constructed from dictionary-based term frequencies. To address the concern that attention results reflect longer reports or generic policy language, we construct cleaned attention measures by residualizing attention against report length, total policy terms, and uncertainty terms with firm, province-year, and industry-year fixed effects. We also examine climate-term shares and climate-to-policy term ratios, which scale climate language against broader dictionary use. Online Appendix Table A20 summarizes the construct-validation logic across baseline, cleaned, relative, and placebo-language tests. Appendix Table A22 reports dictionary categories and English glosses; Table A23 presents public-

report examples and English contextual summaries; and Table A24 reports the manual coding protocol used to structure the audit.

Innovation outcomes are measured using log one plus patent counts. Patent measures are widely used indicators of inventive output (Griliches, 1990; Hall, Jaffe, & Trajtenberg, 2005). Environmental patent indicators are common in studies of directed technological change (Popp, 2005), and Berrone et al. (2013) use green inventions to study environmental innovation under institutional pressure. The main outcomes are green patent applications, green invention applications, green invention grants, and broader invention applications. These are output measures, not direct observations of search behavior. We therefore use the term innovation-search outcomes and rely on relative outcomes to bound the interpretation. We construct non-green patent outcomes by subtracting green counts from total counts, as well as green shares and green-minus-non-green measures, to test whether exposure intensity redirects innovation toward green categories or instead expands inventive activity more broadly.

For conversion heterogeneity, absorptive capacity is measured as the firm's pre-policy log R&D amount, averaged before the ETS window and split at the industry median. Financing constraints are measured using the Hadlock-Pierce SA-style size-age constraint proxy in the firm-year data, averaged before the ETS window; lower values indicate lower constraints, and low-constraint firms are defined relative to industry medians (Hadlock & Pierce, 2010). These variables are measured over the pre-policy period before the main ETS window to reduce simultaneity in the heterogeneity tests.

Control variables include firm size, Tobin's Q, leverage, return on assets, fixed assets, cash flow, growth, board size, independent director share, non-executive director ratio, average board tenure, state ownership, listing age, and firm age. The preferred specifications include firm fixed effects, province-year fixed effects, and industry-year fixed effects.

4. Empirical Design

4.1 Main exposure-intensity specification

The main specification estimates:

$$Y_{it} = \beta_1 ETS_{it} + \beta_2 ETS_{it} \times PreCO2_i + Controls_{it} + FirmFE_i + ProvinceYearFE_{pt} + IndustryYearFE_{jt} + \epsilon_{it}$$

The coefficient of interest is β_2, the effect of ETS exposure for firms with higher pre-policy CO2 emissions. The fixed-effect structure absorbs time-invariant firm characteristics, local-year shocks, and industry-year shocks. Standard errors are clustered at the firm level in the main tables, and robustness tests use province-industry, pilot-industry, and two-way firm plus province-industry clustering to address the policy-cell nature of the shock (Bertrand, Duflo, & Mullainathan, 2004). This design does not treat pre-policy CO2 emissions as randomly assigned. Instead, it treats pre-policy emissions as an inherited firm characteristic whose strategic meaning changes under ETS exposure. The identifying assumption is that, conditional on fixed effects and controls, high- and low-pre-CO2 firms within comparable local-year and industry-year environments would not have experienced differential changes in attention and innovation exactly when ETS exposure activated carbon emissions as a strategic issue.

The same specification is applied to attention outcomes, innovation outcomes, relative green outcomes, and placebo outcomes. A positive beta2 for attention tests Hypothesis 1. A positive beta2 for green innovation outcomes tests Hypothesis 2a, while a positive beta2 for broader invention outcomes tests Hypothesis 2b. Null results for green-share outcomes define the boundary of the claim.

4.2 Event-study timing checks

We estimate dynamic specifications around the 2014 pilot implementation window. Event time is binned from five years before to seven years after implementation, with t = -1 omitted. The event-study design interacts event-time indicators with ever-ETS exposure and

with ever-ETS exposure multiplied by pre-policy CO2 emissions. The key check is whether the ETS x pre-policy CO2 event coefficients are flat before implementation and positive after implementation.

The event study assesses timing around the policy window; it is not proof of a known counterfactual trend. This interpretation follows recent cautions that difference-in-differences designs can be fragile under heterogeneous effects and dynamic treatment responses (de Chaisemartin & D'Haultfoeuille, 2020; Callaway & Sant'Anna, 2021). Borusyak, Jaravel, and Spiess (2024) further motivate careful event-study implementation in staggered and dynamic settings.

4.3 Matching and weighting

To improve comparability between ETS-exposed and non-exposed firms, we construct firm-level inverse-probability weights and nearest-neighbor matched samples based on pre-treatment characteristics, following the logic of propensity-score weighting for treatment-effect estimation (Hirano, Imbens, & Ridder, 2003). The matching variables include pre-treatment levels and trends for climate-policy attention, climate attention, green patenting, invention applications, firm size, ROA, leverage, and CO2 emissions. Balance improves substantially: the mean absolute standardized mean difference declines from 0.046 in the unweighted sample to 0.005 under inverse-probability weighting and 0.007 in the nearest-neighbor sample. The maximum absolute standardized mean difference declines from 0.210 to 0.017 and 0.025, respectively.

These analyses do not replace the fixed-effect design. They provide a complementary check that the core results are not driven by large pre-treatment differences in attention, patenting, firm fundamentals, or CO2 trajectories.

4.4 Attention-to-innovation channel

We use two approaches to study the temporal channel from attention to subsequent innovation. First, we estimate lag models in which climate-policy attention at time t predicts innovation outcomes at t+1 and t+2, controlling for current innovation, ETS exposure, ETS x pre-policy CO2, firm controls, firm fixed effects, province-year fixed effects, and industry-year fixed effects. Second, we compare the exposure-intensity coefficient in future-innovation models with and without contemporaneous climate-policy attention, reading the resulting attenuation as evidence on the empirical sequence.

We scope these as channel evidence: because exposure intensity can reach innovation through cost pressure and technology needs as well as attention, the tests establish whether the timing is consistent with the attention-based framework rather than isolating a causal mediation effect.

5. Results

5.1 Activated carbon exposure and climate-policy attention

Table 2 tests whether carbon-market exposure turns inherited emissions into visible climate-policy attention. The baseline coefficient on ETS x pre-policy CO2 is 0.138 for the climate-policy attention index and 0.128 for climate attention. These magnitudes are meaningful: they correspond to about 19 percent of the main-sample standard deviation of climate-policy attention and about 15 percent of the standard deviation of climate attention. A one-standard-deviation higher inherited carbon profile therefore predicts a visible shift in the climate-policy content of firm communication once ETS exposure begins.

Table 2. Exposure intensity and climate-policy attention.

Panel	Outcome	Spec.	ETS x pre-CO2	N
A. Attention construct checks	Climate-policy attention	Baseline	0.138*** (0.019)	35,000
	Climate-policy attention	Residualized attention	0.142*** (0.017)	35,000
	Climate attention	Baseline	0.128*** (0.021)	35,000

Panel	Outcome	Spec.	ETS x pre-CO2	N
	Climate attention	Residualized attention	0.128*** (0.020)	35,000
	Climate share	Relative climate-language	0.024*** (0.004)	34,917
	Climate-to-policy ratio	Relative climate-language	0.037*** (0.006)	35,000
	Climate-policy attention	IPW ATT	0.138*** (0.020)	34,959
B. Matched/weighted attention checks	Climate attention	IPW ATT	0.130*** (0.021)	34,959
	Climate-policy attention	3-nearest-neighbor	0.139*** (0.021)	20,943
	Climate attention	3-nearest-neighbor	0.131*** (0.022)	20,943

Note. The focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2. Residualized attention measures net out report length, generic policy terms, and uncertainty terms. Relative climate-language measures scale climate terms against broader dictionary and policy-language denominators. All models include firm controls, firm fixed effects, province-year fixed effects, and industry-year fixed effects. Standard errors are clustered by firm. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The cleaned measures indicate that the response is concentrated in climate-policy language. After netting out report length, policy terms, and uncertainty terms, the coefficient is 0.142 for the clean climate-policy attention index and 0.128 for clean climate attention. The climate share of CPU dictionary terms also increases by 0.024, and the climate-to-policy term ratio increases by 0.037. The first observable response appears in climate-policy language rather than generic disclosure volume.

The matched and weighted specifications remain close to the baseline estimates. Under inverse-probability weighting, the coefficient is 0.138 for climate-policy attention and 0.130 for climate attention. In the nearest-neighbor matched sample, the coefficients are 0.139 and 0.131. Balancing on pre-treatment attention, patenting, firm fundamentals, and CO2 levels and trends does little to change the estimate, indicating that the attention result is not a by-product of large baseline differences between treated and comparison firms.

5.2 Activated carbon exposure and innovation-search outcomes

Table 3 moves from attention to output-side evidence of search. ETS x pre-policy CO2 is associated with higher green applications, green invention applications, and broader invention applications. In the inverse-probability-weighted specification, the coefficients are

0.166 for green applications, 0.161 for green invention applications, and 0.186 for invention applications. Interpreted as semi-log approximations, these estimates imply increases of about 18 percent, 17 percent, and 20 percent, respectively. The nearest-neighbor matched estimates remain similar.

Table 3. Exposure intensity and patent-based innovation-search outcomes.

Outcome	Method	ETS x pre-CO2	N	Within R2
Green applications	Unweighted	0.169*** (0.037)	35,025	0.096
Green applications	IPW ATT	0.166*** (0.035)	34,984	0.104
Green applications	3-nearest-neighbor	0.156*** (0.037)	20,963	0.096
Green invention applications	Unweighted	0.155*** (0.035)	35,025	0.086
Green invention applications	IPW ATT	0.161*** (0.034)	34,984	0.093
Green invention applications	3-nearest-neighbor	0.151*** (0.035)	20,963	0.086
Invention applications	Unweighted	0.202*** (0.050)	35,025	0.124
Invention applications	IPW ATT	0.186*** (0.049)	34,984	0.134
Invention applications	3-nearest-neighbor	0.180*** (0.051)	20,963	0.128

Note. Patent outcomes are log(1 + count). The focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2. IPW ATT uses inverse-probability weights based on pre-treatment attention, patenting, firm fundamentals, and CO2 levels and trends. 3-nearest-neighbor estimates use the matched sample. All models include firm controls and firm, province-year, and industry-year fixed effects. Standard errors are clustered by firm. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The estimates support both parts of Hypothesis 2, but the innovation evidence is more bounded than the attention evidence. High-pre-CO2 firms exposed to ETS show higher green innovation outcomes and higher broader invention applications. Green invention grants are positive in several checks, although grant outcomes are delayed, can reflect earlier applications, and are more sensitive to demanding trend specifications. Applications are the main downstream margin because they are closer to the firm's search and filing decisions, while grants depend on patent-office examination and longer lags.

Table 4 defines the portfolio interpretation. In the weighted specification, green application shares, green invention application shares, green grant shares, green-minus-non-green applications, green invention minus non-green invention applications, and green-minus-non-green grants are statistically insignificant. At the same time, non-green applications and non-green invention applications rise. The response therefore looks like portfolio expansion around a carbon-regulatory problem, with green innovation as one component, more than reallocation of a fixed invention portfolio toward green patents. The findings extend Berrone

et al. (2013) by locating the institutional-pressure-to-green-invention link inside an issue-activation process: the same pressure can generate different innovation responses depending on whether inherited carbon exposure makes the regulation strategically salient. They also preserve Delmas and Toffel's (2008) point that firms translate environmental demands through heterogeneous organizational response routines.

Table 4. Portfolio boundary: green-relative outcomes and non-green expansion.

Panel	Outcome	ETS x pre-CO2	N
A. Green-relative outcomes	Green application share	0.002 (0.003)	34,984
	Green grant share	-0.001 (0.003)	34,984
	Green invention application share	0.006 (0.004)	34,984
	Green invention minus non-green invention applications	-0.017 (0.032)	34,984
	Green minus non-green applications	0.034 (0.036)	34,984
	Green minus non-green grants	0.041 (0.038)	34,984
B. Non-green expansion checks	Non-green applications	0.133*** (0.051)	34,984
	Non-green invention applications	0.178*** (0.048)	34,984

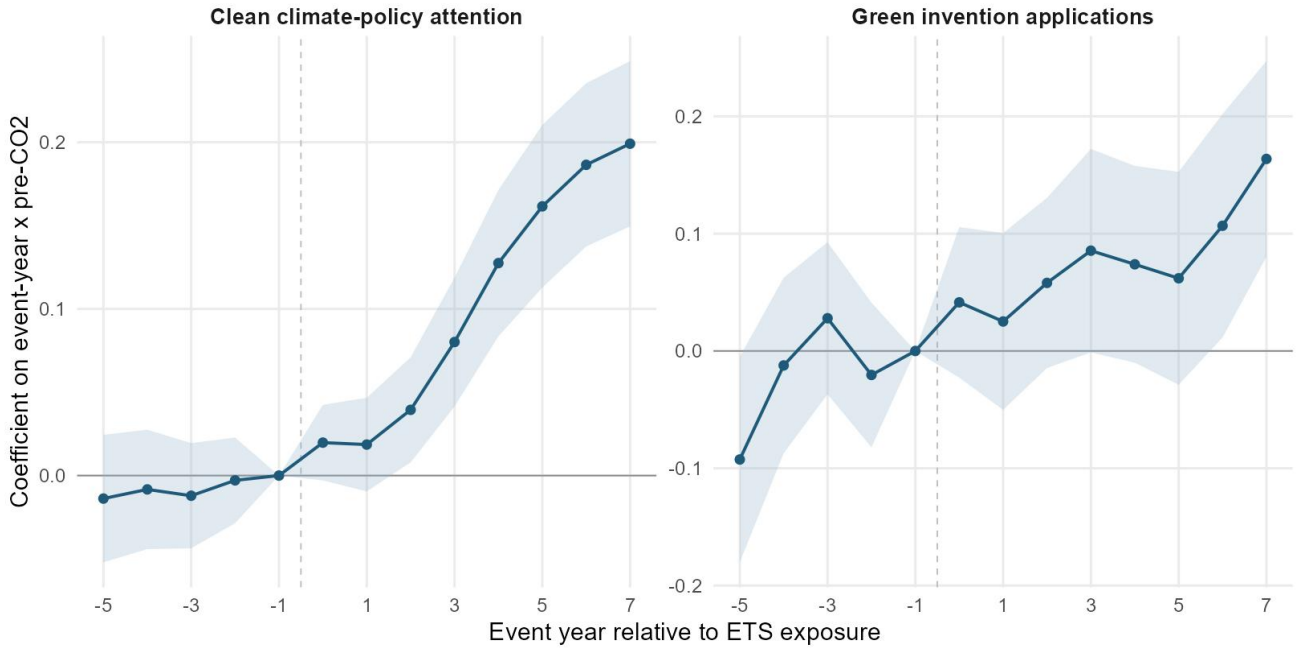
Note. The table reports IPW ATT estimates for compactness. The focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2. Green-relative outcomes are portfolio shares or green-minus-non-green differences. Non-green outcomes are log(1 + count). Full unweighted and matched estimates are reported in Appendix Tables A6-A7. Standard errors are clustered by firm. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The carbon market does not merely force a zero-sum reallocation of R&D toward green patents; it activates a regulatory shock that broadens patenting activity around the carbon-regulatory issue. The green patent increase is substantively important for environmental strategy, but the absence of a green-share increase prevents the claim from collapsing into a narrow directed-green-innovation story.

5.3 Dynamic evidence and timing

Figure 2 provides timing evidence for the proposed sequence. The main panel for clean climate-policy attention has a pretrend p-value of 0.932 and a post-treatment joint p-value below 0.001. Appendix event-study checks show similar timing for clean climate attention, with a pretrend p-value of 0.455 and a post-treatment p-value below 0.001. The timing evidence is therefore strongest for attention: the attention margin is quiet before the policy window and rises after ETS exposure, consistent with policy-triggered issue activation.

Figure 2. Timing of climate-policy attention and patent-based innovation response.



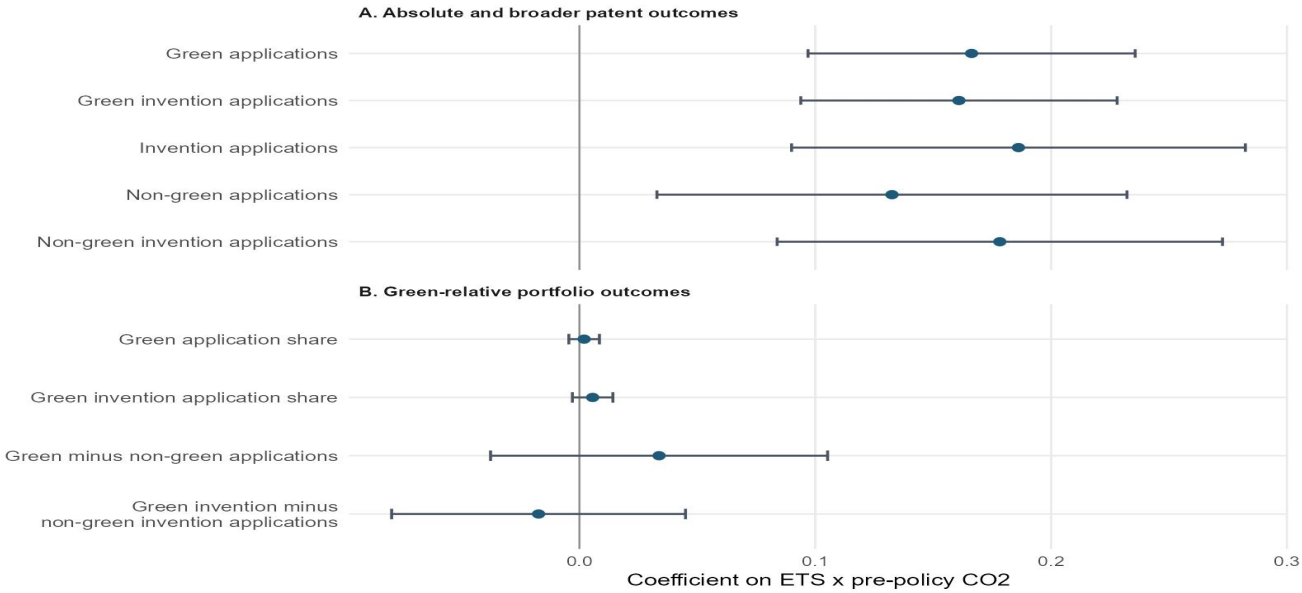
Note. Points report IPW ATT event-study estimates of event-year x standardized 2010-2012 pre-policy CO2. Event year -1 is the omitted reference period. Shaded areas indicate 95% confidence intervals. Models include firm fixed effects, province-year fixed effects, industry-year fixed effects, and firm controls. Panel B is timing support, not standalone identification evidence.

The patent dynamics unfold more slowly and noisily. The second panel focuses on green invention applications, the main downstream patent margin; broader invention applications become significant around event year +6 and green invention grants are positive but less precisely estimated in appendix timing checks. Because the later event years overlap with macro-level shifts such as the 2020 carbon-neutrality pledge and the 2021 national ETS launch, we treat the late patent dynamics as timing support rather than standalone identification evidence. The pre-2020 and pre-2021 restrictions in Section 5.6 show that the

core attention and invention associations are already present before those national shocks. The timing fits the theory: attention should move before resource commitment and patent filing, while grants should appear later because examination adds delay and noise.

Figure 3 returns to the portfolio interpretation. Absolute and broader patent outcomes move to the right, while green-relative portfolio outcomes cluster around zero. The visual pattern reinforces the core boundary of the innovation claim: carbon-market issue activation expands patenting activity around the regulatory problem without producing a green-only portfolio reallocation.

Figure 3. Portfolio expansion rather than green-only reallocation.



Note. Points report IPW ATT estimates of ETS exposure x standardized 2010-2012 pre-policy CO2. Horizontal bars indicate 95% confidence intervals. Absolute patent outcomes are log(1 + count) measures; green-relative outcomes are portfolio shares or green-minus-non-green differences.

5.4 Attention and future innovation

Table 5 asks whether firms that allocate attention to climate-policy issues subsequently show more innovation activity. Clean climate-policy attention at time t predicts green applications at t+1 and t+2, with coefficients of 0.131 and 0.140. It predicts green invention applications at t+1 and t+2, with coefficients of 0.094 and 0.103. With log patent outcomes, these coefficients indicate a nontrivial association between higher climate-policy

attention and later green patenting. The lag models control for current innovation, ETS exposure, ETS x pre-policy CO2, firm fixed effects, province-year fixed effects, industry-year fixed effects, and firm controls, so the estimates compare firms after accounting for their existing innovation level. Green invention grants are reported in the appendix as a supplemental downstream outcome because grant timing can reflect earlier application decisions as well as patent-office examination. The lagged estimates are consistent with Hypothesis 3 without identifying formal mediation.

Table 5. Climate-policy attention and subsequent green innovation.

Panel	Outcome	Horizon	Attention coefficient	Attenuation of exposure-intensity coefficient	N
A. Lagged attention and future green innovation	Green applications	t+1	0.131*** (0.015)		32,386
	Green applications	t+2	0.140*** (0.021)		29,625
	Green invention applications	t+1	0.094*** (0.013)		32,386
	Green invention applications	t+2	0.103*** (0.018)		29,625
B. Exposure-intensity attenuation after attention	Green applications	t+1		19.9%	32,386
	Green applications	t+2		17.7%	29,625
	Green invention applications	t+1		15.1%	32,386
	Green invention applications	t+2		12.1%	29,625

Note. Panel A reports coefficients from lagged models in which clean climate-policy attention at time t predicts green innovation outcomes at t+1 and t+2. Models control for current innovation, ETS exposure, ETS exposure x standardized 2010-2012 pre-policy CO2, firm controls, firm fixed effects, province-year fixed effects, and industry-year fixed effects. Standard errors are clustered by firm. Panel B reports descriptive attenuation in the exposure-intensity coefficient after adding contemporaneous clean climate-policy attention. These estimates are sequence-consistent checks, not formal causal mediation estimates. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

The sequence checks ask whether the exposure-intensity association with later green innovation changes after accounting for attention. Controlling for contemporaneous climate-policy attention attenuates the exposure-intensity coefficient by 12 to 20 percent. Because

dictionary-based attention is a noisy proxy for issue prioritization, this attenuation is a conservative reading of how far climate-policy attention carries exposure intensity into later green innovation.

Panel A of Table 6 reports the stricter downstream checks that separate attention from pure cost and scale stories. The scale result is a necessary boundary: adding ETS x pre-policy firm size absorbs the reduced-form green-invention coefficient. That does not eliminate the carbon-exposure interpretation. When absolute pre-policy CO2 is replaced with within-industry emissions rank, which strips out much of the absolute firm-size variation, green invention applications remain associated with inherited carbon position with a coefficient of 0.142. Climate attention also continues to predict later green invention after adding observed emission and cost proxies, although those rows use the smaller subsample with observed emission and cost proxies. The downstream evidence is strongest as a bounded conversion claim: scale helps activate attention, but the movement from high-carbon status to green patents depends on whether climate-policy attention is converted into technical response.

5.5 Conversion conditions: absorptive capacity and financing flexibility

Panel B of Table 6 tests whether attention is converted into green innovation more readily when firms have the capability and resources to act. The evidence supports Hypotheses 4a and 4b. High absorptive capacity and low financing constraints significantly strengthen the attention-to-green-invention slope. The incremental slope is 0.071 for high-absorptive-capacity firms at t+1 and 0.084 at t+2. The corresponding incremental slope for low-financing-constraint firms is 0.135 at t+1 and 0.187 at t+2.

Table 6. Scope conditions and empirical boundaries.

Panel	Check	Outcome	Estimate (SE)	N
A. Boundary and scope checks	ETS x size control	Climate-policy attention	0.090*** (0.026)	35,000
	ETS x size control	Green invention applications	-0.054 (0.042)	35,025
	Within-industry rank	Green invention applications	0.142*** (0.032)	35,025
	Cost-proxy controls	Green invention applications	0.051** (0.020)	8,120

Panel	Check	Outcome	Estimate (SE)	N
		t+1		
	High absorptive capacity	Green invention applications t+1	0.071*** (0.016)	26,250
	High absorptive capacity	Green invention applications t+2	0.084*** (0.023)	24,019
B. Conversion conditions	Low financing constraint	Green invention applications t+1	0.135*** (0.016)	32,386
	Low financing constraint	Green invention applications t+2	0.187*** (0.023)	29,625

Note. Panel A reports boundary checks for scale, relative carbon position, and cost-proxy controls. Cost-proxy rows use the subsample with observed emission/cost proxies; other rows use the main 2010-2012 pre-CO2 sample. Panel B reports incremental attention-to-green-invention slopes from conversion-condition models; moderator groups are defined using pre-policy industry medians. Estimates are not formal mediation effects. All models include firm controls and fixed effects unless noted. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

These tests help separate issue recognition from technical conversion. High absorptive capacity and low financing constraints strengthen the effect of exposure intensity on green applications and green invention applications, while these splits do little to moderate the attention first stage. Issue recognition and technical conversion are therefore different organizational processes. ETS exposure can make inherited emissions salient across a broad set of firms, but the movement from attention to green invention is concentrated among firms with the knowledge base and financing flexibility to fund uncertain technical experimentation. This distinction echoes Hoffman and Ocasio's (2001) view that attention is structured by context and Cohen and Levinthal's (1990) insight that recognizing external information is not the same as being able to use it.

5.6 Empirical boundaries and alternative explanations

Appendix Tables A12-A25 report the full robustness and validation package. The attention evidence is concentrated in climate-policy language. The main results survive attention cleaning, climate-term shares, and climate-to-policy ratios. Appendix Table A20 consolidates these checks with non-climate and environmental-disclosure placebo outcomes, while Appendix Tables A22-A24 document the dictionary categories, public-report examples, English contextual summaries, and validation protocol. Uncertainty attention is insignificant. Most environmental-disclosure placebo categories do not show comparable responses, although environmental strengths also increase. The specificity claim therefore rests on the

cleaned climate-policy attention measures, climate shares, climate-to-policy ratios, and the absence of comparable movement in penalties, concerns, pollution, green-product, and energy-saving disclosure.

Timing and policy-shock checks address the most natural identification threats. The main 2010-2012 CO2 window avoids using 2013 pilot-preparation years to construct the exposure-intensity proxy. The broader 2010-2013 window gives similar estimates with slightly larger coverage, and earlier CO2 windows, 2007-2010 and 2005-2010, preserve the main signs and significance despite smaller samples. Restricting the panel to pre-2020 observations gives coefficients of 0.078 for climate-policy attention, 0.094 for climate attention, 0.095 for green invention applications, and 0.133 for broader invention applications. Results are similar in the pre-2021 sample. Under province-industry, pilot-industry, and two-way firm plus province-industry clustering, the coefficients are unchanged by construction and the standard errors remain close to the firm-clustered values: 0.020-0.021 for climate attention, 0.019-0.020 for climate-policy attention, 0.035-0.036 for green invention applications, and 0.050-0.056 for broader invention applications.

China's policy environment also includes other industrial and innovation policies, including Made in China 2025, green credit initiatives, R&D tax preferences, local patent subsidies, and low-carbon city or industrial-upgrading programs. Province-year and industry-year fixed effects absorb common local-year and sector-year shocks, while matching and weighting balance pre-treatment innovation, attention, fundamentals, and CO2 trajectories. These design features reduce the scope for broad policy-bundle explanations. The remaining risk is a policy that targeted the same pilot-region, covered-industry, high-carbon firms at the same time and moved climate-policy attention and patenting through a non-ETS channel. Appendix Table A25 reports a MIC2025 triple-difference check: the interaction between exposure intensity and MIC2025-target status is not positive for green invention, and the

green-invention result remains in non-MIC2025 industries. The evidence is strongest on the margins least vulnerable to broad policy-bundle alternatives: cleaned climate-policy attention, which nets out generic policy and uncertainty terms; climate-term shares, which scale climate language against broader dictionary use; and event timing concentrated around the ETS implementation window rather than the broader Made-in-China-2025 rollout.

Scale and capability shape the downstream innovation result. The attention coefficients remain positive when the 2010-2012 CO2 measure is replaced with carbon intensity, within-industry emissions rank, or when ETS x pre-policy firm size is added. Innovation outcomes are more scale-sensitive: carbon intensity is weaker and adding ETS x pre-policy size reduces the incremental pre-CO2 coefficient for green invention. The within-industry rank test matters because it replaces absolute allocated CO2 with a relative carbon position inside the industry. Green invention applications remain positive and significant under that measure, indicating that the carbon-exposure interpretation has independent traction beyond absolute firm scale even though scale absorbs a meaningful share of the reduced-form innovation effect. The downstream evidence is strongest as a conversion claim: climate-policy attention predicts later green innovation after cost controls, and the conversion is stronger among firms with higher absorptive capacity and lower financing constraints.

Trend tests reinforce that boundary. Province-industry trends and pre-outcome trends preserve the attention and main innovation-search results. Firm-specific linear trends are an intentionally demanding pressure test and absorb much of the exposure-intensity association, especially for clean climate-policy attention and reduced-form innovation outcomes. We therefore do not treat that specification as the main design. It shows that the estimates rely on differential post-ETS shifts rather than within-firm deviations net of firm-specific slopes. The evidence is strongest for attention formation, several trend-adjusted innovation-search estimates, and capability-conditioned conversion.

6. Discussion

6.1 Theoretical implications

The findings suggest that market-based environmental regulation should be understood as both a price signal and an issue-activation mechanism. Prior work has established that emissions trading can induce low-carbon innovation under certain conditions. We add that carbon markets change which firm attributes become salient inside the firm. Pre-policy emissions are more than an environmental exposure measure; they become a managerial issue when ETS coverage connects them to allowance needs, compliance costs, and regulatory scrutiny.

This account makes the firm's internal response visible: firms move from regulation to innovation through attention, interpretation, and search. The evidence that cleaned climate-policy attention responds strongly to ETS x pre-policy CO2 shows that firms attend to the climate-policy content of the regulation rather than broad disclosure expansion.

We also refine the interpretation of green innovation in carbon-market research. Green patents are important, but they are not the only strategic response to ETS. Our results show absolute increases in green innovation outcomes, while green-share and green-minus-non-green measures remain unchanged. The contribution is therefore not a simple directed-green-innovation claim. It is a bounded innovation-search claim: high-carbon-exposure firms exposed to ETS increase green and broader inventive activity, but the evidence does not show a green-only reallocation of the patent portfolio.

Finally, we identify the capability and financing conditions that shape the conversion from attention to green innovation. Attention alone is insufficient. Firms need absorptive capacity to translate climate-policy issues into technical opportunities and financing flexibility to sustain uncertain innovation projects. This helps explain why climate regulation can create attention without producing uniform green innovation across all firms.

6.2 Practical and policy implications

The most actionable implication concerns the strategic status of pre-policy emissions. Heavy-carbon firms that read ETS purely as compliance administration miss a more important signal: inherited emissions intensity becomes a strategic indicator that can trigger allowance planning, abatement assessment, energy-saving retrofits, process redesign, and green R&D screening at the same time. Investors and other external users can read climate-policy attention as an early observable signal of this activation. But conversion from attention to green innovation depends on absorptive capacity and financing flexibility, so attention signals are most informative when paired with capability indicators. For policymakers, the broader-search result implies that ETS alone directs attention but does not automatically deliver green-share reallocation; complementary R&D, financing, covered-entity transparency, and technology-guidance instruments are needed when the policy goal is specifically green innovation rather than aggregate inventive response.

6.3 Limitations and future research

Our design bounds the interpretation in several ways. Empirically, the location-by-sector ETS assignment captures policy exposure rather than verified allowance positions or trading behavior, and the allocated CO2 measure captures an inherited carbon-scale profile rather than smokestack emissions. Conceptually, disclosure-based attention traces observable issue prioritization rather than direct boardroom cognition; future work combining annual reports with internal decision documents, earnings-call transcripts, or facility-level emissions could sharpen the cognition-versus-compliance distinction. The channel tests are sequence-consistent rather than formal causal mediation, and the green-relative null means we speak to absolute green innovation and broader patent-based search, not within-portfolio substitution toward every green technology category. Future research could examine whether specific

technologies, such as carbon capture, energy efficiency, or process retrofits, follow different substitution dynamics inside the broader search portfolio.

7. Conclusion

Carbon markets are designed to price emissions, yet their strategic impact depends on how that price signal is decoded inside the firm. This study establishes market-based climate regulation as an issue-activation mechanism: ETS exposure turns inherited emissions into an organizational issue, climate-policy attention is the observable trace of that issue, and capabilities condition whether attention becomes green technological output.

Our perspective reframes the policy-design question: not only how strongly to price emissions, but which firm attributes the price activates and whether firms can convert that activation into technical response. The evidence is bounded in two ways: it supports innovation-search outcomes including green innovation, not a green-only substitution effect, and the downstream innovation result is more scale-sensitive than the attention result. Carbon markets shape environmental strategy by changing what firms attend to and how they search for responses.

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Online Appendix

When Carbon Exposure Becomes Strategic

This appendix reports validation, robustness, timing, and boundary checks supporting the main manuscript. Coefficients are shown with standard errors in parentheses where applicable. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.10.

Table A1. Identification sample structure for the 2010-2012 main window

Metric	Value
panel_rows	59,195
firms	5,271
firms_with_2010_2012_pre_co2	1,929
ever_ets_firms_with_2010_2012_pre_co2	423
nn_matched_firms_with_2010_2012_pre_co2	1,165

Note. The main manuscript uses 2010-2012 pre-policy CO2 to avoid incorporating 2013 pilot-preparation years into the exposure-intensity proxy. The broader 2010-2013 window is reported as a robustness check.

Table A2. Full pre-treatment balance

Covariate	Method	Treated mean	Control mean	SMD
pre_cpu_index_mean	Unweighted	0.174	0.168	0.038
pre_cpu_index_trend	Unweighted	0.012	0.012	0.005
pre_climate_attention_mean	Unweighted	1.152	1.162	-0.028
pre_climate_attention_trend	Unweighted	0.006	0.023	-0.113
pre_ln_green_patent_apply_mean	Unweighted	0.296	0.187	0.170
pre_ln_green_patent_apply_trend	Unweighted	0.026	0.027	-0.007
pre_ln_green_invention_apply_mean	Unweighted	0.207	0.117	0.178
pre_ln_green_invention_apply_trend	Unweighted	0.024	0.021	0.021
pre_ln_invention_patent_apply_mean	Unweighted	1.461	1.261	0.210
pre_ln_invention_patent_apply_trend	Unweighted	0.090	0.091	-0.004
pre_Size_mean	Unweighted	21.670	21.685	-0.018
pre_Size_trend	Unweighted	0.108	0.114	-0.066
pre_ROA_mean	Unweighted	0.048	0.048	0.016
pre_ROA_trend	Unweighted	-0.010	-0.010	0.023
pre_Lev_mean	Unweighted	0.399	0.419	-0.140
pre_Lev_trend	Unweighted	0.013	0.013	-0.011
pre_ln_co2_emissions_allocated_mean	Unweighted	3.367	3.485	-0.079
pre_ln_co2_emissions_allocated_trend	Unweighted	-0.063	-0.071	0.031
pre_cpu_index_mean	IPW ATT	0.174	0.173	0.007
pre_cpu_index_trend	IPW ATT	0.012	0.012	0.001
pre_climate_attention_mean	IPW ATT	1.152	1.150	0.007
pre_climate_attention_trend	IPW ATT	0.006	0.006	-0.002
pre_ln_green_patent_apply_mean	IPW ATT	0.296	0.291	0.007
pre_ln_green_patent_apply_trend	IPW ATT	0.026	0.026	0.000
pre_ln_green_invention_apply_mean	IPW ATT	0.207	0.202	0.011
pre_ln_green_invention_apply_trend	IPW ATT	0.024	0.025	-0.004
pre_ln_invention_patent_apply_mean	IPW ATT	1.461	1.452	0.010
pre_ln_invention_patent_apply_trend	IPW ATT	0.090	0.093	-0.011
pre_Size_mean	IPW ATT	21.670	21.669	0.001
pre_Size_trend	IPW ATT	0.108	0.108	0.001
pre_ROA_mean	IPW ATT	0.048	0.048	0.002
pre_ROA_trend	IPW ATT	-0.010	-0.009	-0.014
pre_Lev_mean	IPW ATT	0.399	0.399	-0.002
pre_Lev_trend	IPW ATT	0.013	0.013	0.010
pre_ln_co2_emissions_allocated_mean	IPW ATT	3.367	3.393	-0.017
pre_ln_co2_emissions_allocated_trend	IPW ATT	-0.063	-0.062	-0.005
pre_cpu_index_mean	3-nearest-neighbor	0.174	0.174	0.003
pre_cpu_index_trend	3-nearest-neighbor	0.012	0.012	0.003
pre_climate_attention_mean	3-nearest-neighbor	1.152	1.149	0.007
pre_climate_attention_trend	3-nearest-neighbor	0.006	0.003	0.016
pre_ln_green_patent_apply_mean	3-nearest-neighbor	0.296	0.281	0.019
pre_ln_green_patent_apply_trend	3-nearest-neighbor	0.026	0.020	0.024
pre_ln_green_invention_apply_mean	3-nearest-neighbor	0.207	0.195	0.019
pre_ln_green_invention_apply_trend	3-nearest-neighbor	0.024	0.020	0.020
pre_ln_invention_patent_apply_mean	3-nearest-neighbor	1.461	1.442	0.016
pre_ln_invention_patent_apply_trend	3-nearest-neighbor	0.090	0.092	-0.004
pre_Size_mean	3-nearest-neighbor	21.670	21.666	0.004
pre_Size_trend	3-nearest-neighbor	0.108	0.107	0.013
pre_ROA_mean	3-nearest-neighbor	0.048	0.048	-0.001
pre_ROA_trend	3-nearest-neighbor	-0.010	-0.010	0.010

Covariate	Method	Treated mean	Control mean	SMD
pre_Lev_mean	3-nearest-neighbor	0.399	0.400	-0.007
pre_Lev_trend	3-nearest-neighbor	0.013	0.013	0.001
pre_ln_co2_emissions_allocated_mean	3-nearest-neighbor	3.367	3.413	-0.024
pre_ln_co2_emissions_allocated_trend	3-nearest-neighbor	-0.063	-0.054	-0.025
Missing-indicator max abs. SMD	Unweighted			0.099
Missing-indicator max abs. SMD	IPW ATT			0.006
Missing-indicator max abs. SMD	3-nearest-neighbor			0.013

Note. CO2 exposure intensity uses the 2010-2012 main window in the manuscript. Balance variables use pre-pilot levels and trends and are not used to redefine the exposure moderator. Missing-indicator covariates are summarized by their maximum absolute SMD.

Table A3. Unweighted event-study timing checks for the 2010-2012 main window

Outcome	N	Pretrend joint p	Post joint p	First positive significant event year
Clean climate attention	35,000	0.342	<0.001	3
Clean climate-policy attention	35,000	0.789	<0.001	2
Green invention applications	35,025	0.158	0.042	7
Green invention grants	35,025	0.195	0.192	7
Green applications	35,025	0.056	0.110	7
Invention applications	35,025	0.302	0.002	6

Note. Event coefficients interact event-time indicators with the standardized 2010-2012 pre-policy CO2 exposure-intensity moderator.

Table A4. Matched and weighted event-study timing checks for the 2010-2012 main window

Method	Outcome	N	Pretrend joint p	Post joint p	First positive significant event year
3-nearest-neighbor	Clean climate attention	20,943	0.662	<0.001	3
IPW ATT	Clean climate attention	34,959	0.455	<0.001	3
Unweighted	Clean climate attention	35,000	0.342	<0.001	3
3-nearest-neighbor	Clean climate-policy attention	20,943	0.980	<0.001	2
IPW ATT	Clean climate-policy attention	34,959	0.932	<0.001	2
Unweighted	Clean climate-policy attention	35,000	0.789	<0.001	2
3-nearest-neighbor	Green applications	20,963	0.036	0.266	7
IPW ATT	Green applications	34,984	0.037	0.055	3
Unweighted	Green applications	35,025	0.056	0.110	7
3-nearest-neighbor	Green invention applications	20,963	0.060	0.115	6
IPW ATT	Green invention applications	34,984	0.064	0.020	6
Unweighted	Green invention applications	35,025	0.158	0.042	7
3-nearest-neighbor	Green invention grants	20,963	0.267	0.125	7
IPW ATT	Green invention grants	34,984	0.304	0.065	7
Unweighted	Green invention grants	35,025	0.195	0.192	7
3-nearest-neighbor	Invention applications	20,963	0.437	0.003	6
IPW ATT	Invention applications	34,984	0.390	<0.001	6
Unweighted	Invention applications	35,025	0.302	0.002	6

Note. Event coefficients interact event-time indicators with the standardized 2010-2012 pre-policy CO2 exposure-intensity moderator.

Table A5. Attention cleaning and relative climate-language checks for the 2010-2012 main window

Outcome	Specification	Coef. on ETS x pre-CO2	p	N
Climate-policy attention	Baseline	0.138*** (0.019)	<0.001	35,000
Climate-policy attention	Residualized attention	0.142*** (0.017)	<0.001	35,000
Climate attention	Baseline	0.128*** (0.021)	<0.001	35,000
Climate attention	Residualized attention	0.128*** (0.020)	<0.001	35,000
Climate share	Relative climate-language	0.024*** (0.004)	<0.001	34,917
Climate-to-policy ratio	Relative climate-language	0.037*** (0.006)	<0.001	35,000

Note. Focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2.

Table A6. Green-relative and green-minus-non-green tests for the 2010-2012 main window

Outcome	Method	Coef. on ETS x pre-CO2	p	N
Green application share	3-nearest-neighbor	0.002 (0.004)	0.541	20,963
Green application share	IPW ATT	0.002 (0.003)	0.548	34,984
Green application share	Unweighted	0.002 (0.003)	0.558	35,025
Green grant share	3-nearest-neighbor	-0.000 (0.003)	0.947	20,963
Green grant share	IPW ATT	-0.001 (0.003)	0.699	34,984
Green grant share	Unweighted	-0.002 (0.003)	0.624	35,025
Green invention application share	3-nearest-neighbor	0.005 (0.005)	0.292	20,963
Green invention application share	IPW ATT	0.006 (0.004)	0.201	34,984
Green invention application share	Unweighted	0.007 (0.005)	0.165	35,025
Green invention minus non-green invention applications	3-nearest-neighbor	-0.022 (0.033)	0.505	20,963
Green invention minus non-green invention applications	IPW ATT	-0.017 (0.032)	0.586	34,984
Green invention minus non-green invention applications	Unweighted	-0.037 (0.031)	0.226	35,025
Green minus non-green applications	3-nearest-neighbor	0.030 (0.038)	0.416	20,963
Green minus non-green applications	IPW ATT	0.034 (0.036)	0.354	34,984
Green minus non-green applications	Unweighted	0.010 (0.035)	0.768	35,025
Green minus non-green grants	3-nearest-neighbor	0.047 (0.039)	0.229	20,963
Green minus non-green grants	IPW ATT	0.041 (0.038)	0.282	34,984
Green minus non-green grants	Unweighted	0.024 (0.037)	0.515	35,025
Non-green applications	3-nearest-neighbor	0.125** (0.053)	0.018	20,963
Non-green applications	IPW ATT	0.133*** (0.051)	0.009	34,984
Non-green applications	Unweighted	0.159*** (0.053)	0.003	35,025
Non-green invention applications	3-nearest-neighbor	0.173*** (0.050)	<0.001	20,963
Non-green invention applications	IPW ATT	0.178*** (0.048)	<0.001	34,984
Non-green invention applications	Unweighted	0.192*** (0.049)	<0.001	35,025

Note. Focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2.

Table A7. Placebo and boundary outcome checks for the 2010-2012 main window

Group	Outcome	Method	Coef. on ETS x pre-CO2	p	N
environmental_disclosure_placebo	Energy-saving disclosure	3-nearest-neighbor	-0.004 (0.034)	0.908	5,393
environmental_disclosure_placebo	Energy-saving disclosure	IPW ATT	-0.001 (0.033)	0.966	8,726
environmental_disclosure_placebo	Energy-saving disclosure	Unweighted	-0.012 (0.030)	0.691	8,741
environmental_disclosure_placebo	Environmental certification	3-nearest-neighbor	0.003 (0.030)	0.909	5,393
environmental_disclosure_placebo	Environmental certification	IPW ATT	0.013 (0.029)	0.645	8,726
environmental_disclosure_placebo	Environmental certification	Unweighted	0.008 (0.028)	0.770	8,741
environmental_disclosure_placebo	Environmental concerns	3-nearest-neighbor	0.038 (0.025)	0.132	5,393
environmental_disclosure_placebo	Environmental concerns	IPW ATT	0.034 (0.025)	0.170	8,726
environmental_disclosure_placebo	Environmental concerns	Unweighted	0.028 (0.021)	0.174	8,741
environmental_disclosure_placebo	Environmental penalty	3-nearest-neighbor	0.002 (0.008)	0.754	5,393
environmental_disclosure_placebo	Environmental penalty	IPW ATT	0.003 (0.008)	0.645	8,726
environmental_disclosure_placebo	Environmental penalty	Unweighted	0.004 (0.007)	0.557	8,741
environmental_disclosure_placebo	Environmental strengths	3-nearest-neighbor	0.279*** (0.096)	0.004	5,393
environmental_disclosure_placebo	Environmental strengths	IPW ATT	0.285*** (0.092)	0.002	8,726
environmental_disclosure_placebo	Environmental strengths	Unweighted	0.232*** (0.090)	0.010	8,741
environmental_disclosure_placebo	Green product disclosure	3-nearest-neighbor	0.054* (0.032)	0.087	5,393
environmental_disclosure_placebo	Green product disclosure	IPW ATT	0.048 (0.031)	0.115	8,726
environmental_disclosure_placebo	Green product disclosure	Unweighted	0.040 (0.030)	0.179	8,741
environmental_disclosure_placebo	Pollution disclosure	3-nearest-neighbor	0.034 (0.027)	0.207	5,393
environmental_disclosure_placebo	Pollution disclosure	IPW ATT	0.028 (0.026)	0.272	8,726
environmental_disclosure_placebo	Pollution disclosure	Unweighted	0.022 (0.022)	0.309	8,741
main_attention	Climate attention	3-nearest-neighbor	0.131*** (0.022)	<0.001	20,943
main_attention	Climate attention	IPW ATT	0.130*** (0.021)	<0.001	34,959
main_attention	Climate attention	Unweighted	0.128*** (0.021)	<0.001	35,000
main_attention	Climate-policy attention	3-nearest-neighbor	0.139*** (0.021)	<0.001	20,943
main_attention	Climate-policy attention	IPW ATT	0.138*** (0.020)	<0.001	34,959
main_attention	Climate-policy attention	Unweighted	0.138*** (0.019)	<0.001	35,000
main_green_innovation	Green applications	3-nearest-	0.156*** (0.037)	<0.001	20,963

Group	Outcome	Method	Coef. on ETS x pre-CO2	p	N
main_green_innovation	Green applications	3-nearest-neighbor	0.166*** (0.035)	<0.001	34,984
main_green_innovation	Green applications	IPW ATT	0.169*** (0.037)	<0.001	35,025
main_green_innovation	Green applications	Unweighted	0.151*** (0.035)	<0.001	20,963
main_green_innovation	Green invention applications	3-nearest-neighbor	0.161*** (0.034)	<0.001	34,984
main_green_innovation	Green invention applications	IPW ATT	0.155*** (0.035)	<0.001	35,025
main_green_innovation	Green invention applications	Unweighted	0.113*** (0.032)	<0.001	20,963
main_green_innovation	Green invention grants	3-nearest-neighbor	0.113*** (0.032)	<0.001	34,984
main_green_innovation	Green invention grants	IPW ATT	0.104*** (0.030)	<0.001	35,025
main_green_innovation	Green invention grants	Unweighted	4.339** (1.798)	0.016	20,943
nonclimate_attention_placebo	Policy terms	3-nearest-neighbor	3.866** (1.772)	0.029	34,959
nonclimate_attention_placebo	Policy terms	IPW ATT	3.464** (1.644)	0.035	35,000
nonclimate_attention_placebo	Policy terms	Unweighted	-0.017 (0.013)	0.205	20,943
nonclimate_attention_placebo	Uncertainty attention	3-nearest-neighbor	-0.017 (0.013)	0.197	34,959
nonclimate_attention_placebo	Uncertainty attention	IPW ATT	-0.017 (0.013)	0.173	35,000
nonclimate_attention_placebo	Uncertainty attention	Unweighted	0.409* (0.219)	0.062	20,943
nonclimate_attention_placebo	Uncertainty terms	3-nearest-neighbor	0.398* (0.212)	0.060	34,959
nonclimate_attention_placebo	Uncertainty terms	IPW ATT	0.375* (0.202)	0.064	35,000
nonclimate_attention_placebo	Uncertainty terms	Unweighted	0.125** (0.053)	0.018	20,963
nongreen_patent_placebo	Non-green applications	3-nearest-neighbor	0.133*** (0.051)	0.009	34,984
nongreen_patent_placebo	Non-green applications	IPW ATT	0.159*** (0.053)	0.003	35,025
nongreen_patent_placebo	Non-green applications	Unweighted	0.087* (0.052)	0.097	20,963
nongreen_patent_placebo	Non-green grants	3-nearest-neighbor	0.097* (0.050)	0.055	34,984
nongreen_patent_placebo	Non-green grants	IPW ATT	0.115** (0.052)	0.026	35,025
nongreen_patent_placebo	Non-green grants	Unweighted	0.173*** (0.050)	<0.001	20,963
nongreen_patent_placebo	Non-green invention applications	3-nearest-neighbor	0.178*** (0.048)	<0.001	34,984
nongreen_patent_placebo	Non-green invention applications	IPW ATT	0.192*** (0.049)	<0.001	35,025
nongreen_patent_placebo	Non-green invention applications	Unweighted			

Note. Focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2. Environmental-strength disclosure also increases; the placebo interpretation therefore rests on the broader pattern across non-climate and environmental-disclosure categories rather than a uniformly null environmental block.

Table A8. Trend alternatives and pressure tests

Outcome	Specification	Method	Coef. on ETS x pre-CO2	p	N
Clean climate-policy attention	baseline	Unweighted	0.142*** (0.017)	<0.001	35,000
Clean climate-policy attention	baseline	IPW ATT	0.142*** (0.018)	<0.001	34,959
Clean climate-policy attention	baseline	3-nearest-neighbor	0.142*** (0.019)	<0.001	20,943
Clean climate-policy attention	province_industry_trend	Unweighted	0.117*** (0.019)	<0.001	34,991
Clean climate-policy attention	province_industry_trend	IPW ATT	0.128*** (0.020)	<0.001	34,950
Clean climate-policy attention	province_industry_trend	3-nearest-neighbor	0.126*** (0.020)	<0.001	20,931
Clean climate-policy attention	pre_outcome_linear_trend_controls	Unweighted	0.065*** (0.015)	<0.001	32,756
Clean climate-policy attention	pre_outcome_linear_trend_controls	IPW ATT	0.067*** (0.018)	<0.001	32,733
Clean climate-policy attention	pre_outcome_linear_trend_controls	3-nearest-neighbor	0.066*** (0.018)	<0.001	19,606
Clean climate-policy attention	pre_outcome_flexible_year_controls	Unweighted	0.053*** (0.015)	<0.001	32,756
Clean climate-policy attention	firm_specific_trend_pressure_test	Unweighted	-0.003 (0.015)	0.830	35,000

Outcome	Specification	Method	Coef. on ETS x pre-CO2	p	N
Clean climate-policy attention	firm_specific_trend_pressure_test	IPW ATT	0.002 (0.015)	0.903	34,959
Clean climate-policy attention	firm_specific_trend_pressure_test	3-nearest-neighbor	-0.001 (0.015)	0.954	20,943
Clean climate attention	baseline	Unweighted	0.128*** (0.020)	<0.001	35,000
Clean climate attention	baseline	IPW ATT	0.130*** (0.020)	<0.001	34,959
Clean climate attention	baseline	3-nearest-neighbor	0.130*** (0.021)	<0.001	20,943
Clean climate attention	province_industry_trend	Unweighted	0.109*** (0.022)	<0.001	34,991
Clean climate attention	province_industry_trend	IPW ATT	0.122*** (0.022)	<0.001	34,950
Clean climate attention	province_industry_trend	3-nearest-neighbor	0.118*** (0.022)	<0.001	20,931
Clean climate attention	pre_outcome_linear_trend_controls	Unweighted	0.088*** (0.017)	<0.001	32,756
Clean climate attention	pre_outcome_linear_trend_controls	IPW ATT	0.089*** (0.017)	<0.001	32,733
Clean climate attention	pre_outcome_linear_trend_controls	3-nearest-neighbor	0.084*** (0.017)	<0.001	19,606
Clean climate attention	pre_outcome_flexible_year_controls	Unweighted	0.062*** (0.016)	<0.001	32,756
Clean climate attention	firm_specific_trend_pressure_test	Unweighted	0.043* (0.025)	0.089	35,000
Clean climate attention	firm_specific_trend_pressure_test	IPW ATT	0.056** (0.025)	0.029	34,959
Clean climate attention	firm_specific_trend_pressure_test	3-nearest-neighbor	0.050* (0.026)	0.058	20,943
Green applications	baseline	Unweighted	0.169*** (0.037)	<0.001	35,025
Green applications	baseline	IPW ATT	0.166*** (0.035)	<0.001	34,984
Green applications	baseline	3-nearest-neighbor	0.156*** (0.037)	<0.001	20,963
Green applications	province_industry_trend	Unweighted	0.143*** (0.035)	<0.001	35,016
Green applications	province_industry_trend	IPW ATT	0.143*** (0.034)	<0.001	34,975
Green applications	province_industry_trend	3-nearest-neighbor	0.139*** (0.035)	<0.001	20,951
Green applications	pre_outcome_linear_trend_controls	Unweighted	0.134*** (0.041)	0.001	32,779
Green applications	pre_outcome_linear_trend_controls	IPW ATT	0.128*** (0.038)	<0.001	32,756
Green applications	pre_outcome_linear_trend_controls	3-nearest-neighbor	0.120*** (0.040)	0.003	19,624
Green applications	pre_outcome_flexible_year_controls	Unweighted	0.142*** (0.040)	<0.001	32,779
Green applications	firm_specific_trend_pressure_test	Unweighted	0.044 (0.040)	0.267	35,025
Green applications	firm_specific_trend_pressure_test	IPW ATT	0.038 (0.039)	0.328	34,984
Green applications	firm_specific_trend_pressure_test	3-nearest-neighbor	0.039 (0.040)	0.330	20,963
Green invention applications	baseline	Unweighted	0.155*** (0.035)	<0.001	35,025
Green invention applications	baseline	IPW ATT	0.161*** (0.034)	<0.001	34,984
Green invention applications	baseline	3-nearest-neighbor	0.151*** (0.035)	<0.001	20,963
Green invention applications	province_industry_trend	Unweighted	0.135*** (0.034)	<0.001	35,016
Green invention applications	province_industry_trend	IPW ATT	0.136*** (0.034)	<0.001	34,975
Green invention applications	province_industry_trend	3-nearest-neighbor	0.133*** (0.035)	<0.001	20,951
Green invention applications	pre_outcome_linear_trend_controls	Unweighted	0.120*** (0.039)	0.002	32,779
Green invention applications	pre_outcome_linear_trend_controls	IPW ATT	0.123*** (0.037)	<0.001	32,756
Green invention applications	pre_outcome_linear_trend_controls	3-nearest-neighbor	0.117*** (0.038)	0.002	19,624
Green invention applications	pre_outcome_flexible_year_controls	Unweighted	0.127*** (0.038)	<0.001	32,779
Green invention applications	firm_specific_trend_pressure_test	Unweighted	0.039 (0.036)	0.273	35,025
Green invention applications	firm_specific_trend_pressure_test	IPW ATT	0.042 (0.034)	0.218	34,984
Green invention applications	firm_specific_trend_pressure_test	3-nearest-neighbor	0.042 (0.036)	0.247	20,963
Green invention grants	baseline	Unweighted	0.104*** (0.030)	<0.001	35,025
Green invention grants	baseline	IPW ATT	0.113*** (0.032)	<0.001	34,984

Outcome	Specification	Method	Coef. on ETS x pre-CO2	p	N
Green invention grants	baseline	3-nearest-neighbor	0.113*** (0.032)	<0.001	20,963
Green invention grants	province_industry_trend	Unweighted	0.100*** (0.029)	<0.001	35,016
Green invention grants	province_industry_trend	IPW ATT	0.101*** (0.031)	0.001	34,975
Green invention grants	province_industry_trend	3-nearest-neighbor	0.101*** (0.032)	0.001	20,951
Green invention grants	pre_outcome_linear_trend_controls	Unweighted	0.061** (0.030)	0.041	32,779
Green invention grants	pre_outcome_linear_trend_controls	IPW ATT	0.057* (0.030)	0.057	32,756
Green invention grants	pre_outcome_linear_trend_controls	3-nearest-neighbor	0.054* (0.031)	0.079	19,624
Green invention grants	pre_outcome_flexible_year_controls	Unweighted	0.065** (0.030)	0.028	32,779
Green invention grants	firm_specific_trend_pressure_test	Unweighted	-0.006 (0.023)	0.776	35,025
Green invention grants	firm_specific_trend_pressure_test	IPW ATT	-0.001 (0.023)	0.967	34,984
Green invention grants	firm_specific_trend_pressure_test	3-nearest-neighbor	0.000 (0.024)	0.987	20,963
Invention applications	baseline	Unweighted	0.202*** (0.050)	<0.001	35,025
Invention applications	baseline	IPW ATT	0.186*** (0.049)	<0.001	34,984
Invention applications	baseline	3-nearest-neighbor	0.180*** (0.051)	<0.001	20,963
Invention applications	province_industry_trend	Unweighted	0.165*** (0.049)	<0.001	35,016
Invention applications	province_industry_trend	IPW ATT	0.148*** (0.049)	0.003	34,975
Invention applications	province_industry_trend	3-nearest-neighbor	0.152*** (0.051)	0.003	20,951
Invention applications	pre_outcome_linear_trend_controls	Unweighted	0.187*** (0.054)	<0.001	32,779
Invention applications	pre_outcome_linear_trend_controls	IPW ATT	0.169*** (0.053)	0.001	32,756
Invention applications	pre_outcome_linear_trend_controls	3-nearest-neighbor	0.164*** (0.054)	0.003	19,624
Invention applications	pre_outcome_flexible_year_controls	Unweighted	0.202*** (0.053)	<0.001	32,779
Invention applications	firm_specific_trend_pressure_test	Unweighted	0.038 (0.046)	0.399	35,025
Invention applications	firm_specific_trend_pressure_test	IPW ATT	0.031 (0.045)	0.500	34,984
Invention applications	firm_specific_trend_pressure_test	3-nearest-neighbor	0.031 (0.047)	0.506	20,963

Table A9. Reduced-form heterogeneity by capability and financing

Split	Outcome	Interaction increment	p	N
High absorptive capacity	Climate-policy attention	-0.012 (0.038)	0.750	28,349
High absorptive capacity	Climate attention	-0.118** (0.046)	0.012	28,349
High absorptive capacity	Green applications	0.186** (0.082)	0.023	28,367
High absorptive capacity	Green invention applications	0.143* (0.075)	0.058	28,367
High absorptive capacity	Green invention grants	0.047 (0.061)	0.440	28,367
Low financing constraint	Climate-policy attention	-0.005 (0.039)	0.902	35,000
Low financing constraint	Climate attention	-0.019 (0.046)	0.682	35,000
Low financing constraint	Green applications	0.174*** (0.067)	0.010	35,025
Low financing constraint	Green invention applications	0.167*** (0.062)	0.007	35,025
Low financing constraint	Green invention grants	0.068 (0.054)	0.213	35,025
High financial slack	Climate-policy attention	0.006 (0.034)	0.857	35,000
High financial slack	Climate attention	-0.042 (0.040)	0.293	35,000
High financial slack	Green applications	0.039 (0.077)	0.614	35,025
High financial slack	Green invention applications	0.042 (0.071)	0.550	35,025
High financial slack	Green invention grants	0.006 (0.058)	0.918	35,025

Table A10. Attention-to-innovation heterogeneity

Split	Attention	Outcome	Horizon	Incremental attention slope	p	N
High absorptive capacity	Climate-policy attention	Green applications	t+1	0.045** (0.019)	0.020	26,250
Low financing constraint	Climate-policy attention	Green applications	t+1	0.149*** (0.018)	<0.001	32,386
High absorptive capacity	Climate attention	Green applications	t+1	0.050*** (0.015)	0.001	26,250
Low financing constraint	Climate attention	Green applications	t+1	0.117*** (0.014)	<0.001	32,386
High absorptive capacity	Climate-policy attention	Green applications	t+2	0.050* (0.027)	0.063	24,019
Low financing constraint	Climate-policy attention	Green applications	t+2	0.200*** (0.025)	<0.001	29,625
High absorptive	Climate attention	Green applications	t+2	0.059*** (0.021)	0.004	24,019

Split	Attention	Outcome	Horizon	Incremental attention slope	p	N
capacity						
Low financing constraint	Climate attention	Green applications	t+2	0.149*** (0.019)	<0.001	29,625
High absorptive capacity	Climate-policy attention	Green invention applications	t+1	0.071*** (0.016)	<0.001	26,250
Low financing constraint	Climate-policy attention	Green invention applications	t+1	0.135*** (0.016)	<0.001	32,386
High absorptive capacity	Climate attention	Green invention applications	t+1	0.066*** (0.013)	<0.001	26,250
Low financing constraint	Climate attention	Green invention applications	t+1	0.102*** (0.012)	<0.001	32,386
High absorptive capacity	Climate-policy attention	Green invention applications	t+2	0.084*** (0.023)	<0.001	24,019
Low financing constraint	Climate-policy attention	Green invention applications	t+2	0.187*** (0.023)	<0.001	29,625
High absorptive capacity	Climate attention	Green invention applications	t+2	0.080*** (0.018)	<0.001	24,019
Low financing constraint	Climate attention	Green invention applications	t+2	0.135*** (0.017)	<0.001	29,625
High absorptive capacity	Climate-policy attention	Green invention grants	t+1	0.059*** (0.013)	<0.001	26,250
Low financing constraint	Climate-policy attention	Green invention grants	t+1	0.089*** (0.012)	<0.001	32,386
High absorptive capacity	Climate attention	Green invention grants	t+1	0.047*** (0.010)	<0.001	26,250
Low financing constraint	Climate attention	Green invention grants	t+1	0.062*** (0.009)	<0.001	32,386
High absorptive capacity	Climate-policy attention	Green invention grants	t+2	0.074*** (0.019)	<0.001	24,019
Low financing constraint	Climate-policy attention	Green invention grants	t+2	0.123*** (0.018)	<0.001	29,625
High absorptive capacity	Climate attention	Green invention grants	t+2	0.065*** (0.015)	<0.001	24,019
Low financing constraint	Climate attention	Green invention grants	t+2	0.087*** (0.013)	<0.001	29,625

Table A11. Attention-to-innovation sequence checks

Panel	Outcome	Horizon	Check	Estimate	p	N
A. Exposure-intensity total association	Green applications	t+1	exposure-intensity total	0.080*** (0.022)	<0.001	32,410
B. Exposure-intensity after adding attention	Green applications	t+1	exposure-intensity after attention	0.064*** (0.022)	0.003	32,386
C. Lagged attention sequence	Green applications	t+1	climate-policy attention	0.131*** (0.015)	<0.001	32,386
D. Descriptive attenuation check	Green applications	t+1	attenuation after attention	19.9%		32,386
A. Exposure-intensity total association	Green applications	t+2	exposure-intensity total	0.088*** (0.028)	0.002	29,648
B. Exposure-intensity after adding attention	Green applications	t+2	exposure-intensity after attention	0.073** (0.028)	0.011	29,625
C. Lagged attention sequence	Green applications	t+2	climate-policy attention	0.140*** (0.021)	<0.001	29,625
D. Descriptive attenuation check	Green applications	t+2	attenuation after attention	17.7%		29,625
A. Exposure-intensity total association	Green invention applications	t+1	exposure-intensity total	0.078*** (0.020)	<0.001	32,410
B. Exposure-intensity after adding attention	Green invention applications	t+1	exposure-intensity after attention	0.066*** (0.020)	<0.001	32,386
C. Lagged attention sequence	Green invention applications	t+1	climate-policy attention	0.094*** (0.013)	<0.001	32,386
D. Descriptive attenuation check	Green invention applications	t+1	attenuation after attention	15.1%		32,386
A. Exposure-intensity total association	Green invention applications	t+2	exposure-intensity total	0.096*** (0.026)	<0.001	29,648
B. Exposure-intensity after adding attention	Green invention applications	t+2	exposure-intensity after attention	0.085*** (0.026)	0.001	29,625

Panel	Outcome	Horizon	Check	Estimate	p	N
C. Lagged attention sequence	Green invention applications	t+2	climate-policy attention	0.103*** (0.018)	<0.001	29,625
D. Descriptive attenuation check	Green invention applications	t+2	attenuation after attention	12.1%		29,625
A. Exposure-intensity total association	Green invention grants	t+1	exposure-intensity total	0.068*** (0.016)	<0.001	32,410
B. Exposure-intensity after adding attention	Green invention grants	t+1	exposure-intensity after attention	0.059*** (0.016)	<0.001	32,386
C. Lagged attention sequence	Green invention grants	t+1	climate-policy attention	0.072*** (0.011)	<0.001	32,386
D. Descriptive attenuation check	Green invention grants	t+1	attenuation after attention	13.2%		32,386
A. Exposure-intensity total association	Green invention grants	t+2	exposure-intensity total	0.085*** (0.022)	<0.001	29,648
B. Exposure-intensity after adding attention	Green invention grants	t+2	exposure-intensity after attention	0.074*** (0.022)	0.001	29,625
C. Lagged attention sequence	Green invention grants	t+2	climate-policy attention	0.097*** (0.014)	<0.001	29,625
D. Descriptive attenuation check	Green invention grants	t+2	attenuation after attention	13.2%		29,625

Note. These checks compare future-innovation models with and without clean climate-policy attention. They are sequence-consistent checks, not formal causal mediation estimates.

Table A12. 2010-2012 pre-CO2 weighted and matched core regressions

Outcome	Method	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Climate attention	3-nearest-neighbor	0.131*** (0.022)	<0.001	20,943	0.032	Yes	Yes	Yes	Yes	Firm
Climate attention	IPW ATT	0.130*** (0.021)	<0.001	34,959	0.027	Yes	Yes	Yes	Yes	Firm
Climate attention	Unweighted	0.128*** (0.021)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes	Firm
Climate-policy attention	3-nearest-neighbor	0.139*** (0.021)	<0.001	20,943	0.068	Yes	Yes	Yes	Yes	Firm
Climate-policy attention	IPW ATT	0.138*** (0.020)	<0.001	34,959	0.063	Yes	Yes	Yes	Yes	Firm
Climate-policy attention	Unweighted	0.138*** (0.019)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes	Firm
Green applications	3-nearest-neighbor	0.156*** (0.037)	<0.001	20,963	0.096	Yes	Yes	Yes	Yes	Firm
Green applications	IPW ATT	0.166*** (0.035)	<0.001	34,984	0.104	Yes	Yes	Yes	Yes	Firm
Green applications	Unweighted	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes	Firm
Green invention applications	3-nearest-neighbor	0.151*** (0.035)	<0.001	20,963	0.086	Yes	Yes	Yes	Yes	Firm
Green invention applications	IPW ATT	0.161*** (0.034)	<0.001	34,984	0.093	Yes	Yes	Yes	Yes	Firm
Green invention applications	Unweighted	0.155*** (0.035)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes	Firm
Green invention grants	3-nearest-neighbor	0.113*** (0.032)	<0.001	20,963	0.054	Yes	Yes	Yes	Yes	Firm
Green invention grants	IPW ATT	0.113*** (0.032)	<0.001	34,984	0.057	Yes	Yes	Yes	Yes	Firm
Green invention grants	Unweighted	0.104*** (0.030)	<0.001	35,025	0.049	Yes	Yes	Yes	Yes	Firm
Invention applications	3-nearest-neighbor	0.180*** (0.051)	<0.001	20,963	0.128	Yes	Yes	Yes	Yes	Firm

Outcome	Method	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Invention applications	IPW ATT	0.186*** (0.049)	<0.001	34,984	0.134	Yes	Yes	Yes	Yes	Firm
Invention applications	Unweighted	0.202*** (0.050)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes	Firm

Note. Focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2. All specifications include firm controls and firm, province-year, and industry-year fixed effects.

Table A13. Alternative pre-policy CO2 windows

Pre-CO2 window	Outcome	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
2005_2010	Climate attention	0.069** (0.029)	0.017	26,934	0.020	Yes	Yes	Yes	Yes	Firm
2005_2010	Climate-policy attention	0.107*** (0.024)	<0.001	26,934	0.058	Yes	Yes	Yes	Yes	Firm
2005_2010	Green applications	0.134*** (0.045)	0.003	26,954	0.096	Yes	Yes	Yes	Yes	Firm
2005_2010	Green invention applications	0.126*** (0.043)	0.003	26,954	0.084	Yes	Yes	Yes	Yes	Firm
2005_2010	Green invention grants	0.093** (0.040)	0.019	26,954	0.048	Yes	Yes	Yes	Yes	Firm
2005_2010	Invention applications	0.179*** (0.060)	0.003	26,954	0.128	Yes	Yes	Yes	Yes	Firm
2007_2010	Climate attention	0.069** (0.029)	0.018	26,150	0.020	Yes	Yes	Yes	Yes	Firm
2007_2010	Climate-policy attention	0.107*** (0.024)	<0.001	26,150	0.058	Yes	Yes	Yes	Yes	Firm
2007_2010	Green applications	0.139*** (0.046)	0.002	26,170	0.097	Yes	Yes	Yes	Yes	Firm
2007_2010	Green invention applications	0.131*** (0.043)	0.002	26,170	0.086	Yes	Yes	Yes	Yes	Firm
2007_2010	Green invention grants	0.096** (0.041)	0.018	26,170	0.050	Yes	Yes	Yes	Yes	Firm
2007_2010	Invention applications	0.175*** (0.061)	0.004	26,170	0.127	Yes	Yes	Yes	Yes	Firm
2010_2012	Climate attention	0.128*** (0.021)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes	Firm
2010_2012	Climate-policy attention	0.138*** (0.019)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes	Firm
2010_2012	Green applications	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes	Firm
2010_2012	Green invention applications	0.155*** (0.035)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes	Firm
2010_2012	Green invention grants	0.104*** (0.030)	<0.001	35,025	0.049	Yes	Yes	Yes	Yes	Firm
2010_2012	Invention applications	0.202*** (0.050)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes	Firm
2010_2013	Climate attention	0.128*** (0.021)	<0.001	35,733	0.021	Yes	Yes	Yes	Yes	Firm
2010_2013	Climate-policy attention	0.138*** (0.019)	<0.001	35,733	0.058	Yes	Yes	Yes	Yes	Firm
2010_2013	Green applications	0.171*** (0.037)	<0.001	35,759	0.097	Yes	Yes	Yes	Yes	Firm
2010_2013	Green invention applications	0.157*** (0.035)	<0.001	35,759	0.086	Yes	Yes	Yes	Yes	Firm
2010_2013	Green	0.103***	<0.001	35,759	0.048	Yes	Yes	Yes	Yes	Firm

Pre-CO2 window	Outcome	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
	invention grants	(0.030)								
2010_2013	Invention applications	0.199*** (0.050)	<0.001	35,759	0.127	Yes	Yes	Yes	Yes	Firm

Note. Focal coefficient is ETS exposure x standardized pre-policy CO2 measured over the listed window.

Table A14. Pre-2020, pre-2021, and power-sector sample restrictions

Sample	Outcome	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Excluding power sector	Climate attention	0.134*** (0.022)	<0.001	33,742	0.019	Yes	Yes	Yes	Yes	Firm
Excluding power sector	Climate-policy attention	0.144*** (0.021)	<0.001	33,742	0.056	Yes	Yes	Yes	Yes	Firm
Excluding power sector	Green applications	0.132*** (0.037)	<0.001	33,767	0.096	Yes	Yes	Yes	Yes	Firm
Excluding power sector	Green invention applications	0.122*** (0.035)	<0.001	33,767	0.086	Yes	Yes	Yes	Yes	Firm
Excluding power sector	Green invention grants	0.076** (0.031)	0.013	33,767	0.049	Yes	Yes	Yes	Yes	Firm
Excluding power sector	Invention applications	0.148*** (0.051)	0.004	33,767	0.127	Yes	Yes	Yes	Yes	Firm
Full 2001-2024	Climate attention	0.128*** (0.021)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes	Firm
Full 2001-2024	Climate-policy attention	0.138*** (0.019)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes	Firm
Full 2001-2024	Green applications	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes	Firm
Full 2001-2024	Green invention applications	0.155*** (0.035)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes	Firm
Full 2001-2024	Green invention grants	0.104*** (0.030)	<0.001	35,025	0.049	Yes	Yes	Yes	Yes	Firm
Full 2001-2024	Invention applications	0.202*** (0.050)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes	Firm
Pre-2020 only	Climate attention	0.094*** (0.022)	<0.001	26,207	0.012	Yes	Yes	Yes	Yes	Firm
Pre-2020 only	Climate-policy attention	0.078*** (0.016)	<0.001	26,207	0.035	Yes	Yes	Yes	Yes	Firm
Pre-2020 only	Green applications	0.118*** (0.038)	0.002	26,214	0.065	Yes	Yes	Yes	Yes	Firm
Pre-2020 only	Green invention applications	0.095*** (0.034)	0.005	26,214	0.058	Yes	Yes	Yes	Yes	Firm
Pre-2020 only	Green invention grants	0.059** (0.027)	0.028	26,214	0.027	Yes	Yes	Yes	Yes	Firm
Pre-2020 only	Invention applications	0.133*** (0.048)	0.005	26,214	0.098	Yes	Yes	Yes	Yes	Firm
Pre-2021 only	Climate attention	0.109*** (0.022)	<0.001	27,983	0.014	Yes	Yes	Yes	Yes	Firm
Pre-2021 only	Climate-policy attention	0.094*** (0.016)	<0.001	27,983	0.039	Yes	Yes	Yes	Yes	Firm
Pre-2021 only	Green applications	0.126*** (0.038)	<0.001	27,993	0.072	Yes	Yes	Yes	Yes	Firm
Pre-2021 only	Green invention applications	0.104*** (0.034)	0.002	27,993	0.065	Yes	Yes	Yes	Yes	Firm
Pre-2021 only	Green invention	0.065** (0.027)	0.014	27,993	0.029	Yes	Yes	Yes	Yes	Firm

Sample	Outcome	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Pre-2021 only	grants Invention applications	0.148*** (0.048)	0.002	27,993	0.104	Yes	Yes	Yes	Yes	Firm

Note. Focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2.

Table A15. Alternative clustering for 2010-2012 pre-CO2 specification

Outcome	Cluster	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE
Climate attention	Firm	0.128*** (0.021)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes
Climate attention	Firm + province-industry	0.128*** (0.020)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes
Climate attention	Pilot-industry	0.128*** (0.020)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes
Climate attention	Province-industry	0.128*** (0.020)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes
Climate-policy attention	Firm	0.138*** (0.019)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes
Climate-policy attention	Firm + province-industry	0.138*** (0.020)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes
Climate-policy attention	Pilot-industry	0.138*** (0.019)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes
Climate-policy attention	Province-industry	0.138*** (0.020)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes
Green applications	Firm	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes
Green applications	Firm + province-industry	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes
Green applications	Pilot-industry	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes
Green applications	Province-industry	0.169*** (0.037)	<0.001	35,025	0.096	Yes	Yes	Yes	Yes
Green invention applications	Firm	0.155*** (0.035)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes
Green invention applications	Firm + province-industry	0.155*** (0.035)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes
Green invention applications	Pilot-industry	0.155*** (0.036)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes
Green invention applications	Province-industry	0.155*** (0.035)	<0.001	35,025	0.086	Yes	Yes	Yes	Yes
Green invention grants	Firm	0.104*** (0.030)	<0.001	35,025	0.049	Yes	Yes	Yes	Yes
Green invention grants	Firm + province-industry	0.104*** (0.035)	0.003	35,025	0.049	Yes	Yes	Yes	Yes
Green invention grants	Pilot-industry	0.104*** (0.036)	0.004	35,025	0.049	Yes	Yes	Yes	Yes
Green invention grants	Province-industry	0.104*** (0.035)	0.003	35,025	0.049	Yes	Yes	Yes	Yes
Invention applications	Firm	0.202*** (0.050)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes
Invention applications	Firm + province-industry	0.202*** (0.054)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes
Invention applications	Pilot-industry	0.202*** (0.056)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes
Invention applications	Province-industry	0.202*** (0.055)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes

Note. Focal coefficient is ETS exposure x standardized 2010-2012 pre-policy CO2.

Table A16. Carbon intensity, within-industry rank, and scale placebo checks

Specification	Outcome	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Carbon intensity	Climate attention	0.061** (0.030)	0.040	35,000	0.017	Yes	Yes	Yes	Yes	Firm
Carbon intensity	Climate-policy attention	0.070*** (0.021)	<0.001	35,000	0.051	Yes	Yes	Yes	Yes	Firm
Carbon intensity	Green applications	0.040 (0.038)	0.293	35,025	0.092	Yes	Yes	Yes	Yes	Firm
Carbon intensity	Green invention applications	0.020 (0.034)	0.562	35,025	0.082	Yes	Yes	Yes	Yes	Firm
Carbon intensity	Green invention grants	-0.022 (0.028)	0.430	35,025	0.047	Yes	Yes	Yes	Yes	Firm
Carbon intensity	Invention applications	0.070 (0.053)	0.190	35,025	0.121	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy invention stock	Climate attention	0.027 (0.023)	0.251	40,937	0.015	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy invention stock	Climate-policy attention	0.022 (0.020)	0.269	40,937	0.047	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy invention stock	Green applications	0.093** (0.036)	0.010	40,962	0.085	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy invention stock	Green invention applications	0.121*** (0.035)	<0.001	40,962	0.077	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy invention stock	Green invention grants	0.224*** (0.031)	<0.001	40,962	0.057	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy invention stock	Invention applications	-0.052 (0.046)	0.264	40,962	0.107	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy size	Climate attention	0.106*** (0.021)	<0.001	40,937	0.018	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy size	Climate-policy attention	0.119*** (0.019)	<0.001	40,937	0.053	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy size	Green applications	0.238*** (0.036)	<0.001	40,962	0.090	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy size	Green invention applications	0.240*** (0.034)	<0.001	40,962	0.083	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy size	Green invention grants	0.223*** (0.035)	<0.001	40,962	0.055	Yes	Yes	Yes	Yes	Firm
ETS x pre-policy size	Invention applications	0.225*** (0.051)	<0.001	40,962	0.111	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-invention stock	Climate attention	0.128*** (0.021)	<0.001	35,000	0.021	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-invention stock	Climate-policy attention	0.138*** (0.019)	<0.001	35,000	0.058	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-invention stock	Green applications	0.171*** (0.037)	<0.001	35,025	0.097	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-invention stock	Green invention applications	0.157*** (0.035)	<0.001	35,025	0.089	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-invention stock	Green invention grants	0.108*** (0.028)	<0.001	35,025	0.065	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-invention stock	Invention applications	0.201*** (0.050)	<0.001	35,025	0.124	Yes	Yes	Yes	Yes	Firm

Specification	Outcome	Focal coefficient	p	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Pre-CO2 + ETS x pre-size	Climate attention	0.082*** (0.031)	0.008	35,000	0.021	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-size	Climate-policy attention	0.090*** (0.026)	<0.001	35,000	0.059	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-size	Green applications	-0.029 (0.044)	0.518	35,025	0.101	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-size	Green invention applications	-0.054 (0.042)	0.199	35,025	0.094	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-size	Green invention grants	-0.123*** (0.038)	0.001	35,025	0.065	Yes	Yes	Yes	Yes	Firm
Pre-CO2 + ETS x pre-size	Invention applications	0.047 (0.056)	0.402	35,025	0.126	Yes	Yes	Yes	Yes	Firm
Within-industry emissions rank	Climate attention	0.113*** (0.021)	<0.001	35,000	0.020	Yes	Yes	Yes	Yes	Firm
Within-industry emissions rank	Climate-policy attention	0.115*** (0.019)	<0.001	35,000	0.055	Yes	Yes	Yes	Yes	Firm
Within-industry emissions rank	Green applications	0.145*** (0.035)	<0.001	35,025	0.095	Yes	Yes	Yes	Yes	Firm
Within-industry emissions rank	Green invention applications	0.142*** (0.032)	<0.001	35,025	0.085	Yes	Yes	Yes	Yes	Firm
Within-industry emissions rank	Green invention grants	0.122*** (0.029)	<0.001	35,025	0.050	Yes	Yes	Yes	Yes	Firm
Within-industry emissions rank	Invention applications	0.151*** (0.046)	0.001	35,025	0.122	Yes	Yes	Yes	Yes	Firm

Note. Focal coefficient varies by specification. The size-placebo and prior-patent-placebo rows use ETS exposure x the named pre-policy attribute.

Table A17. Strength of the exposure-intensity association with attention

Outcome	Association coefficient	p	Approx. t statistic	N	Within R2	Controls	Firm FE	Province-year FE	Industry-year FE	Cluster
Climate-policy attention	0.138*** (0.019)	<0.001	7.38	35,000	0.058	Yes	Yes	Yes	Yes	Firm
Climate attention	0.128*** (0.021)	<0.001	6.05	35,000	0.021	Yes	Yes	Yes	Yes	Firm

Note. This table reports the association between ETS exposure x standardized 2010-2012 pre-policy CO2 and attention. It is not an instrumental-variable first stage.

Table A18. Sample-selection summary for 2010-2012 pre-CO2 availability

Group	Firms	Mean first year	Share with 2010-2012 rows	Mean Size	Mean ROA	Mean Lev	Mean SOE	Mean invention	Mean green
Excluded: no 2010-2012 pre-CO2	3,342	2017.525	0.099	21.659	0.060	0.419	0.424	0.704	0.284
Retained: has 2010-2012 pre-CO2	1,929	2005.587	1.000	21.766	0.054	0.409	0.445	1.499	0.481

Note. Retained firms have the 2010-2012 pre-policy CO2 records required to construct the main exposure-intensity proxy.

Table A19. Observable differences by 2010-2012 pre-CO2 availability

Variable	Retained mean	Excluded mean	SMD
pre_Size	21.766	21.659	0.085
pre_ROA	0.054	0.060	-0.118
pre_Lev	0.409	0.419	-0.040
pre_SOE	0.445	0.424	0.041
pre_invention	1.499	0.704	0.658
pre_green	0.481	0.284	0.267

Note. SMD is the standardized mean difference between firms with and without the 2010-2012 pre-policy CO2 records required to construct the exposure-intensity proxy.

Table A20. Attention-measure validation and construct triangulation for the 2010-2012 main window

Validation concern	Observable test	Evidence	Interpretation
Baseline construct response	Raw climate-policy and climate-attention measures	Climate-policy attention: 0.138*** (0.019), p <0.001; Climate attention: 0.128*** (0.021), p <0.001	The exposure-intensity proxy predicts the two main attention measures.
Cleaned climate-policy attention	Attention models residualized against report length, policy terms, and uncertainty terms	Clean climate-policy attention: 0.142*** (0.017), p <0.001; Clean climate attention: 0.128*** (0.020), p <0.001	The estimate remains strong after accounting for reporting volume and generic policy/uncertainty language.
Relative climate language	Climate share of dictionary terms and climate-to-policy term ratio	Climate share: 0.024*** (0.004), p <0.001; Climate-to-policy ratio: 0.037*** (0.006), p <0.001	Climate language rises relative to broader dictionary and policy language.
Non-climate uncertainty placebo	Uncertainty-attention placebo outcome	Uncertainty attention: -0.017 (0.013), p 0.197	The effect does not appear for generic uncertainty attention.
Generic policy-term contrast	Raw policy-term outcome compared with relative climate-policy ratios	Policy terms: 3.866** (1.772), p 0.029; Climate-to-policy ratio: 0.037*** (0.006), p <0.001	Generic policy words move, but relative climate-policy measures remain strong.
Environmental-disclosure boundary	Representative environmental-disclosure placebo outcomes	Environmental strengths: 0.285*** (0.092), p 0.002; Environmental concerns: 0.034 (0.025), p 0.170; Pollution disclosure: 0.028 (0.026), p 0.272; Energy-saving disclosure: -0.001 (0.033), p 0.966	Environmental strengths also increase, while concerns, pollution, and energy-saving categories do not show comparable movement.

Note. This table triangulates construct validity using cleaned, relative, and placebo-language tests. It is not a manual text audit of individual annual-report passages.

Table A21. Downstream innovation boundary and conversion checks

Risk addressed	Test	Outcome	Evidence	Interpretive implication
Scale-driven reduced form	Add ETS x pre-policy size to the ETS x pre-CO2 specification	Climate-policy attention	0.090*** (0.026), p <0.001, N = 35,000	The attention margin remains positive after accounting for scale activation.
Scale-driven reduced form	Add ETS x pre-policy size to the ETS x pre-CO2 specification	Green invention applications	-0.054 (0.042), p 0.199, N = 35,025	The reduced-form innovation coefficient is absorbed by pre-policy size; the innovation result is scale-sensitive.
Prior innovation capacity	Add ETS x pre-policy invention stock to the ETS x pre-CO2 specification	Green invention applications	0.157*** (0.035), p <0.001, N = 35,025	The innovation result is not simply prior patent stock; it survives this patent-capability placebo.
Within-industry carbon position	Replace absolute pre-CO2 with within-industry emissions rank	Green invention applications	0.142*** (0.032), p <0.001, N = 35,025	Relative carbon position inside industry predicts green invention, supporting a carbon-exposure interpretation beyond raw size.
Attention-to-green conversion after cost controls	Climate attention t -> green invention applications t+1, with emission/cost proxies	Green invention applications	0.051** (0.020), p 0.011, N = 8,120	The attention-to-green-invention sequence remains visible after controlling observed emission/cost proxies.
Attention-to-green conversion after cost controls	Climate attention t -> green invention grants t+1, with emission/cost proxies	Green invention grants	0.051*** (0.016), p 0.001, N = 8,120	The attention-to-green-grant sequence remains visible after controlling observed emission/cost proxies.
Broader invention boundary after cost controls	Climate-policy attention t -> invention applications t+1, with emission/cost proxies	Invention applications	0.033 (0.025), p 0.187, N = 8,120	The broader-invention channel is weaker after cost controls; this is a boundary of the broader-search claim.

Note. This table reports the full version of the boundary and conversion checks summarized in main-text Table 6. It separates the reduced-form innovation boundary from the attention-to-innovation conversion evidence. The cost-control rows include observed emission and cost proxies and therefore use a smaller sample. Capability and financing conversion heterogeneity is reported in Table A10 and Panel B of Table 6 in the main manuscript.

Table A22. Attention dictionary categories and English glosses

Dictionary family	Chinese example terms	English gloss	Coding relevance
Climate / carbon terms	气候变化; 二氧化碳; 低碳; 碳排放; 温室气体; 碳中和; 碳达峰; 清洁能源	climate change; carbon dioxide; low carbon; carbon emissions; greenhouse gas; carbon neutrality; carbon peaking; clean energy	Identifies whether the passage concerns climate or carbon issues.
Climate-policy trigger terms	碳试点; 碳税; 绿色信贷; 巴黎协定; 环境保护税; 环保税	carbon pilot; carbon tax; green credit; Paris Agreement; environmental protection tax	Identifies whether climate language is linked to policy instruments or regulatory regimes.
Policy and regulatory terms	政策; 制度; 监管; 政府; 国务院; 改革; 整治	policy; system; regulation; government; State Council; reform; rectification	Used to distinguish climate-policy attention from generic policy language.
Uncertainty terms	不确定; 不明确; 不清晰; 难以预测; 无法预计; 不可预测	uncertain; unclear; difficult to predict; impossible to estimate; unpredictable	Used to separate climate-policy attention from generic uncertainty language.
Broad environmental terms	环境; 可持续; 绿色产品; 可再生能源; 绿色低碳	environment; sustainability; green products; renewable energy; green and low-carbon	Used as a contrast against broad environmental or ESG disclosure.

Note. The categories are used to separate climate/carbon language, climate-policy trigger language, generic policy language, uncertainty language, and broad environmental language.

Table A23. Public annual-report examples and contextual pilot coding

Firm	Year	Trigger term	English contextual summary	Contextual code	Coding reason	Dataset climate terms	Core carbon terms	Policy terms
300675 建科院	2,021	低碳 (low carbon)	The report discusses dual-carbon goals as changing the development path of cities and the construction industry, creating new challenges and opportunities under national carbon-peaking and carbon-neutrality policy documents.	Substantive climate-policy attention	Trigger term appears with policy, strategy, risk, management, target, transition, or disclosure language.	195	132	177
688051 佳华科技	2,021	低碳 (low carbon)	The firm reports establishing a low-carbon development center and developing low-carbon products, greenhouse-gas monitoring equipment, carbon-asset management software, and dual-carbon information platforms.	Substantive climate-policy attention	Trigger term appears with policy, strategy, risk, management, target, transition, or disclosure language.	139	127	117
600968 海油发展	2,021	温室气体 (greenhouse gas)	The passage defines certified voluntary emission reductions and greenhouse-gas reduction trading under National Development and Reform Commission rules, alongside carbon capture, utilization, and storage language.	Substantive climate-policy attention	Trigger term appears with policy, strategy, risk, management, target, transition, or disclosure language.	162	126	97
688051 佳华科技	2,022	碳达峰 (carbon peaking)	The report defines carbon peaking and carbon neutrality and links them to the firm's information-sensing and monitoring technology context.	Substantive climate-policy attention	Trigger term appears with policy, strategy, risk, management, target, transition, or disclosure language.	147	125	161
002658 雪迪龙	2,022	二氧化碳 (carbon dioxide)	The passage describes continuous monitoring of carbon dioxide from fixed-source emissions and defines carbon monitoring and carbon peaking in the firm's environmental-technology context.	Substantive climate-policy attention	Trigger term appears with policy, strategy, risk, management, target, transition, or disclosure language.	132	124	136
002488 金固股份	2,021	二氧化碳 (carbon dioxide)	The firm links lightweight wheel technology to reduced carbon dioxide emissions and to national carbon-peaking, carbon-neutrality, energy-saving, and emission-reduction objectives.	Substantive climate-policy attention	Trigger term appears with policy, strategy, risk, management, target, transition, or disclosure language.	120	122	64

Note. Table A23 reports English summaries of public annual-report passages used in the pilot contextual audit. The source excerpts are in Chinese in the archived coding files; the broader manual validation protocol is summarized in Table A24.

Table A24. Pilot attention-validation materials and manual coding protocol

Validation component	Status	File
Dictionary categories	Completed	attention_dictionary_categories.csv
Public-report excerpt examples	Completed for 6 public annual reports	attention_public_report_excerpt_examples.csv
Contextual pilot coding	Completed as a pilot contextual audit	attention_public_report_excerpt_examples.csv
Manual coding protocol	Protocol documented; independent reliability statistic not estimated in this pilot audit	attention_manual_validation_summary.csv

Note. The appendix reports dictionary categories, pilot contextual coding, and the protocol used to structure manual validation. No independent two-coder reliability statistic is reported.

Table A25. Made in China 2025 alternative-policy tests

Specification	Outcome	Sample	Term	Estimate	p	N	Within R2
Triple difference: exposure intensity x MIC2025 target	Climate-policy attention	full	ETS x pre-CO2	0.092*** (0.035)	0.010	35,000	0.043
Triple difference: exposure intensity x MIC2025 target	Climate-policy attention	full	ETS x pre-CO2 x MIC2025 target	0.057 (0.042)	0.169	35,000	0.043
Split sample: Non-MIC2025 industries	Climate-policy attention	Non-MIC2025 industries	ETS x pre-CO2	0.087** (0.035)	0.014	15,048	0.026
Split sample: MIC2025-target industries	Climate-policy attention	MIC2025-target industries	ETS x pre-CO2	0.147*** (0.022)	<0.001	19,901	0.051
Triple difference: exposure intensity x MIC2025 target	Green applications	full	ETS x pre-CO2	0.251*** (0.078)	0.001	35,025	0.096
Triple difference: exposure intensity x MIC2025 target	Green applications	full	ETS x pre-CO2 x MIC2025 target	-0.120 (0.092)	0.192	35,025	0.096
Triple difference: exposure intensity x MIC2025 target	Green invention applications	full	ETS x pre-CO2	0.260*** (0.073)	<0.001	35,025	0.087
Triple difference: exposure intensity x MIC2025 target	Green invention applications	full	ETS x pre-CO2 x MIC2025 target	-0.137 (0.086)	0.114	35,025	0.087
Split sample: Non-MIC2025 industries	Green invention applications	Non-MIC2025 industries	ETS x pre-CO2	0.267*** (0.076)	<0.001	15,059	0.055
Split sample: MIC2025-target industries	Green invention applications	MIC2025-target industries	ETS x pre-CO2	0.080* (0.043)	0.066	19,916	0.107
Triple difference: exposure intensity x MIC2025 target	Invention applications	full	ETS x pre-CO2	0.365*** (0.116)	0.002	35,025	0.125
Triple difference: exposure intensity x MIC2025 target	Invention applications	full	ETS x pre-CO2 x MIC2025 target	-0.251* (0.131)	0.055	35,025	0.125
Split sample: Non-MIC2025 industries	Invention applications	Non-MIC2025 industries	ETS x pre-CO2	0.351*** (0.123)	0.004	15,059	0.069
Split sample: MIC2025-target industries	Invention applications	MIC2025-target industries	ETS x pre-CO2	0.048 (0.055)	0.379	19,916	0.163

Note. MIC2025 target status is coded at the industry level using industry-name matches to priority sectors. The triple-difference specification adds ETS x pre-CO2 x MIC2025 target to the main fixed-effect model; split-sample rows report the exposure-intensity coefficient separately for MIC2025-target and non-target industries. All models include firm controls and firm, province-year, and industry-year fixed effects; standard errors are clustered by firm.