Stakeholder Support and the Effectiveness of Carbon Disclosure Mandate*

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This draft: Nov 18, 2025

Abstract

We show that stakeholder support plays a critical role in enabling disclosure mandates to achieve effective carbon reduction. Specifically, we examine a 2021 Chinese disclosure mandate intended to incentivize corporate carbon reduction and show that it produces different effects depending on the level of stakeholder support. We define treatment firms as those that undertook emission-reduction efforts in response to the mandate, and control firms as those that did not. We then categorize firms based on the level of institutional support in their headquarter regions, including the availability of carbon management professionals, green financing from local central bank branches, and environmental spending by local governments. We find that only treatment firms in regions with strong stakeholder support significantly reduce carbon intensity and emissions relative to matched control firms. These findings suggest that disclosure regulations alone cannot drive substantive emission reductions, and effective corporate decarbonization requires coordinated support from multiple external stakeholders.

Keywords: disclosure regulation, carbon emissions, ESG, real effects, stakeholder
JEL Classification: Q54, Q58, M41, M48

We appreciate helpful comments from Ashiq Ali, Nan Jia, Stanimir Markov, Suresh Radhakrishnan, Yuan Zhang, Ran Zhao, Qiang Cheng, Mingyi Hung and the seminar participants at the University of Texas at Dallas, China Business Research Network, Peking University, and the Asian Bureau of Finance and Economics Research (ABFER) Conference. We are grateful to Jonathan Wen for his research assistance. We are grateful for the financial support from the Social Sciences and Humanities Research Council of Canada and the Guanghua-Rotman Centre for Information and Capital Market Research. Lu acknowledges the support from McCutcheon Professorship in International Business at the University of Toronto.

1 | INTRODUCTION

As the impacts of climate change are felt worldwide, governments have increasingly turned to disclosure regulations as a policy instrument to encourage firms to address climate change. By mandating the reporting of carbon-reduction measures, such regulations aim to enhance transparency, strengthen accountability, and ultimately drive firms toward more sustainable practices. Prior studies show that carbon disclosure mandates in the UK and the US have led to reductions in corporate carbon emissions (Downar et al., 2021; Tomar, 2023). However, these findings reflect the joint effect of the disclosure regulation and institutional complementarities (Christensen et al., 2021; Leuz & Wysocki 2016). Specifically, while disclosure regulations alone create an incentive for firms to reduce emissions, achieving meaningful reductions often requires human capital and financial resources beyond what firms can provide internally. In such cases, complementary support from external stakeholders, which have both the interest and responsibility to facilitate emission reductions, is crucial. Many countries, however, lack the level of stakeholder awareness and support present in the UK or US, leaving the effects of carbon disclosure regulations in these environments uncertain.

China exemplifies a context with varying levels of stakeholder support. As the world's largest emitter of carbon dioxide (World Bank, 2022), China has committed to an ambitious goal of reaching carbon neutrality by 2060. However, unlike in the US or the UK, where firms can easily offset carbon emissions through the purchase of green electricity or renewable energy certificates (RECs), such mechanisms were largely unavailable in China until 2021.[1] Moreover, sustainable development remains in its early stages, and stakeholders' environmental awareness is comparatively limited. This is evidenced by the shortage of ESG expertise (Economist Impact, 2023; Lu et al., 2021; Lu et al., 2024) and the

[1] As of 2021, China's domestic markets for green electricity and RECs remain in an early stage of development, and REC trading has not yet been incorporated into the country's official accounting framework for emissions reduction. As a result, firms could not report lower Scope 2 emissions through these mechanisms and instead often had little choice but to invest directly in substantive green projects to achieve verifiable reductions.

underdevelopment of advanced green financing schemes (World Economic Forum, 2022).[2] While some stakeholders, such as local governments and banks, do provide resources to support firms' carbon reduction efforts, the extent of support varies significantly across regions. Leveraging the uniqueness of the setting in China, this study attempts to investigate how disclosure regulation, when combined with complementary support from stakeholders such as governments and local financial institutions, can contribute to carbon emission reductions. Specifically, we provide evidence that stakeholder engagement through professional skills, green financing, and government commitment is essential to transform disclosure from a procedural compliance exercise into a mechanism that facilitates real carbon reduction.

Our study focuses on the Chinese Securities Regulatory Commission (CSRC)'s first attempt to encourage public firms to disclose information related to their carbon reduction initiatives in annual reports. In 2021, the CSRC mandated that all listed firms include an "Environmental and Social Responsibility" section in their annual reports and urged them to disclose the measures taken to reduce their carbon emissions during the reporting period, along with the results of those measures (CSRC, 2021a). Firms comply by creating a subsection titled "Measures Taken to Reduce Carbon Emissions and the Resulting Effects," where they either select "applicable" and elaborate or select "not applicable" and leave the section blank. We expect that firms will disclose truthfully, as the government can easily verify firms' carbon reduction measures through private channels, and false disclosures in annual reports are punishable under securities law.[3] Moreover, we conduct a nationwide survey to understand firms' decisions to disclose (or not disclose) carbon reduction efforts in the 2021 annual report.

In a stakeholder-focused economy like China, disclosure serves not only to inform capital providers but also to satisfy the demand of a broader set of key stakeholders, including the government (Cheng et al.,

[2] Based on the Environmental Performance Index published by the Yale Center for Environmental Law & Policy, China ranks 154 out of 180 countries included in the ranking (Block et al., 2024). In comparison, the UK ranks 5th and the US ranks 34th. This shows that China is at a much less advanced stage in terms of sustainability compared to countries such as the UK and US.

[3] Anecdotal evidence suggests that local government monitor firms' carbon emissions through private channels. Two authors of the study travelled to Jiangsu province, China, in July 2023 and had meetings with the officials from the Development and Reform Commission of several municipal governments. They claim that they have their own assessment of carbon emissions per unit of economic output for each enterprise in the respective city.

2022; Lu et al., 2023). Given the Chinese government's commitment to achieving the "dual carbon" goals and the CSRC's explicit statement that the 2021 disclosure requirement was introduced to support these goals (CSRC, 2021b), firms are likely to view carbon disclosure as a public endorsement of government objectives.[4] Accordingly, reducing emissions may yield potential benefits by helping firms maintain favorable relationships with the government, which is pivotal for accessing capital, resources, and economic opportunities in China (Haveman et al., 2017; Sun et al., 2014). The 2021 regulation increases these potential benefits by featuring firms' carbon reduction efforts prominently in annual reports, making them more visible to the government. As a result, some firms would perceive an increase in the marginal benefit of implementing carbon reduction measures while the marginal costs remain unchanged. This shift prompts such firms to expand their carbon reduction initiatives in pursuit of greater reductions.

However, many firms that choose to act face significant barriers in identifying and implementing effective emission-reduction measures, primarily due to a lack of expertise and financial support (De Haas et al., 2024). These challenges are common in institutional environments characterized by limited human capital and underdeveloped green financing. Without necessary expertise, firms struggle to accurately measure emissions and identify effective strategies (Degot et al., 2021). Moreover, it can be prohibitively costly for firms to search for and engage carbon management professionals when such expertise is not readily available locally. Access to green financing or subsidies is also a major constraint. Many green projects require significant upfront investments and have long payback periods, making it difficult for firms to pursue without external support. These constraints cannot be overcome through firm-level efforts alone and necessitate collaboration with broader stakeholders.

We conjecture that firms that attempt to cut emissions will only succeed if they are located in regions with high levels of stakeholder support. Specifically, we identify three types of stakeholders that provide such support: carbon verification agencies that supply human capital and technical expertise, local

[4] In September 2020, Chinese President Xi Jinping announced at the 75th session of the United Nations General Assembly that China will aim to peak its carbon dioxide emissions by 2030 and achieve carbon neutrality by 2060. The two goals are often referred to together as the "dual carbon" goals in China.

central bank branches that implement green financing policies, and local governments that allocate resources to energy-saving and environmental protection initiatives. We expect that firms in regions with high stakeholder support will be better positioned to implement effective carbon reduction strategies, while those in low-support regions are more likely to encounter resource constraints and resort to less effective measures. Thus, we hypothesize that in regions with high stakeholder support, firms undertaking carbon reduction efforts in 2021 will exhibit a significant decrease in emissions relative to firms that did not undertake such efforts. In contrast, in low-support regions, we expect no significant difference in emissions.

We use a difference-in-differences design to test the hypothesis. Based on firms' annual report disclosures, we define treatment firms as those that made efforts to reduce emissions in 2021 and control firms as those that did not. We obtain firms' carbon emissions information from QuantData.[5] The difference-in-differences model compares changes in carbon intensity and emissions between treatment and control firms around 2021.[6] More importantly, we capture how the carbon-reduction effect of the disclosure regulation varies with stakeholder support by interacting three variables: *Treat* (an indicator variable equal to one for treatment firms, and zero otherwise), *Post* (a year indicator variable equal to one from 2021 onwards, and zero otherwise) and *Support* (a categorical variable representing the availability of stakeholder support in a firm's headquarters region, including support related to human capital, green financing, and government environmental spending). In addition to control variables, we include both year and firm fixed effects to account for time trends and firm characteristics.

Our sample consists of CSI 800 firms listed on the Shanghai Stock Exchange and Shenzhen Stock Exchange between 2018 and 2021, subject to the availability of carbon emissions data from QuantData. We analyze the determinants of treatment and find that firms with higher historical carbon emissions, larger sizes, and lower price-to-book ratios are more likely to undertake carbon reduction measures. Some

[5] QuantData is a data provider that collects voluntarily disclosed annual carbon emissions (scope 1 and scope 2) from firms in the CSI 800 index and estimates the emissions for the remaining CSI 800 firms. The CSI 800 index (China Securities Index) consists of large, mid, and small-cap stocks listed in the Shanghai Stock Exchange and Shenzhen Stock Exchange.

[6] Carbon intensity is defined as the natural logarithm of carbon emissions to sales over the reporting period.

treatment firms may have already begun reducing emissions prior to 2021, raising concerns about their comparability with control firms. To mitigate this concern, we conduct our analyses using a coarsen exact matching (CEM) sample, wherein treatment and control firms are matched by their carbon emissions and intensity in 2018. This approach helps ensure that the two groups have comparable incentives to reduce emissions and would likely follow similar trends in the absence of the disclosure regulation.[7]

Our analysis reveals that treatment firms reduce their carbon intensity and emissions relative to control firms. Furthermore, treatment firms significantly reduce carbon intensity and emissions compared to control firms only when they have access to stakeholder support that provides human capital, green financing, and environmental infrastructure. In regions with low stakeholder support, there is no significant difference in the changes in carbon intensity and emissions between treatment and control firms. These results are robust across different CEM matching specifications and fixed effect structures. We conduct further analyses to test whether the impact of each support measure is more pronounced for firms expected to benefit the most. For human capital support, the effect is significant only for firms without prior carbon accounting and management experience, as proxied by Emission Trading System (ETS) participation. For green financing, the impact is evident only among non-state-owned enterprises, which face greater financial constraints and rely on green financing opportunities to support their carbon reduction efforts. For government environmental spending, the effect is stronger for firms in energy-intensive industries, as they are more likely to benefit from subsidies and green infrastructure investments. Together, all evidence suggests that disclosure regulations alone are insufficient and effective carbon reduction requires complementary support from other stakeholders.

Our study contributes to the growing literature on the real effects of greenhouse gas (GHG) disclosure regulations. Downar et al. (2021) and Jouvenot and Krueger (2021) examine a mandate which requires all UK-incorporated listed firms to report GHG emissions in annual reports, and Tomar (2023) investigates the public disclosure of industrial facilities' GHG emissions mandated by the US

[7] In Section 4.1, we discuss in detail why we believe any residual self-selection bias does not compromise our main inferences.

Environmental Protection Agency. All three prior studies find that firms reduce their carbon emissions in response to disclosure requirements. However, our study differs in important ways: While these studies operate under well-established GHG control systems and mature green finance markets, the variation in regional institutional environments within China enables us to examine the effects of a disclosure regulation both with and without stakeholder support. Comparing our findings with their conclusions provides valuable insights into the conditions under which carbon disclosure regulations are most effective. Given China's status as the world's largest carbon emitter, our findings carry global policy relevance.

Our paper also contributes to the broader literature on the real effects of ESG reporting by analyzing the interaction of disclosure regulation and detailed stakeholder support. Several prior studies examine how the mandatory disclosure of CSR reports or specific ESG-related issues, such as mine-safety records, human rights performance, or carbon emissions, affects corporate behavior and related ESG outcomes (Chen et al., 2018; Fiechter et al., 2022; Christensen et al., 2017; She, 2022; Grewal et al., 2022). Beyond accounting, economic research also provides evidence on the real effects of mandatory disclosure related to restaurant hygiene, workplace safety, public health, and extraction payments (Jin & Leslie, 2003; Johnson, 2020; Dranove et al., 2003; Rauter, 2020). However, as Leuz and Wysocki (2016) highlight, disclosure research often overlooks how reporting standards interact with broader institutional systems. This paper addresses that gap by examining the moderating effect of the support from stakeholders rather than shareholders, which is underexplored in the literature. Unlike conventional cross-sectional tests which often capture variations in incentives (e.g., regulation effects are more pronounced for firms facing stronger shareholder pressure, higher reputation costs, or stricter enforcement because these factors strengthen firms' incentives), stakeholder support enhances firms' capabilities, offering a perspective that is orthogonal to incentive-based mechanisms. This distinction is particularly relevant given that many firms currently lack the capacity to implement ESG initiatives effectively.

The rest of our paper is organized as follows. Section 2 describes the institutional background. Section 3 introduces our empirical predictions. Section 4 outlines the research design and describes our

sample and data. Section 5 presents the empirical findings. Section 6 shows additional analyses and field evidence. Section 7 concludes the paper.

2 | INSTITUTIONAL BACKGROUND

2.1 | China's low-carbon transition and sources of stakeholder support

The systematic reduction of carbon emissions in China has been a slow, gradual process, characterized by an increasing policy focus and ongoing governmental experimentation with effective strategies. In a joint statement with the US in 2014, China set a preliminary target to peak carbon emissions around 2030. Since then, the Chinese government has tested various approaches to curtail corporate carbon emissions, including establishing regional pilot carbon trading markets, mandating carbon accounting and verification for key emitters, and incorporating carbon reduction targets into the evaluation criteria for regional government officials. However, these measures were not systematically implemented at the national level, as the government prioritized addressing air and water pollution and ecological degradation, which had more immediate impacts on living standards (National Bureau of Statistics of China, 2019).

Instead, provincial and city-level governments have formulated and implemented their own policies aimed at curtailing carbon emissions. These include environmental initiatives such as energy conservation subsidies, pollution control measures, the development of clean energy industries, and the expansion of green finance. Due to differences in local governments' resource endowments and green development strategies, stakeholder support for carbon reduction varies significantly across regions.

Carbon reduction has gained significant policy importance since 2020, when China announced its "dual carbon" goals at the 75th session of the United Nations General Assembly: to achieve peak carbon emissions by 2030 and carbon neutrality by 2060, committing to "adopt more vigorous policies and measures" (China Global Television Network [CGTN], 2020).

2.2 | Disclosure regulation in support of the Dual Carbon goals

To support the "dual carbon" goals, the Chinese Securities Regulatory Commission (CSRC) announced a new disclosure regulation on June 28th, 2021 (henceforth referred to as the "2021 carbon disclosure regulation"). In the regulation, the CSRC mandates that all listed firms include an

"Environmental and Social Responsibility" section in their annual reports and encourages them to disclose within that section the measures taken to reduce their carbon emissions during the reporting period and the effects of these measures (CSRC, 2021a).[8] This marks the first time that Chinese listed firms are required to disclose information related to carbon emissions in any public report. To comply with the regulation, all firms establish a subsection within their annual reports specifically for disclosing their carbon reduction efforts. Within this subsection, they select one of two checkboxes labeled "applicable" or "not applicable." Those that select "applicable" would then continue to describe how they attempted to reduce emissions and the results they achieved. Those that selected "not applicable" would leave the subsection blank.[9] Examples of firms' disclosures are shown in Online Appendix I.

Given the government's extensive promotion of "dual carbon" goals, firms are likely to perceive the 2021 carbon disclosure regulation as a government signal prompting them to reduce carbon emissions and, accordingly, to increase their efforts. This is because maintaining a favorable relationship with the government is pivotal for accessing capital, resources, and economic opportunities in China (Haveman et al., 2017; Sun et al., 2014), and actively responding to the disclosure regulation serves as a strategic move for firms to establish political legitimacy (Marquis & Qian, 2014). Indeed, Bloomberg data show that the proportion of Chinese listed firms that disclosed their GHG reduction measures increased from 17% in 2020 to 59% in 2021.[10]

We expect firms' disclosures to truthfully reflect their efforts to reduce emissions. This expectation has two implications. First, firms are unlikely to strategically choose whether to disclose based on the success of their efforts. Regardless of whether a firm's initiatives have resulted in significant carbon

[8] This is reflected in Article 41, Item 7 of the *Guidelines for the Content and Format of Information Disclosure by Companies Offering Securities No.2 – Content and Format of Annual Reports* (2021 Version).
[9] The term "not applicable" is frequently used in annual reports to indicate that a particular item or circumstance does not pertain to the firm. For example, firms may select "not applicable" to denote the absence of changes in accounting policies, accounting estimates, or significant accounting errors compared to the previous financial report.
[10] We document the change in the "GHG Emissions Reduction Policy" variable in Bloomberg, which equals one if a firm has taken any measures to reduce GHG emissions during the reporting period. This dataset incorporates disclosures from both annual reports and other sources, such as stand-alone ESG reports. The proportion of disclosing firms was 7% in 2015, 13% in 2019, 17% in 2020, and 59% in 2021. This increase is not driven by Bloomberg coverage changes.

reductions, disclosing such efforts serves as a public demonstration of support for national goals, while avoiding disclosure would leave a conspicuous blank in the annual report, potentially attracting unwanted regulatory attention. Therefore, we expect firms to disclose any carbon reduction efforts that they have undertaken.

Second, firms are unlikely to "greenwash" by fabricating their carbon reduction efforts, as the government can verify disclosures through private channels. Consistent with the theory that Chinese firms operate under a "stakeholder" governance model, where information asymmetry between managers and stakeholders can be resolved through private "inside" communications (Ball et al., 2000a; Ball et al., 2000b, 2003; Lu et al., 2023), anecdotal evidence suggests that local governments regularly monitor firms' carbon emissions to meet the carbon reduction targets set by the central government. As a result, firms that have not implemented genuine carbon reduction measures are unlikely to falsely claim otherwise, since discrepancies between their disclosures and actual practices can be easily detected.

To better understand the factors influencing firms' disclosure decisions, we conduct a determinants test in the first reporting year following the implementation of the regulation. We download the FY 2021 annual reports of 4,659 firms listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange. Within the "Environmental and Social Responsibility" section of their annual reports, we search for the text "measures taken to reduce carbon emissions during the reporting period and the resulting effects." We find that 1,958 (42%) firms selected "applicable" in response to the text and disclosed their carbon reduction efforts, while the rest of the firms chose "not applicable." Next, to investigate the factors that influence a firm's disclosure, we run a logistic regression with the dependent variable set to one if a firm selected "applicable" and zero otherwise. We include three categories of explanatory variables. First, we include a firm's pre-2021 carbon emissions, measured using the first principal component of its FY 2020 scope 1 and 2 carbon emissions and carbon intensity (*EmissionPCA*). Since carbon emissions data are only available for CSI 800 firms, we conduct this analysis on a subsample of CSI 800 firms that have the required data on control variables. Second, to capture a firm's historical environmental awareness and reporting quality, we use the firm's ESG rating, CSR report filing, mentions of "dual carbon" goals in its annual report, and

reporting quality rating measured in FY 2020. Third, we account for stakeholder demand for a firm's environmental information, measured by current-year firm characteristics such as size, return on assets, price-to-book ratio, state ownership, institutional holdings, holdings by overseas investors, and analyst coverage.

We present the logistic regression results in Table 1 and summarize the key findings as follows. First, the main factor driving firms' disclosure in 2021 is their historical carbon emissions. The coefficient on *EmissionPCA* is positive, significant at the 1% level, and has the largest economic magnitude calculated by multiplying the coefficient by within-industry variation. This can be because high-emission firms feel a greater need to reduce emissions in response to the disclosure regulation, or because they have already begun reducing emissions before 2021 due to pressure from environmental regulators or other stakeholders. Second, while some of the disclosing firms may have started reducing emissions prior to 2021, there are also some firms that initiated new carbon reduction efforts in response to the disclosure regulation. If the disclosure regulation had only prompted disclosure from firms already engaged in emission-cutting practices, we would expect to observe significant coefficients on the variables capturing prior environmental awareness. However, these coefficients are statistically insignificant, indicating an incremental regulatory effect. Lastly, larger firms and those with lower price-to-book ratios are more likely to disclose, potentially reflecting a stronger obligation to align with government directives.

3 | HYPOTHESIS DEVELOPMENT

Firms' disclosures in response to the carbon disclosure regulation allow us to observe whether they have made efforts to cut emissions. However, survey evidence suggests that many Chinese firms may lack knowledge on how to take effective measures when it comes to ESG activities (Lu et al., 2021). We posit that while firms are likely to increase their carbon reduction efforts in response to the disclosure regulation, these efforts will only lead to substantial emission reductions with sufficient stakeholder support, which facilitates firms in overcoming those barriers of implementing ESG activities.

We argue that the disclosure regulation encourages firms to cut carbon emissions by increasing the perceived benefits of carbon reduction activities. Specifically, following the 2021 regulation, carbon reduction efforts that were previously disclosed only in ESG reports are now featured prominently in the annual report. The increased salience of disclosure makes it more likely that the government will recognize such efforts and potentially reward them with political benefits. Similarly, other stakeholders, such as environmentally conscious investors, will have easier access to this information, potentially prompting positive responses (Matsumura et al., 2014; Amel-Zadeh & Serafeim, 2018). Anticipating such stakeholder reactions, firms may perceive a greater marginal benefit of implementing carbon reduction measures, while the corresponding marginal costs remain unchanged. Consequently, firms whose perceived benefits outweigh the costs would increase their carbon reduction efforts and disclose them in their 2021 annual reports. Assuming that increased effort results in greater carbon reduction, we should observe a decrease in carbon intensity and emissions among the treatment firms relative to control firms in 2021.

However, even when firms decide to implement carbon reduction measures, they may face difficulties in identifying and executing effective measures. A global survey conducted by the Boston Consulting Group in 2021 reveals that while 96% of surveyed companies set emissions reduction targets, only 11% achieved these targets over the past five years (Degot et al., 2021). We contend that Chinese firms face two major challenges in emission reduction. First, many lack access to professionals with emissions management expertise, which is essential for accurate emissions measurement and effective reduction strategies. Measuring carbon emissions involves identifying emission sources, collecting activity data, selecting emission factors, and utilizing calculation tools—all of which are often impeded by limited guidance and a shortage of skilled experts (Ranganathan & Bhatia, 2004; Degot et al., 2021).[11] While specialized professionals for measuring carbon emissions and developing emission reduction strategies are

[11] According to the Boston Consulting Group's global survey in 2021, 81% of respondents omitted some of their scope 1 and 2 emissions, and respondents estimate a 30% to 40% average error rate in their emission measurements. The emission estimates are often computed by multiplying operating data with emission factors. 49% of respondents identified granular operating data as "hard" or "very hard" to find, and 55% of respondents identified granular emission factors as "hard" or "very hard" to find.

crucial, this type of expertise remains scarce in China. In fact, firms cite the lack of detailed ESG reporting guidance and a shortage of ESG-related experts as major obstacles to engaging in ESG activities (Lu et al., 2021; Lu et al., 2024). When firms cannot easily access carbon management professionals near their operations, they may struggle to find the necessary expertise and may resort to implementing less effective measures without professional guidance.

Second, firms may encounter inadequate financial support for emissions reduction. In China's bank-dominated financial system, firms primarily rely on debt financing to fund green projects or structural upgrades. However, securing loans with low interest rates and long maturities can be difficult, as green projects, which often require substantial upfront investment and have delayed payback periods, are deemed high-risk by financial institutions. Without external funding, however, firms may be deterred by the high cost associated with investing in green projects that could systematically reduce carbon intensity, opting instead for simpler, less impactful measures. This lack of funding thus hampers firms' carbon reduction progress (De Haas et al., 2024), even when encouraged by the disclosure regulation.

Given the above challenges, the success of firms' emission reduction efforts depends on the extent to which stakeholders are willing and able to share the costs associated with the transition. Sufficient stakeholder support lowers the costs associated with identifying and implementing effective carbon reduction measures, enabling firms to make tangible progress when they choose to respond to the disclosure regulation. Without adequate support, we expect no significant change in a firm's carbon intensity (emissions) following the disclosure regulation, even if it attempts to cut emissions. The above discussions lead to the following hypothesis:

H1: *Firms that attempted to reduce carbon emissions in response to the disclosure regulation show a greater decrease in carbon intensity (emissions) than firms that took no action, but only if they receive adequate stakeholder support.*

4 | RESEARCH DESIGN AND DATA

4.1 | Measures and empirical tests

To test our hypothesis, we construct three measures of stakeholder support that correspond to human capital, green financing, and government environmental spending.

First, to assess human capital support, we gauge the presence of authorized carbon emission verification agencies near a firm's headquarters. These agencies validate reported carbon emissions, verify emission reduction projects, and certify carbon credits. An agency may be authorized by the government to participate in the emissions trading system if it is local, adequately funded, and maintains a minimum number of certified carbon verification professionals. [12] Thus, the number of authorized carbon verification agencies contracted by a local government serves as a proxy for the presence of skilled carbon management professionals in the area. To measure the availability of such professionals for each firm, we construct a variable, *Personnel*, which represents the number of verification agencies contracted by the government in the firm's headquarters region, scaled by the size of the local economy (measured as the regional GDP for 2021 in trillions of RMB). We obtain data from local governments' official procurement websites.

Second, we assess financial support provided by the central bank through the "re-lending" policies backing green initiatives. Re-lending is a monetary policy tool used by the central bank (People's Bank of China) to channel funds into priority areas identified in government policy agendas. Over the past decade, provincial and city-level governments have collaborated with local central bank branches to introduce green re-lending policies, aiming to address the maturity mismatch between green projects and firms' financing options. Specifically, when a commercial bank lends to finance a firm's carbon reduction initiatives, it can apply for credit loans from the central bank featuring low interest rates and long repayment cycles. In essence, the central bank subsidizes commercial banks' lending, encouraging them to finance green projects

[12] China has established eight carbon trading pilot regions since 2013 (i.e., Beijing, Tianjin, Shanghai, Chongqing, Hubei, Guangdong, Shenzhen, and Chongqing). Each pilot region sets up and independently manages its own emissions trading system (ETS). The national ETS was launched in July 2021. Although the national ETS only covers the power sector so far, more industries will be required to participate in the future. In preparation for the national or local ETS, most of the provincial governments in China have appointed authorized carbon emission verification agencies through procurement contracts.

that typically require substantial upfront investment and have longer implementation periods. To measure the availability of such green lending for a firm, we use data from Wang et al. (2021) to construct an indicator variable, *GreenFinance*, which is equal to one if a firm's headquarters region has re-lending policies for green projects by the end of 2021 and equal to zero otherwise.

Lastly, to measure financial support provided through fiscal policies, we assess the amount of "energy-saving and environmental protection expenditure" incurred by the local government at a firm's headquarters region. This subcategory of fiscal expenditure reflects the government's investment and spending on energy saving, pollution reduction, recycling, tackling climate change, and building environmental monitoring facilities. A local government with high spending in this category is likely to have developed the infrastructure necessary to support firms in reducing carbon emissions. For example, such spending can provide subsidies and rewards for firms' carbon reduction projects, while also fostering a local green industry ecosystem, enabling firms to easily access clean energy, green technologies, and equipment. We capture a firm's access to these subsidies and well-developed environmental infrastructure through the variable *EnvSpending*, which is calculated as the local government's energy-saving and environmental protection expenditure, scaled by the region's GDP for 2021, and multiplied by one hundred. We obtain data on environmental spending from *China Fiscal Yearbook*.

To measure the overall stakeholder support experienced by a firm, we summarize the above measures using a categorical variable named *Support*. For each firm *i*, *Support* is calculated as the sum of three indicator variables: the first equals one if *Personnel* is above the sample median, and zero otherwise; the second equals one if *GreenFinance* takes the value of one, and zero otherwise; the last equals one if *EnvSpending* is above the sample median, and zero otherwise. The resulting *Support* measure ranges from zero to three, with a higher value indicating stronger stakeholder support for firm *i*.

We note that all three forms of stakeholder support were present in their respective regions prior to 2021 and exhibit little variation over time.[13] We interpret these support measures as reflecting the supportiveness of stakeholders in each region when the 2021 carbon disclosure regulation was implemented. To assess how the effectiveness of the disclosure regulation varies with different levels of stakeholder support, we estimate the following equation using the CEM-matched sample:

$$Carbon_{it} = \beta_0 + \beta_1 \times Treat_i \times Post_t \times InstSupport_i + \beta_2 \times Treat_i \times Post_t + \beta_3 \times Post_t \times InstSupport_i + \sum Controls_{it} + Firm\ FE + Year\ FE + \varepsilon_{it}, \quad (1)$$

where *i* indicates firm and *t* indicates year. The dependent variable, *Carbon*, takes the value of *Intensity* or *Emission*. *Intensity* is defined as the natural logarithm of yearly emissions of carbon dioxide scaled by sales in the same period. *Emission* is defined as the natural logarithm of yearly emissions of carbon dioxide in metric tons.

Treat is an indicator variable equal to one for firms that selected "applicable" in response to the 2021 carbon disclosure regulation and zero otherwise. *Post* is an indicator variable equal to one for fiscal year 2021, and zero otherwise. The fiscal year for all Chinese listed firms starts on January 1st and ends on December 31st. Since the disclosure regulation we examine is effective starting from June 28th, 2021, fiscal year 2021 is the first year of its implementation. *Support* captures the overall stakeholder support available to firm *i*. We also separately examine the effect of each type of stakeholder support by estimating a modified version of Eq. (1), where we substitute *Support* with *Personnel*, *GreenFinance*, or *EnvSpending*.

We control for observable firm characteristics that may influence the carbon emissions of a firm. Following Downar et al. (2021), we include firm size, asset intensity, price-to-book ratio, and leverage in our regression model. We include firm fixed effects and year fixed effects to account for unobserved firm characteristics that persist through time and shocks to the economy that may affect firms' emissions in a particular year. To mitigate the influence of outliers, we winsorize all continuous variables at the 1st and

[13] For *Personnel*, the number of carbon verification agencies that contract with a local government roughly stays constant over time. For *GreenFinance*, nearly all re-lending policies are issued before 2021. For *EnvSpending*, the amount spent by each local government exhibits little variation over time.

99th percentiles. The detailed definition of all variables can be found in Appendix 1, and detailed descriptions of *Personnel*, *GreenFinance*, or *EnvSpending* are presented in Appendix 2.

For firms that implement effective measures to systematically reduce emissions, we expect to observe a decrease in carbon intensity and total emissions.[14] To support this hypothesis, the coefficient on *Treat* × *Post* × *Support* should be negative and significant. Specifically, we expect that firms attempting to reduce carbon emissions in response to the disclosure regulation can only do so successfully when they receive adequate stakeholder support. In places without sufficient stakeholder support, firms would not be able to effectively curtail emissions even when they increase their efforts following the disclosure regulation.

Our research design is not ideal since firms can self-select into the treatment group. Specifically, treatment firms may have chosen to disclose carbon reduction efforts in response to the 2021 regulation because they have already been cutting emissions under external pressure in the pre-period. This may result in an overestimation of the treatment effect. To address this selection issue, we first try to match treatment and control firms based on observable characteristics that affect their carbon reduction incentives in the absence of the disclosure regulation. Based on the evidence presented in Table 1, we consider historical carbon emissions and intensity as the primary drivers of firms' carbon reduction incentives. Therefore, we use coarsened exact matching (CEM) to match treatment firms with control firms based on their carbon emissions and carbon intensity measured in the first year of our sample period. The CEM method divides all observations into distinct bins based on the characteristics we specify, discards extreme observations in strata that either have no treatment or no control observations, then assigns weights to control observations such that the representation of the control group in each stratum matches that of the treatment group (Blackwell et al., 2009; Iacus et al., 2012). The method is widely used in accounting and finance literature in recent years (Choy et al., 2024; Beshears et al., 2022; Younkin & Kuppuswamy, 2018). The matching process removes treatment firms with the highest historical emissions due to the lack of comparable control

[14] The effect on total emissions is less clear because firms with positive sales growth may experience stable or even increasing total emissions despite the decrease in carbon intensity.

firms. Within the matched sample, treatment and control firms show no significant differences in carbon emissions or intensity, and are therefore likely to have similar incentives to reduce emissions. We validate the parallel trend assumption (Table 5) and present our main results using the CEM-matched sample. This enables us to conclude with greater confidence that the post-treatment difference in emissions between the two groups is attributable to the disclosure regulation.

However, the CEM matching cannot completely address the self-selection issue resulting from unobservable incentives. It is possible, for instance, that treatment firms choose to disclose carbon reduction measures in their 2021 annual reports because they respond more actively to the "dual carbon" policy goal. In this case, treatment firms' reduction in emissions cannot be attributed to the disclosure regulation. To provide more direct causal inference, we present survey evidence in Section 6.3 which shows that most firms indeed took actions in response to the carbon disclosure regulation. Nonetheless, we acknowledge that our research design cannot fully isolate the causal effect of the disclosure regulation.

Despite the imperfect identification strategy, we argue that the self-selection concern does not alter our key inference about how stakeholder support affects the effectiveness of the disclosure regulation (i.e., the coefficient on *Treat* × *Post* × *Support*). For any self-selection bias to affect our inference, the difference between treatment and control firms needs to be systematically greater in regions with high stakeholder support. In Online Appendix III, we match firm characteristics separately in high- and low-support regions to improve comparability within different levels of support. The coefficient on *Treat* × *Post* × *Support* remains negative, significant, and similar in magnitude to that in our main analysis. Additionally, we examine whether firms in high-support regions were more likely to respond to the dual carbon goals, as reflected in more frequent mentions of related key words in the MD&A section of their 2020 annual reports. We do not find that such concern is valid. Finally, while one may be concerned that treatment firms in high-support regions are systematically more experienced in reducing emissions than those in low-support regions, we find in additional analyses (Section 6) that our results are driven by inexperienced firms. Taken together, these findings suggest that our main conclusions, which will be discussed later, are unlikely to be driven by unaddressed self-selection issues.

4.2 | Data and sample

We obtain emissions data from QuantData, a database that provides scope 1 and scope 2 carbon emissions data for the 800 firms in China Securities Index (CSI 800) from 2018 onwards. Data for the control variables, other firm characteristics, and regional GDP are obtained from the China Security Market and Accounting Research (CSMAR) database. Data on verification agencies are hand-collected from government procurement contracts found on provincial governments' websites, data on re-lending are obtained from the 2020 and 2021 *Annual Report on the Development of Local Green Finance in China*, and data on energy-saving and environmental protection fiscal expenditure are obtained from the *China Fiscal Yearbook*. Online Appendix II lists the stakeholder support provided by each region.

We delineate the sample selection process in Table 2. Our initial sample consists of CSI 800 firms for which carbon emissions data are available for the period 2018–2021 (768 unique firms, 2750 firm-year observations). We exclude 122 firm-years that are missing data required for the control variables. We also exclude 98 firms (114 firm-years) without at least one observation each in the periods before and after the implementation of the 2021 disclosure regulation. Next, we remove firms that experience any year-over-year change in carbon intensity that ranks among the top or bottom 1% among all firm-years. This is because our manual reading of the sample firms' CSR reports suggests that such drastic changes in carbon emissions usually result from endogenous changes in the scope of measurement or data errors.[15] We drop 35 firms (134 firm-years) that exhibit such drastic changes, so that they do not confound our results. This leaves us a sample of 633 unique firms and 2380 firm-years, which we refer to as the "CSI 800" sample.

In the last step, we use the CEM method to match the treatment and control firms on their carbon emissions and carbon intensity measured in 2018. The CEM method "coarsens" all observations into distinct bins based on the characteristics we specify and discards extreme observations in bins that lack either treatment or control observations. After the CEM method drops observations that lack common

[15] For example, China Merchants Bank (600036.SH) disclosed its total carbon emissions from 2019 to 2021 in its sustainability report for 2021. However, the emissions reported for 2019 and 2020 only account for emissions from the head office building, whereas the reported emissions for 2021 include both the head office and 44 additional branches in mainland China. This expansion in the measurement scope results in China Merchants Bank's carbon intensity in 2021 being 22.41 times greater than that of 2020.

support, our final sample comprises 492 unique firms and 1961 firm-year observations. We refer to this final sample as the "CEM-matched sample" and use it for our main analysis.

Panel A of Table 3 presents descriptive statistics for the CEM-matched sample. The average natural logarithm of yearly carbon emissions is 10.372 for the CEM-matched sample (equivalent to 31,952 metric tons), and the average carbon intensity is -6.159. The sample consists of 63% treatment firms and 37% control firms. The *Support* score ranges from 0 to 3, with an average of 1.745. The *Personnel* score ranges from 0 to 10.211, with an average of 3.492. This shows considerable verification in the availability of carbon management professionals across different regions. The *GreenFinance* indicator variable has an average of 0.701, suggesting that 70% of the firms in our sample are located in regions that implement green re-lending policies. The *EnvSpending* variable shows that local governments spend 0.125% to 1.32% of their local GDP on environmental protection, with the average being 0.487%.

Panel B of Table 3 compares treatment and control firms for both the pre-matching CSI 800 sample and the CEM-matched sample. In the CSI 800 sample, treatment firms exhibit significantly higher carbon intensity and emissions than control firms. After CEM matching, these differences become negligible, indicating that the matched treatment and control firms face similar regulatory pressure to reduce emissions. Other firm characteristics also become more comparable between the two groups after matching.

Panel C of Table 3 shows the Pearson correlations among the variables used in Eq. (1). We do not observe any high correlations among control variables. The three stakeholder support measures exhibit positive correlations, but the correlations are lower than 0.6, suggesting that they reflect distinct dimensions of stakeholder support. The correlations between *Support* and firm characteristic variables, as shown in column (4), suggest that firms in high-support regions are slightly larger, lower in asset intensity and price-to-book ratio, and have higher leverage. The correlations between *Support* and *Intensity* (and *Emissions*), as shown in row (4), show that the overall stakeholder support is positively correlated with local firms' carbon emissions, but not significantly correlated with their carbon intensity. We do not expect these differences to influence our main results.

5 | EMPIRICAL RESULTS

5.1 | Main results

Table 4 reports our main results. We start by presenting the results of a difference-in-differences test, that is, Eq. (1) without the interaction terms involving *Support*. In Panel A, column (1) uses carbon intensity as the dependent variable and shows a negative coefficient on *Treat* × *Post* (coefficient= -0.078, p-value < 0.05). Column (2), in which the dependent variable is carbon emissions, also shows a significantly negative coefficient on *Treat* × *Post* (coefficient= -0.09, p < 0.10). This implies that on average, the treatment firms reduced their emissions per thousand yuan of sale by 7.5% (1 - exp(-0.078)) and their total carbon emissions by 8.6% (1 - exp(-0.09)) following the disclosure regulation. These results are consistent with the prior literature that finds a reduction in carbon emissions as a response to carbon disclosure regulations (Downar et al., 2021; Tomar 2023).

Columns (3) and (4) of Panel A report the results of estimating Eq. (1). Here, we aggregate all three types of stakeholder support into one measure named *Support*. The variable takes on values from zero to three based on the extent of supportive infrastructure available within the region where a firm is headquartered. Accordingly, the coefficient on *Treat* × *Post* captures the effectiveness of the low-support treatment firms' carbon reduction efforts, while the coefficient on *Treat* × *Post* × *Support* reflects the incremental effect of stakeholder support.

In column (3) of Panel A, the coefficient on *Treat* × *Post* × *Support* is negative and significant (coefficient= -0.081, p-value < 0.05), indicating that treatment firms experience greater reductions in carbon intensity in response to the disclosure regulation when they receive more stakeholder support. The coefficient on *Treat* × *Post* is positive and statistically insignificant (coefficient = 0.065, p-value > 0.10), suggesting no significant change in carbon intensity for treatment firms when there is no adequate stakeholder support and that the average effect is driven by firms with high support. Column (4) shows similar results for carbon emissions, with the coefficient on *Treat* × *Post* × *Support* being negative and significant (coefficient= -0.099, p-value < 0.05) and the coefficient on *Treat* × *Post* being statistically insignificant (coefficient = 0.087, p-value > 0.10). These findings are consistent with our prediction that

even when firms increase carbon reduction efforts following the disclosure regulation, they can only effectively reduce carbon intensity (emissions) if they receive adequate stakeholder support to facilitate such efforts.

In Table 4 Panel B, we re-estimate Eq. (1), substituting *Support* with specific types of stakeholder support, i.e., we replace *Support* with *Personnel*, *GreenFinance,* and *EnvSpending,* respectively. Column (1) shows a negative and significant coefficient on *Treat* × *Post* × *Personnel* (coefficient= -0.032, p-value < 0.05). Column (3) shows a negative and significant coefficient on *Treat* × *Post* × *GreenFinance* (coefficient= -0.216, p-value < 0.01), whereas column (5) shows a negative and marginally significant coefficient on *Treat* × *Post* × *EnvSpending* (coefficient= -0.330, p-value < 0.10). This suggests that all three types of stakeholder support are effective in helping firms reduce carbon intensity. The results for carbon emissions are shown in columns (2), (4), and (6), and are similar to the results for carbon intensity. Overall, Panel B demonstrates that all three types of stakeholder support can facilitate firms' carbon reduction efforts.

Collectively, the findings presented in Table 4 highlight the crucial role of stakeholder support in mitigating firms' carbon emissions. When related stakeholders create an institutional environment with adequate human capital and financial resources, the implementation of a disclosure regulation can lead to a reduction in carbon emissions by increasing firms' efforts. However, in the absence of sufficient support, the disclosure regulation by itself cannot yield substantial carbon reduction.

5.2 | Robustness tests

We assess the key assumption underlying the difference-in-differences approach by examining whether the matched treatment and control groups exhibit parallel trends before the year of treatment. Specifically, we regress carbon intensity (or emissions) on the interaction terms of *Treat* and indicator variables for the year 2019, 2020, and 2021, respectively, applying the same control variables and fixed effects as shown in Eq. (1). Panel A of Table 5 presents the results of estimating the above regression model. Column (1) shows the result with carbon intensity as the dependent variable. The coefficients on *Treat* × *2019* and *Treat* × *2020* are close to zero and statistically insignificant, indicating that there is no significant

difference between the carbon intensity of treatment and control firms during the pre-treatment period. The coefficient turns negative and significant only in year 2021 (coefficient = -0.107, p-value <0.05). Column (2) shows carbon emissions as the dependent variable. Similarly, the statistically insignificant coefficients on *Treat* × *2019* and *Treat* × *2020* show a common trend in treatment and control firms' pre-treatment emissions. The coefficient on *Treat* × *2021* suggests that the treatment firms' emissions become lower compared to those of the control firms in 2021, although the coefficient is marginally insignificant (coefficient = -0.103, t= -1.459). Overall, we find no violation of the parallel trend assumption.

Next, we test whether our findings are robust to variations in the CEM process and fixed-effect structures. First, to examine the effect of CEM weights, we estimate Eq. (1) for an unweighted CEM sample. As shown in columns (1) and (2) of Table 5, Panel B, the coefficients on the key variable, *Treat* × *Post* × *Support*, are similar to those obtained using the weighted sample (Table 4, Panel A). This suggests that our findings are not affected by the composition of the control group. Second, we match treatment and control firms using additional firm characteristics. In our main analysis, we match treatment and control firms on their past carbon intensity and emissions in order to align their pre-treatment carbon reduction tendencies while keeping the sample size as large as possible. However, Table 1 shows that firm size and price-to-book ratio are also significant determinants of treatment. We thus form a new sample by matching treatment and control firms based on past carbon intensity and emissions, as well as their firm size and price-to-book ratio, and report the main regression results in columns (3) and (4) of Table 5, Panel B. Coefficients on the key variable, *Treat* × *Post* × *Support*, are similar in magnitude to those in the main regressions. The coefficient in column (3) has a p-value of 0.1003 while that in column (4) is marginally significant at the 10% level. The low statistical significance may be due to the reduced sample size (from 1961 to 1039 observations). As shown in Online Appendix III, we also try to increase the number of bins used in the CEM matching process to achieve more precise matching, and use industry-year or province-year fixed effects to account for potential variations in emission trends across different industries or regions. Our results remain unchanged.

Additionally, since two of our stakeholder support measures, *Personnel* and *EnvSpending*, are both scaled by regional GDP, we conduct robustness tests to alleviate the concern that variations in regional GDP confound our results. As shown in Online Appendix III, we estimate Eq. (1) substituting *Support* with province- or city-level GDP. The coefficient on *Treat* × *Post* × *GDP* is statistically insignificant. Moreover, as an alternative measure of *Personnel*, we categorize regions into three equal groups (*High*, *Median*, and *Low*) based on the absolute number of verification agencies. Consistent with the scaled personnel measure, we find that the coefficient on *Treat* × *Post* × *High* is negative and significant, while the coefficient on *Treat* × *Post* × *Median* is negative but statistically insignificant. This suggests that firms in regions with a high level of human capital support reduce their carbon intensity (emissions) more than those in regions with the lowest human capital support.

6 | ADDITIONAL ANALYSES

Since our stakeholder support variables are measured at the regional level, there may be concerns that they correlate with other institutional factors, leading to omitted variable bias. To alleviate this concern, we conduct cross-sectional tests on each type of stakeholder support and perform falsification tests to ensure that our results are not driven by alternative explanations.

6.1 | Validation tests for each type of stakeholder support

Based on the nature of each type of stakeholder support, we infer which firms are likely to experience a stronger supporting effect. We then test the effect of each form of stakeholder support separately on firms expected to experience stronger versus weaker effects. Results that align with our expectations would further support our hypothesis.

First, we expect the supporting effect of human capital to be significant only for the firms that lack carbon management experience before 2021. To test this, we divide the sample firms into two groups based on whether a firm or its subsidiaries have been required to participate in regional or national emissions

trading systems (ETS).[16] Firms participating in an ETS are required to regularly verify their carbon emissions and report them to regulators, and are therefore experienced in measuring their carbon emissions. In contrast, firms not participating in an ETS are less likely to have prior experience in carbon accounting or management before they were encouraged to reduce emissions in 2021. Within each subsample, we use CEM to match treatment and control firms, then estimate Eq. (1) substituting *Support* with *Personnel*.

Panel A of Table 6 presents the regression results. The coefficient on *Treat* × *Post* × *Personnel* is negative and significant in columns (1) and (2), suggesting that non-ETS treatment firms reduce carbon intensity and emissions more when there is a higher availability of carbon management professionals in their headquarters region. On the other hand, the effect of human capital support appears weaker for ETS firms. As shown in columns (3) and (4), the coefficients on *Treat* × *Post* × *Personnel* have a smaller economic magnitude compared to those for non-ETS firms and are statistically insignificant. These results support the intuition that ETS treatment firms do not derive further benefits from human capital support. The coefficient on *Treat* × *Post* has no economic interpretability because there are few observations where *Personnel* equals zero. For non-ETS firms, the coefficient on *Post* × *Personnel* is positive and significant, potentially indicating that those located in regions with high human capital support exhibit increasing carbon emissions and intensity compared to those in regions with low support.

Second, we expect the supporting effect of green financing to be evident only among firms that are not state-owned enterprises (SOEs). Since SOEs have easier access to loans due to their close relationship with the government, they may easily obtain the funding necessary to implement any carbon reduction measure. Non-SOEs, however, may lack financial support unless their local regions provide green financing opportunities. To test this, we divide the sample firms into non-SOEs and SOEs, use CEM to match treatment and control firms within each group, and estimate Eq. (1) separately for the two groups, replacing *Support* with *GreenFinance*. Results are presented in Panel B of Table 6. As shown in columns (1) and (2),

[16] Within each ETS pilot regions, regulators identify a list of locally registered firms to participate in the ETS. Typically, firms in high-emission sectors and those exceeding a specified carbon emissions threshold are required to participate.

the coefficients on *Treat* × *Post* × *GreenFinance* are negative and significant for the non-SOE group, indicating that non-SOE treatment firms successfully reduce carbon emissions and intensity when supported by green financing. The coefficients on *Treat* × *Post* are positive and significant, suggesting that in regions without green financing support, non-SOE treatment firms experience increasing carbon emissions and intensity over time compared to control firms. In contrast, columns (3) and (4) show that the coefficients on *Treat* × *Post* × *GreenFinance* are statistically insignificant for SOE firms, consistent with our expectation.

Lastly, we expect the supporting effect of government environmental spending to be greater among firms in energy-intensive industries. This is because such firms are more likely to benefit from energy-saving subsidies and complementary facilities associated with higher government environmental spending. Accordingly, we divide the sample firms into two groups based on their energy consumption data at the industry level, apply CEM matching respectively, then estimate Eq. (1) for each group, substituting *Support* with *EnvSpending*. Panel C of Table 6 shows that the coefficient on *Treat* × *Post* × *EnvSpending* is negative and significant for the energy-intensive group, while it is statistically insignificant for the non-energy-intensive group. The coefficient on *Treat* × *Post* has no economic interpretability because there is no region where *EnvSpending* equals zero.

Overall, the evidence from Table 6 suggests that the stakeholder support measures indeed facilitate treatment firms' carbon reduction efforts through our proposed channels.

6.2 | Falsification tests

An alternative explanation of our results is that political pressure on local governments to reduce carbon emissions may influence both the level of stakeholder support and local firms' carbon emissions. The central government in China assigns carbon reduction targets to each province and incorporates these targets into the performance evaluations for local government officials. When a local government faces higher carbon reduction targets, it may provide additional resources while also pressuring local firms to reduce emissions following the 2021 disclosure regulation.

We conduct a falsification test to rule out this alternative explanation. To measure the political pressure faced by each local government, we use the regional carbon reduction targets announced in the 13th Five-Year Plan (2016–2020) and construct a variable, *Target*, representing the intended percentage reduction in greenhouse gas emissions for a region.[17] We re-estimate Eq. (1), replacing *Support* with *Target*. The results are shown in Panel A of Table 7. In columns (1) and (2), the coefficients on *Treat* × *Post* × *Target* are statistically insignificant, suggesting that greater political pressure on local governments does not cause local firms to reduce emissions more in response to the 2021 disclosure regulation. This is possible because 2021 marks the first year of the 14th Five-Year Plan, and mandatory emission reduction directives had not yet played a significant role. In columns (3) and (4), we simultaneously include *Support*, *Target*, and their respective interactions with *Treat* × *Post* in the regression. In both columns, the coefficients on *Treat* × *Post* × *Support* remain negative and statistically significant, indicating that political pressure on local governments is not a major factor driving our results.

Another possible explanation is that treatment firms in high-support regions are more likely to implement the carbon reduction measures they disclose, as local governments in these regions may have greater ability to detect and prevent greenwashing. Firms may feel pressured to appear supportive of the country's "dual carbon" goals, leading them to falsely claim that they have taken steps to reduce emissions. While we argue in Section 2 that such greenwashing behavior is unlikely due to the governments' ability to monitor firms' emissions, this monitoring ability may vary across regions. For example, local governments with higher "energy-saving and environmental protection expenditure" might allocate more resources to tracking firms' emissions, reducing the likelihood of false disclosures. If our stakeholder support measure correlates with government monitoring abilities, then our findings could reflect differences in treatment firms' tendencies to engage in greenwashing across high- and low-support regions.

We address this concern by conducting another falsification test, using the number of environmental enforcement cases as a proxy for a local government's monitoring ability. Although excess

[17] We assume that local governments' perceived political pressure in 2021 persisted from the 13th Five-Year Plan, as the regional carbon reduction targets for 2021–2025 were not yet established at the time.

carbon emissions do not constitute an environmental violation, the number of environmental enforcement cases reflects the local government's focus on environmental issues and its capability to monitor firms' pollution-related activities. We construct an indicator variable, *Enforcement*, which equals one if the number of environmental enforcement cases in a region is above the median and the repeat offense rate is below the median and zero otherwise (Zhu, 2018).[18] We then re-estimate Eq. (1), replacing *Support* with *Enforcement*. The results, presented in Panel B of Table 7, show that in columns (1) and (2), the coefficients on *Treat* × *Post* × *Enforcement* are negative but statistically insignificant. In columns (3) and (4), where we include *Support*, *Enforcement*, and their respective interactions with *Treat* × *Post*, the coefficients on *Treat* × *Post* × *Support* are negative and statistically significant, while those on *Treat* × *Post* × *Enforcement* become smaller and remain insignificant. These findings indicate that while local governments' monitoring abilities may influence firms' carbon reduction behavior, they do not account for our main results.

6.3 | Field evidence

Besides empirical analyses, we conduct a nationwide survey to corroborate our interpretation of the 2021 disclosure regulation. Following Lu et al. (2023), we targeted board secretaries as our survey audience because they are responsible for their respective firms' information disclosure. We collaborated with New Fortune Magazine to distribute our survey questionnaire. In January 2023, New Fortune Magazine distributed a smartphone/website link containing our survey questions to the board secretaries of 4,662 listed firms in China. We received 535 valid responses, yielding a response rate of 11.5%. Among the survey respondents, 64% indicated that their firms disclosed carbon reduction efforts in response to the regulation, while 36% indicated that their firms did not.

We first try to understand why some firms chose not to disclose carbon reduction measures. Figure 1 (A) shows that 52% of the non-disclosing firms had inherently low carbon emissions and perceived no

[18] We incorporate the repeat offense rate (i.e., the ratio of repeat offenders to the number of total environmental enforcement cases in a year) in addition to the number of environmental enforcement cases in the variable measurement because the repeat offense rate more effectively captures the subjective mindset of the regulated parties as well as the quality of administrative enforcement in China. Both the number of environmental enforcement cases and the repeat offense rate are obtained from Zhu (2018). We use the data measured in 2017, which is the last year these data are available.

necessity to reduce them. 31% indicated that the disclosure requirements were unclear, 15% indicated other reasons, while 2% indicated that they abstained from disclosure because they had high emissions and had not initiated emissions reduction.

Next, for the firms that disclosed in response to the regulation, we ask whether they increased their carbon reduction efforts. Figure 1 (B) shows that 45% of these firms indicated that they did increase carbon reduction efforts. 38% indicated that they had already been reducing carbon emissions prior to 2021 and therefore did not need to put in incremental effort. This is consistent with our expectation and confirms the necessity of conducting our analyses using a CEM-matched sample. After matching, the treatment firms remaining in our sample are likely to be those that increased carbon reduction efforts in 2021.

Lastly, for the firms that increased carbon reduction efforts, Figure 1 (C) presents the reasons behind their decisions. 95% of these firms chose to reduce emissions due to their perception that the disclosure regulation aligns with the country's broader policy trends. Additionally, 71% of the firms indicated that the increased attention from investors, regulators, and other stakeholders served as a motivating factor for their emissions reduction efforts. These findings suggest that a significant number of firms take the 2021 carbon disclosure regulation as a signal from the government and respond by disclosing and taking actions to cut emissions.

7 | CONCLUSION

Regulators worldwide increasingly use disclosure regulations to encourage firms to meet nonfinancial goals and believe transparency should facilitate the process of achieving the goals. In the case of reducing carbon emissions, studies on US and UK firms show that mandating emission disclosures leads to significant reductions in their emissions (Downar et al., 2021; Tomar, 2023). However, many high-emission countries lag behind the US and UK in sustainability development, and disclosure regulation alone may not be sufficient to achieve the desired outcomes in their institutional environments.

In this paper, we examine the effect of a carbon disclosure regulation in China and find that while it appears to reduce corporate carbon emissions, not all firms attempting to curtail emissions manage to do

so successfully. By leveraging variations in stakeholder support across different regions in China, we find that the disclosure regulation effectively reduces carbon intensity and emissions for firms in regions with access to skilled professionals, green financing, and supportive infrastructure. In contrast, the regulation has no significant impact in regions lacking adequate stakeholder support. The evidence is consistent with the argument that stakeholder support reduces the costs of implementing effective measures of reducing corporate carbon emissions.

This study contributes to the literature on the real effects and the limitations of ESG-related disclosure regulations. While prior studies examine carbon disclosure mandates as standalone regulations, we investigate how the effectiveness of a regulation varies depending on the support provided by multiple stakeholders. Our findings highlight that disclosure regulations alone are often insufficient in regions where stakeholders do not coordinate to provide the necessary expertise, financial resources, and institutional backing for firms' carbon reduction efforts. The policy implication is that policymakers should not only incentivize firms to cut emissions through disclosure regulations, but also promote coordinated stakeholder engagement, ensuring that stakeholders jointly provide the resources and support needed to enable meaningful and effective corporate action.

Since the decision to implement carbon reduction measures is endogenous, there may be inherent differences between treatment and control firms that CEM matching cannot fully address. However, for this to affect our results, the differences between treatment and control firms would need to vary systematically across regions with high and low support, which is less likely. In addition, the use of CEM matching in our main tests alters the sample composition, limiting our ability to estimate treatment effects for the broader population of firms. With these caveats in mind, the conclusion from our study has broad implications—disclosure regulations alone are insufficient and complementary investments by stakeholders are essential building blocks for successful carbon reduction.

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APPENDIX 1: VARIABLE DEFINITIONS

Variable	Definition	Data source
Main regressions		
Intensity	Natural logarithm of "annual greenhouse gas emissions (scope1 + scope2) scaled by sales (in thousand RMB)"	QuantData
Emissions	Natural logarithm of annual greenhouse gas emissions (scope1 + scope2) in metric tons of CO_2eq	QuantData
Treat	An indicator variable equal to one if the firm disclosed its carbon reduction measures and results in the annual report for 2021, and zero otherwise.	Hand collected from firms' annual reports
Post	An indicator variable equal to one for fiscal year 2021, and zero otherwise.	NA
Size	Natural logarithm of a firm's market value in thousand RMB.	CSMAR
AssetIntensity	Fixed assets divided by total assets.	CSMAR
PB	Market value to book value of equity.	CSMAR
Leverage	Total liabilities divided by total assets.	CSMAR
Personnel	The number of authorized carbon verification agencies in the region where a firm's headquarter is located, measured as of 2021, and scaled by the corresponding GDP (in trillion RMB) in 2021. By "region," we refer to either a province or a city, depending on whether the procurement contract for the verification agencies was issued by a provincial or city-level government. See Appendix 2 Panel A for details.	The China Government Procurement Network (http://www.ccgp.gov.cn/), its regional branches, and other government websites
GreenFinance	An indicator variable equal to one if a firm's headquarters region provides re-lending support for green projects by the end of 2021, and zero otherwise. See Appendix 2 Panel B for details.	Wang, Liu, and Li (2021)
EnvSpending	The local government's energy-saving and environmental protection expenditure for 2021 in the region where a firm's headquarters is located, scaled by the corresponding GDP in 2021, and multiplied by 100. See Appendix 2 Panel C for details.	*China Fiscal Yearbook* obtained from https://data.cnki.net/
Support	The extent of overall stakeholder support in the region where a firm's headquarter is located, defined as the sum of three indicator variables: the first indicator variable equals 1 if *Personnel* is above the sample median, and zero otherwise; the second indicator variable equals 1 if *GreenFinance* is greater than zero, and zero otherwise; the third indicator variable equals 1 if *EnvSpending* is above the sample median, and zero otherwise.	NA
Determinant model		
ROA	Net income divided by total assets.	CSMAR

SOE	An indicator variable equal to one for state-owned enterprises whose ultimate controlling owner is the government, and zero otherwise.	CSMAR
InstHolding	The number of shares held by funds divided by the total number of outstanding shares.	CSMAR
Oversea	An indicator variable equal to one if the firm has at least one oversea shareholder among its top 10 shareholders, and zero otherwise.	CSMAR
AnalystCov	Natural logarithm of the number of analysts (teams) covering the firm.	CSMAR
ESG	A firm's ESG rating provided by WIND (1: C, 2: B, 3: BB, 4: BBB, 5: A, 6: AA). There is no rating lower than "C" or higher than "AA" in 2020.	WIND
CSRReport	An indicator variable equal to one if the firm issues a standalone CSR report, and zero otherwise.	CSMAR
MDA2020	An indicator variable equal to one if the firm discussed "carbon peak," "carbon neutrality," or "dual carbon" in the Management Discussion and Analysis section of its annual report for 2020, and zero otherwise.	Hand collected from firms' annual reports
RepQuality	A firm's reporting quality rating provided by the stock exchanges (0: D, 1: C, 2: B, 3: A).	CSMAR
EmissionPCA	The first principal component of *Emission* and *Intensity* obtained from a principal component analysis. Both *Emission* and *Intensity* are measured in 2020.	QuantData
Additional tests		
ETS Firm	We define a listed firm as an ETS firm if it directly participates in the regional or national carbon emission trading systems (ETS), or if its subsidiaries participate in the ETS and the total registered capital of the subsidiaries participating in the ETS accounts for at least 5% of the listed firm's total assets.	CSMAR
Energy-Intensive Industry	We classify an industry as energy-intensive if it belongs to the economic sector with the highest emission (i.e., the second sector according to the National Economic Industry Classification) and has above-median energy consumption among industries within this economic sector, based on the data in 2020.	*China Energy Statistical Yearbook* obtained from https://data.cnki.net/
Target	The intended percentage of reduction in greenhouse gas emissions in a region during the 13th Five-Year Plan (2016–2020), as stipulated by the central government's emission reduction objectives.	Hand collected from government websites
Enforcement	An indicator variable equal to 1 if the number of environmental enforcement cases in a region in 2017 is above the median and the repeat offense rate is below the median.	Zhu (2018)

APPENDIX 2: DETAILS OF STAKEHOLDER SUPPORT

Panel A: Authorized carbon verification agencies

We use the density of authorized carbon verification agencies within a region to proxy for carbon-management professionals provided by local governments. Carbon verification agencies are organizations responsible for verifying and certifying carbon emissions data provided by businesses. Firms participating in carbon emissions trading are required to undergo emissions verification, which is conducted by authorized carbon verification agencies staffed with certified experts in carbon accounting and verification.

We gather data on carbon verification agencies primarily from publicly disclosed government procurement contracts found on regional government websites. While these contracts may not capture all local carbon verification agencies, we rely on this data for several reasons. First, verification agencies identified through governmental contracts are legitimate entities staffed with certified experts, unlike unverified agencies that may lack such credentials and may introduce noise to our measure of carbon-management human capital. This is because such contracts undergo government quality assessments, where suppliers are scored based on specific criteria, and projects are awarded to the highest-scoring suppliers. Second, these contracts are expected to correlate positively with the overall number of agencies in a region. Governments typically sign contracts with multiple verification agencies, such that the competition among them can help ensure service quality. Consequently, governments in regions with more qualified agencies tend to contract with more agencies, whereas governments in regions with fewer qualified agencies would not be able to sign so many procurement contracts.

To ensure data quality, we cross-reference government evaluations of the contracted carbon verification agencies. Some regional governments conduct evaluations, categorizing agencies as either "qualified" or "unqualified" based on their performance in carbon verification. In cases where the number of qualified agencies identified in these evaluations exceeds the count listed in the procurement contracts, we use the number taken from the evaluations in our analysis. Panel A of Online Appendix II shows the number of authorized carbon verification agencies identified for each province or city as of 2021.

Panel B: Re-lending policies supporting green initiatives

We use re-lending policies targeted at supporting green initiatives to proxy for one type of financial support. Re-lending is a monetary policy tool whereby the central bank influences the flow of credit into certain sectors or initiatives by extending special-purpose credit loans to commercial banks at favorable terms, which the banks can then lend to businesses or projects within those sectors or initiatives. The Chinese government often uses re-lending policies to support targeted sectors or initiatives deemed important for policy objectives.

In August 2016, the People's Bank of China and seven other ministries jointly released *the Guiding Opinions on Building a Green Financial System*, proposing the use of measures such as re-lending to support the development of green finance. Subsequently, various provinces and cities gradually implemented specific re-lending policies targeted at supporting green initiatives. Since central-bank re-lending involves lower interest rates and longer repayment cycles compared to regular commercial bank loans, it encourages commercial banks to finance green projects, which usually require substantial upfront investment and have longer implementation periods. Through this channel, the government provides financial support for firms that plan to implement carbon reduction projects.

We obtain the re-lending policy data from the 2020 and 2021 Annual Report on the Development of Local Green Finance in China. The report is written by scholars from the International Institute of Green Finance at the Central University of Finance and Economics. It summarizes the regional re-lending policies supporting green initiatives since 2010. The report has been cited by the China Regional Financial Operations Report released by the People's Bank of China. Panel B of Online Appendix II lists the provinces, cities, and counties with re-lending policies supporting green initiatives.

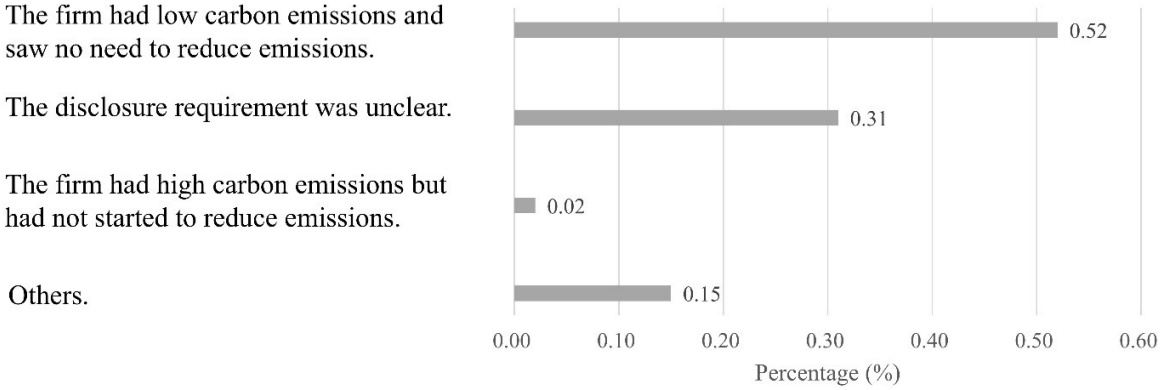
Panel C: Local government's environmental spending

We use a local government's environmental spending as a proxy for the overall environmental support available in that region. This spending, formally named "energy-saving and environmental protection expenditure," has been an official subcategory of government expenditure since 2011, encompassing total fiscal outlays for environmental initiatives within a region. It primarily funds efforts in pollution reduction, ecological conservation, energy efficiency, and environmental management, while also supporting related areas like renewable energy projects that contribute to carbon reduction.

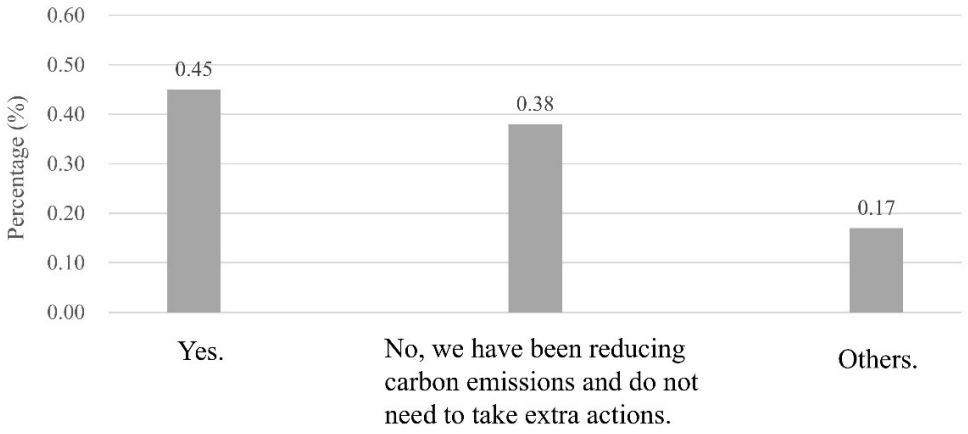
This fiscal spending supports firms' carbon reduction efforts through multiple channels. Firms may benefit directly from subsidies and incentives for energy-saving and carbon-reduction projects. Additionally, government-led pollution control initiatives foster the growth of local energy-saving and environmental protection industries, enhancing firms' access to advanced environmental equipment, services, and technologies that can aid firms in their carbon reduction activities.

We collect data on energy-saving and environmental protection fiscal expenditure in 2021 from the *China Fiscal Yearbook*. The data are reported at the provincial or city level, depending on the level of fiscal final accounts compilation. We scale the data by the regional GDP for the same year to account for differences in economic sizes and multiply the result by 100. Panel C of Online Appendix II provides a breakdown of environmental spending by region as of 2021.

(A) Why did your firm choose not to disclose carbon reduction efforts in the 2021 annual report? (N=191)



(B) Did your firm increase carbon reduction efforts in response to the disclosure regulation? (N=328)



(C) Why did your firm increase carbon reduction efforts in response to the disclosure regulation? (N=146)

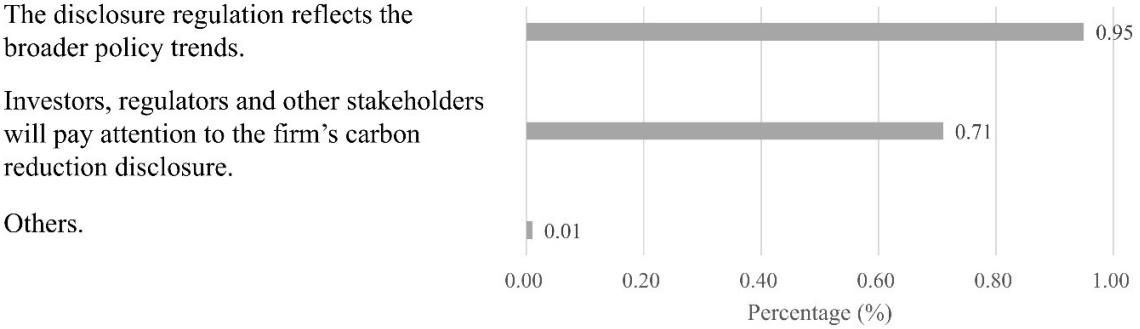


FIGURE 1 Survey results. (A) Reasons for non-disclosure; (B) Firms' response to the disclosure regulation; (C) Reasons for firms' decision to reduce carbon emissions. The figure summarizes survey responses related to firms' disclosure decisions and carbon reduction efforts. Respondents who had not disclosed their carbon reduction measures and effects in response to the 2021 carbon disclosure provision were asked to choose a reason for their non-disclosure. The figure also reports whether firms chose to increase their carbon reduction efforts in response to the regulation, as well as the reasons underlying those decisions. Each part displays the corresponding options provided for each survey question and the percentages of respondents selecting each option.

TABLE 1 Determinants of carbon reduction disclosure.

	CSI 800 sample ***Treat***
Historical carbon emission	
EmissionPCA	0.483***
	(3.531)
Historical environmental awareness and reporting quality	
ESG	-0.177
	(-0.919)
CSRReport	0.113
	(0.792)
MDA2020	0.274
	(1.029)
RepQuality	0.377
	(1.138)
Current firm characteristics	
Size	0.359**
	(2.442)
ROA	3.306
	(1.464)
PB	-0.072**
	(-2.184)
SOE	0.100
	(0.421)
InstHolding	0.029
	(1.287)
Oversea	-0.392
	(-0.658)
AnalystCov	0.044
	(0.324)
Industry fixed effects	Yes
Constant	-9.296**
	(-2.555)
Observations	573
Pseudo R^2	0.205

Note: This table presents the results of a logistic regression using the CSI 800 firms, which is the subsample with carbon emissions data. The dependent variable is *Treat*, an indicator variable equal to one if a firm choose to disclose its carbon reduction efforts and results in its 2021 annual report and equal to zero otherwise. Among the independent variables, historical carbon emissions, environmental awareness, and reporting quality are measured as of year 2020. Current firm characteristics are measured as of year 2021. All variables are defined in Appendix 1, and all continuous variables are winsorized at the 1st and 99th percentiles. *t-statistics*, based on robust standard errors, are presented below the coefficient estimates.

***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 2 Sample selection.

Step	Firm years	Unique firms
CSI 800 firms with non-missing carbon emissions data between 2018–2021	2750	768
Less: firm-years with missing control data	(122)	(2)
Less: firms without at least one observation before and after implementation of the disclosure regulation	(114)	(98)
Less: firms with drastic changes in carbon intensity	(134)	(35)
CSI 800 sample	2380	633
Less: firms that cannot be matched in CEM	(419)	(141)
Final sample	1961	492

Note: This table delineates the sample selection procedure. We start from CSI 800 firms for which carbon emissions data are available between 2018–2021. We first exclude firm-years that are missing data required for control variables in Eq. (1). We also exclude firms that do not have at least one observation each in the periods before and after the implementation of the disclosure regulation in 2021. Next, we exclude a firm from our sample if its year-over-year change in carbon intensity ranks among the top or bottom 1% in the sample period. Our manual reading of the firms' annual reports suggests that such drastic changes in carbon emissions nearly all result from endogenous changes in the scope of measurement (e.g., including more segments in the measurement process) or data errors. By this step, we have a sample of 633 unique firms and 2380 firm-years (CSI 800 sample). In the last step, we use coarsened exact matching (CEM) to match treatment and control firms. Specifically, we coarsen our sample into 50 CEM strata based on the firms' carbon emissions and intensity measured as of 2018. In the coarsening process, the number of equally sized bins is specified using Sturge's rule. Each CEM variable is coarsened using 11 equally spaced cutpoints, leading to 50 strata. The CEM method drops observations that lack common support (i.e., firms in strata without both a treatment and control observation), and that gives us a final sample of 492 unique firms and 1961 firm-year observations.

TABLE 3 Descriptive statistics.

Panel A: Summary statistics for CEM sample

	N	Mean	SD	Min	Median	Max
Intensity	1961	-6.159	2.170	-11.074	-6.338	-0.052
Emissions	1961	10.372	2.642	3.841	10.208	18.463
Treat	1961	0.630	0.483	0.000	1.000	1.000
Support	1961	1.745	1.148	0.000	2.000	3.000
Personnel	1961	3.492	2.296	0.000	3.008	10.211
GreenFinance	1961	0.701	0.458	0.000	1.000	1.000
EnvSpending	1961	0.487	0.172	0.125	0.464	1.320
Size	1961	17.211	0.881	15.675	17.027	20.323
AssetIntensity	1961	0.205	0.184	0.001	0.155	0.715
PB	1961	2.780	2.943	0.276	1.707	17.332
Leverage	1961	0.506	0.202	0.067	0.500	0.929

Panel B: Summary statistics by sample

	CSI 800 sample, N=2380					CEM sample, N=1961				
	Treatment, N=1558		Control, N=822		Difference	Treatment, N=1234		Control, N=727		Difference
	Mean	SD	Mean	SD	Mean	Mean	SD	Mean	SD	Mean
Intensity	-5.867	2.296	-7.184	1.989	1.317***	-6.168	2.147	-6.145	2.209	-0.023
Emissions	10.891	2.972	8.694	2.632	2.197***	10.386	2.623	10.347	2.677	0.039
Support	1.733	1.137	1.809	1.133	-0.076	1.703	1.154	1.817	1.135	-0.114*
Personnel	3.540	2.372	3.529	2.348	0.011	3.437	2.261	3.586	2.354	-0.149
GreenFinance	0.664	0.473	0.749	0.434	-0.085***	0.654	0.476	0.782	0.413	-0.128***
EnvSpending	0.498	0.191	0.490	0.176	0.008	0.496	0.181	0.472	0.155	0.024***
Size	17.404	0.966	17.108	0.840	0.296***	17.253	0.892	17.141	0.857	0.112**
AssetIntensity	0.227	0.188	0.135	0.145	0.092***	0.223	0.186	0.175	0.176	0.048***
PB	2.946	3.334	4.176	4.234	-1.23***	2.728	2.864	2.867	3.072	-0.139
Leverage	0.516	0.205	0.455	0.220	0.061***	0.512	0.204	0.494	0.198	0.018

Panel C: Pearson correlations for CEM sample

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) *Intensity*	1.000										
(2) *Emissions*	0.891***	1.000									
(3) *Treat*	0.210***	0.271***	1.000								
(4) *Support*	0.015	0.072***	-0.049**	1.000							
(5) *Personnel*	0.017	0.100***	-0.018	0.776***	1.000						
(6) *GreenFinance*	-0.001	0.029	-0.112***	0.723***	0.410***	1.000					
(7) *EnvSpending*	0.047**	0.062***	0.042*	0.570***	0.591***	0.063***	1.000				
(8) *Size*	-0.033	0.186***	0.095***	0.079***	0.073***	0.062***	-0.006	1.000			
(9) *AssetIntensity*	0.555***	0.475***	0.221***	-0.079***	-0.027	-0.128***	0.015	-0.173***	1.000		
(10) *PB*	-0.134***	-0.272***	-0.156***	-0.053**	-0.119***	0.000	-0.048**	0.287***	-0.113***	1.000	
(11) *Leverage*	-0.088***	0.169***	0.141***	0.074***	0.119***	0.056**	-0.025	0.201***	-0.172***	-0.317***	1.000

Note: This table shows the descriptive statistics for all variables used in the main regressions. Panel A reports summary statistics for the CEM sample. Panel B reports the mean and standard deviation for each variable for the treatment and control groups across the CSI 800 sample and the CEM sample. Panel C shows the Pearson correlations of the variables. All variables are defined in Appendix 1.
***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 4 The effect of disclosure regulation given stakeholder support.

Panel A: Baseline regression and overall stakeholder support

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
Treat × *Post*	-0.078**	-0.090*	0.065	0.087
	(-2.008)	(-1.888)	(0.954)	(1.149)
Treat × *Post* × *Support*			-0.081**	-0.099**
			(-2.304)	(-2.448)
Post × *Support*			0.053**	0.072**
			(1.970)	(2.098)
Size	-0.013	0.463***	-0.013	0.465***
	(-0.318)	(5.987)	(-0.301)	(6.012)
AssetIntensity	0.080	0.391	0.058	0.368
	(0.300)	(1.071)	(0.211)	(0.998)
PB	-0.002	-0.061***	-0.002	-0.061***
	(-0.281)	(-4.186)	(-0.308)	(-4.198)
Leverage	-0.187	0.802**	-0.168	0.829**
	(-0.830)	(2.320)	(-0.763)	(2.453)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Constant	-5.832***	2.097	-5.874***	2.024
	(-7.470)	(1.479)	(-7.583)	(1.434)
Observations	1961	1961	1961	1961
R^2	0.008	0.113	0.015	0.121

Panel B: Different types of stakeholder support

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*	(1) *Intensity*	(2) *Emissions*
Treat × *Post* × *Personnel*	-0.032**	-0.033*				
	(-2.023)	(-1.867)				
Treat × *Post* × *GreenFinance*			-0.216***	-0.211**		
			(-2.926)	(-2.199)		
Treat × *Post* × *EnvSpending*					-0.330*	-0.644***
					(-1.691)	(-2.689)
Treat × *Post*	0.035	0.028	0.085	0.072	0.082	0.221*
	(0.541)	(0.336)	(1.421)	(0.921)	(0.815)	(1.807)
Post × *Personnel*	0.022	0.025*				
	(1.643)	(1.661)				
Post × *GreenFinance*			0.168***	0.186**		
			(3.213)	(2.279)		
Post × *EnvSpending*					0.131	0.359*
					(0.819)	(1.681)

(Continues)

TABLE 4 (Continued)

Panel B: Different types of stakeholder support

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*	(1) *Intensity*	(2) *Emissions*
Size	-0.016	0.461***	-0.011	0.467***	-0.016	0.460***
	(-0.373)	(5.900)	(-0.257)	(6.030)	(-0.370)	(5.955)
AssetIntensity	0.062	0.374	0.103	0.421	0.044	0.328
	(0.231)	(1.018)	(0.381)	(1.136)	(0.167)	(0.910)
PB	-0.002	-0.060***	-0.002	-0.061***	-0.001	-0.060***
	(-0.213)	(-4.135)	(-0.346)	(-4.207)	(-0.196)	(-4.140)
Leverage	-0.187	0.804**	-0.159	0.830**	-0.191	0.803**
	(-0.832)	(2.314)	(-0.711)	(2.433)	(-0.854)	(2.327)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-5.807***	2.111	-5.928***	1.982	-5.801***	2.115
	(-7.375)	(1.473)	(-7.634)	(1.402)	(-7.417)	(1.492)
Observations	1961	1961	1961	1961	1961	1961
R^2	0.013	0.117	0.016	0.119	0.012	0.120

Note: This table presents the results from estimating Eq. (1) using the CEM sample. Panel A reports the results of overall stakeholder support. Columns (1) and (2) show the baseline DiD regression results without accounting for the role of stakeholder support. Columns (3) and (4) introduce the interaction between *Treat*, *Post*, and stakeholder support. The dependent variables in columns (1) and (3) are the natural logarithm of annual carbon emissions scaled by sales. The dependent variables in columns (2) and (4) are the natural logarithm of annual carbon emissions. *Support* is defined as the sum of three indicator variables: the first indicator variable equals 1 if *Personnel* is above the sample median, and zero otherwise; the second indicator variable equals 1 if *GreenFinance* is greater than zero, and zero otherwise; the third indicator variable equals 1 if *EnvSpending* is above the sample median, and zero otherwise. *Personnel* is computed as the number of authorized carbon verification agencies in a firm's headquarters region in 2021 scaled by the corresponding GDP (in trillion RMB). *GreenFinance* is an indicator variable equal to one if a firm's headquarters region provides re-lending support for green projects by the end of 2021, and zero otherwise. *EnvSpending* is defined as the local government's energy-saving and environmental protection expenditure for 2021 scaled by the corresponding GDP and multiplied by 100. In Panel B, we individually examine the effects of the three types of support. All variables are defined in Appendix 1. All continuous variables are winsorized at the 1st and 99th percentiles. The within R-squared values are reported in this table as well as in the subsequent tables. *t-statistics*, based on standard errors clustered by firm, are presented below the coefficient estimates.

***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 5 Robustness tests.

Panel A: Parallel trends in baseline regression

	(1) *Intensity*	(2) *Emissions*
Treat × *2019*	-0.021	0.006
	(-0.907)	(0.194)
Treat × *2020*	-0.064	-0.045
	(-1.367)	(-0.712)
Treat × *2021*	-0.107**	-0.103
	(-2.007)	(-1.459)
Controls & FEs	Yes	Yes
Observations	1961	1961
R^2	0.010	0.114

Panel B: Adjustments in Coarsened Exact Matching

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
	CEM unweighted		**CEM with additional covariates**	
Treat × *Post*	0.057	0.029	0.045	0.039
	(0.875)	(0.393)	(0.689)	(0.488)
Treat × *Post* × *Support*	-0.073**	-0.073**	-0.064	-0.081*
	(-2.283)	(-2.017)	(-1.649)	(-1.849)
Post × *Support*	0.045*	0.046	0.063**	0.077**
	(1.917)	(1.587)	(2.040)	(2.247)
Controls & FEs	Yes	Yes	Yes	Yes
Observations	1961	1961	1039	1039
R^2	0.012	0.148	0.022	0.146

Note: This table presents robustness tests. In Panel A, we validate the parallel trend assumption. In Panel B, we vary the conditions used on CEM matching. The dependent variable *Intensity* is defined the natural logarithm of annual carbon emissions scaled by sales, while the dependent variables *Emissions* is the natural logarithm of annual carbon emissions. All variables are defined in Appendix 1. All continuous variables are winsorized at the 1st and 99th percentiles. *t-statistics*, based on standard errors clustered by firm, are presented below the coefficient estimates.
***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 6 Validation of stakeholder support.

Panel A: Personnel

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
	Non-ETS firms		**ETS firms**	
Treat × *Post* × *Personnel*	-0.057***	-0.061**	-0.034	0.014
	(-2.597)	(-2.316)	(-0.764)	(0.246)
Treat × *Post*	0.146**	0.208**	-0.077	-0.435
	(2.008)	(2.138)	(-0.301)	(-1.167)
Post × *Personnel*	0.041**	0.054**	0.016	-0.029
	(2.132)	(2.277)	(0.389)	(-0.524)
Size	0.001	0.516***	0.028	0.343*
	(0.031)	(5.732)	(0.208)	(1.753)
AssetIntensity	0.018	0.078	-0.121	0.559*
	(0.049)	(0.169)	(-0.307)	(1.763)
PB	-0.004	-0.066***	-0.010	-0.044
	(-0.519)	(-4.126)	(-0.440)	(-1.363)
Leverage	0.112	1.322***	-0.693	-0.867
	(0.567)	(4.433)	(-0.962)	(-0.905)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Constant	-6.499***	0.635	-5.212**	6.101*
	(-7.741)	(0.390)	(-2.019)	(1.668)
Observations	1593	1593	320	320
R^2	0.018	0.183	0.068	0.148

Panel B: Green finance

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
	Non-SOEs		**SOEs**	
Treat × *Post* × *GreenFinance*	-0.132*	-0.360**	-0.179	-0.094
	(-1.662)	(-2.193)	(-1.312)	(-0.686)
Treat × *Post*	0.139**	0.381***	0.024	-0.059
	(2.444)	(2.682)	(0.239)	(-0.562)
Post × *GreenFinance*	0.075	0.298*	0.120	0.111
	(1.238)	(1.912)	(1.289)	(1.150)
Size	0.022	0.638***	-0.026	0.354***
	(0.337)	(5.806)	(-0.456)	(3.349)
AssetIntensity	0.507	1.208***	-0.322	-0.771
	(1.585)	(3.125)	(-0.813)	(-1.454)
PB	-0.012	-0.079***	0.008	-0.039**
	(-1.154)	(-4.373)	(1.039)	(-2.225)
Leverage	0.016	1.029***	0.168	0.951**
	(0.061)	(2.856)	(0.587)	(2.008)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Constant	-6.695***	-1.517	-5.698***	4.336**
	(-5.936)	(-0.770)	(-5.757)	(2.323)
Observations	948	948	916	916
R^2	0.020	0.241	0.015	0.097

Panel C: Government environmental spending

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
	Energy-intensive industries		**Non-energy-intensive industries**	
Treat × *Post* × *EnvSpending*	-0.691*	-1.038***	-0.037	-0.220
	(-1.894)	(-2.764)	(-0.165)	(-0.679)
Treat × *Post*	0.301*	0.465***	-0.064	0.070
	(1.869)	(2.712)	(-0.528)	(0.398)
Post × *EnvSpending*	0.504	0.758**	-0.021	0.006
	(1.489)	(2.173)	(-0.136)	(0.022)
Size	-0.022	0.423***	0.035	0.558***
	(-0.366)	(3.399)	(0.605)	(5.467)
AssetIntensity	0.383	0.368	0.538	0.872
	(1.510)	(1.051)	(1.129)	(1.451)
PB	-0.004	-0.063**	-0.006	-0.067***
	(-0.355)	(-2.201)	(-0.705)	(-4.148)
Leverage	-0.180	0.691	-0.112	0.973***
	(-0.652)	(1.351)	(-0.550)	(3.535)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Constant	-5.408***	3.426	-7.612***	-0.858
	(-4.893)	(1.540)	(-7.210)	(-0.472)
Observations	854	854	974	974
R^2	0.025	0.119	0.014	0.186

Note: This table presents the results from estimating a modified version of Eq. (1) across different subsamples, focusing on the varying importance of personnel, green finance, and government environmental spending. In Panel A, we split the sample based on whether firms or their subsidiaries have participated in carbon emissions trading systems (ETS) and examine the effect of personnel support. In Panel B, we divide the sample into state-owned enterprises (SOEs) and non-SOEs to investigate the effect of green finance. In Panel C, we classify observations into energy-intensive industries and other industries and analyze the effect of environmental spending. In each panel, the dependent variables in columns (1) and (3) are the natural logarithm of annual carbon emissions scaled by sales, and the dependent variables in columns (2) and (4) are the natural logarithm of annual carbon emissions. All variables are defined in Appendix 1. All continuous variables are winsorized at the 1st and 99th percentiles. *t-statistics*, based on standard errors clustered by firm, are presented below the coefficient estimates.
***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

TABLE 7 Falsification tests.

Panel A: Political pressure to reduce emissions

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
Treat × *Post* × *Target*	-0.007	0.033	0.002	0.046
	(-0.309)	(0.710)	(0.077)	(1.026)
Treat × *Post* × *Support*			-0.079**	-0.103**
			(-2.270)	(-2.576)
Treat × *Post*	0.064	-0.754	0.035	-0.829
	(0.150)	(-0.804)	(0.088)	(-0.920)
Post × *Target*	0.015	-0.022	0.006	-0.036
	(0.803)	(-0.512)	(0.338)	(-0.878)
Post × *Support*			0.052*	0.077**
			(1.954)	(2.271)
Controls & FEs	Yes	Yes	Yes	Yes
Observations	1961	1961	1961	1961
R^2	0.009	0.114	0.016	0.122

Panel B: Environmental enforcement

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
Treat × *Post* × *Enforcement*	-0.053	-0.122	0.008	-0.056
	(-0.465)	(-0.942)	(0.071)	(-0.417)
Treat × *Post* × *Support*			-0.072**	-0.077*
			(-2.162)	(-1.911)
Treat × *Post*	-0.059*	-0.050	0.053	0.069
	(-1.652)	(-1.052)	(0.820)	(0.903)
Post × *Enforcement*	0.117	0.204*	0.070	0.154
	(1.261)	(1.786)	(0.770)	(1.317)
Post × *Support*			0.040*	0.044
			(1.784)	(1.334)
Controls & FEs	Yes	Yes	Yes	Yes
Observations	1961	1961	1961	1961
R^2	0.013	0.122	0.019	0.126

Note: This table presents the results from estimating a modified version of Eq. (1), where the variable the *Support* variable is replaced with *Target* in Panel A and with *Enforcement* in Panel B. *Target* is defined as the intended percentage of reduction in greenhouse gas emissions in a region during the 13th Five-Year Plan (2016–2020). *Enforcement* is an indicator variable equal to 1 if the number of environmental enforcement cases in a region is above median and the violation rebound rate is below median. All variables are defined in Appendix 1. Continuous variables are winsorized at the 1st and 99th percentiles. *t-statistics*, based on standard errors clustered by firm, are presented below the coefficient estimates.

***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.