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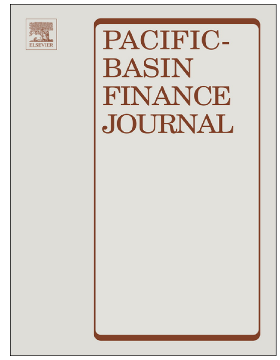

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Institutional Ownership and Corporate Greenhouse Gas Emissions: The Evidence from China[1]

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Abstract

This paper examines the impact of corporate ownership structure on greenhouse gas (GHG) emissions in China, with a focus on the role of institutional investors. Using data on Chinese listed companies, we find that institutional ownership has a significant negative effect on corporate GHG emissions. We also observe that pressure-resistant institutional investors and qualified foreign institutional investors have a more substantial impact on reducing emissions. Our results suggest that institutional investors act as active monitors, influencing corporate behavior through both "exit and selection" and "voice" mechanisms. Furthermore, we find that institutional investors are more concerned with policy uncertainty risk than physical risk. These findings have implications for policymakers and investors seeking to promote sustainable development and address climate change.

Keywords: Greenhouse gas (GHG) emissions, institutional ownership, QFIIs, policy uncertainty

1. Introduction

Climate change, driven by greenhouse gas (GHG) emissions, has emerged as one of the most severe environmental challenges the world has ever confronted (Bekun et al., 2019). The escalation of GHG emissions has resulted in global warming, a calamitous phenomenon that humanity must confront and resolve. China has been the largest global carbon emitter since 2006 (Meng et al., 2017). In 2020, the country emitted 10.67 billion metric tonnes of carbon dioxide (CO2), the primary greenhouse gas contributing to climate change, which accounted for 30.64% of global emissions (UNEP, 2021). Over the past decade, both the Chinese government and the general public have increasingly focused on climate and environmental issues. China recently committed to reaching its peak carbon emissions by 2030 and achieving net-zero emissions by 2060. To accomplish this "dual carbon" national objective, the government has implemented a series of energy and environmental policies and regulations aimed at reducing carbon emissions (Stern and Xie, 2022). Prior research indicates that these policies positively impact energy conservation and emissions reduction (Hu et al., 2020; Xuan et al., 2020; Yu et al., 2021). In addition to complying with policies, firms face mounting pressure from market participants, particularly institutional investors, to diminish their carbon footprint and operate more sustainably (Azar et al., 2021). Unlike individual investors, institutional investors possess a larger share of listed companies, and their monitoring and disciplining of high-emission firms can help mitigate climate change. Consequently, understanding the role of institutional investors in reducing GHG emissions is vital for transitioning to a low-carbon economy. However, research exploring whether institutional investors drive corporate GHG emissions reductions remains limited. Thus, this paper aims to address this knowledge gap and offer insights for policy and practice.

Existing literature primarily concentrates on the influence of climate change or sustainability risks on institutional investment decisions, examining aspects such as market reactions, policy uncertainty, investment sentiment, and the repurchase effect in derivatives markets. The primary objective of these studies is to offer guidance to investors in evaluating corporate climate risk within investment decisions. Bolton and Kacperczyk (2021) investigate the impact of carbon emissions on US stock returns, demonstrating that institutional investors devise portfolio strategies based on direct emissions intensity. Their research also suggests that carbon risks are already incorporated into asset prices. Krueger et al. (2020) utilize survey data to reveal that institutional investors perceive climate risk as an investment risk that has begun to materialize. Pedersen et al. (2021) argue that environmental, social responsibility, and governance performance (ESG) significantly influence the required return for specific portfolios. Likewise, Pástor et al. (2021) discover that holding green assets effectively hedges against uncertainty related to climate risk.

While the previous studies have discussed the relationship between climate risk and institutional investors in terms of how the former affects the latter, however, less attention has been paid to whether and how institutional investors influence corporate GHG emissions. As one of the most influential participants in the market, institutional investors can affect corporate emissions by exiting and selecting investment strategies. In addition, Kelly (2021) finds that institutional investors, as block holders, can significantly influence emissions through their voting power and dialogue with investee companies. More specifically, institutional investors can express their views on climate change mitigation via voting on shareholder proposals and directly communicating with management teams. To align with their long-term investment strategy and improve their social image, institutional investors have a strong incentive to monitor and discipline investee firms to curb their GHG emissions and increase the value of the portfolio.

We, therefore, endeavor to examine the influence of institutional investor holdings on the reduction of corporate GHG emissions in China. To empirically investigate this issue, we obtain corporate emissions, financial and institutional ownership data from the China Stock Market and Accounting Research (CSMAR) database for all Chinese listed firms from 2011 to 2020. To our best knowledge, this paper is the first to examine the GHG emissions of Chinese firms by manually calculating the firm-level GHG emissions among corporate emissions data.[2]

[2] Previous literature on China's greenhouse gas emissions have mainly focused on studying carbon emissions at the regional or provinial level (Chen et al., 2020; Du et al., 2012; Wang et al., 2012; Zhang and Cheng, 2009; Zheng et al., 2019)

In this study, we initially investigate the association between overall institutional ownership and corporate GHG emissions. Our findings reveal a negative correlation between institutional shareholding and GHG emissions, with both statistically and economically significant effects. Specifically, a one-standard-deviation increase in institutional shareholding results in an approximate 0.26% reduction in corporate GHG emissions. We employ fixed effects and instrumental variable (IV) approaches to mitigate potential endogeneity concerns, and the results corroborate our primary finding that institutional ownership facilitates emission reduction in firms. Subsequently, we delve into the influence of institutional investors on emission reduction in state-owned enterprises (SOEs) and non-SOEs, respectively. The results indicate that the negative association is predominantly concentrated in SOEs, suggesting that institutional investors play a more active role in reducing GHG emissions in SOEs compared to non-SOEs. Moreover, we assess the impact of various types of institutional investors on GHG emissions. In line with the monitor theory, the evidence implies that pressure-resistant institutional investors (PRIIs) have a more pronounced effect on GHG emissions reduction than pressure-sensitive institutional investors (PSIIs). Lastly, our empirical findings also support the social norm motive, indicating that qualified foreign institutional investors (QFIIs) from countries with superior compliance exert a more significant impact on GHG emission reductions than domestic institutional investors.

Subsequently, we expand our analysis to explore the mechanisms through which institutional investors may affect corporate GHG emissions. Drawing on Dyck et al. (2019), we examine the potential roles of "exit and selection" and "voice" mechanisms. On one hand, institutional investors may proactively select low-emitting firms while exiting high-emitting ones. On the other hand, they can influence corporate emissions through environmentally relevant shareholder proposals. The Granger causality test and regression analyses indicate that both mechanisms serve as means for institutional investors to influence corporate emissions behaviour. Lastly, we investigate the incentives for institutional investors to reduce corporate GHG emissions from a risk perspective. Physical risk, policy uncertainty risk, and market risk constitute the three primary risks associated with corporate GHG emissions that may affect the underlying assets of institutional investors. We employ a difference-in-differences (diff-in-diff) model to examine the impact of these distinct risks in relation to the establishment of the carbon market and the Beijing haze event, respectively. Our findings imply that institutional investors display greater concern for policy uncertainty risk than physical risk.

This study makes several contributions to the existing literature. Firstly, we enrich the understanding of determinants of corporate GHG reductions. The current literature has examined various factors influencing GHG emissions, including green investments (Hao et al., 2021), natural resources (Ahmad et al., 2020; Bekun et al., 2019), effective government policies (Du et al., 2018), institutional innovations (Jia, 2022), urbanization (Murshed, 2020), foreign direct investment (Murshed and Dao, 2020), financial development (Charfeddine and Khediri, 2016), and gender diversity (Fan et al., 2023). Recent studies by Azar et al. (2021) and Benlemlih et al. (2022) have investigated the role of institutional ownership in reducing corporate carbon emissions in the USA and UK, respectively. Our research complements their work by offering novel evidence that institutional investors can also drive GHG emissions reductions in the world's largest GHG emitter. We underscore the significance and effectiveness of institutional investors, particularly PRIIs and QFIIs, as pivotal agents in the reduction of GHG emissions from firms listed in China.

Secondly, this paper contributes to the extensive literature on shareholder activism, specifically enriching the ongoing discourse surrounding the long-term versus short-term roles of institutional investors. Some literature contends that institutions with substantial shareholdings tend to monitor management teams to maximize long-term value (Callen and Fang, 2013; Monks and Minow, 2011; Shleifer and Vishny, 1986). Conversely, others argue that institutions are passive shareholders due to high monitoring costs and diversified investment strategies (Coffee Jr, 1991; Manconi et al., 2012). Under such conditions, institutions, acting as traders, place greater emphasis on short-term performance, thereby compelling managers to prioritize near-term outcomes to prevent the exit of institutional investors (Bushee, 1998, 2001; Graves and Waddock, 1990). In our study, we discover that institutional investors select firms with more robust social responsibilities or divest from those with weaker social responsibilities. Additionally, we demonstrate the effectiveness of shareholder proposals in influencing corporate GHG emissions. By examining two mechanisms through which institutional investors can affect GHG emissions, our findings suggest that institutional investors adopt active roles, consequently promoting long-term corporate sustainability, which lends support to the long-term theory.

Furthermore, this paper contributes to the literature examining the role of foreign institutional investors. Existing research has established that foreign institutional investors are more actively involved in firms' operations, leading to improved corporate governance and performance (Huang and Shiu, 2009; Huang and Zhu, 2015; Li et al., 2021b). Our study demonstrates that QFIIs significantly reduce firms' GHG emissions, thereby supplementing the literature by providing evidence that foreign institutional investors actively influence sustainability. These findings hold substantial implications not only for academic research but also for policymakers. While foreign investors face numerous restrictions in the Chinese capital market, their positive role is increasingly acknowledged. Our paper offers compelling support for liberalising investment restrictions on foreign investors in terms of their impact on GHG emissions, as they have the potential to substantially reduce such emissions.

The structure of this paper is as follows. Section 2 develops our hypotheses and offers an overview of the pertinent literature. Section 3 outlines the data and methodologies employed in our research. Section 4 presents the empirical results. Section 5 delves into further discussions regarding mechanisms and motivations, and Section 6 concludes the study.

2. Literature and hypotheses Development

Prior literature establishes a positive relationship between the proportions of shareholder ownership and monitoring benefits.[3] As large and professional shareholders, institutional investors possess both strong incentives and capabilities to enhance the monitoring of managers' activities and improve corporate governance through their monitoring role (Gillan and Starks, 2003). The effectiveness of such monitors has been well-documented in the

[3] Demsetz (1983) argues that owners of large blocks of shares have greater incentives to monitor managers. Shleifer and Vishny (1986) point out that only large shareholders have sufficient incentives to monitor because those shareholders benefit from the monitoring actions without incurring the costs.

literature.[4] Furthermore, some studies have demonstrated that the monitoring role of institutional investors can potentially enhance a company's long-term value, thereby realizing synergies for stakeholders and other agents.[5] Consequently, institutional investors have the capacity to influence corporate decisions and performance.

Institutional investors generally maintain a long-term investment horizon and are concerned with the long-term value and sustainability of the companies in which they invest. Recent studies have extensively documented the significant impacts of a firm's environmental performance and concerns on its value. Li et al. (2020), Albuquerque et al. (2019), and Karpoff (2012) demonstrate that firms can reduce long-term risk exposure by assuming environmental responsibility. Other studies, such as Brinkman et al. (2008) and Wang et al. (2022), confirm a negative effect of carbon risk on firm performance and value. Furthermore, indifference towards GHG emissions can result in regulatory penalties and an increased risk of financial losses and reputational damage (Dyck et al., 2019). Moreover, Krueger et al. (2020) suggest that institutional investors perceive climate risk as a significant factor in determining a firm's underlying value. Bolton and Kacperczyk (2021) also document that institutional investors are concerned about carbon risk and tend to adopt a proactive approach by divesting from industries with high CO2 emissions. Consequently, institutional investors have financial motives to encourage companies to reduce their carbon emissions, through which they can decrease a company's long-term risk exposure and protect their investments.

Evidence from some studies suggests that investors value sustainability beyond mere financial motives (Hartzmark and Sussman, 2019; Riedl and Smeets, 2017). As significant stakeholders, institutional investors can leverage their influence to encourage companies to adopt more sustainable and environmentally friendly practices that reduce corporate carbon emissions while also enhancing firms' long-term financial performance. In addition to exerting pressure,

[4] Jarrell and Poulsen (1987) document that institutional holdings help to avoid harmful amendments. Agrawal and Mandelker (1990) show that large shareholders monitor managers when they propose antitakeover amendments. McConnell and Servaes (1990) document a positive relation between Tobin’s Q and institutional ownership. Holderness and Sheehan (1988) document that insititutions can be involved in setting corporate policies.

[5] It is well documented that to achieve long-term benefits, management incentives from institutional investors influence managerial behaviors by taking a monitoring role (Cornett et al., 2007; Duggal and Millar, 1999; McGuinness et al., 2017; Woidtke, 2002).

institutional investors may also be willing to provide funding and other resources to support companies in implementing energy-efficient technologies to diminish their carbon footprint and develop effective strategies for achieving their sustainability objectives, even if the benefits may not realized immediately (Kaminker and Stewart, 2012).

Empirical evidence also indicates a positive association between institutional ownership and corporate disclosure (e.g. Bird and Karolyi, 2016; Cheng et al., 2020; Tsang et al., 2019). Institutional investors may demand companies to disclose information about their greenhouse gas emissions and other environmental performance indicators, fostering greater accountability and transparency. This requirement can generate a market-based incentive for companies to reduce their GHG emissions to evade reputational damage and adverse market reactions.

Building upon the aforementioned discussion, we posit that institutional ownership can foster heightened environmental responsibility and inspire companies to reduce corporate greenhouse gas emissions. Consequently, we formulate the following testable hypothesis:

***H1**: Institutional ownership is negatively related to corporate GHG emissions, implying that higher institutional ownership leads to greater GHG emissions reductions.*

The literature demonstrates that the efficacy of monitoring varies across different types of institutional investors (Aggarwal et al., 2011; Brickley et al., 1988; Ding et al., 2020; Gillan and Starks, 2003). In comparison to domestic investors, research indicates that foreign institutional investors often exhibit greater involvement in shaping corporate governance for the firms in which they invest (Aggarwal et al., 2011; Ferreira and Matos, 2008). Concurrently, social norms concerning environmental protection may impact investor behaviour. QFIIs originating from countries with more stringent environmental regulations and elevated ethical standards could integrate these norms into their investment strategies (Dyck et al., 2019; Li et al., 2020). Li et al. (2021a) reveal that, in China, over 90% of QFIIs hail from well-governed economies where social awareness of environmental issues has been established for an extended period. Their findings suggest that QFIIs provide a potent channel for enhancing the socially responsible practices of Chinese firms. Consequently, we also posit that QFIIs in China can effectively influence corporate GHG emissions and possess the motivation to do so.

Furthermore, Brickley et al. (1988) contend that investors with potential business relationships tend to avoid conflicts with the management teams of invested firms. As a result, these investors (defined as PSIIs), in comparison to those without potential business relationships with the invested firms (i.e., PRIIs), do not assume active monitoring roles in corporate governance and exert substantial influence on firms' decisions and policies (e.g., Almazan et al., 2005; Chen et al., 2009; Cornett et al., 2007; David et al., 1998). Cao et al. (2020) discover that PSIIs and PRIIs play distinct roles in Chinese firms' investment and innovation decisions. Similarly, Jiang and Bai (2022) also demonstrate that PRIIs promote invested firms to undertake more significant green innovation compared to PSIIs.

Given our research questions, actively monitoring and influencing managerial behaviour regarding sustainable practices can create conflicts with management teams and result in lost business opportunities. Therefore, unlike PRIIs, PSIIs may lack the incentive to assume monitoring roles that can affect corporate GHG emissions. Based on the aforementioned discussion, we hypothesize:

H2: *The relationship between institutional ownership and corporate GHG emissions varies across different types of institutional investors.*

H2a: Pressure-resistant institutional investors (PRIIs) have a stronger negative relationship with corporate GHG emissions than pressure-sensitive institutional investors (PSIIs).

H2b: Qualified foreign institutional investors (QFIIs) have a stronger negative relationship with corporate GHG emissions than domestic institutional investors.

3. Data and Methodology

3.1 Sample Construction

This study collects data on GHG emissions from the CSMAR database for listed companies in the Chinese stock market from 2011 to 2020. Institutional ownership and financial data are obtained from the CSMAR database, which provides information on institutional investor ownership for all listed firms in China. During the sample period, 1,063 companies disclosed 2,900 emissions data. We obtain 2152 firm-year level GHG observations by filtering these data against the Intergovernmental Panel on Climate Change (IPCC) greenhouse gas standards, including direct greenhouse gases, indirect greenhouse gases, and volatile organic compounds. The manually processed GHG data is cross-checked with the latest publicly available CSMAR GHG database (which includes only 416 observations) to ensure the accuracy of the results.

We then merge the institutional investor data with the firms' financial data. We exclude 704 observations 1) with missing financial information; 2) with ST*/PT* indicator;[6] 3) in financial sectors; 4) with total institutional ownership less than 1%. And we require firms in our sample with more than two years of continuous observations (resulting in the deletion of 170 observations). After these processes, we arrive at a sample of 1,278 firm-year observations for 653 firms.

3.2 Empirical model

To investigate whether institutional shareholding is a driving force behind firm GHG emissions reductions, we estimate the following equation:

$$GHG_{i,t} = \alpha + \beta TIOwn_{i,t-1} + \gamma Controls_{i,t-1} + \theta_t + \tau_t + \delta_t + \varepsilon_{i,t} \qquad (1)$$

where the dependent variable is the logarithm of GHG emissions or industry-adjusted GHG emissions (IA GHG) of firm *i* in year *t*, and $TIOwn_{i,t-1}$ represents the total institutional ownership of firm *i* in year *t*−1. In this paper, we define total institutional ownership as the aggregate percentage of outstanding shares held by all institutional investors at the end of a given year (Lin and Fu, 2017). Consequently, we define total institutional ownership as the sum of ownership of six types of institutional investors.[7]

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[6] The Shanghai and Shenzhen Stock Exchanges announced that a special treatment (ST*) for listed companies with unusual financial or other conditions on 22 April 1998. This mainly refers to two situations: first, the net profit of a listed company for two audited fiscal years is negative, and second, the audited net asset per share of a listed company for the latest fiscal year is below the nominal value of the shares. Listed companies with a particular transfer (PT*) indicator are those suffering losses for three consecutive years.

[7] Following Brickley et al. (1988) and Chen et al. (2007), we define trusts and insurance institutions as

To control for firm-level variations, we include *Firm Size*, *PPE* (property, plant, & equipment) ratio, *Leverage*, *ROA* (return on assets), and *Revenue* as main control variables. *Firm Size* is measured by the logarithm value of total asset. Previous literature shows that larger firms are subject to more external pressures than smaller firms (Azar et al., 2021; Dyck et al., 2019). As environmental issues in China have become widespread external pressures, large firms are likely to be under higher level of public scrutiny regarding their environmental impact than small firms. *Revenue* is the logarithm value of total revenue. We include those two variables to control for the volume of the firm's business activities, and we expect GHG emissions are positively related to firms' business activities. *ROA* is defined as net income as a proportion of total assets. We include it to control for the impact of the past performance. *Leverage* is the ratio of total debt to total assets. *PPE* is the ratio of property, plant, and equipment to total assets. Baber et al. (2012) suggest that financial constraints also predicts whether a firm is environmentally responsible. Firms with lower leverage and higher PPE are less subject to credit constraints in attracting more investment. In comparison, highly leveraged firms need to cope with regular cash outflows and are precluded from financing environmentally beneficial investments (Azar et al., 2021). Therefore, we expect a positive relationship between leverage and GHG emissions but a negative relationship between PPE and GHG emissions. All independent variables are lagged by one year to eliminate the simultaneous causality problem.

Our arguments presuppose that institutional ownership influences firms' GHG emissions. However, it is possible that institutional ownership and GHG emissions are simultaneously determined by other exogenous variables associated with industry, location, and year. For example, areas with better environment conditions and special investment environments attract more institutional investors while also requiring firms to maintain lower levels of GHG emissions. Additionally, industries with high revenue are attractive to institutional investors but may also include high GHG emission firms due to the volume of business. During times surrounding major national events, some areas may temporarily require firms to control their emissions. To tackle potential endogeneity issues, time, industry, and location fixed effects are

PSIIs, while funds and security funds are PRIIs for additional analysis.

used in the main regressions to eliminate omitted variable effects. $\theta_t, \tau_t,$ and δ_t represent the industry, location, and year fixed effects.

Table 1 presents the descriptive statistics. Panel A shows dependent variables used in this paper. The mean (median) of the logarithm of GHG emissions (Log (GHG)) is 5.07 (4.07), with a standard deviation of 5.27. Industry-adjusted GHG emissions have a mean (median) value of 0.57 (0.01) and a standard deviation of 2.30, indicating that more than half of the firms in the sample have lower than average GHG emissions. As shown in Panel B, the average institutional ownership in our sample is 7.41%, with a standard deviation of 6.09% and a median value of 5.78%. This is in line with prior studies on institutional ownership in China (Cao et al., 2020; Wen et al., 2020). However, the level of institutional ownership is much lower than the global level of 21.4% as shown in Dyck et al. (2019)[8].

Subdividing institutions, the mean value for the QFIIs dummy variable is 0.15, indicating that around 15% of the observations have QFIIs during the sample period. Shares owned by PRIIs (PRII Own) have a mean (median) value of 4.94% (2.97%). The mean (median) value of PSIIs (PSII Own) is 2.44% (1.37%), which is lower than that for PRII ownership.

[Insert Table 1 here]

Figure 1 illustrates the marginal increase in institutional ownership over the sample period. Among all types of institutional ownership, domestic institutional investors constitute a significant proportion. Moreover, QFIIs represent only a small part of institutional investors, peaking in 2014.[9] The degree of PRIIs' and PSIIs' ownership converged around 2015; since then, PRII ownership has continued to increase.

[Insert Figure 1 here]

[8] The large difference between China and other developed countries may arise from low quality of market regulation and weak market investors proctection.
[9] Before May 2020, the State Administration of Foreign Exchange had strict limits on the number of investments that could be made by QFIIs. The increase in QFII investments may be explained by the corporate tax exemption policy claimed by the China Securities Regulatory Commission in 2014.

Figure 2 displays corporate GHG emissions from our sample from 2011 to 2020. It is worth noting that China's GHG emissions have decreased significantly throughout the sample period, aligning with the central government's policy expectations and the improvement in energy efficiency.[10] Additionally, we observe a substantial increase in carbon emissions in 2020. One possible explanation is that China has undertaken more manufacturing to sustain the global supply chain. Benefitting from its rapid recovery from the pandemic, China has undertaken more manufacturing than ever, leading to increased GHG emissions in 2020.[11]

[Insert Figure 2 here]

3.2 Univariate analysis

In this section, we perform univariate tests on the impact of different institutional ownership on GHG emissions in our sample to gain an overall picture of the impact of different ownership structures. We divide our sample into subgroups based on the amount of institutional ownership and on the state-owned status. Table 2 presents a comparison of GHG emissions and key control variables between subsamples. Column (4) reports the results of the two-sample t-tests.

Panel A shows the difference between firms with high institutional ownership and low institutional ownership. The results indicate that firms with high institutional ownership have fewer GHG emissions than firms with low institutional ownership. In addition, firms with high institutional ownership are significantly different from their counterparts in that they have a higher ROA ratio and a lower PPE ratio.

Panel B reports the comparison between SOEs and non-SOEs. The results in Panel B show that SOEs have much higher GHG emissions than non-SOEs. This difference inspires us to investigate the role of institutional investors in SOEs. Furthermore, SOEs have larger firm sizes, higher leverage, and higher PPE ratios.

[Insert Table 2 here]

[10] According to the Ministry of Ecology and Environment, China's carbon emissions intensity in 2020 was 18.8% lower than in 2015, consistent with the trend of our sample.

[11] The increased emissions level can also be supported by the only positive global GDP growth rate (for China) in 2020 (2.3% compared to −3.5% for the US).

4. Empirical Results

4.1 Institutional investors and GHG emissions

Our baseline model examines the relationship between total institutional ownership and firm GHG emissions and the results of the regression are presented in Table 3. The coefficient estimates on $TIOwn_{i,t-1}$ in all regressions suggest that institutional ownership is negatively related to corporate GHG emissions. These results are economically meaningful. For example, in Column (3), a one-standard-deviation increase in total institutional ownership is associated with a 0.26% decrease in GHG emissions (6.09% × (−0.042)). According to the latest data from 2020, this would equate to a reduction of approximately 1,834,460 tones (705565 thousand tones * 0.26%). The result is robust after controlling for a combination of industry, location, and year fixed effects, suggesting that time-invariant unobserved industry and location characteristics do not have an impact on the findings. Besides, the results are robust when the dependent variable is replaced by industry-adjusted GHG emissions. Our findings are consistent with Dyck et al. (2019), in that institutional investors improve firm environmental performance. The control variables generally exhibit signs consistent with our predictions. Specifically, *Firm Size*, *Leverage*, *ROA*, and *Revenue* are positively associated with GHG emissions. the *PPE* is positively related to GHG emissions, which is the same as the finding of Azar et al. (2021).

[Insert Table 3 Here]

4.2 Endogeneity

We have considered the simultaneous causality and omitted variables issues in our main regression. In this section, we consider using the instrumental variables to make our results more robust. We conduct a two-stage least square (2SLS) approach (Wooldridge, 2015) to deal with the potential endogeneity of institutional ownership. As the higher the risk of a stock, the higher the uncertainty of institutional investors' returns, institutions base their investments on the risk appetite of their clients and therefore the risk of the stock affects the holdings of institutional investors. Referring to Callen and Fang (2013), we then employ two risk measures — the market exposure and unsystematic risk — as instrumental variables.

Market exposure measures the risk of firms to the market risk factors. Unsystematic risk is caused by specific factors, such as managerial and labour issues of listed companies. It is a risk specific to a particular company or industry and only affects the returns of certain stocks.

$First\ stage$:

$TIOwn_{i,t} = \alpha + Market\ Beta_{i,t} + Unsystematic\ risk_{i,t} + Controls_{i,t} + \theta + \varepsilon$

$Second\ Stage$:

$GHG_{i,t+1} = \alpha + \beta \widehat{TIOwn}_{i,t} + Controls_{i,t} + \theta + \varepsilon$ (2)

where $Market\ Beta_{i,t}$ is estimated by the capital asset pricing model (CAPM), and $unsystematic\ risk_{i,t}$ is the standard deviation of the error term of CAPM. $Controls_{i,t}$ are defined in Section 3.1. Table 4 reports the results of the 2SLS estimations. Column (1) presents the first stage of Eq. (2). Consistent with our prediction that market beta and unsystematic risk are significantly negatively related to institutional ownership. Column (2) and column(3) report the results of IV regressions. $TIOwn_{i,t}$ is loaded with negative and significant coefficients, including on the logarithm of GHG emissions and industry-adjusted GHG emissions, which is consistent with the results of our main regressions.

[Insert Table 4 here]

4.3 Heterogeneous Effects of Different Types of Institutional Investors

The univariate test in Table 2 shows that SOEs' GHG emissions account for a substantial proportion of overall emissions. SOEs are naturally connected to the government through their government ownership (Chen et al., 2011). This natural relationship between SOEs and the government tends to shape their behavior in favor of policy orientation (Wu et al., 2020). To further discuss the effectiveness of institutional investors, we divide the sample into state-owned and non-state-owned enterprises. Wang et al. (2014) report that SOEs in China are significantly affected by policy uncertainty as they rely mainly on government lending policies. Thus, we expect to find that institutional investors, in order to mitigate policy uncertainty risk, would be more effective in SOEs than non-SOEs.

Table 5 presents the role of institutional ownership in SOEs and non-SOEs subsamples. The negative and significant coefficient in the SOEs subsample indicates the effectiveness of institutional investors, which is consistent with our prediction.

[Insert Table 5 here]

To test the second hypothesis regarding foreign institutional investors in China, we use Eq (3) to investigate whether there is a difference in the impact of QFIIs and domestic institutional investors (DIIs) on firms' GHG emissions:

$$GHG_{i,t} = \alpha + \beta_1 QFII\ Own_{i,t-1} + \beta_2 DII\ Own_{i,t-1} + \gamma Controls_{i,t-1} + \theta_t + \tau_t + \delta_t + \varepsilon_{i,t} \quad (3)$$

Where $QFII\ Own_{i,t-1}$ is the percentage of shares owned by QFIIs for firm i in year t-1. $DII\ Own_{i,t-1}$ is the percentage of shares owned by DIIs for firm i in year t-1. Column (1) of Table 6 reports negative and significant coefficients for the QFIIs and DIIs on GHG emissions, indicating that both types of institutional investors are effective in affecting GHG emissions. The results suggest that foreign institutional investors play an active role in corporate governance, improving long-term sustainability (Aggarwal et al., 2011; Dyck et al., 2019; Ferreira and Matos, 2008). To ensure the robustness of our results, we include only QFII ownership or DII ownership in Columns (2) and (3) and the results are consistent with our prediction. These outcomes are not affected when the dependent variable is replaced by industry-adjusted GHG emissions, as shown in Columns (4)–(6).

[Insert Table 6 here]

In addition, we distinguish institutional investors by their potential business relationship with the investee companies:

$$GHG_{i,t} = \alpha + \beta_1 PRII\ Own_{i,t-1} + \beta_2 PSII\ Own_{i,t-1} + \gamma Controls_{i,t-1} + \theta_t + \tau_t + \delta_t + \varepsilon_{i,t} \quad (4)$$

Table 7 shows the regression results for Eq. (4), with negative coefficients on PRII ownership (PRII Own) for both GHG emissions and industry-adjusted GHG emissions after controlling for industry, year, and location fixed effects. These results are consistent with previous findings that PRIIs focus on long-term development and therefore actively exert influence on firms' behavior (Boone and White, 2015; Chen et al., 2007; Cornett et al., 2007; Ferreira and

Matos, 2008). In contrast, we do not find that PSIIs have a significant impact on GHG emissions. According to Brickley et al. (1988) and Chen et al. (2007), PSIIs have business relationships with the firms they invest in, and this dependence leads PSIIs to adopt a moderating or supporting attitude when participating in corporate decision-making.

[Insert Table 7 here]

5. Further Discussion

5.1 What mechanisms do institutional investors use to push for GHG changes?

Following Dyck et al. (2019), we attempt to examine what mechanisms institutional investors use to affect corporate GHG emissions. From the viewpoint of investors, large investors can exert influence over managers without explicit engagement by simply presenting their investment preferences. Firms try to attract institutional investors and therefore have incentives to align to institutions' investment expectations. Dyck et al. (2019) argue that to attract institutional investments and reduce the cost of capital, firms care about the exit and selection process of institutional investors. Therefore, institutional investors can affect firms' behavior by exiting and selection. Parrino et al. (2003) find that the exit of institutions influences the decision of the board. Azar et al. (2021) document that the "Big Three" institutions affect firm behavior by proposing their investment strategies. The corporate social responsibility (CSR) rating considers the performance of firms' socially responsible investment, in which the environment responsible investment accounts for over 20%. To examine the exit and selection view, we use the CSR rating as a proxy for firms' capacity and incentives to support environmentally friendly behavior and apply a granger causality test. The data on CSR rating is collected from the HEXUN database.[12]

$$TIOwn_{i,t} = \alpha_{i,t} + CSR_{i,t-1} + +TIOwn_{i,t-1} + Controls_{i,t-1} + \varepsilon_{i,t}$$
$$CSR_{i,t} = \alpha_{i,t} + TIOwn_{i,t-1} + CSR_{i,t-1} + Controls_{i,t-1} + \varepsilon_{i,t} \quad (5)$$

Table 8 shows that institutional ownership also drives firms to improve CSR. Column (1) shows that after controlling the existing institutional ownership, firms' CSR ratings have an

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[12] We use CSR instead of GHG emissions because GHG emissions data are unbalanced in our sample. Applying the granger causality test on GHG emissions reduces our sample size by almost 40% and thus cannot be a convincing measure of the mechanism.

impact on institutional ownership in the future, indicating that institutional investors may select firms with higher CSR performance. Column (2) shows that after controlling existing CSR performance, institutional ownership improves firms' CSR rating in the future. As a result, in alignment with the exit and selection mechanism, institutional ownership is positively related to firms' past CSR levels.

[Insert Table 8 here]

From the shareholder perspective, institutional investors can engage with management and influence firm decisions using the voice that comes from their shareholdings (Dyck et al., 2019; Edmans, 2009; Edmans and Holderness, 2017; Edmans and Manso, 2011; Gillan and Starks, 2003; Hirschman, 1970). To explore the voice mechanism, we collect all shareholder proposals and use textual analysis to examine whether GHG-related proposals have an impact on GHG emissions.[13] If institutional investors affect firms' GHG emissions by voice mechanism, we expect that GHG-related proposals are negatively related to GHG emissions.[14]

$$GHG_{i,t} = \alpha_{i,t} + Proposals_{i,t} + TIOwn_{i,t-1} + Controls_{i,t-1} + \varepsilon_{i,t} \quad (6)$$

Where $Proposals_{i,t}$ is a dummy variable equal to 1 if a company has submitted an environmentally relevant shareholder proposal within 2 years, otherwise, it is equal to 0. Table 9 presents the results of Eq. (6). Column (1) shows a negative relationship between environment-related shareholder proposals and firms' GHG emissions, indicating the effectiveness of shareholder proposals. Column (2) is the robust check with industry-adjusted GHG emissions. In sum, the significant and negative coefficient proves the mechanism of shareholder's voice on GHG emissions.

[Insert Table 9 here]

5.2 *What risks do institutional investors' concern?*

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[13] We abstract the words "environmental protection, pollution, energy consumption, emission reduction, emissions, ecology, green, low carbon, air pollution, COD, SO2, CO2, PM10, PM2.5, energy saving, climate change, carbon" as GHG related words.

[14] Dyck et al. (2019) find shareholder proposals are an important mechanism to drive E&S changes in the US and around the world.

Previous literature summarizes climate change risks associated with GHG emissions into three categories: physical effects, regulatory effects, and market risks (Busch et al., 2012; Elijido-Ten, 2017; Sakhel, 2017). Market risk has been proven in many studies to influence the behavior of institutional investors.[15] Nevertheless, the literature examining the other two risks has focused on how they affect firm value, but few studies have shown the attitudes of institutional investors towards either risk. Stroebel and Wurgler (2021) assert that market participants identify regulatory risk as the top climate risk for firms and investors over the next five years. In this section, we investigate whether institutional investors believe that these two risks associated with corporate emissions affect their investments.

We use the establishment of China's carbon trading rights market and the Beijing haze event that occurred in 2015 to test institutional investors' reactions to regulatory risks and physical risks, respectively. Shenzhen, Shanghai, Beijing, Guangdong, and Tianjin became pilot regions for the carbon trading market in 2013, and in 2014, the carbon trading markets in Hubei and Chongqing were launched. After the implementation of the carbon trading market policy, the carbon emissions of enterprises have been based on quotas. If a company's carbon emissions exceed its quota, it needs to purchase more emission rights in the carbon trading market. Therefore, excessive carbon emissions increase the operating costs and revenue of the company. Consequently, after the implementation of this policy, institutional investors who value economic benefits will encourage companies to reduce their carbon emissions. For this test, we employ a time-varying DID approach (Eq. (7)), using data from 2011 to 2016. $GHG_{i,t}$ is the logarithm of GHG emissions or industry-adjusted GHG emissions; $Post\ Event_{i,t}$ is a dummy variable indicating whether the observation is after the carbon market pilot event or not. If the observation is located in one of the seven locations of Shenzhen, Beijing, Shanghai, Guangdong, Tianjin, Hubei, or Chongqing, then $Treated_{i,t}$ equals 1, and 0 otherwise. Therefore, β_2 represents the effect of the carbon market on corporate GHG emissions, and β_3 shows the reaction of institutional investors to the carbon market on corporate GHG emissions. Equation (7) is as follows:

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[15] A sizable literature has documented that equity, bond, real estate, and derivatives markets appear to incorporate climate risk in asset prices (Baldauf et al., 2020; Bernstein et al., 2019; Bolton and Kacperczyk, 2021; Engle et al., 2020).

$$GHG_{i,t} = \alpha + \beta_1 TI\ Own_{i,t} + \beta_2 Post\ Event_{i,t} * Treated_{\ i,t} + \beta_3 TI\ Own_{i,t} * Post\ Event_{i,t} * Treated_{\ i,t} + \gamma Controls_{i,t} + \theta + \varepsilon_{i,t} \quad (7)$$

Similarly, a severe environmental haze issue that occurred in December 2015 led to the activation of a red alert for air pollution in Beijing, affecting local production and livelihoods.[16] This event serves as an exogenous shock, highlighting the importance that institutional investors assign to physical risks. If institutional investors possess a high level of awareness of physical risks, they would have been motivated to push companies to reduce carbon emissions following the Beijing haze event.

Table 10 reports the results of Eq. (7) for the carbon market event (Columns (1) and (2)) and the haze event (Columns (3) and (4)). The negative and significant coefficient, β_3, for the carbon market event indicates that institutional investors took action to reduce GHG emissions due to the carbon exchange market policy. The finding is consistent with our prediction that institutional investors are concerned about the regulatory effects. In addition, the negative but nonsignificant coefficient, β_3, for the Beijing haze event suggests that institutional investors do not react to physical risk.

[Insert Table 10 here]

To summarize, our findings confirm the negative effect of the carbon market on institutional ownership and GHG emissions (β_1). However, it appears that institutional investors are more concerned about regulatory effects rather than physical risk.

5.3 How can institutional investors help firms reduce GHG emission?

In our analysis, we scrutinize the mechanisms through which institutional investors compel firms to contemplate greenhouse gas (GHG) reduction. We have established that under institutional investor pressure, firms are incentivized to reduce their GHG emissions. Our empirical results substantiate this motivation by demonstrating the resultant emission reductions. However, the primary focus of this paper is to investigate whether institutional

[16] Beijing's air pollution warning system began in 2013 and, since then, the city has experienced several severe hazes, but the red alert was not activated until 8 December 2015.

investors can influence firms' emissions-related behaviour, not to explicitly delve into the methodologies firms utilize to achieve these reductions. Such investigations are being actively pursued by other researchers, and several of these mechanisms have been partially validated through practical examinations in this paper. Consequently, this section will centre around a discussion of several major emission reduction mechanisms that have piqued academic interest.

Firms and managers deploy various strategies to satisfy the demands precipitated by the pressure or assistance from institutional investors. For instance, new investments from institutional investors can stimulate green R&D to enhance utility efficiency (Lee and Min, 2015; Lee et al, 2015; Li et al, 2021; Kaminker and Stewart, 2012). Additionally, a deeper understanding of the policy landscape by institutional investors (Pfeifer and Sullivan, 2008) can expedite firm responses, and accrued experience (Yan and Zhang, 2009) can augment firm awareness (Dyck et al, 2019; Aggarwal et al., 2011), among others.

Past empirical findings elucidate some of these methods. Firstly, in section 4.3, we explore heterogeneity, discovering that Qualified Foreign Institutional Investors (QFIIs) play a more significant role in reducing firms' GHG emissions. Drawing from Dyck et al. (2019), we suggest that institutional investors from developed countries may possess a heightened environmental consciousness. We thus propose that these investors can foster a stronger environmental ethos within firms.

Secondly, institutional investors often maintain specialized teams to monitor regulatory and policy alterations. These teams' advanced comprehension of new policies, enabled by superior information access (Yang and Zhang, 2009) and ample resources (Ivanova,2017), can prove invaluable to firms lacking the internal resources or expertise to keep pace with these shifts. As these investors oversee expansive investment portfolios, they command a comprehensive market perspective and insight into different firms' responses to new policies. They can benchmark varied strategies, identify best practices, and relay this knowledge to the firms they invest in. Section 5.2 employs the Difference in Differences (DID) approach to confirm that institutional investors are positively associated with emission reduction, signifying a swift response to emergent, significant policies. This aligns with the mechanism through which institutional investors assist firms in rapidly understanding and responding to policy changes.

Lastly, new funding can incentivize firms to prioritize R&D, a direct avenue for GHG emission reduction. To explore this channel, we conduct a new test examining the correlation between institutional investors and the promotion of green patents. The results, presented in Appendix 2, indicate that within our sample, institutional investors do not correlate with firms' green patent applications, citations, or more broadly, R&D intensity.

In conclusion, our discussion suggests that institutional investors influence firms' GHG emissions by enhancing awareness and imparting policy-response experience, rather than funding R&D investments.

6. Conclusion

This paper examines the relationship between institutional investors and firms' greenhouse gas (GHG) emissions. Utilizing data from 655 listed companies in China, we discover that institutional investors significantly contribute to the reduction of GHG emissions. The impact of institutional ownership is particularly pronounced among State-Owned Enterprises (SOEs), which are responsible for a large proportion of high-GHG emissions. Our results reveal that Qualified Foreign Institutional Investors (QFIIs) play a more significant role in GHG emissions reduction compared to domestic institutional investors. This finding aligns with existing literature on foreign investors who actively engage in corporate governance and adhere to higher social norms concerning environmental issues. Furthermore, pressure-resistant institutional investors have a greater impact on GHG emissions reduction than their pressure-sensitive counterparts.

Contrary to research conducted in developed countries, we find that institutional investors in China do not prioritize physical risks. We reach this conclusion by applying the Difference-in-Differences (DID) model for carbon exchange market events and haze events. Consequently, there is still much progress to be made in raising the environmental and social responsibility awareness of institutional investors in China to encourage proactive GHG emissions reduction.

In conclusion, our research highlights the substantial role financial market participants play in achieving China's carbon-neutral target. While we identify the need to raise environmental awareness among institutional investors in China, our study demonstrates the effectiveness of national policies in reducing corporate GHG emissions. The impact of institutional investors, particularly QFIIs and pressure-resistant institutional investors, on GHG emissions reduction provides valuable evidence for policymakers. Encouraging institutional investors to engage in corporate governance and reduce GHG emissions is crucial. Moreover, the growing influence of QFIIs in corporate emissions supports the relaxation of QFII investment in securities markets implemented in May 2020.

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Appendix A. Variable Definitions

Variables	**Definition**
Log (GHG)	The logarithm of total greenhouse gas emissions.
IAGHG	Firm's GHG emissions divided by the industry average GHG emissions.
TI Own	The percentage of shares owned by institutional investors
QFII Own	The percentage of shares owned by qualified foreign institutional investors
DII Own	The percentage of shares owned by domestic institutional investors
PSII Own	The percentage of shares owned by insurance and trust
PRII Own	The percentage of shares owned by funds and security
Market Beta	Market beta estimated by the capital asset pricing model
Systematic Risk	The standard deviation of the error term of the capital asset pricing model
CSR	Corporate social responsibility score by Hexun dataset
Proposals	Dummy variable equal to one for the two years following the submission of a shareholder proposal and zero otherwise.
Firm Size	The logarithm value of the total asset
PPE	The ratio of property, plant, and equipment to total assets
Leverage	The ratio of total debt to total assets
ROA	Net income as a proportion of total assets
Revenue	The logarithm value of total revenue

Appendix 2. Do institutional investors promote the (green) technologies?

This table presents the relationship between institutional investors and firms. The control variables are same as the main regression. Industry, location, and year fixed effects are controlled in all of the three models. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)
	Green Patent Apply	Utility Patent Apply	Total Patent Apply
TI Own	0.0448	0.0227	2.309
	(0.31)	(0.26)	(0.11)
Firm Size	3.557**	2.041***	635.6**
	(2.40)	(3.23)	(2.09)
Revenue	0.380	0.187	-251.1
	(0.41)	(0.41)	(-1.32)
ROA	4.798	6.018	2714.7
	(0.37)	(0.95)	(1.17)
PPE	-9.707*	0.0306	-878.4
	(-1.77)	(0.01)	(-1.61)
Leverage	1.059	-3.980	282.6
	(0.24)	(-1.42)	(0.41)
Industry	YES	YES	YES
Location	YES	YES	YES
Year	YES	YES	YES
N	973	973	973
R^2	0.0734	0.0789	0.1653

Figures and Tables

Figure 1. Institutional Ownership: Different Measures Over Time

This figure shows average total institutional ownership, average QFII ownership, average DII ownership, average PRII ownership, and average PSII ownership. Data are collected from CSMAR and Wind for the period 2011 to 2020.

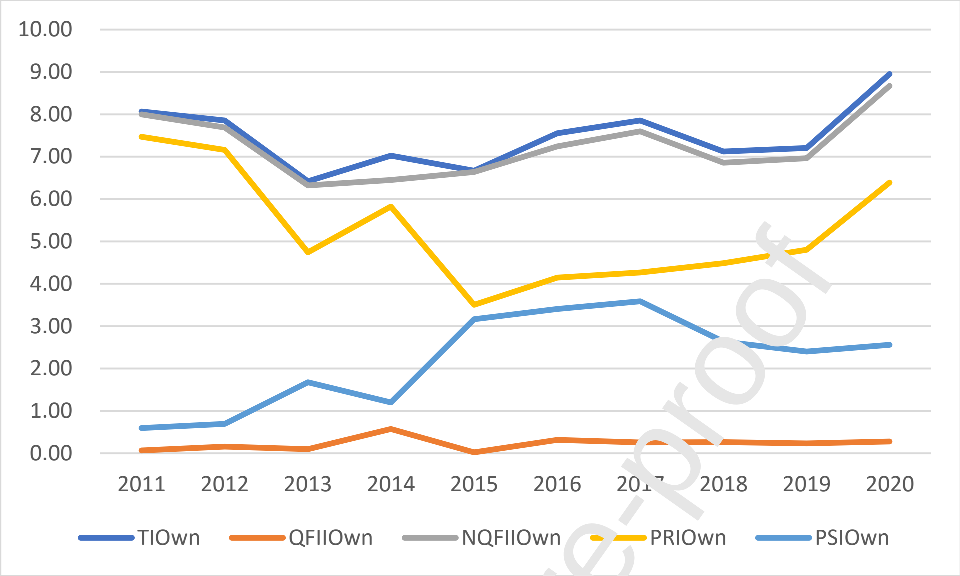

Figure 2. GHG Emissions

This figure presents the average GHG emissions for 649 public firms from 2011 to 2020.

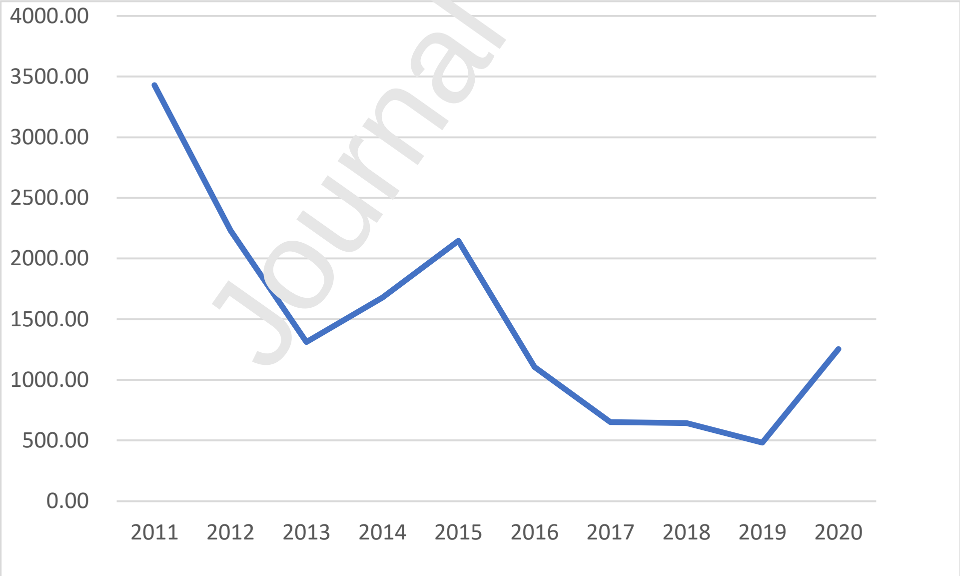

Table 1. Descriptive Statistics

This table reports descriptive statistics for the variables used in our study. The sample spans 2011 to 2020 and includes 1,278 firm-year observations. Panel A presents the following dependent variables: the logarithm of GHG emissions (Log(GHG)) and industry-adjusted GHG emissions(IA GHG). TI Own is total institutional ownership calculated as the sum of the fund, securities fund, broker, insurance, trust, and qualified foreign institutions ownership. PRII Own is the sum of fund and security ownership. PSII Own is a combination of insurance and trust ownership. Panel C shows firm-level characteristics, including the firm size, leverage ratio, return on assets (ROA), property, plant, and equipment (PPE) ratio (PPE/Total Assets), revenue, and state-owned dummy. All continuous variables are winsorized at the 1st and 99th percentiles.

Variables	Obs.	Mean	Median	SD
Panel A. Dependent Variables				
Log(GHG)	1,278	5.07	4.07	5.27
IA GHG	1,278	0.57	0.01	2.30
Panel B. Institutional Ownership				
TI Own(%)	1,278	7.41	5.78	6.09
Dummy_QFII	1,278	0.15	0	0.35
PSII Own(%)	1,278	2.44	1.37	2.30
PRII Own(%)	1,278	4.94	2.97	5.28
Panel C. Firm Characteristics				
Firm Size (Millions, RMB)	1,278	60352	11247.53	149461
Leverage	1,278	0.46	0.46	0.18
ROA	1,278	0.05	0.04	0.05
PPE	1,278	0.29	0.27	0.16
Revenue (Thousands, RMB)	1,278	35.77	7.01	90.52
State-owned	1,278	0.51	1	0.50

Table 2. Univariate Test

This table shows GHG emissions and firm characteristics by group. Panel A presents the means of GHG emissions and firm size, leverage ratio (total debt/total assets), return on assets (ROA), property, plant, and equipment (PPE) ratio (PPE/Total Assets), and revenue for firms with low and high institutional ownership. Panel B shows the difference between SOEs and non-SOEs.

Panel A: High Ownership vs Low Ownership

Variables	Low	High	High−Low	T-value
GHG emissions (tonnes)	1776764	1058885	-717878.8*	-1.66
Firm Size	52380.62	68423.69	16043.06**	1.92
Leverage	0.46	0.46	-0.002	-0.18
ROA	0.04	0.06	0.02***	7.82
PPE	0.31	0.26	-0.05***	-5.53
Revenue	29.43	42.18	12.75**	2.52

Panel B: SOEs vs Non-SOEs

Variables	Non-SOEs	SOEs	SOEs-NonSOEs	T-value
GHG Emissions (tonnes)	379.21	2425.7	2046.49***	4.77
Firm Size	16552.61	102668.8	86116.23 ***	10.75
Leverage	0.399	0.515	0.116***	11.85
ROA	0.0510	0.0450	-0.006*	-1.85
PPE	0.270	0.306	0.036***	4.02
Revenue	10.32	60.36	50.036***	10.28

Table 3. Institutional Investors and Firm GHG Emissions

This table reports regression estimates of GHG emissions on total institutional ownership and control variables (Eq (1)). The dependent variable is the natural logarithm of GHG emissions (see Columns (1)–(3)); this is replaced by the industry-adjusted GHG emissions (IA GHG) in Columns (4)–(6). TI Own is the percentage of shares owned by institutional investors. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. Columns (1)–(6) present regression results with different levels of fixed effects. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable:	Log(GHG)			IA GHG		
	(1)	(2)	(3)	(4)	(5)	(6)
TI Own	-0.0454**	-0.0499***	-0.0422**	-0.0330**	-0.0329***	-0.0305***
	(-2.39)	(-2.59)	(-2.19)	(-3.60)	(-3.68)	(-3.48)
Firm Size	0.465	0.422	0.138	0.149	0.131	0.0518
	(1.51)	(1.39)	(0.43)	(0.76)	(0.67)	(0.26)
Revenue	1.173***	1.187***	1.412***	0.318*	0.337*	0.367*
	(4.15)	(4.27)	(4.74)	(1.73)	(1.80)	(1.93)
ROA	1.807	3.052	2.146	1.715	1.959	1.764
	(0.68)	(1.14)	(0.78)	(0.97)	(1.11)	(1.10)
PPE	4.860***	4.682***	4.336***	0.443	0.412	0.577
	(6.36)	(6.25)	(5.60)	(1.15)	(1.06)	(1.40)
Leverage	1.209	1.041	1.056	-0.0537	-0.0606	0.215
	(1.45)	(1.26)	(1.29)	(-0.11)	(-0.13)	(0.48)
Industry	NO	YES	YES	NO	NO	NO
Location	NO	NO	YES	NO	NO	YES
Year	NO	YES	YES	NO	YES	YES
N	1,278	1,278	1,278	1,278	1,278	1,278
R^2	0.414	0.457	0.465	0.364	0.382	0.386

Table 4. Institutional Ownership and GHG Emissions: Instrumental Variable Regression

This table presents an instrumental variable two-stage least squares analysis of the association between institutional ownership and firm GHG emissions. The analysis exploits market beta and unsystematic risk calculated by the market model. Column (1) presents the first stage with the dependent variable of TI Own (institutional ownership). Columns (2) and (3) are the results of the second stage. The dependent variable is the natural logarithm of GHG emissions (see Column (2)); this is replaced by the industry-adjusted GHG emissions (IA GHG) in Column (3). TI Own is the percentage of shares owned by institutional investors. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	First Stage	Second Stage	
Dependent Variable	(1)	(2)	(3)
	TI Own	Log(GHG)	IA GHG
TI Own		-0.0982***	-0.0373***
		(-3.42)	(-2.83)
Market Beta	-2.323***		
	(-8.43)		
Systematic Risk	-5.176**		
	(-2.82)		
Firm Size	1.280***	0.218	0.0790
	(3.20)	(0.68)	(0.40)
Revenue	-0.900**	1.382***	0.354*
	(-2.67)	(4.62)	(1.87)
ROA	19.69***	3.333	1.926
	(8.17)	(1.22)	(1.19)
PPE	-1.611	4.280***	0.650
	(-1.43)	(5.50)	(1.53)
Leverage	2.451**	1.010	0.234
	(0.52)	(1.25)	(0.50)
Weak instrument	P value<0.001		
Overidentification		P value=0.0248	P value=0.0728
Industry	YES	YES	NO
Location	YES	YES	YES
Year	YES	YES	YES
N	1241	1241	1241
R^2	0.134	0.464	0.100

Table 5. Institutional Ownership and GHG Emissions: SOEs and Non-SOEs

This table presents the regression estimates of GHG emissions on institutional ownership and control variables for SOEs and non-SOEs. The dependent variable is the natural logarithm of GHG emissions (see Columns (1)–(2)); this is replaced by the industry-adjusted GHG emissions (IA GHG) in Columns (3)–(4). TI Own is the percentage of shares owned by institutional investors. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	Log(GHG)		IAGHG	
	(1)	(2)	(3)	(4)
	SOES	Non-SOEs	SOES	Non-SOEs
TI Own	-0.103***	-0.0189	-0.0262*	-0.0402
	(-3.22)	(-0.74)	(-1.85)	(-0.65)
Firm Size	-0.921*	1.263***	-0.762**	0.829***
	(-1.86)	(3.17)	(-2.36)	(3.18)
Revenue	2.155***	0.515	1.198***	-0.295
	(4.38)	(1.44)	(3.80)	(-1.65)
ROA	3.892	2.211	3.650	-0.939
	(0.99)	(0.54)	(1.45)	(-0.43)
PPE	2.294**	6.630***	0.954	-0.472
	(2.14)	(5.16)	(1.48)	(-1.13)
Leverage	0.681	2.137*	-0.252	1.110***
	(0.55)	(1.79)	(-0.31)	(2.60)
Industry	YES	YES	NO	NO
Location	YES	YES	YES	YES
Year	YES	YES	YES	YES
N	650	628	650	628
R^2	0.458	0.422	0.125	0.165

Table 6. Institutional Ownership and GHG Emissions: Qualified Foreign Institutional Investors

This table presents regression estimates of GHG emissions on QFII ownership, DII ownership, and control variables. The dependent variable is the natural logarithm of GHG emissions (Columns (1) – (3)) or industry-adjusted GHG emissions (IA GHG) (Columns (4)–(6)). QFII Own is the percentage of shares owned by qualified foreign institutional investors. DII Own is the percentage of shares owned by domestic institutional investors. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

	Log (GHG)			IA GHG		
	(1)	(2)	(3)	(4)	(5)	(6)
QFII Own	-0.561**	-0.565**		-0.244**	-0.246**	
	(-2.18)	(-2.19)		(-2.50)	(-2.52)	
DII Own	-0.0365*		-0.0370*	-0.0287***		-0.0289***
	(-1.91)		(-1.93)	(-3.22)		(-3.26)
Firm Size	0.157	0.108	0.130	0.0607	0.0223	0.0490
	(0.49)	(0.34)	(0.41)	(0.31)	(0.11)	(0.24)
Revenue	1.415***	1.446***	1.416***	0.367	0.391**	0.368*
	(4.75)	(4.87)	(4.76)	(1.93)	(2.05)	(1.93)
ROA	2.874	2.225	1.975	2.06[illegible]	1.559	1.678
	(1.03)	(0.79)	(0.72)	(1.27)	(0.98)	(1.05)
PPE	4.301***	4.365***	4.347***	0.561	0.611	0.581
	(5.58)	(5.64)	(5.61)	(1.35)	(1.46)	(1.41)
Leverage	0.994	0.935	1.043	0.190	0.143	0.213
	(1.21)	(1.14)	(1.28)	(0.42)	(0.32)	(0.47)
Industry	YES	YES	YES	NO	NO	NO
Location	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
N	1,278	1,278	1,278	1,278	1,278	1,278
R^2	0.475	0.474	0.473	0.102	0.099	0.101

Table 7. Institutional Ownership and GHG Emissions: Pressure-Resistant and Pressure-Sensitive Institutional Investors

This table presents regression estimates of GHG emissions on PRII ownership (PRII Own), PSII ownership (PSII Own), and control variables. The dependent variable is the natural logarithm of GHG emissions (see Columns (1)–(3)) or industry-adjusted GHG emissions (IA GHG; see Columns (4)–(6)). PRII Own is the percentage of shares owned by fund and security. PSII Own is the percentage of shares owned by insurance and trust. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Dependent Variable	Log (GHG)			IA GHG		
	(1)	(2)	(3)	(4)	(5)	(6)
PRII Own	-0.0678***	-0.0685***		-0.0383***	-0.0372***	
	(-2.87)	(-2.92)		(-3.83)	(-3.81)	
PSII Own	0.0128		0.0208	-0.0174		-0.0129
	(0.44)		(0.71)	(-1.28)		(-0.97)
Firm Size	0.117	0.126	0.0664	0.0474	0.0350	0.0189
	(0.37)	(0.40)	(0.21)	(0.24)	(0.18)	(0.09)
Revenue	1.401***	1.399***	1.449***	0.364*	0.366*	0.391**
	(4.70)	(4.70)	(4.89)	(1.91)	(1.93)	(2.04)
ROA	3.097	3.044	1.431	2.029	2.101	1.087
	(1.10)	(1.08)	(0.51)	(1.25)	(1.29)	(0.70)
PPE	4.325***	4.319***	4.420***	0.573	0.581	0.627
	(5.58)	(5.59)	(5.67)	(1.39)	(1.41)	(1.51)
Leverage	1.175	1.164	1.009	0.248	0.262	0.154
	(1.43)	(1.41)	(1.24)	(0.55)	(0.58)	(0.34)
Industry	YES	YES	YES	NO	NO	NO
Location	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
N	1,278	1,278	1,278	1278	1,278	1,278
R^2	0.474	0.475	0.472	0.101	0.101	0.096

Table 8. Mechanism of institutional investors to GHG emissions: Exit and Selection

This table presents the results of the Granger causality test of the exit and selection mechanism. Column (1) is the results of the first equation of Eq. (6). Column (2) is the second equation of Eq. (6). The dependent variable is the institutional ownership or firms' CSR performance. CSR is the corporate socially responsible performance score. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

	(1)	(2)
	TI Own	CSR
CSR (Lag 1 year)	0.244***	0.409***
	(5.83)	(34.50)
TI Own (Lag 1 year)	0.704***	0.00651***
	(87.50)	(12.22)
Firm Size	0.0185	-0.0195**
	(0.35)	(-2.19)
Revenue	0.129***	0.0649***
	(2.82)	(7.98)
ROA	0.0282**	-0.00261
	(2.43)	(-0.47)
PPE	-0.173	-0.138***
	(-0.85)	(-4.37)
Leverage	0.109**	-0.0594**
	(2.24)	(-2.[illegible]8)
Industry	YES	YES
Year	YES	YES
Location	YES	YES
N	25340	25340
R^2	0.548	0.258

Table 9. Mechanism of institutional investors to GHG emissions: Voice

This table presents the results of the voice mechanism (Eq. (7)). The dependent variable is the natural logarithm of GHG emissions (See Column (1)) or industry-adjusted GHG emissions (IA GHG; see Column (2)). Proposals is a dummy variable equal to one for the two years following the submission of a shareholder proposal and zero otherwise. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5% and 10% levels, respectively.

Dependent Variables	(1) Log(GHG)	(2) IAGHG
TI Own	-0.0421**	-0.0305***
	(-2.22)	(-3.50)
Proposals	-0.510*	-0.414*
	(1.65)	(-1.91)
Firm Size	0.126	0.0568
	(0.40)	(0.28)
Revenue	1.418***	0.364*
	(4.75)	(1.90)
ROA	1.958	1.841
	(0.71)	(1.13)
PPE	4.284***	0.598
	(5.52)	(1.44)
Leverage	1.031	0.226
	(1.26)	(0.49)
Industry	YES	NO
Year	YES	YES
Location	YES	YES
N	1,278	1,278
R^2	0.474	0.101

Table 10. Policy Uncertainty Risk and Physical Risk: Carbon Market and Beijing Haze

This table reports institutional investors' reactions to state policy (carbon exchange market) and environmental pollution (Beijing haze). Columns (1) and (2) are time-varying DID processes for the policy carbon market state policy. Columns (3) and (4) are DID regressions for a quasi-natural experiment: Beijing haze. The dependent variable is the logarithm of GHG emissions or industry-adjusted GHG emissions. The coefficient estimates of TI Own x Post Event x Treated firm show the differential effects of institutional ownership on GHG emissions for treated firms compared to the rest of the sample firms. Firm size is the logarithm of total firm assets. Revenue is the logarithm of book revenue. ROA is the return on assets. PPE is the ratio of property, plant, and equipment to total assets. Leverage is the ratio of total debt to total assets. All independent variables are lagged by one year. Standard errors are clustered at the firm level, and t-values are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Policy: Carbon Market		Quasi-natual Experiment: Beijing Haze	
Dependent Variable	Log(GHG)	IA GHG	Log(GHG)	IA GHG
	(1)	(2)	(3)	(4)
TI Own	-0.0568	-0.0243*	-0.0385*	-0.0412***
	(-1.02)	(-2.23)	(-1.84)	(-3.41)
Post*Treat	1.169*	0.334	-0.0682	0.810
	(2.17)	(1.84)	(-0.04)	(0.75)
TI Own*Post*Treat	-0.256***	-0.103***	0.186	0.0508
	(-3.74)	(-4.54)	(1.15)	(0.78)
Firm Size	0.841*	0.363*	0.0317	-0.133
	(1.88)	(2.27)	(0.08)	(-0.54)
Revenue	0.322	0.141	1.473***	0.578**
	(0.82)	(0.94)	(4.12)	(2.37)
ROA	12.78***	4.266***	4.011	2.873*
	(3.50)	(4.26)	(1.32)	(1.78)
PPE	1.842	-1.288**	5.080***	0.676
	(1.00)	(-3.18)	(5.47)	(1.28)
Leverage	7.207***	0.843**	0.577	0.322
	(4.79)	(2.34)	(0.64)	(0.60)
Industry	YES	YES	YES	YES
N	218	218	909	909
R^2	0.513	0.024	0.475	0.093

Highlights

- Institutional ownership plays a significant role in corporate GHG emission reductions in China.
- The impacts of pressure-resistant and qualified foreign institutional investors on GHG emission reductions are more pronounced.
- The mechanisms by which institutional investors may influence corporate GHG emissions examined
- Institutional investors are more concerned with policy uncertainty risk than physical risk.