RESEARCH ARTICLE

Carbon emissions, corporate governance, and hostile takeover threats

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Abstract

Exploiting a unique measure of takeover vulnerability principally based on state legislations, we investigate how corporate carbon reduction efforts are influenced by the takeover market, which is widely regarded as a crucial instrument of external corporate governance. Our results show that more takeover exposure brings about significantly greater efforts to reduce carbon emissions. A rise in takeover susceptibility by one standard deviation improves carbon reduction performance by 12.81%. The findings corroborate the notion that the takeover market, acting as an external governance mechanism, compels managers to adopt policies that benefit shareholders in the long run. Our results imply that carbon emissions are a crucial corporate outcome as it is subject to the pressure from the takeover market. Companies should pay a close attention to this matter. Further analysis robustly validates the results, including propensity score matching, entropy balancing, an instrumental variable analysis, and heteroscedastic identification. Our measure of takeover vulnerability is plausibly exogenous and thus probably reveals a causal effect, rather than a mere association.

KEYWORDS
agency theory, carbon emissions, climate change, corporate governance, takeover market

1 | INTRODUCTION

Climate change has become one of the focal issues in several disciplines. Emissions of greenhouse gases (GHGs) and an excessive reliance on carbon-based fossil fuels are among the most severe concerns confronting companies and economies worldwide in the twenty-first century (Elsayih et al., 2021; Hatakeda et al., 2012; Hoffmann & Busch, 2008). A growing amount of empirical evidence demonstrates that excessive carbon emissions impair corporate value

(Chapple et al., 2013; Clarkson et al., 2014; Griffin et al., 2017; Luo & Tang, 2014; Matsumura et al., 2014). So, the significance of carbon emissions cannot be overemphasized. We contribute to the literature by exploring how corporate carbon emission performance is influenced by the takeover market.

The takeover market, also frequently known as the market for corporate control, has long been regarded as one of the most critical instruments of external governance (Cain et al., 2017; Fama, 1980; Fama & Jensen, 1983; Lel & Miller, 2015; Manne, 1965). Not unexpectedly, a great deal of research has been conducted on the effects of the takeover market on a variety of corporate policies, strategies, and outcomes (Bertrand & Mullainathan, 2003; Chatjuthamard,

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Part of this research was carried out while Pornsit Jiraporn served as visiting professor of finance at Sasin School of Management in Bangkok, Thailand.

Jiraporn, Lee, et al., 2021; Cheng et al., 2005; Garvey & Hanka, 1999; Low, 2009; Ongsakul et al., 2022; Ongsakul et al., 2021). Clearly, this is a sizable and significant area of the literature.

Based on the literature, we advance two competing hypotheses. First, it can be argued that more takeover threats lead to better carbon emission performance. The disciplinary mechanism of the takeover market induces managers to take actions that benefit shareholders. As carbon reductions are found to be beneficial to the firm and ultimately to shareholders (Chapple et al., 2013; Clarkson et al., 2014; Griffin et al., 2017; Luo & Tang, 2014; Matsumura et al., 2014), managers are more driven to undertake investments that reduce carbon emissions when they are less shielded from hostile takeovers. We refer to this view as the carbon reduction hypothesis.

By contrast, it is well-known that managers can be prone to managerial myopia (Bhojraj & Libby, 2005; Graham et al., 2005; Laverty, 1996, 2004; Lundstrum, 2002; Mizik, 2010). Hostile takeover threats reduce managers' employment security and induce them to behave myopically. Because the benefits of carbon reductions are likely not realized in the short run, myopic managers are less inclined to support policies that reduce carbon emissions. This hypothesis predicts that more takeover threats bring about weaker carbon reduction efforts. This view is referred to as the managerial myopia hypothesis.

Our findings, based on a large sample of US companies, show that the disciplinary mechanism associated with the takeover market is one of the primary factors in carbon emission performance. Stronger takeover vulnerability, in particular, motivates managers to make much larger efforts to cut carbon emissions. The results support the idea that the takeover market, as an external governance instrument, motivates managers to pursue corporate policies that benefit shareholders in the long term. In particular, a one standard deviation increase in takeover susceptibility translates into a 12.81% improvement in carbon emission performance. As a result, the extent of the demonstrated impact is not only statistically significant but also economically tangible.

It is important to note that our measure of takeover vulnerability is principally based on state legislations and is thus plausibly exogenous to firm-specific characteristics (Cain et al., 2017). In any case, to alleviate endogeneity even further, we execute a variety of robustness checks, namely, propensity score matching, entropy balancing, an instrumental variable (IV) analysis, and Lewbel's (2012, 2018) heteroscedastic identification. All of the robustness checks strongly confirm that better carbon emission performance results from a higher degree of takeover susceptibility. Therefore, our conclusion is unlikely tainted by endogeneity and probably reflects causality, rather than a mere association.

Notably, our results aptly corroborate those in Cain et al. (2017), who find that more takeover susceptibility raises firm value significantly, implying that the takeover market functions as an effective external governance instrument that alleviates agency conflicts and managerial entrenchment. Finally, we demonstrate that the takeover market's influence remains robust even when internal corporate governance, i.e., board characteristics, is taken into consideration. As a result, the takeover market's position as an external governance mechanism is not supplanted by the board of directors, which serves as the primary internal governance mechanism.

The findings of our study make several key contributions to the literature. First, we contribute to the literature on climate change and carbon emissions. According to a growing body of empirical research, excessive carbon emissions diminish corporate value (Chapple et al., 2013; Clarkson et al., 2014; Griffin et al., 2017; Luo & Tang, 2014; Matsumura et al., 2014). Therefore, the importance of carbon emissions could not be overstated. We contribute to the literature in this field by showing that one of the critical determinants of corporate carbon emissions is the market for corporate control, which is widely regarded as an important instrument of external corporate governance.

Second, our results are aptly germane to the literature in corporate governance. Functioning as an external governance mechanism, the takeover market has been found to influence a variety of corporate outcomes (Bertrand & Mullainathan, 2003; Chatjuthamard, Jiraporn, Lee, et al., 2021; Cheng et al., 2005; Garvey & Hanka, 1999; Low, 2009; Ongsakul et al., 2020). We extend the literature in this area by demonstrating that the takeover market has a critical impact on carbon emission performance. Our study is the first to link the market for corporate control to carbon emissions.

Third, our results enrich the literature in managerial myopia (Bebchuk & Stole, 1993; Bhojraj & Libby, 2005; Gigler et al., 2014; Laverty, 1996, 2004; Lundstrum, 2002; Marginson & McAulay, 2008; Mizik, 2010; Narayanan, 1985; Schuster et al., 2018). We show that, as far as carbon emissions are concerned, hostile takeover threats do not appear to exacerbate managerial myopia. Rather, we find that stronger takeover susceptibility improves carbon emission performance significantly.

In addition, we contribute to a growing body of work that uses the hostile takeover index as an exogenous measure of takeover susceptibility (Cain et al., 2017; Chatjuthamard, Jiraporn, Lee, et al., 2021; Ongsakul et al., 2022; Ongsakul, Chatjuthamard, et al., 2021). While still in its infancy, this is a fascinating field that will almost certainly yield a significant amount of research in the future because exogenous changes in takeover exposure are difficult to come by.

2 | PRIOR RESEARCH AND HYPOTHESIS DEVELOPMENT

2.1 | Carbon emissions

Financial investors have been increasingly conscious of climate change as a growing issue in recent years. Several international and national programs have been launched to combat global warming and to motivate economic players to take actions to speed up the transition to a low-carbon economy. The Paris Agreement was signed in December 2015 with the primary goal of limiting the average temperature rise to 2°C, over the preindustrial levels (Palea & Drogo, 2020).

An increasing body of empirical evidence suggests that high carbon emissions reduce corporate value (Chapple et al., 2013; Clarkson et al., 2014; Griffin et al., 2017; Luo & Tang, 2014; Matsumura et al., 2014). In the United States, Matsumura et al. (2014) report a loss of company value of US$212 per metric ton of carbon. Similarly, Clarkson et al. (2014) discover that investors view excess emissions above carbon allowances as a liability for EU companies Luo and Tang (2014). Therefore, carbon emissions are a critically important issue for companies. Carbon risk, which is associated with climate change and global warming, has the potential to disrupt corporate operations and to have a large negative impact on shareholder wealth. The adverse effects on companies associated with carbon risk may stem from strict government regulations, increased lawsuit expenses, or the reputational repercussions of climate change (Jung et al., 2018; Tang & Luo, 2014).

One strand of the literature focuses on the effect of corporate governance on the broader issue of corporate social responsibility (CSR). Recent studies, in particular, have examined the role of corporate boards of directors in encouraging CSR programs that impact corporate environmental performance (de Villiers et al., 2011; Glass et al., 2016; Hussain et al., 2018; Post et al., 2015; Shaukat et al., 2016), but the findings have been inconclusive (for a literature review, see Jain & Jamali, 2016).

Fewer studies directly examine the influence of corporate governance on corporate carbon performance. For instance, Haque (2017) demonstrates empirically that companies with greater board independence and gender diversity are more likely to engage in substantial carbon reduction activities. Haque and Ntim (2018) demonstrate that enacting environmental regulation (such as the Climate Change Act) improves corporate carbon performance and that firms with weaker corporate governance exhibit poorer carbon performance than their more well-governed counterparts (Haque & Ntim, 2018; Luo & Tang, 2014).[1]

Prior research that links corporate governance to carbon emissions concentrates on internal governance mechanisms, such as board characteristics. We extend the literature in this area by investigating how carbon emissions are influenced by the takeover market, which is a crucial instrument of external governance. As far as we are aware, our study is the first to look into the effect of hostile takeover exposure on corporate carbon performance.

In recent years, social and environmental responsibility has been a focal point of society, and this tendency has spread to the financial markets. An increasing percentage of socially conscious investors include ESG data into their investment decisions, indicating that ESG data have assumed more significance in the investing process (Amel-Zadeh & Serafeim, 2018).

2.2 | The market for corporate control and corporate governance

The market for corporate control, frequently known as the takeover market, is a significant external disciplinary mechanism for corporate governance, according to the literature (Cain et al., 2017; Chatjuthamard, Jiraporn, Lee, et al., 2021; Fama, 1980; Fama & Jensen, 1983; Lel & Miller, 2015; Manne, 1965; Ongsakul et al., 2020; Ongsakul, 2021). Numerous prior studies exploit variations in specific takeover defenses or anti-takeover laws to assess changes in takeover vulnerability (Bertrand & Mullainathan, 2003; Karpoff & Malatesta, 1989; Schwert, 2000). Yet, a significant weakness of previous research in this area has been its exclusive focus on a single or a chosen set of anti-takeover legislations (Cain et al., 2017).

To address the concerns noted in earlier studies, Cain et al. (2017) construct a hostile takeover index based on 17 takeover legislations enacted between 1965 and 2014, taking into account plausibly exogenous variables. Using this novel measure of takeover susceptibility, they demonstrate that more takeover protection results in worse company value, corroborating the managerial entrenchment and agency cost arguments. Their results are notable not just because they represent a significant step toward resolving endogeneity but also because they include the whole range of state legislations.[2]

The takeover index has gained popularity in recent years and has been used in a number of studies. For example, Ongsakul et al. (2021) indicate that a higher degree of takeover vulnerability, as measured by the takeover index, results in stronger corporate integrity. Similarly, Chatjuthamard, Jiraporn, Lee, et al. (2021) demonstrate a significant drop in corporate complexity in response to increased takeover susceptibility, using an innovative metric of corporate complexity based on textual analysis. According to the authors, increased takeover threats worsen management myopia, resulting in fewer long-term and more complicated investments. Additionally, Ongsakul et al. (2022) discover that increased takeover vulnerability reduces innovation efficiency as measured by research quotient. Hostile takeover threats have also been shown to have a substantial impact on board governance, because they affect critical board attributes, such as board independence and gender diversity, on the board (Chatjuthamard, Jiraporn, Lee, et al., 2021).

2.3 | The carbon reduction hypothesis

This view argues that greater threats of hostile takeovers result in reduced carbon emissions. The takeover market's disciplinary mechanism discourages managers from straying from the objective of maximizing shareholder value. As a result, managers that face more takeover threats are compelled to adopt long-term investments and policies that benefit shareholders, including reducing carbon emissions. Because carbon reductions benefit the firm and, ultimately, shareholders (Chapple et al., 2013; Clarkson et al., 2014; Griffin et al., 2017; Luo & Tang, 2014; Matsumura et al., 2014), managers are more motivated to make investments that enhance carbon reductions when they are less protected from hostile takeovers. In summary, this perspective implies that greater takeover threats result in lower carbon emissions.

2.4 | The managerial myopia hypothesis

This hypothesis implies that the takeover pressure inherent in the takeover market results in weaker carbon reductions. The takeover market's disciplinary mechanism diminishes managers' job security, prompting them to act myopically (Bhojraj & Libby, 2005; Chatjuthamard, Jiraporn, Lee, et al., 2021; Graham et al., 2005; Laverty, 1996, 2004; Lundstrum, 2002; Mizik, 2010). By focusing only on the short term, managers are less likely to make investments that promote carbon reductions in the long run, even if such investments are compatible with shareholders' long-term goals. Carbon reductions on a sustainable basis cannot be accomplished immediately. Promoting sustainable carbon reduction policies takes time. Due to their vulnerability to takeover threats, managers are hesitant to make investments whose results will likely be realized far into the future, potentially after they are no longer with the firm. Rather, they focus on short-term investments that bring immediate rewards. In conclusion, this hypothesis predicts that increased vulnerability to hostile takeovers results in higher carbon emissions.

3 | SAMPLE CONSTRUCTION AND DATA DESCRIPTION

3.1 | Sample formation

The data on carbon emission performance are from Refinitiv. The data for the hostile takeover index are from Cain et al. (2017). Firm-specific

attributes are from COMPUSTAT. Outliers are excluded at the 1% and 99%, where necessary. The final sample consists of 6236 observations from 2002 to 2014, an unbalanced panel data set.[3] The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. So, a higher score implies better carbon emission performance. This measure of carbon emissions has gained traction in the literature recently. For instance, Görgen et al. (2021) incorporate carbon risk into their portfolio selection and demonstrate that it is possible to design a portfolio with a desired level of carbon risk exposure.

3.2 | Measuring takeover vulnerability

We use the hostile takeover index to quantify takeover vulnerability, which is consistent with previous studies (Cain et al., 2017; Chatjuthamard et al., 2022; Ongsakul et al., 2021). This index has a significant benefit in that it is based on factors that are plausibly exogenous. The index is composed of three components: (1) legal determinants (17 state laws regulating takeovers); (2) macroeconomic determinants (capital liquidity); and (3) a company-specific factor that is not sensitive to firm choice (firm age). A higher index value indicates more takeover vulnerability. The value of the index ranges from zero to one. This measure is considerably less susceptible to endogeneity than any other metric used in prior research.

TABLE 1 Descriptive statistics

	Mean	SD	25th	Median	75th
Carbon emissions					
Emissions score	26.798	31.411	0.000	11.515	50.600
Takeover vulnerability					
Hostile takeover index	0.192	0.106	0.109	0.168	0.273
Firm-specific attributes					
Total assets	15998.550	43793.190	2595.475	5258.250	12394.500
Total debt/total assets	0.240	0.176	0.115	0.222	0.335
EBIT/total assets	0.112	0.084	0.065	0.105	0.155
Capital expenditures/total assets	0.049	0.048	0.020	0.034	0.059
Advertising expense/total assets	0.015	0.035	0.000	0.000	0.014
R&D expense/total assets	0.029	0.053	0.000	0.004	0.035
Cash holdings/total assets	0.150	0.147	0.042	0.101	0.209
Dividends/total assets	0.017	0.023	0.000	0.008	0.025
Fixed assets/total assets	0.505	0.354	0.220	0.407	0.741
SG&A expense/total assets	0.209	0.172	0.078	0.168	0.297
ESG score	−1.816	11.815	−10.106	−2.481	6.315

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.

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Using the results from their logistic regression analysis, Cain et al. (2017) develop a firm-level takeover index as the likelihood of a hostile takeover. Cain et al. (2017) go into further detail on the development of the takeover index. The hostile takeover index has been widely used in the recent literature (Cain et al., 2017; Chatjuthamard et al., 2022; Chatjuthamard, Jiraporn, Lee, et al., 2021; Ongsakul et al., 2020; Ongsakul et al., 2021).

3.3 | Additional variables and empirical modeling

Essentially, we estimate the following regression analysis:

$$\text{Emissions Score}_{its} = a + b\,(\text{Hostile Takeover Index})_{its} + c\,(\text{Controls})_{its}$$

where i indexes firms, t indexes years, and t indexes states.

Based on prior research (Chintrakarn et al., 2016; Haque & Ntim, 2018; Jo & Harjoto, 2012), we also include several variables to control for other factors that may potentially influence carbon reduction efforts. Specifically, we include firm size (Ln of total assets), profitability Earnings before interest and taxes (EBIT)/total assets), leverage (total debt/total assets), investments (capital expenditures/total assets), intangible assets Research and development (R&D)/total assets and advertising expense/total assets), discretionary spending (selling, general, and administrative expense, SG&A expense/total assets), cash holdings (cash holdings/total assets), dividend payouts (dividends/total assets), and asset tangibility (fixed assets/total assets). To account for possible variation over time and across industries, we include year and industry fixed effects (based on the first two digits of Standard Industrial Classification (SIC)).

To control for state-specific variables, we also include state fixed effects. Typically, it would be helpful to include firm fixed effects to account for any time-invariant unobservable firm characteristics. However, because the hostile takeover index changes only slowly over time (Cain et al., 2017), a fixed-effects analysis, which captures only the variation over time, may not be appropriate in the context of our study. Importantly, to ensure that our carbon emission measure does not simply reflect the degree of CSR in general, we control for the level of CSR by including the overall ESG score provided by Refinitiv. This score incorporates several aspects of CSR/ESG into a single score.[4] Table 1 displays the descriptive statistics for the emissions score, the hostile takeover index, and the firm-specific attributes.[5]

TABLE 2 The effect of hostile takeover threats on carbon emissions

	(1) ordinary least squares (OLS) Emissions score	(2) ordinary least squares (OLS) Emissions score	(3) Random effects Emissions score
Hostile takeover index	95.204*** (9.500)	37.953*** (4.797)	39.256*** (6.769)
Firm size		14.989*** (22.207)	10.410*** (19.855)
Leverage		−7.613** (−1.968)	0.387 (0.172)
Profitability		14.662* (1.910)	3.672 (0.904)
Capital investments		−33.249* (−1.888)	−17.829* (−1.912)
Advertising intensity		−7.563 (−0.391)	5.468 (0.324)
R&D intensity		22.717 (1.252)	11.978 (1.364)
Cash holdings		9.996** (2.006)	10.699*** (3.650)
Dividend payouts		63.542** (2.140)	68.250*** (4.528)
Asset tangibility		14.798*** (4.542)	4.256** (2.189)
Discretionary spending		29.245*** (4.339)	17.312*** (4.017)
ESG score		−0.296*** (−5.825)	−0.423*** (−19.140)
Constant	8.279*** (4.299)	−126.702*** (−19.219)	−90.267*** (−4.728)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
Observations	6197	6197	6197
Adjusted R-squared	0.269	0.500	0.473

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
Robust t-statistics in parentheses.
***$p < .01$. **$p < .05$. *$p < .1$.

4 | RESULTS

4.1 | Main regression results

Table 2 shows the main regression results where the dependent variable is corporate carbon emission performance. The standard errors are clustered by the firm. The coefficients of the takeover index are positive and significant in both Model 1 and Model 2, suggesting that more takeover threats enhance carbon reductions significantly. The evidence is consistent with the carbon reduction hypothesis. Managers make significantly more efforts to reduce carbon emissions when they are more exposed to the disciplinary mechanism of the takeover market. Our findings corroborate the argument that the takeover market functions as an instrument of external governance that mitigates agency problems, compelling managers to adopt corporate policies that benefit shareholders in the long run.

To demonstrate that the results are not sensitive to the estimation method, we execute as a robustness check a random effects regression in Model 3. The result in Model 3 remains similar. Importantly, our findings aptly dovetail with those in Cain et al. (2017), who report that more takeover vulnerability improves firm value significantly, suggesting that the takeover market alleviates agency conflicts and managerial entrenchment.

Notably, the coefficients of firm size (log of total assets) and profitability (EBIT/total assets) are both significantly positive. Large and more profitable firms perform significantly better in terms of carbon reductions. These findings corroborate the prediction of the resource dependence theory (Drees & Heugens, 2013; Hillman et al., 2009). Larger firms and firms with higher profitability are equipped with more and better resources and are expected to accomplish carbon reductions more effectively.

In terms of economic significance, we estimate the magnitude of the effect of the takeover market on carbon reductions as follows: One standard deviation of the hostile takeover index is 0.106. The coefficient of the hostile takeover index is 37.953 in Model 2 in Table 2. Therefore, a rise in takeover vulnerability by one standard deviation raises the emissions score by 0.106 times 37.953, which is 4.023. Because one standard deviation of the emissions score is 31.411, an increase by 4.023 represents 12.81%. A rise in takeover susceptibility by one standard deviation improves carbon emission performance by 12.81%. Hence, the effect of takeover threats is not only statistically significant but also economically meaningful as well.

4.2 | Propensity score matching (PSM)

We verify the findings using propensity score matching (Lennox et al., 2012; Rosenbaum & Rubin, 1983). The hostile takeover index is used to split the sample into quartiles. The treatment group contains observations that fall inside the top quartile (highest takeover vulnerability). Then, for each observation in the treatment group, we choose the observation from the remainder of the sample that is the most comparable to it based on 11 governance and firm characteristics (i.e., the

11 control variables included in the regression analysis). Except for their takeover susceptibility, our treatment and control firms are almost identical in every observable aspect.

We execute diagnostic testing to ensure that our matching is accurate. Table 3A summarizes the results. Model 1 is a logistic regression with a binary dependent variable equal to one if the firm is in the treatment group (greater takeover vulnerability) and zero otherwise. Model 1 contains the full sample (pre-match). The result reveals that the treatment firms are significantly different in a number of respects from the rest of the sample. In particular, the treatment firms are larger in size, make less capital investments, hold less cash, pay larger dividends, and exhibit a higher ESG score. These material differences have to be accounted for as they might skew our results.

Model 2 is a logistic regression constructed for the propensity score-matched sample (post-match). In Model 2, none of the coefficients are significant. As a consequence, in all observable dimensions, our treatment and control firms are statistically identical. To the degree that takeover vulnerability is irrelevant, our treatment and control firms should have comparable carbon emissions. Table 3B illustrates the regression result for the propensity score-matched sample. The coefficient of the hostile takeover index remains significantly positive, confirming the carbon reduction hypothesis once again. Due to the consistency of our PSM findings, our conclusion does not seem to be principally driven by endogeneity.

TABLE 3A Propensity score matching: Diagnostic testing

	(1) Pre-match Treatment (high takeover vulnerability)	(2) Post-match Treatment (high takeover vulnerability)
Firm size	0.437*** (5.269)	0.012 (0.137)
Leverage	−0.761 (−1.542)	−0.000 (−0.000)
Profitability	−1.384 (−1.372)	0.300 (0.248)
Capital investments	−6.490** (−2.574)	0.268 (0.098)
Advertising intensity	2.113 (0.779)	2.646 (0.720)
R&D intensity	−0.917 (−0.457)	3.183 (0.970)
Cash holdings	−2.458*** (−3.332)	−0.554 (−0.609)
Dividend payouts	12.231*** (3.728)	−3.119 (−0.831)
Asset tangibility	0.527 (1.604)	−0.088 (−0.246)
Discretionary spending	−0.013 (−0.020)	−0.322 (−0.406)
ESG score	0.010* (1.942)	0.004 (0.660)
Constant	−4.503*** (−5.422)	−0.012 (−0.014)
Pseudo R-squared	0.096	0.003
Observations	6236	3118

Robust z-statistics in parentheses.
***$p < .01$. **$p < .05$. *$p < .1$.

TABLE 3B Propensity score matching: The effect of hostile takeover threats on carbon emissions

	(1) Emissions score
Hostile takeover index	43.469*** (4.897)
Firm size	16.038*** (18.308)
Leverage	−6.902 (−1.184)
Profitability	43.296*** (3.365)
Capital investments	−45.832 (−1.601)
Advertising intensity	37.731 (1.082)
R&D intensity	135.300*** (3.826)
Cash holdings	11.874 (1.335)
Dividend payouts	−58.954* (−1.658)
Asset tangibility	20.089*** (4.652)
Discretionary spending	18.766* (1.794)
ESG score	−0.357*** (−5.506)
Constant	−141.722*** (−15.949)
Year fixed effects	Yes
Industry fixed effects	Yes
State fixed effects	Yes
Observations	3080
Adjusted R-squared	0.553

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
Robust t-statistics in parentheses.
***p < .01. **p < .05. *p < .1.

4.3 | Entropy balancing

Previous research has mainly depended on the notion of observable selection. To sidestep this assumption, we employ Hainmueller's (2012) entropy balancing technique, a variant on standard matching methods. Entropy balancing, in particular, provides a high degree of covariate balance by directly including covariate balance into the weight function applied to sample units (Balima, 2020; Hainmueller, 2012). Hainmueller (2012) discusses entropy balancing in further detail. This unique approach for matching has been frequently used in the recent literature (Bol et al., 2020; Chatjuthamard et al., 2022; Freier et al., 2015; Glendening et al., 2019; Marcus, 2013; McMullin & Schonberger, 2020; Neuenkirch & Neumeier, 2016; Neuenkirch & Tillmann, 2016; Ongsakul, et al., 2021; Truex, 2014; Wilde, 2017).

This is how we perform entropy balancing. We choose firms whose takeover vulnerability is in the top quartile as our treatment group. The remaining sample is referred to as the control group. Then, on all of the control variables, we perform entropy balancing to ensure

TABLE 4 Entropy balancing

	(1) Emissions score
Hostile takeover index	25.053*** (2.796)
Firm size	14.684*** (17.079)
Leverage	−8.320 (−1.348)
Profitability	15.940 (1.287)
Capital investments	−84.481*** (−2.979)
Advertising intensity	49.596 (1.427)
R&D intensity	236.476*** (5.880)
Cash holdings	15.249 (1.460)
Dividend payouts	55.004 (1.145)
Asset tangibility	20.119*** (4.821)
Discretionary spending	18.603** (2.199)
ESG score	−0.310*** (−5.197)
Constant	−124.045*** (−13.986)
Year fixed effects	Yes
Industry fixed effects	Yes
State fixed effects	Yes
Observations	6236
Adjusted R-squared	0.512

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
Robust t-statistics in parentheses.
***p < .01. **p < .05. *p < .1.

that the mean, variance, and skewness of the observations in the two groups are similar. The regression result for the entropy-balanced sample is shown in Table 4. The coefficient of the hostile takeover index remains positive and significant. Firms with stronger takeover vulnerability exhibit better carbon performance. The carbon reduction hypothesis is once again corroborated.

4.4 | IV analysis

We also perform an IV analysis to reduce endogeneity even more. Historical takeover exposure is our IV. This is the value of each firm's hostile takeover index in the earliest year in the sample. The rationale is that the degree of takeover susceptibility in the earliest year could not have been caused by carbon emissions in any of the following years. As a result, reverse causality is unlikely. The results are shown in Table 5. Model 1 is the first-stage regression where the hostile takeover index is the dependent variable. The coefficient of the hostile takeover index from the earliest year is positive and significant, as expected. Model 2 is the second-stage regression where the

TABLE 5 Instrumental variable analysis using the earliest value of takeover vulnerability as the instrument

	(1) First stage Full sample Hostile takeover index	(2) Second stage Full sample Emissions score	(3) Second stage High variance Emissions score
Hostile takeover index (earliest)	0.932*** (55.275)		
Hostile takeover index (instrumented)		29.289*** (3.061)	28.618*** (5.450)
Firm size	0.003** (2.400)	15.330*** (22.265)	15.393*** (35.238)
Leverage	−0.010 (−1.522)	−10.189*** (−2.673)	−7.488** (−2.562)
Profitability	−0.011 (−1.301)	11.128 (1.456)	24.037*** (3.820)
Capital investments	−0.035* (−1.818)	−34.528* (−1.915)	−62.060*** (−3.952)
Advertising intensity	−0.003 (−0.132)	−6.506 (−0.329)	−21.233 (−1.500)
R&D intensity	0.039** (2.500)	32.697* (1.835)	26.165** (2.231)
Cash holdings	−0.006 (−0.599)	11.611** (2.251)	21.439*** (5.652)
Dividend payouts	0.112** (2.289)	67.684** (2.258)	−10.701 (−0.450)
Asset tangibility	0.001 (0.226)	12.155*** (3.909)	10.046*** (4.944)
Discretionary spending	0.003 (0.476)	29.175*** (4.548)	32.838*** (6.767)
ESG score	−0.000 (−0.240)	−0.279*** (−5.361)	−0.359*** (−10.110)
Constant	0.011 (0.990)	−126.051*** (−19.024)	−117.667*** (−18.411)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
Observations	6236	6236	3162
Adjusted R-squared	0.857	0.470	0.495

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.

Robust t-statistics in parentheses.

***$p < .01$. **$p < .05$. *$p < .1$.

dependent variable is the emissions score. The coefficient of the hostile takeover index instrumented from the first stage is significantly positive. Our IV results show that increasing takeover exposure considerably increases carbon reductions, validating the carbon reduction hypothesis once again.

One potential critique of this IV is that it may be sticky, changing only slowly over time. As a result, the value of the index in the earliest year may not change much from the value in any subsequent year. We address this concern by computing the standard deviation of the hostile takeover index for each company across time. A larger standard deviation indicates that the takeover index for a given firm has more fluctuation across time. Then, we perform an IV analysis on just the companies with standard deviations greater than the median. Essentially, we only concentrate on those organizations where the takeover index fluctuates more quickly over time. This strategy alleviates concerns about the takeover index's stickiness. The second-stage regression result is shown in Model 3. The coefficient of the hostile takeover index instrumented from the first stage is significantly positive. For further robustness, we apply propensity score matching and entropy balancing on the IV analysis. Table 6 shows the second-stage

regression results where the dependent variable is the emissions score. The coefficients of the takeover index remain significantly positive in both regressions.

Furthermore, we use an alternate IV based on geography. In particular, we use the average hostile takeover index of all companies in the same city. Companies in close proximity are often subject to the same economic conditions. In addition, the location of the firm's headquarters was often chosen in the distant past, early in the firm's life, and very seldom changes over time (Pirinsky & Wang, 2006). As a result, the location of the headquarters is likely exogenous to contemporaneous firm characteristics. This approach, which is based on geographic identification, has recently been embraced in the recent literature (Chintrakarn et al., 2015, 2017; Jiraporn et al., 2014).

The regression results are shown in Table 7. Model 1 is the first-stage regression using the hostile takeover index as the dependent variable. As predicted, the coefficient of the average takeover index of all firms in the same city is significantly positive. Model 2 is the second-stage regression where the emissions score is the dependent variable. The hostile takeover index instrumented from the first stage has a significantly positive coefficient. We also use propensity score

TABLE 6 Instrumental variable analysis using the earliest value of takeover vulnerability as the instrument with propensity score matching and entropy balancing

	(1) Propensity score matching Emissions score	(2) Entropy balancing Emissions score
Hostile takeover index (instrumented)	49.491*** (6.987)	34.573*** (5.752)
Firm size	16.570*** (30.325)	14.369*** (32.241)
Leverage	0.650 (0.164)	−0.755 (−0.222)
Profitability	32.602*** (3.698)	11.590 (1.620)
Capital investments	−79.703*** (−3.835)	−105.859*** (−6.398)
Advertising intensity	5.975 (0.298)	42.413** (2.256)
R&D intensity	171.306*** (7.652)	284.707*** (13.164)
Cash holdings	25.013*** (3.793)	14.264*** (2.639)
Dividend payouts	−54.444* (−1.843)	38.712 (1.375)
Asset tangibility	12.829*** (5.003)	13.065*** (6.244)
Discretionary spending	28.310*** (4.241)	10.226* (1.790)
ESG score	−0.365*** (−8.640)	−0.385*** (−11.247)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
State fixed effects	Yes	Yes
Observations	2036	3162
Adjusted R-squared	0.530	0.531

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
z-statistics in parentheses.
***p < .01. **p < .05. *p < .1.

TABLE 7 Instrumental variable analysis based on geographic location

	(1) First stage Hostile takeover index	(2) Second stage Emissions score
Hostile takeover index (earliest)	0.871*** (24.820)	
Hostile takeover index (instrumented)		11.711** (2.426)
Firm size	0.016*** (7.186)	15.809*** (50.200)
Leverage	−0.025* (−1.864)	−10.605*** (−5.385)
Profitability	−0.000 (−0.019)	10.177** (2.429)
Capital investments	−0.269*** (−4.549)	−40.971*** (−4.051)
Advertising intensity	−0.013 (−0.131)	−7.408 (−0.717)
R&D intensity	0.047 (1.072)	31.396*** (4.105)
Cash holdings	−0.013 (−0.854)	10.511*** (3.961)
Dividend payouts	0.282*** (2.872)	77.847*** (5.014)
Asset tangibility	0.026** (2.518)	12.853*** (9.195)
Discretionary spending	0.024 (1.211)	30.462*** (10.590)
ESG score	0.001*** (3.391)	−0.267*** (−10.181)
Constant	−0.118*** (−5.598)	−122.294*** (−23.845)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
State fixed effects	Yes	Yes
Observations	6236	6236
Adjusted R-squared	0.613	0.469

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
Robust t-statistics in parentheses.
***p < .01. **p < .05. *p < .1.

matching and entropy balancing on top of the IV analysis to increase robustness. The results are shown in Table 8. Once again, the results remain similar.

4.5 | Lewbel's (2012, 2018) heteroscedastic identification

Finally, we employ Lewbel's (2012, 2018) heteroscedastic identification as our final robustness check for endogeneity. This method does not rely on the exclusion condition and does not necessitate the use of an external IV. Rather, this strategy makes use of the variables' heteroscedasticity and is ideal for circumstances where identifying a suitable IV is difficult. Lewbel (2012, 2018) goes into much greater depth about this strategy. Table 9 shows the regression result using this estimating approach. The hostile takeover index's coefficient remains significantly positive, validating the notion that improved carbon emission performance results from greater takeover vulnerability.

TABLE 8 Instrumental variable analysis based on geographic location with propensity score matching and entropy balancing

	(1) Propensity score matching	(2) Entropy balancing
	Emissions score	Emissions score
Hostile takeover index (instrumented)	21.589*** (3.572)	14.406*** (3.381)
Firm size	16.541*** (38.293)	14.780*** (48.690)
Leverage	−11.036*** (−3.422)	−8.497*** (−3.383)
Profitability	46.011*** (6.232)	15.425*** (2.824)
Capital investments	−66.791*** (−3.713)	−87.656*** (−7.180)
Advertising intensity	47.846*** (2.773)	49.959*** (3.685)
R&D intensity	142.170*** (7.768)	236.096*** (15.224)
Cash holdings	15.273*** (2.799)	14.832*** (3.694)
Dividend payouts	−58.486*** (−2.747)	60.051*** (2.876)
Asset tangibility	17.581*** (8.164)	20.295*** (13.221)
Discretionary spending	18.330*** (3.804)	19.397*** (5.736)
ESG score	−0.318*** (−8.879)	−0.308*** (−12.265)
Constant	−132.058*** (−19.560)	−109.583*** (−22.101)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
State fixed effects	Yes	Yes
Observations	3118	6236
Adjusted R-squared	0.518	0.511

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
z-statistics in parentheses.
***p < .01. **p < .05. *p < .1.

TABLE 9 Lewbel's (2012) heteroscedastic identification

	(1) Emissions score
Hostile takeover index	35.346*** (8.801)
Firm size	15.060*** (48.982)
Leverage	−7.673*** (−3.898)
Profitability	14.555*** (3.544)
Capital investments	−34.133*** (−3.444)
Advertising intensity	−7.758 (−0.749)
R&D intensity	22.607*** (2.931)
Cash holdings	9.847*** (3.651)
Dividend payouts	65.115*** (4.265)
Asset tangibility	14.905*** (10.524)
Discretionary spending	29.408*** (10.000)
ESG score	−0.294*** (−11.524)
Constant	−135.898*** (−16.568)
Year fixed effects	Yes
Industry fixed effects	Yes
State fixed effects	Yes
Observations	6197
Adjusted R-squared	0.500

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
z-statistics in parentheses.
***p < .01. **p < .05. *p < .1.

4.6 | Controlling for internal corporate governance

To ensure that our results are robust, we control for internal corporate governance. The board of directors is widely acknowledged as the paramount mechanism of internal corporate governance. Two crucial aspects of the board of directors that have been frequently used to proxy for board quality are board size (Cheng, 2008; Chintrakarn et al., 2019; Coles et al., 2008; Dalton et al., 1999; Huang & Wang, 2015; Jensen, 1993; Padungsaksawasdi, Treepongkaruna, Jiraporn, and Uyar, 2021; Uchida, 2011; Wang, 2012; Yermack, 1996) and board independence (Chatjuthamard, Jiraporn, & Treepongkaruna, 2021; Core et al., 1999; Cotter et al., 1997; Jenwittayaroje & Jiraporn, 2019; Nguyen & Nielsen, 2010; Rosenstein & Wyatt, 1990). Consequently, we include board size and board independence as additional control variables. The regression results are shown in Table 10. The takeover index still exhibits a positive and significant coefficient, bolstering the carbon reduction hypothesis. Therefore, the effect of the takeover market on carbon emission performance remains robust even after accounting for internal corporate governance.[6] The role of the takeover market is apparently not subsumed by the board of directors.

TABLE 10 Controlling for internal governance

	(1)
	Emissions score
Hostile takeover index	23.431** (2.429)
% independent directors	0.116** (2.012)
Ln (board size)	12.124*** (3.202)
Firm size	14.584*** (17.617)
Leverage	−6.449 (−1.368)
Profitability	21.538** (2.215)
Capital investments	−50.440** (−2.317)
Advertising intensity	−14.713 (−0.673)
R&D intensity	10.430 (0.469)
Cash holdings	12.819** (2.043)
Dividend payouts	66.974* (1.752)
Asset tangibility	15.366*** (4.110)
Discretionary spending	27.068*** (3.572)
ESG score	−0.334***
	(−6.113)
Constant	−157.903*** (−15.749)
Year fixed effects	Yes
Industry fixed effects	Yes
State fixed effects	Yes
Observations	4963
Adjusted R-squared	0.528

The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry. The higher the score, the more efforts are made to reduce carbon emissions. The hostile takeover index is from Cain et al. (2017) with a higher value indicating more takeover susceptibility. The ESG score is the overall ESG score provided by Refinitiv. SG&A expense is selling, general, and administrative expense.
Robust t-statistics in parentheses.
***$p < .01$. **$p < .05$. *$p < .1$.

5 | CONCLUSIONS

Climate change has emerged as a central problem in a number of fields. GHG emissions and an excessive dependence on carbon-based fossil fuels are two of the most serious issues plaguing businesses and economies globally in the twenty-first century (Elsayih et al., 2021; Hatakeda et al., 2012; Hoffmann & Busch, 2008). Excessive carbon emissions degrade company value, as an increasing body of empirical evidence reveals (Chapple et al., 2013; Clarkson et al., 2014; Griffin et al., 2017; Luo & Tang, 2014; Matsumura et al., 2014). We contribute to this critically crucial area of research by investigating how corporate carbon emission performance is determined by the takeover market, which is widely regarded as one of the most important external governance instruments (Cain et al., 2017; Fama, 1980; Fama & Jensen, 1983; Lel & Miller, 2015; Manne, 1965).

Our results based on a large sample of US firms demonstrate that the disciplinary mechanism associated with the takeover market acts as one of the crucial determinants of carbon emission performance. In particular, stronger takeover vulnerability induces managers to make significantly greater efforts to reduce carbon emissions. The findings corroborate the notion that the takeover market, functioning as an external governance mechanism, motivates managers to adopt corporate policies that benefit shareholders in the long run. A rise in takeover susceptibility by one standard deviation results in an improvement in carbon emission performance by 12.81%. Hence, the magnitude of the documented effect is not only statistically significant but also economically palpable.

Our results imply that carbon emissions are a crucial corporate outcome where lower carbon emissions are desirable and should be encouraged. Companies should make every effort to improve their carbon emission performance as climate change has increasingly gained attention. Firms that are less subject to the pressure of the takeover market should be more mindful of this issue and should adopt policies that mitigate carbon emissions.

Our measure of takeover vulnerability is substantially less vulnerable to endogeneity as it is principally based on state legislations (Cain et al., 2017). Our findings therefore likely reflect causality, rather than a mere association. In any case, to alleviate endogeneity even further, we execute a variety of robustness checks, namely, propensity score matching, entropy balancing, and an IV analysis. All the robustness checks validate the findings. Finally, we also find that the effect of the takeover market remains robust even after accounting for internal corporate governance, i.e., board characteristics. Consequently, the role of the takeover market as an external governance instrument is not subsumed by the board of directors, which is the paramount internal governance mechanism. It is highly unlikely that our results are significantly tainted by endogeneity. Our study aptly enriches the literature in several areas, including corporate governance, climate change, carbon emissions, the market for corporate control, and corporate governance.

CONFLICT OF INTEREST
The authors have no conflict of interest.

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ENDNOTES
[1] Additional studies on corporate carbon performance are Busch, Bassen, et al. (2020); Busch, Johnson, and Pioch (2020); Busch and Lewandowski (2017); Damert et al. (2017); Doda et al. (2016); Lee (2012); Lewandowski (2017); and Liesen et al. (2017).

[2] More studies in the literature on the market for corporate control are Chen et al. (2017), Dong et al. (2020), Khurana and Wang (2018), Obaydin et al. (2021), Ongsakul et al. (2020), and Ongsakul et al. (2022).

[3] The data on carbon emission performance are available starting 2002. The data on the takeover index are available until 2014.

[4] The ESG score and the emission score are highly correlated, as expected. So, we orthogonalize the ESG score and the emissions score before having it included in the regression so as to control for the company's ESG efforts, excluding carbon emissions.

[5] Whereas it could be argued that the passage of a state law may be endogenous as firms may have some influence over it, a legislation at the state level is beyond the control of any one firm. So, to a given firm, the passage of a state law is plausibly exogenous. This is a reasonable assumption that has been adopted by a large volume of recent research that relies on the enactment of a state law as an exogenous shock.

[6] We did not include board size and board independence earlier in our analysis because the data on board characteristics are not available for all the firms in the sample. That is why we add them only as a robustness check.

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APPENDIX A: Variable definitions

Variable	Definition
Carbon emissions	
Emissions score	The emissions score from Refinitiv indicates the percentile rank score of a firm's commitment and effectiveness toward reducing environmental emission in the production and operational processes relative to its industry.
	The higher the score, the more efforts are made to reduce carbon emissions.
Hostile takeover exposure	
Hostile takeover index	This index is constructed by Cain et al. (2017) based on state legislations, capital liquidity, and firm age.
Firm-specific characteristics	
Firm size	Total assets
Leverage	Total debt/total assets
Profitability	EBIT/total assets
Capital investments	Capital expenditures/total assets
Advertising intensity	Advertising expense/total assets
R&D intensity	R&D expense/total assets
Dividend payouts	Dividends/total assets
Cash holdings	Cash holdings/total assets
Discretionary spending	SG&A expense/total assets
Asset tangibility	Fixed assets/total assets