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Reprint of: Corporate culture and carbon emission performance

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ABSTRACT

Using a large sample of U.S. firms from 2002 to 2020, we investigate the relationship between corporate culture and the extent of carbon emissions. We provide evidence that the quantum of carbon emissions is negatively associated with corporate cultural attributes manifested by integrity, teamwork, innovation, and respect. These results hold after controlling for potential endogeneity issues using several identification techniques. We also document that the negative culture–emissions relationship is magnified in firms with weak corporate governance and in those operating in environmentally sensitive industries. Additionally, this relationship is less salient in the presence of social capital. Finally, we demonstrate that in firms with a stronger culture, elevated carbon emissions result in a lower firm value. Our findings may be of interest to environmental regulators and management in their pursuit of firm-level carbon emission targets.

1. Introduction

Greenhouse gas (GHG) emissions reductions, specifically carbon emissions, are critical components of the Nationally Determined Contributions (NDCs) under the 2015 Paris Agreement. Based on the NDCs, countries design action plans and extend them to firms to outline their strategies for reducing GHG emissions in alignment with the goals of the Paris Agreement. As a result, corporate carbon emissions and climate change-related risks have attracted significant interest from scholars, regulators, and policymakers. Existing literature identifies various macroeconomic and firm-level factors influencing carbon emissions (e.g., Azar et al., 2021; Haque, 2017; Liao et al., 2015; Yu et al., 2021). However, the influence of corporate culture on carbon emissions remains underexplored. This study enriches the existing body of literature by offering deeper insights into how corporate culture affects carbon emissions.

Whilst there is no set definition of what constitutes corporate culture, culture-based research typically incorporates several key factors, such as conventions, customs, traditions, understanding, ideology, values, norms, codes, and rules (Gorton et al., 2022; Linnenluecke and Griffiths, 2010). Broadly, corporate culture can be defined as the "set of norms and values that are widely shared and strongly held throughout the organization" (O'Reilly and Chatman, 1996). To determine whether the strength of firms' corporate

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cultural tenets reduces their propensity to emit carbon, we use firm-specific cultural measures based on the approach employed by Li, Mai, et al. (2021), whereby culture encapsulates five dimensions: integrity, teamwork, innovation, respect, and quality.

A study on the relationship between corporate culture and carbon emissions reduction is crucial, as both survey evidence from corporate executives and external data indicate that cultural factors are key drivers of corporate strategy and financial outcomes (Graham et al., 2022). For example, a survey by Ernst & Young (EY, 2020) revealed that a staggering 83% of managers hold that company culture forms the bedrock of trust and mitigates business risks. Prior studies have highlighted that cultural aspects enhance internal integration and goal alignment within a firm, thereby mitigating its agency-related issues and enhancing its competitive position, productivity, and value (Guiso et al., 2015; Li et al., 2021a, 2021b). Given the pivotal role of corporate culture in shaping corporate strategies and outcomes, as well as the growing global awareness of carbon performance, a study examining the impact of corporate culture on carbon performance is both important and timely.

Drawing insights from the agency-based framework, we propose a negative link between corporate culture and carbon emissions. According to agency theory, owing to the separation of ownership and management, self-interested managers might prioritize immediate financial gains over long-term sustainability goals, including carbon emissions reduction efforts (de Villiers et al., 2011; Haque, 2017; Hossain et al., 2023). This preference is often driven by the short-term nature of their contracts, while substantial capital investment required for green technology typically yields benefits over an extended period (Liao et al., 2015). Nonetheless, recent literature indicates that a strong corporate culture promotes ethical decision-making and innovation (Graham et al., 2022; Li, Mai, et al., 2021). Moreover, firms with strength in cultural attributes exhibit fewer agency problems, as demonstrated by lower levels of earnings management (Li, Mai, et al., 2021) and reduced stakeholder violation (Zaman, 2024). Additionally, these firms consider the environmental impact of their business strategies and operations (Graham et al., 2022; Li, Mai, et al., 2021). Therefore, a corporate culture that puts effective governance structures in place or focuses on stakeholder or societal orientation is likely to implement systems, processes, and technologies that align with energy conservation and environmental sustainability. Consequently, firms with a superior corporate culture are more likely to reduce carbon emissions.

We first explore whether the firm-level corporate culture is associated with carbon emissions performance while controlling for observable factors that might influence carbon emissions. Our analysis reveals that a strong corporate culture significantly reduces carbon emissions, and this outcome holds statistical and economic significance. For example, a one standard deviation increase in the corporate culture score corresponds to a 9.67% reduction in carbon emissions relative to the standard deviation of total carbon emissions.

Next, we examine the association between different dimensions of organizational culture, as defined by Li, Mai, et al. (2021), and carbon emissions reduction performance. Our analysis reveals that carbon emissions exhibit a significant and negative association with the integrity, teamwork, innovation, and respect aspects of culture. Our main finding remains robust across a range of sensitivity tests, including Oster (2019) bound estimates, two-stage least squares regression, entropy balancing tests, and change regression analysis. Collectively, these tests help mitigate potential concerns about endogeneity problems.

In addition, we conduct several cross-sectional tests to examine the influence of corporate governance, and social and environmental factors. Our findings reveal that the inverse relationship between corporate culture and carbon emissions is more prominent among companies with weaker corporate governance structures and those operating in environmentally sensitive sectors. In contrast, this relationship is less evident for companies based in regions with high social capital. Finally, we assess how the interplay between carbon emissions and corporate culture influences firm value. Our result suggests that higher emissions from firms with a strong culture reduce firm value.

Our study extends the existing literature in several important ways. First, while an emerging body of literature has identified that factors such as corporate governance attributes, financing constraints, executive compensation, R&D intensity, and economic policy uncertainty affect corporate carbon performance (Churchill et al., 2019; Hossain et al., 2023; Luo and Tang, 2021; Provaty et al., 2024; Safiullah et al., 2022; Yu et al., 2021), as far as our knowledge extends, there is a lack of research exploring the relationship between firms' propensity to reduce their carbon emissions and their cultural attributes. Our study fills this gap by demonstrating that corporate culture significantly shapes managerial incentives and strategies towards carbon emissions reduction. By highlighting the critical role of corporate culture in mitigating carbon emissions, our study indicates that corporate culture is as instrumental as formal governance factors in shaping a firm's environmental strategies and outcomes. Therefore, our research not only corroborates but also extends the agency theory-based argument pertaining to carbon performance, adding a new dimension to the understanding of environmental strategy and outcomes within the corporate sector (de Villiers et al., 2011; Hossain et al., 2023; Kyaw et al., 2022; Luo and Tang, 2021).

Second, our study extends the burgeoning literature on the effects of corporate culture on corporate outcomes. Recent evidence has shown that corporate culture promotes value generation, ethical decision-making, and innovation, provides resilience during times of crisis and impacts debt selection choice and audit pricing (Chen et al., 2022; Graham et al., 2022; Hasan, 2022; Li, Liu, et al., 2021; Liu, 2016; Zaman, 2024). While this literature primarily focuses on the financial implications of corporate culture, it overlooks the role of organizational culture in shaping carbon emissions performance. By exploring the association between firm-level corporate culture and carbon emissions, our study sheds light on a critical yet understudied aspect of sustainable business practices, with a focus on carbon emissions. The empirical findings not only confirm the importance of corporate culture in reducing carbon emissions but also provide insights into the specific dimensions of culture that are most effective in promoting emissions reduction initiatives.

Third, our research makes a substantial contribution to the existing literature by exploring the moderating role of corporate governance structures and sector-specific environmental sensitivities on carbon emission performance. We build upon Tsang et al. (2023)'s call for an assessment of the moderators that could impact this relationship by conducting analyses that distinguish firms based on their governance quality and industry characteristics. Furthermore, by extending our investigation to include the moderating role of regional social capital, our research offers a broader geographical and socio-economic perspective, thereby generating a more

nuanced comparison across different regional settings and stakeholder environments. Hence, our approach responds to the identified research gap and enhances our understanding of corporate environmental responsibility by highlighting the contextual factors that can amplify or mitigate the influence of corporate culture on sustainability practices.

Our study differs both conceptually and empirically from the literature that integrates environmental sustainability into the concept of corporate culture. Conceptually, corporate culture encompasses values like integrity, teamwork, innovation, quality, and respect that guide internal dynamics and external interactions (Li, Mai, et al., 2021). In contrast, environmental sustainability focuses on the ecological impact of an entity and its efforts towards sustainability (Goodland, 1995). Corporate culture shapes an organization's ethos and stakeholder engagement, promoting collaboration and ethics (Guiso et al., 2015). Conversely, environmental sustainability involves strategies, practices, and policies to minimize ecological harm, conserve resources, and align with green initiatives (Galpin et al., 2015). While both are essential indicators of an organization's well-being, they address distinct aspects – culture reflects an organization's character, while environmental sustainability demonstrates its commitment to the planet and future generations. Empirically, we demonstrate that our findings remain robust after explicitly controlling for corporate environmental sustainability, suggesting the incremental role of corporate culture in reducing carbon emissions.

Finally, we acknowledge recent research indicating that *national* culture influences corporate carbon emissions (Luo and Tang, 2022). While this literature uncovers valuable insights into the role of different dimensions of national culture (e.g., uncertainty avoidance, collectivism, and time orientation) in carbon performance, our study advances this discourse by offering nuanced evidence on how various aspects of a *firm-specific* culture impact carbon emissions. We argue that understanding how a firm-specific corporate culture influences carbon emissions is important because corporate culture exhibits significant cross-sectional fluctuations and evolves slowly over time, as opposed to deeply ingrained national cultural values (Li, Mai, et al., 2021; Luo and Tang, 2022). Accordingly, firm-specific culture is likely to provide deeper insights into its effect on carbon emissions.

The study proceeds as follows: Section 2 introduces the theory and hypothesis. Section 3 details the research design. Section 4 presents the findings, and Section 5 concludes the study.

2. Theory and hypothesis development

2.1. Carbon performance

Corporate carbon performance reflects a company's capacity to effectively manage, reduce, or offset carbon emissions throughout its operations and supply chains. This performance metric is recognized as an essential component of corporate social responsibility (CSR) (Delmas et al., 2015; Tsang et al., 2023). A firm's commitment to CSR and carbon management are increasingly intertwined as companies strive to address environmental sustainability. CSR encompasses a wide range of initiatives and practices aimed at achieving positive social, environmental, and economic outcomes. Within this broad framework, carbon performance is a specific and highly focused component that directly addresses the environmental aspect of CSR by targeting the reduction of carbon footprints and combating climate change. Research indicates that integrating carbon reduction initiatives into CSR frameworks can significantly improve a company's reputation, stakeholder engagement, and financial performance (Eccles et al., 2014). Furthermore, regulatory pressures and consumer demand for sustainable practices drive businesses to adopt comprehensive CSR policies that include carbon management (Dahlmann et al., 2019). Effective CSR practices that prioritize carbon reduction not only help in achieving sustainability goals but also foster long-term business resilience and competitive advantage (Kolk, 2016). A firm lacking commitment to emissions reductions and environmental stewardship is unlikely to develop effective carbon reduction strategies, thereby affecting its carbon performance (Tsang et al., 2023).

While carbon performance is intrinsically linked to CSR, it has developed its own identity as a distinct area of importance, separate from the broader CSR domain (Haque, 2017; Luo and Tang, 2014). Assessing carbon performance independently from other CSR aspects is critical for several reasons. First, carbon emissions uniquely contribute to global warming, necessitating sustainable production practices to mitigate their impact (Vasquez et al., 2019). Second, distinct regulations, knowledge, and innovations are required to address carbon performance. Third, unchecked carbon emissions could significantly impact global productivity with considerable economic costs (Stern, 2008). Moreover, effective carbon management improves a company's operational efficiency, resource utilization, and overall value, aiding stakeholders in making informed decisions and enabling more effective regulatory oversight (Luo and Tang, 2016; Shen et al., 2020).

The extant literature proposes several theories to explain pro-social behavior in general and carbon emissions in particular. These theories include agency theory, signaling theory, and resource-based theory (Bui et al., 2020; de Villiers et al., 2011; Haque, 2017; Tsang et al., 2023). According to agency theory, the division between ownership and control incentivizes managers to prioritize short-term projects offering immediate economic gains or initiatives that align more closely with their personal interests. This emphasis on short-term benefits could potentially overshadow the pursuit of long-term projects that promote environmental sustainability and effectively reduce carbon emissions (Davidson et al., 2019; Jensen & Meckling, 1976). Prior research demonstrates that monitoring by boards and institutional shareholders curbs carbon emissions (de Villiers, 2011; Safiullah et al., 2022), thereby validating the use of agency theory. Signaling theory posits that firms leverage their superior carbon performance to signal their achievements to market and regulatory stakeholders to bolster their reputation and competitive advantage (Clarkson et al., 2008; DesJardine et al., 2021; Ryou et al., 2022). Finally, resource-based theory posits that a company's resources and capabilities play a pivotal role in facilitating environmentally friendly investments aimed at reducing carbon emissions (Branco & Rodrigues, 2006). Drawing on these theoretical foundations, extant literature has identified a wide array of factors that affect CSR and carbon performance. These factors include firm size, profitability, growth, leverage, life cycle, industry belonging, corporate strategy, corporate

governance, and regulations (Chi et al., 2020; Chih et al., 2010; Cowen et al., 1987; Haque, 2017; Hasan & Habib, 2017; Huang & Watson, 2015; Liao et al., 2015; Luo and Tang, 2021; Moussa et al., 2020; Tomar, 2023; Tsang et al., 2023).[1]

In a recent study, Azar et al. (2021) argued that corporate pro-social behavior could be attributed to factors such as altruism, monetary rewards, the cultivation of a favourable image, as well as social pressure. At the macro-level, Disli et al. (2016) investigated how cultural dimensions influence carbon emissions relative to economic output or income. They found that cultural traits pertaining to masculinity, power distance, indulgence, individualism, uncertainty avoidance, and long-term orientation have a significant impact on carbon emissions. Similarly, Luo and Tang (2022) concluded that national cultural dimensions emphasizing future orientation, gender egalitarianism, uncertainty avoidance, and humane orientation enhance corporate carbon performance. However, they noted that in-group collectivism could lead to poorer carbon outcomes. These studies collectively underscore the impact of broad national cultural elements on corporate carbon emissions performance. Nevertheless, our study focuses on *firm-level* cultural attributes as they may more directly influence a firm's propensity to reduce carbon emissions compared to that achieved via broader national cultural traits.

2.2. Corporate culture

Corporate culture, encapsulating shared beliefs and values that guide organizational behavior, can have a profound influence on corporate operational, strategic, and financial outcomes. Although the concept of corporate culture captures several complex dimensions, its underlying premise incorporates the views, beliefs, values, ideologies, and strategies of firm management (Linnenluecke and Griffiths, 2010). Corporate culture shapes organizational mission, vision, and core values, and it can significantly influence the dynamics within a firm and the way in which it responds to its immediate environment.

Li, Mai, et al. (2021) developed a text-based measure to capture significant cultural attributes within organizations, comprising innovation, integrity, teamwork, respect, and quality. Specifically, they found that corporate culture considerably affects operational outcomes, as evidenced by asset turnover and inventory management. They also concluded that a strong corporate culture fosters a long-term positive orientation towards social trust, governance, and control, ultimately leading to increased firm value. Likewise, Li, Liu, et al. (2021) demonstrated that culture contributes to organizational resilience, particularly during crisis periods. Studies also revealed that culture can reduce corporate reliance on private debt (Hasan, 2022) and mitigate stakeholder violations (Zaman, 2024). Afzali (2023) found that a strong corporate culture results in higher accounting comparability, while Liu (2016) documented that companies with a corruption culture tend to engage in financial manipulation and accounting fraud, including backdating stock options. However, Guggenmos (2020) showed that an innovative corporate culture allows managers to pursue more real earnings management. We extend this literature by examining how corporate culture influences carbon emissionds.

2.3. Hypothesis

We follow prior studies (e.g., de Villiers et al., 2011; Liao et al., 2015; Luo and Tang, 2021) in using agency theory to explain the relationship between corporate culture and corporate carbon performance. Agency theory suggests that the separation of ownership and control can lead managers to prioritize personal gains over shareholders' interests, potentially jeopardizing firm value (Jensen & Meckling, 1976). This divergence is particularly evident in the context of corporate carbon emissions, where there is a misalignment between managers' short-term goals and shareholders' long-term sustainability aspirations (de Villiers et al., 2011; Luo and Tang, 2021). In particular, shareholders generally prefer long-term projects that enhance firm value through sustainability and emissions reduction, aligning with climate change mitigation and societal expectations. However, the short-term nature of managerial contracts might prompt managers to prioritize immediate financial benefits, neglecting long-term environmental objectives (Tauringana and Chithambo, 2015). The literature suggests that this misalignment can result in inadequate action toward reducing carbon emissions, which managers perceive as contrary to short-term gains, despite their potential for long-term benefits such as energy savings, enhanced environmental reputation, and market opportunities (Liao et al., 2015; Tauringana and Chithambo, 2015). This conflict is further aggravated because managers' efforts in enhancing green practices and internal process redesigns are unobservable and non-verifiable, leading to inadequate motivation (Tauringana and Chithambo, 2015). Empirical studies highlight the significance of corporate governance in addressing this misalignment and enhancing carbon performance (de Villiers et al., 2011; Luo and Tang, 2021).

In the realm of a firm's climate-related endeavours, corporate culture plays a critical role in resolving agency problems by aligning the interests of managers with those of shareholders. Extant literature underscores the significance of corporate culture in mitigating unethical behaviors, ESG violations, and noncompliance activities (Graham et al., 2022). We argue that corporate culture contributes to a reducion in carbon emissions in several ways. First, a strong corporate culture embeds ethical norms and values that prioritize long-term sustainability over short-term financial gains (Graham et al., 2022; Li, Mai, et al., 2021; Zaman, 2024). By fostering a leadership style characterized by altruism and responsibility, such a culture integrates environmental responsibility into core principles, considers the broader societal impact of its actions, and promotes environmental stewardship (Freeman & Auster, 2011; Gao et al., 2014), encouraging sustainable practices and reducing carbon emissions.

Second, corporate culture motivates managers to integrate sustainable practices into strategic goals (Li, Mai, et al., 2021). For

[1] See Huang and Watson (2015) and Tsang et al. (2023) for a detailed discussion on the theory and determinants of CSR.

example, firms with a strong culture may establish mechanisms (e.g., sustainability committees) to set clear sustainability goals, monitor progress, and ensure compliance. By prioritizing environmental performance, these initiatives enhance energy efficiency, promote renewable resources, and implement waste reduction programs (Haque, 2017). This structured approach leads to more effective carbon management as evidenced by reduced emissions. Finally, a strong corporate culture functions as an informal governance mechanism, fostering peer pressure and internal accountability among managers and employees. This discourages deviations from established norms and promotes adherence to environmentally sustainable practices (Jiang et al., 2023; Li, Mai, et al., 2021), ultimately reducing carbon emissions.

Building on the preceding theoretical frameworks and empirical evidence, we predict that a strong corporate culture is pivotal in reducing a firm's carbon emissions. This prediction is rooted in the observation that a strong corporate culture effectively mitigates managerial moral hazard issues and short-termism, thereby aligning the interests of managers with those of shareholders. Such alignment is likely to heighten corporate awareness of climate-related challenges and opportunities. Consequently, corporate culture is likely to incentivize managers to pursue long-term, environmentally sustainable projects. These initiatives, in turn, are anticipated to lead to a notable decrease in carbon emissions. In light of this reasoning, we articulate the following hypothesis.

H1. Corporate culture is negatively associated with carbon emissions.

Extant research has suggested that good corporate governance contributes to lower corporate carbon emissions (Haque, 2017; Luo and Tang, 2021). For instance, Haque (2017) posited that strong corporate governance mechanisms prompt investment in green technologies and emissions control strategies, reducing carbon emissions. Similarly, Luo and Tang (2021) argued that strong corporate governance ensures the optimal allocation of corporate resources towards enhancing carbon performance. Furthermore, Caputo et al. (2021) highlighted that firms with stringent governance policies often require the disclosure of environmental performance, enhancing accountability, transparency, and public pressure to reduce emissions.

Given that culture serves as an informal governance mechanism (Duong et al., 2016), the presence of strong corporate governance could potentially dilute the influence of corporate culture on emissions by standardizing environmental standards and championing sustainability efforts. Conversely, weaker governance might accentuate the effect of corporate culture on emissions due to insufficient oversight and direction. Thus, considering the complementary role of corporate culture and corporate governance, we articulate the following hypothesis.

H2. The negative relationship between corporate culture and carbon emissions is more (less) salient in the presence of weak (strong) corporate governance.

Prior studies have suggested that environmentally sensitive firms are more closely monitored by stakeholders and therefore tend to adopt proactive measures to reduce their emissions and pollution (Hrasky, 2012). Moreover, environmentally sensitive firms are less likely to discontinue socially responsible projects to avoid potential backlash from stakeholders (Cho et al., 2012; Hasan et al., 2022). Therefore, the role of corporate culture in reducing carbon emissions is likely to be more pronounced for environmentally sensitive firms.

Further, studies have indicated that social capital often fosters community engagement, trust, and collaboration, which can lead to collective efforts in addressing environmental issues. Therefore, firms in regions with high social capital exhibit superior environmental and social practices, which in turn improve their carbon performance (Jha & Cox, 2015; Marbuah et al., 2021). Given the proactive stance of these firms towards environmental initiatives, we posit that the emissions-reducing effect of corporate culture might be less evident in such contexts. Thus, we propose the following hypothesis.

H3. *The negative relationship between corporate culture and carbon emissions is more salient for environmentally sensitive firms but less salient for firms operating in regions with higher social capital.*

3. Research design

3.1. Data and sample

Our sample is drawn from several databases. We source carbon emissions data from Refinitiv ESG, corporate culture data from Li, Mai, et al. (2021), financial data from COMPUSTAT, analyst coverage from the Institutional Brokers' Estimate System, and institutional shareholding information from the Thomson Reuters Institutional (13f) Holdings file.

We start our sample by utilizing the carbon emissions data from Refinitiv ESG (7804 firm-year observations). Subsequently, 1993 firm-year observations are lost during the merging of carbon emissions data with the culture score of Li, Mai, et al. (2021). Because of their regulated nature, we do not include financial (SIC 6000–6999) and utility (SIC 4900–4949) firms in our sample (1390 firm-years). Additionally, we exclude observations that lack key variables (320 firm years). Our final sample contains 4101 firm-year observations that represent 686 publicly traded companies between 2002 and 2020.[2] The detailed sampling process is outlined in Internet Appendix 1 (IA.1). We winsorize continuous variables at the 1 percent level on both tails to alleviate the impact of outliers.

[2] Our sample starts in 2002 because the culture data from Li, Mai, et al. (2021) becomes accessible from this period onwards. We note that our final sample falls within the range of prior studies (e.g., Gaganis et al., 2023; Hossain et al., 2023; Provaty et al., 2024).

3.2. Variable measure

3.2.1. Dependent variable: carbon emissions

Following prior literature (Azar et al., 2021; Bolton & Kacperczyk, 2021; Hossain et al., 2023), we employ the natural logarithm of the total annual CO_2 equivalent emissions (in tonnes) to assess corporate carbon performance (Total Emissions (Log)). This measure encompasses both direct emissions (scope 1) and indirect emissions (scope 2 and scope 3).[3] In additional analyses, we separately use the natural logarithm of the total direct emissions (Direct Emissions (Log)) and the total indirect emissions (Indirect Emissions (Log) and Indirect Scope 3 (Log)) as the dependent variable.

3.2.2. Main independent variable: corporate culture (CULTURE)

We employ the corporate culture measure developed by Li, Mai, et al. (2021), which leverages cutting-edge machine learning techniques to derive a culture score.[4] Their method involves using a neural network model to comprehensively understand the contextual meaning of words and phrases found within earnings conference call transcripts. Subsequently, they developed a "culture dictionary" that encompasses terms and expressions associated with five key cultural values: creativity, integrity, quality, respect, and teamwork. This methodology entails calculating a weighted word count associated with each cultural value, which is then normalized by the total word count within the transcript. Notably, the authors substantiated the validity of their culture measurement through empirical analysis.

We estimate corporate culture (CULTURE) using three different measures. Initially, our primary analysis employs a standardized composite score of the five corporate cultural values (zCULTURE). In the sensitivity analysis, we aggregate the scores for these five cultural values (sCULTURE). Additionally, we employ a binary variable, assigning a value of 1 when a company's culture score is above the sample median and 0 otherwise. (dCULTURE).

3.3. Regression model

To assess the impact of corporate culture on carbon performance, we estimate the following ordinary least squares (OLS) regression model:

$$\begin{aligned}\text{Total Emissions} = {} & \propto_0 + \propto_1 zCULTURE + \propto_2 TA + \propto_3 LEV + \propto_4 BTM + \propto_5 ROA + \propto_6 PPE + \propto_7 CASH + \propto_8 CAPX + \propto_9 ANALYST \\ & + \propto_{10} INST + \propto_{11} CFVOL + YearFE + IndustryFE + \epsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)\end{aligned}$$

where Total Emissions is the dependent variable, measured as the natural logarithm of the total carbon emissions (metric tonnes). zCULTURE is the key explanatory variable, measured following Li, Mai, et al. (2021). In the regression model, following previous studies (e.g., Azar et al., 2021; Hossain et al., 2023; Luo and Tang, 2022; Provaty et al., 2024), we incorporate a comprehensive set of firm-level characteristics as controls, including the natural logarithm of the total assets (TA (log)), financial leverage (LEV), book-to-market ratio (BTM), return on assets (ROA), asset tangibility (PPE), corporate cash holdings (CASH), capital investment (CAPX), and cash flow volatility (CFVOL). Overall, these firm-level control variables capture the firm stability, capital structure, profitability, cash-holding, and risk characteristics of the sample. In the context of carbon performance, we also factor in external corporate governance mechanisms, such as the degree of analyst coverage (ANALYST (Log)) and institutional shareholding ownership (INST). Finally, we incorporate year and industry fixed effects and employ robust clustering of standard errors at the firm level to address within-firm serial correlations. A detailed explanation of the variables is provided in Appendix A.

4. Results and discussion

4.1. Descriptive statistics

Table 1 exhibits the descriptive statistics. The average firm in our sample produces 3.018 million tonnes of total emissions. However, the total emissions exhibit skewness in their distribution; therefore, we use log-transformed total emissions in our empirical analysis. We find that the mean and median total emissions (log) are 13.014 and 12.978, respectively. The average for direct carbon emissions (log) stands at 11.861, while the average for indirect carbon emissions (log) is slightly higher at 12.271. This indicates that, on average, firms in our sample produce more indirect carbon emissions than direct ones. Notably, the distribution of carbon emissions falls within the range reported in previous studies (Azar et al., 2021; Bolton & Kacperczyk, 2021). Moreover, the mean (median) for zCULTURE is −0.008 (−0.196). The average log of total assets is 8.054, and the mean ROA is 4.20%. On average, the sample firms possess 28.2% leverage. The mean statistics also show that our sample firms hold 19% cash (CASH) and 24.2% physical assets (*PPE*) compared to total assets.

[3] Direct emissions include those from sources that the company owns or controls, those produced during the production of intermediate energy, those produced during building operations, and those related to the selling self-generated electricity to another business. In contrast, indirect emissions result from the use of imported (purchased) electricity, heat, or steam by the company.

[4] The data on corporate culture is obtained from https://www.dropbox.com/scl/fo/7g859c9h96cnwzb5uxvbe/h?rlkey=gtjua3yik96szjlob7833lng7&e=1&dl=0.

Table 1
Summary statistics.
This table presents summary statistics of the variables. Appendix A presents variable definitions.

	Mean	Std. Dev.	p25	Median	p75
Total Emissions (Log)	13.014	2.050	11.563	12.978	14.458
Total Emissions (mil. Tonnes)	3.018	8.413	0.105	0.433	1.901
zCULTURE	−0.008	0.962	−0.722	−0.196	0.522
sCULTURE	15.718	6.128	11.163	14.516	19.089
dCULTURE	0.250	0.433	0.000	0.000	0.000
zINTEGRITY	−0.010	0.942	−0.686	−0.187	0.477
zTEAMWORK	−0.013	0.917	−0.662	−0.271	0.362
zINNOVATION	−0.010	0.952	−0.707	−0.248	0.446
zRESPECT	−0.011	0.939	−0.682	−0.263	0.388
zQUALITY	−0.008	0.961	−0.692	−0.258	0.402
TA (Log)	8.054	1.554	7.027	8.006	9.025
LEV	0.282	0.210	0.123	0.260	0.400
BTM	0.386	0.359	0.166	0.310	0.525
ROA	0.042	0.182	0.007	0.069	0.130
PPE	0.242	0.221	0.078	0.163	0.346
CASH	0.190	0.207	0.044	0.113	0.252
CAPX	0.043	0.043	0.016	0.030	0.053
ANALYST (Log)	2.513	0.746	2.079	2.639	3.045
INST	0.809	0.174	0.728	0.852	0.937
CFVOL	0.054	0.073	0.019	0.032	0.056
Variables used in the sensitivity analysis and additional analysis					
Total Emissions/Sales	1.931	3.919	0.193	0.456	1.727
Direct Emissions (Log)	11.861	2.715	10.184	11.831	13.686
Indirect Emissions (Log)	12.271	1.833	11.096	12.435	13.561
Indirect – Scope 3 (Log)	12.400	2.897	10.33	11.905	14.534
CEO_TENURE	1.750	0.853	1.099	1.792	2.398
EXE_ VEGA	3.692	2.324	1.714	4.394	5.493
E-INDEX	3.998	1.015	4.000	4.000	5.000
CSR_NET	1.208	2.413	0.000	1.000	2.000
ENV_SEN	0.271	0.444	0.000	0.000	1.000
SUST_COM	0.728	0.445	0.000	1.000	1.000
Tobin's Q	2.171	1.198	1.358	1.818	2.589

IA.2 presents the distribution of total emissions (log) over the years. The total carbon emissions were highest during 2002–2004, after which they progressively decreased until they reached their lowest level in 2020.

4.2. Correlations

Table 2 exhibits the pairwise correlation matrix. The correlation between total carbon emissions and corporate culture (zCULTURE) is negative and significant ($\rho = -0.25$; $p < 0.01$), implying that firms with a higher corporate culture emit less carbon. Our findings also suggest that large firms (TA) and those that are highly leveraged (LEV), as well as firms with higher tangible assets (PPE) and capital expenditure (CAPX), are positively correlated with carbon emissions. In contrast, firms with more institutional shareholdings (INST) and higher liquidity (CASH) and cash flow volatility (CFVOL) are negatively correlated with carbon emissions. All the reported findings are statistically significant at the 1% level.

In Fig. 1, we illustrate the carbon emissions for each quartile of culture. We categorize the sample into annual quartiles according to the culture score. We observe that total emissions gradually decline as corporate culture increases, implying an inverse relationship between them.

4.3. Main regression results

Table 3 displays the regression results that examine the link between corporate culture and total carbon emissions (Equation (1)). We estimate the regression models using OLS regressions, correcting standard errors for heteroscedasticity and within-firm clustering. Our analysis uses total carbon emissions (Total Emissions) as the dependent variable and corporate culture (zCULTURE) as the primary independent variable.

Column (1) estimates Equation (1) without incorporating firm-level controls and industry and year fixed effects. The estimated coefficient for zCULTURE is negative and statistically significant (coefficient = −0.589, $p < 0.01$), indicating that a stronger corporate culture is correlated with lower emissions. In column (2), we re-estimate Equation (1) after including firm-level controls, industry, and year fixed effects. We observe that the estimated coefficient for zCULTURE remains negative and significant (coefficient = −0.206, $p < 0.01$), reinforcing the idea that firms with a strong corporate culture tend to emit less carbon. Thus, our findings support hypothesis H1, which states that a stronger corporate culture results in lower carbon emissions.

Table 2
Pairwise correlations.
This table presents the correlation coefficient between the variables. * indicates significance at the 1% level. Appendix A presents variable definitions.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Total Emissions (Log)	1.00											
(2) zCULTURE	−0.25*	1.00										
(3) TA (Log)	0.62*	−0.18*	1.00									
(4) LEV	0.05*	−0.09*	0.16*	1.00								
(5) BTM	0.16*	−0.21*	0.08*	−0.18*	1.00							
(6) ROA	0.02	−0.19*	0.35*	−0.08*	−0.06*	1.00						
(7) PPE	0.54*	−0.28*	0.19*	0.18*	0.23*	0.08*	1.00					
(8) CASH	−0.37*	0.38*	−0.42*	−0.26*	−0.25*	−0.42*	−0.37*	1.00				
(9) CAPX	0.35*	−0.16*	0.08*	0.02	0.10*	0.10*	0.72*	−0.22*	1.00			
(10) ANALYST (Log)	0.21*	0.00	0.56*	−0.02	−0.15*	0.19*	0.08*	−0.03*	0.14*	1.00		
(11) INST	−0.25*	−0.05*	0.00	0.02	0.05*	0.12*	−0.06*	−0.08*	−0.05*	0.13*	1.00	
(12) CFVOL	−0.09*	0.17*	−0.41*	−0.09*	−0.11*	−0.48*	−0.16*	0.57*	−0.09*	−0.13*	−0.14*	1.00

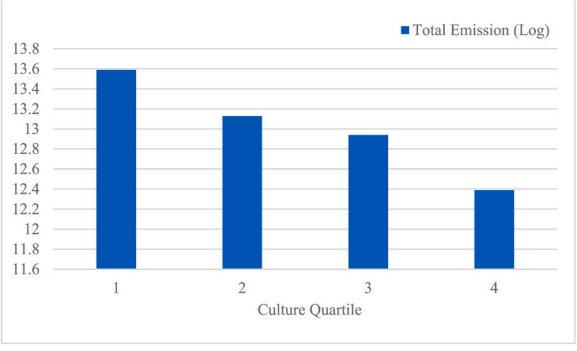

Fig. 1. Total emissions (log) across culture quartile.

From an economic standpoint, an increase of one standard deviation in zCULTURE is associated with a 9.67% reduction in carbon emissions relative to the standard deviation of total carbon emissions ([–0.206 * 0.962]/2.050), which is within the range of prior literature.[5] Thus, the impact of corporate culture on carbon emissions reduction is both statistically significant and economically meaningful.[6]

In Table 3, the coefficients for most of the controls have the expected sign and significance. For instance, larger firms (TA) and those with higher asset tangibility (PPE) tend to emit more carbon, whereas higher firm leverage (LEV), better liquidity (CASH), and more analyst coverage (ANALYST) are associated with lower emissions.

4.4. Corporate culture dimensions and carbon emissions

In our primary analysis, we employ a composite corporate culture score to examine its effect on carbon emissions. Building on this approach, we now dissect the corporate culture score into its five constituent dimensions—integrity, teamwork, innovation, respect, and quality—to evaluate the effects of these specific dimensions on carbon emissions individually. The findings from this analysis are presented in Table 4.

Column (1) reveals that firms with a higher integrity score (zINTEGRITY) exhibit a negative association with carbon emissions (coefficient = −0.084, $p < 0.01$). This finding supports the agency-based argument that an integrity culture mitigates managerial moral hazard and enhances adherence to environmental regulations (Schneider and Theuer, 2019), ethical supply chain practices (Douglas et al., 2022), and transparency in carbon emissions reporting (Bui et al., 2021), ultimately lowering corporate carbon emissions. Column (2) estimates the regression model using teamwork (zTEAMWORK). This analysis uncovers a significant negative relationship between teamwork and carbon emissions (coefficient = −0.303, $p < 0.01$). This result aligns with the argument that a teamwork culture mitigates managerial short-termism, enhances stakeholder relations, and fosters effective collaboration on environmental initiatives, thereby reducing carbon emissions (Bunge et al., 1996; Markey et al., 2019).

[5] Based on an analysis of 182 published papers, Mitton (2021) finds that the median economic significance corresponds to 7% of the standard deviation of the explanatory variables.

[6] In IA.3 we repeat the regression using the sCULTURE and dCULTURE measures of corporate culture, respectively. In both cases, we find that the coefficients are negative and statistically significant (coefficient for sCULTURE = −0.032, $p < 0.01$ and coefficient for dCULTURE = −0.253, $p < 0.01$).

Table 3
Main regression: Corporate culture and carbon emissions performance.
This table presents the main regression results of the impact of corporate culture on carbon emissions. Robust standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Variables	(1)	(2)
	Total Emissions (Log)	Total Emissions (Log)
zCULTURE	**−0.589*** **	**−0.206*** **
	[0.087]	**[0.041]**
TA (Log)		0.973***
		[0.035]
LEV		−0.490**
		[0.225]
BTM		−0.074
		[0.107]
ROA		−0.013
		[0.292]
PPE		3.582***
		[0.503]
CASH		−1.252***
		[0.294]
CAPX		1.022
		[1.366]
ANALYST (Log)		−0.261***
		[0.061]
INST		−0.089
		[0.237]
CFVOL		0.210
		[1.447]
Constant	12.889***	5.762***
	[0.095]	[0.476]
Industry effects	No	Yes
Year effects	No	Yes
Observations	4101	4101
Adj. R^2	0.06	0.79

In columns (3) and (4), we observe that both the innovation and the respect dimensions of culture exert a negative influence on carbon emissions (coefficients of zINNOVATION = −0.176, $p < 0.01$ and zRESPECT = −0.216, $p < 0.01$). Our findings on innovation culture affirm that such a culture promotes the development and adoption of green technologies, aligning managerial efforts with long-term environmental sustainability goals, thereby significantly reducing carbon footprints. Our findings further suggest that a respect-oriented culture focuses on social values, environmental stewardship, and sustainability, prioritizing strategies to mitigate climate change effects. Finally, in column (5), we include a quality aspect of corporate culture (zQUALITY) and find this to have a positive impact on carbon emissions (coefficient = 0.091, $p < 0.05$). Our findings for the quality aspect of culture support the idea that a quality-focused culture may motivate managers to prioritize quality over environmental issues, which may not align with the objective of reducing emissions. Overall, the findings from this analysis show that the conclusions drawn from our primary research are mainly explained by integrity, teamwork, innovation, and respect.

4.5. Endogeneity tests

It is possible that our documented evidence is biased because of potential endogeneity concerns, which might arise from omitted variable bias or reverse causality problems. In particular, one could contend that our regression model does not include all relevant controls, potentially leading to a biased estimation of the beta coefficient. In addition, it is possible that firms emitting lower levels of carbon might adopt a better corporate culture – a concern commonly known as reverse causality. To mitigate these endogeneity concerns, we undertake four identification procedures, which we detail below.

4.5.1. Tests for omitted variable bias using Oster (2019)

To address the concern about omitted variable bias, we employ the bound estimates technique as suggested by Oster (2019). This identification approach evaluates the strength of regression coefficients by adding and removing control variables, along with R-squared values, to produce a new identifiable parameter. If this identifiable set does not include a 0 value, the estimation is unlikely to be susceptible to omitted variable bias. Contemporary literature has employed this procedure to address endogeneity issues (Ferracuti, 2022; Hasan & Uddin, 2022; Jacob & Vossebürger, 2022).

In accordance with earlier studies (e.g., Oster, 2019), we set $\delta = 1$ and Rmax = min (1.3 $\widetilde{R}$, 1). Our findings in Table 5 show that the estimated identified set for corporate culture does not contain 0, suggesting that the omitted variable is unlikely to drive our baseline result. Our inference remains unaffected if we use Rmax = min (1.5 $\widetilde{R}$, 1) or Rmax = min (2.2 $\widetilde{R}$, 1) (untabulated).

Table 4
Corporate culture dimensions and carbon emissions performance.
This table presents the regression results of the impact of individual dimensions of corporate culture on carbon emissions performance. Robust standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Variables	(1)	(2)	(3)	(4)	(5)
	Total Emissions (Log)	Total Emissions (Log)	Total Emissions (Log)	Total Emissions (Log)	Total Emissions (Log)
zINTEGRITY	**−0.084*** **				
	[0.030]				
zTEAMWORK		**−0.303*** **			
		[0.056]			
zINNOVATION			**−0.176*** **		
			[0.040]		
zRESPECT				**−0.216*** **	
				[0.047]	
zQUALITY					**0.091** **
					[0.043]
TA (Log)	0.967***	0.979***	0.966***	0.958***	0.955***
	[0.035]	[0.035]	[0.036]	[0.035]	[0.035]
LEV	−0.447**	−0.529**	−0.478**	−0.449**	−0.417*
	[0.223]	[0.221]	[0.225]	[0.222]	[0.221]
BTM	−0.054	−0.075	−0.074	−0.087	−0.060
	[0.108]	[0.105]	[0.107]	[0.107]	[0.108]
ROA	0.080	−0.095	0.045	0.078	0.170
	[0.302]	[0.291]	[0.294]	[0.301]	[0.303]
PPE	3.700***	3.567***	3.572***	3.612***	3.681***
	[0.509]	[0.496]	[0.502]	[0.502]	[0.505]
CASH	−1.525***	−1.236***	−1.324***	−1.479***	−1.653***
	[0.294]	[0.286]	[0.298]	[0.295]	[0.300]
CAPX	0.752	0.762	0.975	0.637	0.476
	[1.395]	[1.356]	[1.380]	[1.378]	[1.383]
ANALYST (Log)	−0.281***	−0.266***	−0.253***	−0.275***	−0.281***
	[0.062]	[0.060]	[0.062]	[0.062]	[0.063]
INST	−0.081	−0.046	−0.065	−0.078	−0.048
	[0.239]	[0.233]	[0.239]	[0.238]	[0.242]
CFVOL	0.377	0.746	0.002	0.139	0.236
	[1.436]	[1.415]	[1.453]	[1.437]	[1.432]
Constant	5.944***	5.759***	5.804***	5.956***	6.073***
	[0.478]	[0.466]	[0.480]	[0.473]	[0.474]
Industry effects	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Observations	4101	4101	4101	4101	4101
Adj. R^2	0.78	0.79	0.79	0.79	0.78

Table 5
Identification strategy (1): Tests for omitted variable bias using Oster (2019).
This table presents omitted variable bias test results using Oster's (2019) bound estimates.

	(1) Controlled		(2) Uncontrolled		(3) Parameters: $\delta = 1$; $R_{MAX} = \min(1.3\,\tilde{R},1)$
Variable of interest	Beta	R^2	Beta	R^2	Identified Set
zCULTURE	−0.206	0.79	−0.589	0.06	−0.096, −0.206

4.5.2. 2SLS regression

Now, we use a 2SLS regression analysis based on an instrumental variable to address the potential endogeneity issue. We use the state-level tightness–looseness score (TIGHTNESS) as our instrumental variable. Prior literature has posited that cultural tightness affects norms and values and is negatively associated with traits such as openness, tolerance, innovation, artistry, and the generation of new ideas (Harrington & Gelfand, 2014; Hasan, 2022). Such a state-level cultural disposition is also linked with increased behavioral constraints and allows for minimal tolerance of deviations. Supporting this idea, Hasan (2022) showed that U.S. state-level cultural tightness inhibits corporate cultural orientation. Therefore, in this study, we anticipate that firms headquartered in states characterized by a tight culture may be less inclined to take proactive steps towards developing and promoting an enhanced *firm-level* corporate culture, suggesting a negative association between TIGHTNESS and firm-level culture.

While our chosen instrumental variable (i.e., TIGHTNESS) satisfies the relevance criterion, it may not satisfy the exclusion restriction. Specifically, Luo and Tang (2022) found that national culture affects corporate carbon emissions, indicating a possible correlation between state-level cultural attributes and carbon performance. To navigate this, we follow the methodological approach suggested in recent literature (e.g., Amin et al., 2023; Francis et al., 2021; Hasan & Uddin, 2022) and undertake a strategy designed to

effectively isolate the impact of state-level tightness on carbon performance. Specifically, our initial step involves calculating state-level carbon emissions for all firms annually. Subsequently, we regress these emissions on the TIGHTNESS index as follows:

$$TIGHTNESS_{s,t} = \propto_0 + \propto_1 Total\ Emissions_{s,t} + \epsilon_{s,t} \quad (2)$$

where, "*s*" denotes states and "*t*" denotes the year. The residuals obtained from Equation (2) (i.e., TIGHTNESS_RES) capture the aspect of state-level cultural tightness not explained by carbon emissions. We use this variable as our instrumental variable in the 2SLS regression.

Table 6 (columns 1–2) reports the findings of the 2SLS regression. As expected, the first-stage results indicate that TIGHTNESS_RES is negatively related to zCULTURE (coefficient = −0.448, $p < 0.01$) (column 1). Furthermore, the significance of Kleibergen–Paap rk LM statistic ($p < 0.01$) indicates that our results are not affected by under-identification. Additionally, our estimation is robust to the weak-identification issue as the Cragg–Donald F-stat. (=77.70) is much larger than the Stock–Yogo critical value (=16.38). The second-stage results in column (2) confirm a negative and significant association between zCULTURE and total emissions (coefficient = −1.611, $p < 0.01$). Thus, we offer compelling evidence that the endogeneity issue does not substantially bias our finding that corporate culture improves carbon performance by reducing total emissions.

4.5.3. Entropy balance estimates

We employ an entropy balancing estimate to help allay the endogeneity issue. This technique is useful in removing observable differences between the treatment and control groups. Entropy balancing enhances the power of statistical tests by avoiding data loss and random matching, as highlighted by Hainmueller (2012). In our analysis, firm-year observations are categorized into the treatment (control) group based on whether their corporate culture score is above (below) the sample median. IA.4 confirms that entropy balancing successfully neutralizes differences between these groups, establishing a balanced comparison.

Table 6

Identification strategy (2–4): 2SLS regression, entropy balancing estimates, and change analysis.

This table presents the regression results of the impact of individual dimensions of corporate culture on carbon emissions performance using 2SLS (Columns 1–2), entropy balancing estimates (Column 3), and change regression analysis (Column 4). Robust standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Variables	(1)	(2)	(3)	(4)
	2SLS regression		Entropy balancing	Change analysis
	zCULTURE	Total Emissions (Log)	Total Emissions (Log)	Total Emissions (Log)
zCULTURE		**−1.611*** **	**−0.119*** **	**−0.032** **
		[0.512]	**[0.042]**	**[0.016]**
TA (Log)	0.073***	1.083***	0.924***	0.268***
	[0.022]	[0.061]	[0.035]	[0.034]
LEV	−0.273*	−0.881**	−0.304	−0.334***
	[0.152]	[0.353]	[0.229]	[0.083]
BTM	−0.106	−0.131	−0.130	0.012
	[0.069]	[0.149]	[0.112]	[0.029]
ROA	−0.635***	−0.824*	0.050	−0.117
	[0.214]	[0.488]	[0.337]	[0.076]
PPE	−0.587***	2.563***	3.864***	0.634***
	[0.173]	[0.635]	[0.549]	[0.147]
CASH	1.329***	0.781	−1.320***	0.062
	[0.271]	[0.879]	[0.308]	[0.085]
CAPX	0.907	2.931*	1.692	0.507*
	[0.621]	[1.576]	[1.584]	[0.292]
ANALYST (Log)	0.085**	−0.152	−0.287***	−0.000
	[0.043]	[0.095]	[0.067]	[0.024]
INST	−0.157	−0.477	−0.536**	−0.008
	[0.144]	[0.305]	[0.255]	[0.088]
CFVOL	−0.213	0.790	−1.041	−0.841*
	[0.681]	[1.762]	[1.508]	[0.485]
TIGHTNESS	**−0.448*** **			
	[0.101]			
Constant	0.993**	4.301***	6.530***	0.102
	[0.285]	[0.831]	[0.487]	[0.084]
Industry effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Observations	4036	4036	4101	3309
Adj. R^2	0.49	0.24	0.81	0.05
Underidentification test				
Kleibergen-Paap rk LM statistic	23.71			
p-value	0.000			
Weak identification test				
Cragg-Donald *F* statistics	118.58			

Column (3) of Table 6 exhibits the entropy-balanced regression results. We obtain consistent evidence that the coefficient for zCULTURE is negative and significant (coefficient = −0.119, $p < 0.01$), confirming the robustness of our finding.

4.5.4. Change analysis

As an additional attempt to mitigate the endogeneity concerns, we implement a change regression model. This analysis reduces the potential noise of our primary test by removing unobserved effects that persist over time (Hasan et al., 2022). We posit that if corporate culture influences a firm's overall emissions, then an improvement (deterioration) in corporate culture should be accompanied by a reduction (increase) in carbon emissions. Column (4) of Table 6 shows that an increase in corporate culture is correlated with a reduction in total carbon emissions (coefficient = −0.032, $p < 0.05$).

4.6. Cross-sectional analysis

In this section, we conduct several cross-sectional analyses to examine whether the identified negative association between corporate culture and carbon emissions is moderated by corporate governance mechanisms, corporate environmental sensitivity, and regional social capital. These analyses aim to discern whether and how these factors might amplify or attenuate the impact of corporate culture on a firm's carbon emissions.

4.6.1. The moderating role of corporate governance

First, we explore how the corporate governance mechanisms of a firm moderate the relationship between corporate culture and carbon emissions (H2). We consider four corporate governance measures: the entrenchment index (E-INDEX) of Bebchuk et al. (2009), CEO tenure (CEO_TENURE), analyst following (ANALYST), and sensitivity of managerial wealth to stock return volatility (EXE_VEGA). Literature suggests that firms with a higher E-INDEX and EXE_VEGA are linked with more agency problems (Bebchuk et al., 2009; Kim et al., 2015), whereas firms with higher ANALYST and CEO_TENURE scores are associated with less opportunistic behaviour (Ali & Zhang, 2015; Yu, 2008). We use a dummy variable assigning the value of 1 if the governance variables are higher than the sample median and 0 otherwise. We then interact this dummy with the corporate culture and re-estimate the main regression.

Panel A of Table 7 presents the results. Column (1) shows that the interaction between zCULTURE and E-INDEX is negative and significant ($p < 0.05$), suggesting that the role of corporate culture in reducing carbon emissions is accentuated when governance quality is poor. Column (2) shows that the interaction between zCULTURE and CEO_TENURE is positive and significant ($p < 0.01$), signifying that the emissions-reducing role of corporate culture is weaker when governance quality is high. We obtain a similar inference when corporate culture is interacted with ANALYST in Column (3). Finally, we find that the interaction between culture and EXE_VEGA (i.e., zCULTURE * EXE_VEGA) is negative and significant ($p < 0.01$), indicating that the role of corporate culture in reducing carbon emissions is accentuated when the agency problem is strong. Overall, the findings in Panel A of Table 7 confirm our conjecture and suggest that the relationship between corporate culture and carbon emissions is indeed stronger for firms with poor corporate governance.

4.6.2. The moderating role of environmental sensitivity and social capital

Next, we turn our attention to the potential moderating roles of environmental sensitivity (ENV_SEN)[7] and social capital (SK) on the relationship between corporate culture and carbon emissions (H3). In column (1) of Panel B, our analysis reveals that the interaction term (zCULTURE * ENV_SEN) is negative and significant (coefficient = −0.627, $p < 0.01$), confirming our hypothesis that the negative relationship between corporate culture and carbon emissions is more salient for environmentally sensitive firms.

To test the moderating role of social capital, we use the county-level social capital data of Rupasingha and Goetz (2008). Column (2) reveal that the interaction term (zCULTURE * SK) is positive and significant (coefficient = 0.021, $p < 0.10$), suggesting that the influence of corporate culture on reducing emissions is indeed less pronounced among firms with higher levels of social capital.

Overall, the results presented in Panel B substantiate our predictions (H3), demonstrating that the negative impact of corporate culture on carbon emissions is stronger for environmentally sensitive firms, while it is weaker for firms with high social capital.

4.7. Mediation test: the role of CSR and existence of a sustainability committee

This section explores the potential mediation effects of CSR and the existence of a sustainability committee (SUST_COM) on the relationship between corporate culture and carbon emissions. This investigation is important since a sustainability-oriented corporate culture could potentially enhance CSR performance and the formation of a SUST_COM, both of which could have a subsequent impact on reducing carbon emissions. To assess this possibility, we use the following simultaneous equation regression models:

$$Total\ Emissions = \psi_0 + \psi_1 zCULTURE + \psi_2 CSR\_NET + \psi_3 SUST\_COM + \psi' Controls + YearFE + IndustryFE + \epsilon_t \quad (3.1)$$

$$CSR\_NET = \lambda_0 + \lambda_1 zCULTURE + \lambda' Controls + YearFE + IndustryFE + \epsilon_t \quad (3.2)$$

[7] Consistent with past studies (e.g., Cho et al., 2012; Hasan et al., 2022), we define environmentally sensitive industries as those belonging to any of the following 2-digit SIC codes: 10, 12, 13, 29, 26, 28, 33, and 49.

Table 7
Cross-sectional analysis.
This table examines how the impact of corporate culture on carbon emissions performance is moderated by corporate governance (Panel A) and social environmental factors (Panel B). Robust standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Panel A: The moderating role of corporate governance

Variables	(1)	(2)	(3)	(4)
	Total Emissions (Log)	Total Emissions (Log)	Total Emissions (Log)	Total Emissions (Log)
zCULTURE	0.147	−0.306***	−0.477***	−0.021
	[0.174]	[0.064]	[0.141]	[0.076]
E-INDEX	−0.066*			
	[0.039]			
zCULTURE*E-INDEX	**−0.088****			
	[0.043]			
CEO Tenure		−0.042		
		[0.030]		
zCULTURE* CEO TENURE		**0.071*****		
		[0.027]		
ANALYST (Log)			−0.255***	
			[0.061]	
zCULTURE * ANALYST (Log)			**0.092****	
			[0.046]	
EXE_VEGA				−0.011
				[0.021]
zCULTURE * EXE_VEGA				**−0.044*****
				[0.017]
TA (Log)	0.960***	0.976***	0.974***	0.973***
	[0.037]	[0.039]	[0.035]	[0.040]
LEV	−0.496**	−0.452*	−0.472**	−0.346
	[0.229]	[0.245]	[0.225]	[0.250]
BTM	−0.056	−0.028	−0.081	−0.063
	[0.112]	[0.123]	[0.106]	[0.140]
ROA	−0.042	−0.048	−0.001	0.015
	[0.326]	[0.328]	[0.290]	[0.350]
PPE	3.573***	4.304***	3.567***	4.869***
	[0.555]	[0.607]	[0.503]	[0.665]
CASH	−1.352***	−1.211***	−1.282***	−1.027***
	[0.297]	[0.303]	[0.289]	[0.309]
CAPX	2.014	1.002	1.041	0.338
	[1.339]	[1.340]	[1.352]	[1.327]
ANALYST (Log)	−0.103	−0.255	−0.067	−0.452***
	[0.272]	[0.306]	[0.236]	[0.090]
INST	0.993	0.570	0.244	−0.389
	[1.419]	[1.552]	[1.444]	[0.318]
CFVOL	0.993	0.570	0.244	0.281
	[1.419]	[1.551]	[1.443]	[1.577]
Constant	6.295***	6.015***	5.724***	6.207***
	[0.561]	[0.559]	[0.474]	[0.574]
Industry effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Observations	3876	3411	4101	2973
Adj. R^2	0.79	0.80	0.79	0.81

Panel B: The moderating role of environmental sensitivity and social capital

Variables	(1)	(2)
	Total Emissions (Log)	Total Emissions (Log)
zCULTURE	−0.115***	−0.173***
	[0.042]	[0.045]
ENV_SEN	0.942**	
	[0.460]	
zCULTURE*ENV_SEN	**−0.627*****	
	[0.114]	
SK		−0.002
		[0.065]
zCULTURE* SK		**0.096***
		[0.057]
TA (Log)	0.986***	0.971***
	[0.035]	[0.035]
LEV	−0.489**	−0.435*

(*continued on next page*)

Table 7 (*continued*)

Panel B: The moderating role of environmental sensitivity and social capital		
Variables	(1)	(2)
	Total Emissions (Log)	Total Emissions (Log)
	[0.217]	[0.228]
BTM	−0.059	−0.009
	[0.106]	[0.111]
ROA	−0.004	0.089
	[0.285]	[0.298]
PPE	3.485***	3.481***
	[0.487]	[0.514]
CASH	−1.271***	−1.279***
	[0.286]	[0.301]
CAPX	0.958	1.296
	[1.337]	[1.410]
ANALYST (Log)	−0.261***	−0.281***
	[0.060]	[0.065]
INST	−0.048	−0.248
	[0.236]	[0.237]
CFVOL	0.682	0.996
	[1.394]	[1.436]
Constant	5.603***	5.877***
	[0.463]	[0.479]
Industry effects	Yes	Yes
Year effects	Yes	Yes
Observations	4101	3993
Adj. R^2	0.79	0.79

$$SUST\_COM = \gamma_0 + \gamma_1 zCULTURE + \gamma' Controls + YearFE + IndustryFE + \epsilon_t \quad (3.3)$$

The model comprises of three distinct equations. Equation. (3.1) captures the influence of both CSR and SUST_COM on carbon emissions. The inclusion of zCULTURE within this equation captures the potential direct influence of culture on carbon emissions. Equation. (3.2) explains how zCULTURE affects the CSR channel, representing the mediation effect. Finally, Equation (3.3) captures how zCULTURE affects the existence of SUST_COM. Thus, the coefficient $\psi 1$ captures the direct influence of zCULTURE on carbon emissions, while $\psi_2{}^*\lambda_1$ and $\psi_3{}^*\gamma_1$ capture the mediation effects of CSR and SUST_COM, respectively.

Table 8 exhibits the findings from the mediation analysis. Column (1) reveals that zCULTURE has a negative and significant effect on carbon emissions ($p < 0.01$). Additionally, CSR has a negative and significant effect on carbon emissions ($p < 0.01$), whereas SUST_COM is associated with a significant increase in emissions ($p < 0.01$). These results indicate that both zCULTURE and CSR independently reduce carbon emissions. Column (2) demonstrates a positive association between corporate culture and CSR ($p < 0.05$), indicating that a strong corporate culture indeed promotes socially responsible behaviors. However, in column (3), we fail to find any significant relationship between zCULTURE and the formation of SUST_COM.

We also explicitly assess the direct and indirect impact of zCULTURE on carbon emissions. We observe that the direct impact of zCULTURE on emissions is significantly negative (=−0.194, $p < 0.01$), and its impact on carbon emissions through the mediation of CSR (indirect effect) is also significantly negative (=−0.006, $p < 0.05$). However, the mediating effect of SUST_COM is negative but insignificant. Furthermore, the total effect (i.e., the sum of direct and mediating effects) of zCULTURE on carbon emissions is also negative and significant (=−0.203; $p < 0.01$). In essence, the results of this analysis underscore that corporate culture not only exerts a direct negative influence on carbon emissions but also indirectly reduces emissions through enhancing CSR practices.

4.8. Additional analyses

4.8.1. Corporate culture and different forms of carbon emissions

In this section, we investigate the influence of corporate culture on various forms of carbon emissions. In column (1) of Table 9, we examine the impact of corporate culture on direct emissions (log) (i.e., scope 1). As discussed earlier, direct emissions are under the control of the firms, originating from sources that the company owns or controls, those generated during the production of intermediate energy, those produced during building operations, and those associated with the sale of self-generated electricity to another company. We find that zCULTURE has a negative and significant effect on direct carbon emissions (coefficient = −0.318; $p < 0.01$). Column (2) explores how the culture affects indirect emissions (log) (i.e., scope 2). These emissions stem from the consumption of purchased electricity, steam, heat, or cooling, reflecting the organization's indirect energy use. We find that corporate culture also reduces indirect emissions (coefficient = −0.133, $p < 0.01$).

Column (3), which explores how corporate culture affects scope 3 emissions, shows an insignificant relationship. This finding is not surprising since scope 3 emissions originate from sources outside the firm's direct ownership or control. Moreover, the definition and estimation of Scope 3 emissions are open to interpretation, leading to significant variability in reported data (Hossain et al., 2023). Overall, the findings in Table 9 indicate that corporate culture has a negative influence on both direct (scope 1) and indirect (scope 2)

Table 8
Mediation test: the role of CSR and existence of sustainability committee.
This table examines how the CSR_NET and SUST_COM mediate the influence of corporate culture on carbon emissions. Standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Variables	(1)	(2)	(3)
	Total Emissions (Log)	CSR_NET	SUST_COM
zCULTURE	**−0.194*** **	**0.152** **	**−0.010**
	[0.026]	**[0.072]**	**[0.012]**
CSR_NET	**−0.041*** **		
	[0.007]		
SUST_COM	**0.209*** **		
	[0.042]		
TA (Log)	0.997***	0.574***	0.102***
	[0.020]	[0.051]	[0.008]
LEV	−0.519***	−0.412	0.142**
	[0.130]	[0.355]	[0.058]
BTM	−0.149**	−0.347*	−0.069**
	[0.074]	[0.202]	[0.033]
ROA	0.132	0.554	−0.003
	[0.198]	[0.539]	[0.088]
PPE	4.249***	0.383	−0.059
	[0.194]	[0.530]	[0.086]
CASH	−0.897***	2.609***	−0.066
	[0.172]	[0.466]	[0.076]
CAPX	−0.728	−2.988	−0.828**
	[0.771]	[2.099]	[0.342]
ANALYST (Log)	−0.397***	0.837***	0.017
	[0.044]	[0.118]	[0.019]
INST	−0.138	−1.512***	−0.064
	[0.136]	[0.370]	[0.060]
CFVOL	0.326	−1.815	−0.313
	[0.748]	[2.037]	[0.332]
Constant	5.524***	−9.664***	−0.087
	[0.390]	[1.049]	[0.171]
Industry dummies	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	2943	2943	2943
R-squared	0.815	0.362	0.242
Direct effect			
zCULTURE	−0.194***		
	[0.026]		
Mediation effect			
CSR_NET	−0.006**		
	[0.003]		
SUST_COM	−0.002		
	[0.002]		
Total effect	−0.203***		
	[0.027]		

emissions.

4.8.2. Corporate culture and carbon emissions intensity

We further investigate whether corporate culture has any impact on carbon intensity. Following prior studies (Bolton & Kacperczyk, 2021; Luo and Tang, 2021), carbon intensity is measured as the carbon emissions per unit of sale. He et al. (2022) suggested that this measure captures corporate efficiency in carbon management. Table 9 (column 4) shows that the corporate culture has a negative and significant effect on carbon emissions intensity (coefficient for zCULTURE = −0.206, $p < 0.01$), which further strengthens our main findings.

To bolster our finding further, we use industry (2-digit SIC codes)–year adjusted absolute carbon emissions (i.e., IND_ADJ_Total Emissions (Log)) and carbon intensity (i.e., IND_ADJ_Total Emissions/Sales) as dependent variables. In both cases, we obtain consistent evidence (see IA.5). Overall, we show that our findings from the main analysis are not driven by the particular measure of carbon emissions, suggesting robustness to our findings.

4.8.3. Consequence test: corporate culture, carbon emission intensity, and financial performance

In our concluding analysis, we investigate whether the interaction between corporate culture and carbon emissions affects firm value, proxied by Tobin's Q. Choi and Luo (2021) show that carbon emissions have a value-decreasing effect. In an earlier study,

Table 9
Corporate culture, different dimensions of carbon emissions and carbon intensity.
This table examines the impact of corporate culture on different forms of carbon performance and carbon intensity. Robust standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Variables	(1)	(2)	(3)	(4)
	Different forms of carbon performance			Carbon intensity
	Direct Emissions (Log)	Indirect Emissions (Log)	Indirect - Scope 3 (Log)	Total Emissions/Sales
zCULTURE	**−0.318*** **	**−0.133*** **	**0.091**	**−0.195** **
	[0.057]	**[0.048]**	**[0.111]**	**[0.099]**
TA (Log)	1.092***	0.968***	1.245***	0.159*
	[0.048]	[0.041]	[0.127]	[0.087]
LEV	−0.256	−0.667**	−0.445	−0.771
	[0.315]	[0.278]	[0.777]	[0.537]
BTM	−0.220	−0.108	−0.127	0.016
	[0.139]	[0.161]	[0.342]	[0.334]
ROA	0.154	0.057	0.676	−2.250***
	[0.463]	[0.364]	[0.921]	[0.712]
PPE	4.660***	2.664***	2.774**	9.289***
	[0.612]	[0.517]	[1.135]	[2.037]
CASH	−2.406***	−1.112***	0.276	0.541
	[0.414]	[0.337]	[0.871]	[0.433]
CAPX	0.346	2.022	5.697	−8.502*
	[1.760]	[2.009]	[3.997]	[4.614]
ANALYST (Log)	−0.345***	−0.225***	−0.496**	−0.299*
	[0.083]	[0.068]	[0.201]	[0.168]
INST	0.547	0.028	−0.010	1.067
	[0.339]	[0.433]	[0.917]	[0.714]
CFVOL	0.835	−0.930	−0.540	3.301
	[1.989]	[1.664]	[3.804]	[3.696]
Constant	3.738***	5.364***	2.105	0.337
	[0.665]	[0.657]	[1.700]	[2.020]
Industry effects	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
Observations	3509	3434	1835	4101
Adj. R^2	0.80	0.67	0.48	0.47

Matsumura et al. (2014) documented that every additional thousand metric tonnes of carbon emissions, on average, reduces the firm value by $212 thousand. Building on these findings, we predict that a higher level of carbon emissions by firms with a strong corporate culture will be viewed negatively by market participants, leading to a lower firm value. We use the following equation to test this prediction:

$$Tobin's\ Q = \propto_0 + \propto_1 zCULTURE + \propto_2 Total\ Emission + \propto_3 zCULTURE{*}Total\ Emission + YearFE + IndustryFE + \epsilon_t \ldots\ldots\ldots \quad (4)$$

Our primary variable of interest is $\propto_3 zCULTURE{*}Total\ Emission$, for which we expect a negative and significant coefficient.

We report the results in Table 10. We observe that the coefficient for zCULTURE is positive and significant ($p < 0.01$), indicating that a strong corporate culture positively influences firm value. Additionally, we find that the coefficient of Total Emissions (Log) is negative and significant ($p < 0.01$), implying the detrimental impact of emissions on firm value. Importantly, consistent with our expectation, the interaction coefficient is negative and significant (coefficient for zCULTURE * Total Emissions (Log) = −0.055, $p <$ 0.01 in Column (1)), suggesting that for firms with a strong corporate culture, higher emissions result in a reduced firm value. We obtain qualitatively similar results when using a 1-year-ahead firm value (i.e., Tobin's Q_{t+1}) as the dependent variable ($p < 0.05$). This research highlights the importance for firms with strong corporate cultures to proactively engage in reducing carbon emissions.

5. Conclusion

Using a sample of U.S. firms from 2002 to 2020, we examine the link between corporate culture and carbon emissions. Drawing on agency theory, we propose that a strong corporate culture can mitigate managerial short-termism by fostering a commitment to long-term sustainability and environmentally conscious strategies, thereby reducing carbon emissions. Consistent with this assertion, we provide evidence that the quantity of carbon emissions is negatively associated with corporate cultural attributes manifested by integrity, teamwork, innovation, respect, and quality. These results hold after accounting for possible endogeneity issues using two-stage least squares estimation, entropy balancing estimates, and change regression analysis. The negative culture-emissions relationship intensifies in firms with weak corporate governance and those operating in environmentally sensitive sectors but diminishes in the presence of social capital. The evidence suggests that corporate culture plays a crucial, yet often overlooked, role in influencing a firm's carbon footprint. The insights from our study should be of interest to regulators and managers considering the effect of corporate culture on the achievement of firm-level carbon emissions targets.

Table 10
Consequence test.
This table investigates how the interaction between corporate culture and carbon performance affects corporate performance. Robust standard errors clustered at the firm level are presented in parentheses. *, **, and *** signify significance at the 10%, 5% and 1% levels. Appendix A provides variable definitions.

Variables	(1)	(2)
	Tobin's Q_t	Tobin's Q_{t+1}
zCULTURE	0.851***	0.873***
	[0.276]	[0.320]
Total Emissions (Log)	−0.093***	−0.094***
	[0.029]	[0.035]
zCULTURE* Total Emissions (Log)	**−0.055*** **	**−0.058** **
	[0.020]	**[0.024]**
TA (Log)	−0.165***	−0.199***
	[0.040]	[0.045]
LEV	0.997***	1.108***
	[0.230]	[0.260]
ROA	4.766***	4.160***
	[0.599]	[0.620]
PPE	−0.697**	−0.384
	[0.298]	[0.322]
CASH	2.094***	2.037***
	[0.382]	[0.398]
CAPX	4.050***	0.957
	[1.217]	[1.143]
ANALYST (Log)	0.495***	0.555***
	[0.052]	[0.064]
INST	−0.671***	−0.895***
	[0.230]	[0.267]
CFVOL	2.875	1.943
	[1.914]	[2.082]
Constant	0.107**	0.146***
	[0.049]	[0.047]
Industry effects	Yes	Yes
Year effects	Yes	Yes
Observations	4101	3495
Adj. R^2	0.50	0.46

Our study enhances the understanding of how a firm's cultural environment influences governance and compliance, particularly in relation to carbon emissions reduction performance. While previous research has explored the relationship between different forms of culture (e.g., national culture) and carbon emissions performance (Luo and Tang, 2022), to the best of our knowledge, we are the first to specifically examine the impact of firm-specific cultural attributes on carbon emissions performance. We demonstrate that management's incentive to reduce carbon emissions is contingent on a firm's cultural environment. Further, we explicitly focus on carbon emissions reduction performance as opposed to more general coverage of CSR, ESG, greenhouse gas disclosures, or carbon reduction strategies. Hence, we directly address a critical aspect of the 2015 Paris Agreement, focusing on the importance of identifying key factors that drive carbon emissions reductions. Understanding these determinants is crucial for entities aiming to meet their carbon emissions reduction obligations under the Paris Agreement, contributing significantly toward achieving net-zero emissions targets. Moreover, our findings hold significant implications for governments and market participants, especially concerning compliance and reporting requirements related to carbon emissions under the Paris Agreement.

Conflict of interest

Conflict of interest and funding: There are no conflicts of interest and there was no funding from external sources used in this paper.

Data availability

Data will be made available on request.

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Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bar.2024.101462.

Appendix A. Variable Definitions

Variables	Definitions
Total Emissions (Log)	The natural logarithm of total carbon emissions (in tonnes).
zCULTURE	The firm-year-level standardized corporate culture score of Li, Mai, et al. (2021).
sCULTURE	The sum of the five dimensions of the corporate culture score of Li et al. (2021).
dCULTURE	A dummy variable that takes the value of 1 if the composite culture score is in the top quartile and 0 otherwise.
zINTEGRITY	The standardized integrity dimension of corporate culture (Li, Mai, et al., 2021).
zTEAMWORK	The standardized teamwork dimension of corporate culture (Li, Mai, et al., 2021).
zINNOVATION	The standardized innovation dimension of corporate culture (Li, Mai, et al., 2021).
zRESPECT	The standardized respect dimension of corporate culture (Li, Mai, et al., 2021).
zQUALITY	The standardized quality dimension of corporate culture (Li, Mai, et al., 2021).
TA (Log)	The natural logarithm of total assets.
LEV	Financial leverage, measured as total debt over total assets.
BTM	The ratio of book to market value of equity.
ROA	The return on assets, measured as pre-tax income over lagged total assets.
PPE	Property, plant, and equipment over total assets.
CASH	Cash and equivalents over total assets.
CAPX	Capital expenditure over total assets.
ANALYST (Log)	The natural logarithm of the number of analysts following a firm in a year. We replace this variable with zero if a firm is not followed by any analysts.
INST	The proportion of institutional shareholdings.
CFVOL	The standard deviation of operating cash flows over total assets during the past 5 years.
Variables used in the sensitivity analysis and additional analysis	
Total Emissions/Sales	The total carbon emissions (in tonnes) over the total sales of the firm (in millions). We scale the resulting number by 100.
Direct Emissions (Log)	The natural logarithm of total direct carbon emissions (in tonnes).
Indirect Emissions (Log)	The natural logarithm of total indirect carbon emissions (in tonnes).
Indirect – Scope 3 (Log)	The natural logarithm of total indirect (scope 3) carbon emissions (in tonnes).
CEO_TENURE	The natural logarithm of tenure of the CEO.
EXE_VEGA	The natural logarithm of the vega of the executives.
E-INDEX	Managerial entrenchment is proxied by the E-index (Bebchuk et al., 2009).
CSR_NET	The net corporate social responsibility score.
SK	An index of social capital based on social norms and social networks for each county in the US.
ENV_SEN	A binary variable that takes the value of 1 if a firm belongs to an environmentally sensitive industry as identified by any of the following 2-digit SIC codes: 10, 12, 13, 29, 26, 28, 33, and 49.
SUST_COM	A binary variable that takes the value of 1 if a firm has established a CSR sustainability committee and 0 otherwise.
Tobin's Q	The sum of the market value of equity and book value of assets, minus the book value of equity, divided by the book value of assets.

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