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RESEARCH ARTICLE

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Impact of business strategy on carbon emissions: Empirical evidence from U.S. firms

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Abstract

This study examines the nexus between business strategy and carbon emissions by utilising a dataset of U.S. firms from 2007 to 2020. It focuses on two broad types of firms, that is, prospectors and defenders. Regarding carbon emissions, we consider total emissions (Scope 1 & 2), direct emissions (Scope 1) and indirect emissions (Scope 2). The results reveal a significant association between business strategy and total carbon emissions as well as direct carbon emissions. Notably, the results suggest that prospectors, compared to defenders, display higher levels of total and direct carbon emissions. Our findings contribute to the debate on whether prospectors in developed countries mismanage sustainability issues. The study offers valuable insights into the interplay between business strategy and carbon emissions and provides empirical evidence that business strategy is an important determinant of total and direct carbon emissions.

KEYWORDS
business strategy, defenders, direct carbon emissions, indirect carbon emissions, prospectors, U.S

1 | INTRODUCTION

Despite the efforts to combat climate change, a recent report by the International Energy Agency (IEA) reveals a growth in global energy-related CO2 emissions, reaching a high record of over 36.8 Gt (IEA, 2023). While the European Union saw a decrease and China remained relatively stable in 2022, the United States experienced a growth in emissions. This underscores the importance for firms to address climate change in their operational and strategic decisions, considering both pressures and opportunities presented by environmental concerns. The business strategy adopted by firms impacts their responses to such external factors, highlighting the need for a proactive approach to achieve environmental targets while sustaining business. We utilise the Miles and Snow (1978) strategy typology adopted by Bentley et al. (2013) to examine whether different business strategies influence carbon emissions, both directly and indirectly.

Miles and Snow (1978, 2003) outline three business strategies: prospectors, defenders and analysers. Prospectors are characterised by their risk-taking nature, innovation and adaptability to market changes, striving for market leadership by exploring new products/markets and emphasising flexibility and decentralisation. However, they may struggle to achieve maximum operational efficiency.

Abbreviations: 2SLS, two-stage least square; ADF, augmented Dickey–Fuller; CDP, Carbon Disclosure Project; CO_2, carbon dioxide; CSR, corporate social responsibility; ESG, environmental, social and governance; IEA, International Energy Agency; PP, Phillips–Perron tests; Scope 1, direct emissions; Scope 2, indirect emissions; UNEP, United Nations Environment Programme.

Defenders, in contrast, prioritise stability within limited products and market segments, focusing on price, service, quality and operational efficiency through vertical integration and strict control structures. Analysers combine elements of both strategies, resulting in a more complex alignment of strategy, structure and processes compared to prospectors and defenders (Miles et al., 1978).

There is evidence that a firm's business strategy affects cash holdings and dividend payouts (Houqe et al., 2023); annual report readability (Lim et al., 2018); investment efficiency (Navissi et al., 2017); tax avoidance and aggressiveness (Higgins et al., 2015); stock price crash risk (Habib & Hasan, 2017); firm's information asymmetry (Bentley-Goode et al., 2019) and both financial reporting quality and audit efforts (Bentley et al., 2013). Further, existing research has mostly explored the association between business strategy and corporate social responsibility (CSR) or sustainability in general, but the literature shows mixed evidence (Habib et al., 2023). While some studies find prospectors exhibit greater environmental concern and act more socially compared to defenders (e.g., Ho et al., 2022; Kong et al., 2020; Maury, 2022; Yuan et al., 2020), other studies find prospectors are less likely to engage in environmental initiatives and have incentives to act opportunistically (e.g., Liu & Kong, 2021; Maniora, 2018). For instance, Maniora (2018) presents evidence that prospectors in the U.S. display a heightened tendency to participate in unethical business practices in contrast to defenders. Despite a growing body of research investigating the extent and determinants of carbon emissions, the potential impact of a firm's business strategy on carbon emissions remains limited and inconclusive. Arguably, firms' strategic choices play a role in shaping their commitment to sustainability. Given the distinct attributes of prospectors and defenders, it is plausible to expect variations in their responses to the global call for accelerating the transition to net zero (UNEP, 2022). Thus, our research question is:

Do prospectors in the U.S. deprioritise environmental concerns and emit higher levels of direct and indirect carbon than defenders?

This study is relevant for several reasons. First, it enhances our understanding of drivers of carbon emissions at the firm level in developed countries. Evidence suggests that even firms in developed countries, despite voluntarily adopting environmental initiatives, can still have high emissions (Darnall & Sides, 2008; Welch et al., 2000). Second, we focus on the U.S. setting, which is the largest contributor to carbon emissions, accounting for approximately a quarter of all historical CO2, as per the 2022 statistics (Tiseo, 2023). Thirdly, Environmental Social and Governance (ESG) ratings face criticism for their measurement difficulties, leading to inconsistent ratings across rating agencies (Pérez et al., 2022). Thus, we employ carbon emissions as a proxy of firm-level commitment to sustainability, rather than ESG scores.

Using a dataset comprising U.S. firms from 2007 to 2020, our study reveals compelling findings regarding the link between business strategy and carbon emissions. We find that business strategy has a significant positive association with carbon emissions, both total and direct emissions (Scope 1). A one-unit increase in the strategy score corresponds to approximately a 1.4% increase in total carbon emissions and a 2.3% increase in direct carbon emissions. The findings suggest that prospector firms, in comparison to defender firms, exhibit higher levels of emissions. However, no significant differences are observed between prospectors and defenders in the case of indirect carbon emissions. Our additional analysis reveals that the impact of business strategy is more pronounced for non-intensive carbon firms. These findings provide valuable insights into how business strategies influence carbon emissions, enriching our understanding of their environmental impact.

This study contributes to the literature on climate change/sustainability and strategic management. Firstly, it employs an established theoretical framework based on organisational theory and strategic choice theory, which enhances our understanding of firms' business strategies in shaping carbon emissions decisions. We find that firm-level business strategy is an important aspect of corporate sustainability, which has received limited attention in recent sustainability literature. We provide evidence that business strategy is a determinant of total and direct carbon emissions. Secondly, we contribute to the ongoing debate on whether prospectors are more environmentally friendly than defenders (Kong et al., 2020; Liu & Kong, 2021; Yuan et al., 2020). We provide empirical evidence that prospectors in the U.S. are more likely to have higher carbon emissions compared to defenders. This suggests potential ethical concerns (Maniora, 2018) or structural inadequacies within prospector firms that may lead to higher emissions levels (Miles et al., 1978). Finally, the study emphasises the importance of addressing economic and environmental considerations in developed countries. It underscores the necessity of extending the focus beyond emerging economies to all economies (Liu & Kong, 2021; Maniora, 2018). The study has policy implications for regulators, investors and other stakeholders, informing them about the potential responses from different firms to the initiatives of carbon emissions reduction. The findings would help potential investors in allocating investment in sustainable portfolios.

The rest of the paper is structured as follows. Section 2 reviews relevant literature and develops the research hypothesis. Section 3 presents our sample and research design. The results are discussed in Section 4, followed by the endogeneity tests in Section 5. Section 6 concludes the paper.

2 | LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 | Theoretical framework

Theoretically, organisational thought emphasises the relationship between an organisation and its environment, describing how organisations interact with contextual (internal and external) factors. However, the literature raises debates regarding whether organisational behaviour is influenced by external factors or management's strategic decisions. (Child, 1972, 1997). There are two different views of organisational analysis at the micro level, the system-structural view and the strategic choice view (Astley & Van de Ven, 1983). The first follows the deterministic perspective that focuses on roles/positions, not individuals/actors. Accordingly, attention is paid to structuring the roles and thus contextual factors, which are impersonal structural constraints, imposed by the role incumbency and that shape organisational behaviour. This implies that managers play a reactive role. On the other hand, the strategic choice view follows the voluntaristic perspective that considers the role of individuals/actors, whereby the organisational structure and behaviour can be affected by the management's strategic choices; assuming a proactive role of managers (Astley & Van de Ven, 1983). Child (1972) argues that classical organisational theory fails to consider the process of selecting the structures and ignores management's strategic choice as a key element in organisational analysis. The proponents of the strategic-choice theory claim that strategic choices are key determinants of organisational structure and processes (Miles et al., 1978).

Consistent with the strategic choice theory and organisational theory, Miles and Snow (1978, 2003) propose a strategic typology identifying three unique strategies: defenders, prospectors and analysers.[1] Defenders follow a conservative approach, prefer stability and adopt a risk-averse attitude. They focus on a limited number of products and a narrow segment of the market. Defenders emphasise efficiency and use high-cost-efficient technology, with attention to incremental improvement and long-term sustainability to strengthen their competitive advantage (Bentley et al., 2013; Hambrick, 1983; Higgins et al., 2015; Miles et al., 1978; Miles & Snow, 1978).

Prospector firms have a different set of characteristics. Unlike defenders, prospectors are risk-takers who are more likely to innovate, invest in new technologies and follow new approaches and initiatives (Higgins et al., 2015). They are more inclined to change their products, processes and markets (Hambrick, 1983; Miles et al., 1978) and are associated with high uncertainty and more information asymmetry (Houqe et al., 2023). Prospectors are less likely to achieve maximum operational efficiency, are exposed to the risk of resource overextension and are associated with poor performance (Bentley et al., 2013; Zhang, 2016).

While prospectors and defenders present the extremes of the strategy continuum, analysers are in the middle, combining attributes of both prospectors and defenders. Following prior studies (e.g., Bentley et al., 2013; Bentley-Goode et al., 2019; Higgins et al., 2015; Liu & Kong, 2021), we focus on the two ends of the strategy continuum, prospectors and defenders, rather than analysers, owing to their distinctive characteristics. Furthermore, it is anticipated that analyser firms positioned closer to the prospector (defender) boundary are likely to exhibit characteristics more akin to prospectors (defenders) (Bentley-Goode et al., 2017).

2.2 | Climate change and carbon emissions

The climate change and carbon emissions literature encompasses a wide range of studies exploring various aspects. While some studies investigate carbon emissions and their determinants at the macro level (e.g., Nguyen et al., 2021), other studies investigate the determinants of carbon emissions and their disclosure at the firm level (e.g., Bui et al., 2020, 2022; Luo & Tang, 2014; Matsumura et al., 2014). Companies undertake initiatives for carbon reduction to enhance their financial performance (Kim et al., 2015; Nishitani & Kokubu, 2012). Additionally, disclosing carbon emissions is shown to lower the cost of capital for firms (Bui et al., 2020; He et al., 2013; Jung et al., 2018) and enhance their credit ratings and reputation (Safiullah et al., 2021).

Prior studies investigate the impact of carbon emissions on firms' outcomes, suggesting that this influence is not homogenous. It depends on the firm's ability to pass on the carbon compliance cost to the consumers, and the extent of carbon emission allowances (Clarkson et al., 2015). Existing research (e.g., Chapple et al., 2013; Houqe et al., 2022; Matsumura et al., 2014) provides evidence of a negative association between carbon emissions and firm value, indicating potential market penalties for higher emissions. Matsumura et al. (2014) find that markets do penalise carbon emissions, however, the penalties are lower for firms that disclose carbon emissions information voluntarily. The study highlights that firms disclose carbon emissions based on a cost–benefit analysis; disclosing information if the benefits outweigh the costs.

Thus, the firm's strategic choices could affect the extent of direct and indirect carbon emissions. In Australia, Zou (2016) finds that markets perceive the carbon risk of defenders and prospectors differently, leading to varying reactions. Defenders are perceived more adversely than prospectors, but they face relatively less regulatory penalties for their carbon risk compared to prospectors. Furthermore, there is evidence that carbon emissions matter even when firms perform well in CSR activities. Bose et al. (2021) find investors penalise firms that actively promote CSR but simultaneously have higher emissions.

2.3 | Business strategy and carbon emissions

Recent research examines how business strategy influences sustainability and environmental issues, yet findings are inconclusive. In China, Kong et al. (2020) find prospectors engage in environmental protection more than defenders. They argue that defenders emphasise short-term performance and thus are less likely to engage in environmental protection. In the same direction, Yuan et al. (2020) find prospectors in the U.S. are more socially responsible than defenders. Magerakis and Habib (2021) also report that prospectors in the U.S. enjoy higher environmental efficiency. On the other hand, there is an argument that prospectors have their own incentives to act opportunistically regarding environmental concerns. In China, Liu and Kong (2021) study reveals that prospectors are less likely to engage in green innovation compared to defenders. Similarly, Maniora (2018) reports that prospectors in the U.S. mismanage sustainability-related disclosure and environmental initiatives. This is consistent with extant research, which finds prospector firms linked with less readable

[1]Miles et al. (1978) also present reactors as a fourth type of business strategy that has no consistency with process, technology and structure.

reports, more irregularities, more concerned opinions and are more prone to surpass their control systems (Bentley et al., 2013; Bentley-Goode et al., 2017; Chen et al., 2017; Lim et al., 2018).

Noticeably, a range of sustainability issues are discussed in recent environmental management literature. Khan et al. (2016) argue that the materiality of a particular sustainability issue is likely to differ among firms. As such, a specific sustainability issue is unlikely to have the same level of materiality/impact across different firms. For instance, while effectively managing climate change risk may hold strategic importance for some firms, others may prioritise different issues, such as fair trade, community engagement, gender equality or employee health, as more significant strategic concerns. Following the argument of Khan et al. (2016), Maniora (2018) investigates the relationship between business strategy and the mismanagement of sustainability. Their study provides evidence that prospectors in the U.S. demonstrate a greater inclination towards unethical business conduct in comparison to defenders; prospectors intentionally engage more in mismanagement and misreporting of sustainability issues.

The emissions reduction and transformation to net zero have both short-term and long-term implications. Defenders, as conservative firms emphasising operational efficiency and cost-effectiveness, might be more willing to comply with emissions regulations, compared to prospectors who do not prioritise maximum efficiency and do not emphasise higher profitability or cost savings (Bentley et al., 2013).

Based on the unique characteristics of defenders, it is expected that firms that pursue the defender strategy are more likely to adopt strict compliance with environmental regulations to avoid any penalties or risks that could affect their cost efficiency and stability. Furthermore, as defenders emphasise operational and cost efficiency, their approach to effective management of carbon emissions and mitigating climate change is expected to emphasise incremental changes to prioritise emissions reduction initiatives that lead to gradual but sustainable waste reduction and cost savings. However, it is expected that such firms will be less inclined to invest in clean energy technologies or to initiate significant improvements in their products or processes to reduce carbon emissions beyond the regulatory requirements. As such, the strategic choices are expected to shape firms' responses to the recommendations of zero-emission transformation, long-lived environmentally friendly products and circularity (UNEP, 2022).

To act more proactively, firms are expected to initiate some practices to reduce carbon emissions and exceed the regulatory requirements and targets (Torugsa et al., 2013). However, prospectors might suffer from having opaque structures due to their broad and diverse products and operations that are accompanied by the decentralised control systems in these organisations. This can lead to a case of discrimination in prioritising environmental issues such as carbon emissions (Maniora, 2018). This provides a reasonable explanation of the high level of emissions in U.S. firms that voluntarily adopt environmental initiatives for climate change (Darnall & Sides, 2008; Welch et al., 2000).

We postulate that prospectors in the U.S. setting, which is recognised for its elevated carbon emissions, will prioritise their growth objectives, even at the expense of operational efficiency and environmental concerns. Hence, our main hypothesis is stated as follows:

H1. Prospectors are more likely to have higher levels of carbon emissions compared to defenders.

3 | SAMPLE AND RESEARCH METHOD

3.1 | Sample

Due to its history as the biggest contributor to carbon emissions (Houqe et al., in press; Tiseo, 2023), the U.S. is considered a unique setting for our study. This is supported by both data availability and the mixed evidence on U.S. firms, as outlined in the previous sections. We use data from the carbon disclosure project (CDP) database for U.S. firms from 2007 to 2020. This particular period is chosen because the CDP data is only available on a comprehensive basis since the year 2007.

Our initial sample consists of 2,941 firm-year observations with no missing carbon emission data. Firstly, we drop 257 firm-year observations that do not have any identifier (e.g., International Securities Identification Numbers [ISIN]). Finally, due to missing data, 443 firm-year observations are excluded. Consequently, 2,241 firm-year observations are retained after the filtering process. Then for each variable (except business strategy), we winsorise both the top and the bottom 1 % of the observations to decrease the impact of outliers on the results. We collect the financial information from the COMPUSTAT database. Table 1 Panel A provides the sample selection process.

Table 1 Panel B provides the distribution of observations across industries, which includes construction, manufacturing, transportation, mining, insurance and real estate, transportation and public utilities, wholesale trade, retail trade, services and others. The highest number of observations comes from manufacturing (986 firm-years), followed by finance, insurance and real estate (298 firm-years). In terms of year-wise sample distribution, the sample size was smallest in 2007 (0.09%) and 2008 (0.13%), while the largest sample was in 2020 (12.45%), with minimal variation compared to 2012 (8.08%), 2013 (9.24%), 2014 (9.50%), 2015 (9.77%), 2016 (10.31%), 2017 (11.47%), 2018 (12.09%) and 2019 (12.36%).

3.2 | Research method

To study the relationship between business strategy and carbon emissions, we use the following model:

$$\begin{aligned} Carbon\ emissions_{it} = {} & \alpha_0 + \beta_1 STRT_{it} + \beta_2\, SIZE_{it} + \beta_3 ROA_{it} + \beta_4 CAPX_{it} \\ & + \beta_5 TaASSET\_TURN_{it} + \beta_6 TOBINSQ_{it} + Industry_k \\ & + Year_t + \epsilon_{it} \end{aligned}$$

where carbon emissions_{it} is proxied by three measures: *TE* (the logarithm of total carbon emissions divided by total assets); *DE* (the logarithm of direct carbon emissions divided by total assets); and *INE*

TABLE 1 Sample.

Panel A: sample selection	
CDP data from 2007 to 2020 without missing carbon data	2,941
Less: Firms do not have any identifies (ISIN)	257
Firms available with carbon emissions data	2,684
Less: Firms dropped due to missing accounting variables	443
Test sample	2,241

Panel B: Sample distribution by industry			
Industry group	Industry	# of firms	% of sample
10–14	Mining	97	4.33
15–17	Construction	42	1.87
20–39	Manufacturing	986	44.00
40–49	Transportation & Public Utilities	278	12.41
50–51	Wholesale trade	109	4.95
52–59	Retail trade	183	8.17
60–67	Finance, insurance, & real estate	298	13.30
70–89	Services	232	10.35
99	Other	14	062
Total		2,241	100

Panel C: Sample distribution by year		
Year	# of firms	% of sample
2007	2	0.09
2008	3	0.13
2009	15	0.67
2010	23	1.03
2011	63	2.81
2012	181	8.08
2013	207	9.24
2014	213	9.50
2015	219	9.77
2016	231	10.31
2017	257	11.47
2018	271	12.09
2019	277	12.36
2020	279	12.45
Total	2,241	100

(the logarithm of indirect carbon emissions divided by assets total). $STRT_{it}$ is the primary variable of interest, and, following Bentley et al. (2013), strategy composite scores range from 6 to 30 with defenders (6–12); analysers (13–23); and prospectors (24–30). The choice of control variables is influenced by prior research on carbon emissions literature. The size of Firm (*SIZE*) is the natural logarithm of the total assets and is negatively associated with carbon emissions. Since larger companies often face greater environmental scrutiny, they adopt measures to mitigate carbon emissions to maintain a positive public image (Safiullah et al., 2023). Profitability (*ROA*), capital expenditure (*CAPX*) and asset turnover (*ASSET_TURN*) are related to carbon emissions, suggesting that higher revenues, higher capital expenditure and higher turnover may lead to higher profitability alongside increased carbon emissions (Kong et al., 2020). Finally, Tobinsq (*TOBINSQ*) is an established market measure of firm performance, and we expect it to be negatively associated with carbon emissions (Safiullah et al., 2023). The variables are defined in Appendix A, while Appendix B displays the component variables for strategy scores. Our models account for industry and year-fixed effects.

4 | RESULTS

4.1 | Descriptive statistics

Table 2 provides descriptive statistics of our variables. The mean (median) of total carbon emissions (*TE*) is 2.763 (2.949) and the standard deviation is 2.309. The mean (median) of direct carbon emissions (*DE*) is 1.340 (0.595) and the standard deviation is 2.563. The mean (median) of indirect carbon emissions (*INE*) is 1.782 (1.819) and the standard deviation is 1.874. These results confirm that our sample firms emit more indirect carbon emissions compared to direct emissions. The mean (median) of business strategy (*STRT*) is 19.400 (20.000) and the standard deviation is 4.120. The strategy scores derived in this study are comparable with that reported by Bentley et al. (2013) of 18.040. Size of firm (*SIZE*), as expressed by the natural log of total assets, highlights considerable variation with a mean of 9.934 but a standard deviation of 1.458. The return on assets is 12.70%, and capital expenditure is 6.90%. Asset turnover is 78.40%. The mean (median) value of *TOBINSQ* is 1.667 (1.349) and the standard deviation is 1.214. These values are consistent with evidence in the literature.

Following Ozcelebi and Izgi (2023), in Table 2 Panel A, Jarque-Bera normality tests suggest non-normality in most series at the 5% significance level, implying potential nonlinearities in regression model variables. However, this non-normal skewness does not compromise the robustness of regression analysis considering the role of business strategy in carbon emissions. Unit root tests in Table 2 Panel A indicates that all variables are stationary at least at the 10% significance level because of the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests, suggesting the absence of cointegration relationships. Furthermore, the BDS test by Broock et al. (1996) in Table 2 Panel B examines the nonlinear relationship between variables. The test on residuals reveals that linearity conditions for the models are not convincingly met. Consequently, nonlinear models are not explored for assessing the link between business strategy and carbon emissions.

Table 3 shows a significant positive relationship between total carbon emissions (*TE*), direct carbon emissions (*DE*), indirect carbon emissions (*INE*) and strategy (*STRT*) ($r = 0.42, 0.29, 0.27$), respectively. This suggests that the higher carbon emissions are associated with prospector firms. The correlation between firm size (*SIZE*) and carbon emissions (*TE*, *DE* and *INE*) is negative and significant, suggesting that larger companies tend to exhibit lower levels of carbon emissions.

TABLE 2 Descriptive statistics.

Panel A: descriptive statistics and traditional unit root test results										
Variable(s)	Mean	SD	p25	Median	p75	Skewness	Kurtosis	Jarque-Bera	ADF	PPP
TE	2.763	2.309	0.464	2.949	4.374	0.228	2.551	19.32 (0.00)	−12.11 [3]	−27.19 [72]
DE	1.340	2.563	0.000	0.595	2.916	0.124	2.696	6.94 (0.00)	−10.19 [3]	−19.21 [62]
INE	1.782	1.874	0.000	1.819	3.331	−0.083	2.681	4.09 (0.00)	−9.17 [1]	−16.18 [24]
STRT	19.40	4.120	15.000	20.000	24.120	−0.519	3.549	94.86 (0.00)	−8.17 [0]	−9.17 [11]
SIZE	9.934	1.458	8.915	9.803	10.749	0.498	3.419	87.36 (0.00)	−6.11 [3]	−8.11 [22]
ROA	0.127	0.073	0.077	0.122	0.166	−0.363	4.363	49.62 (0.00)	−8.14 [3]	−11.17 [17]
CAPX	0.069	0.098	0.019	0.036	0.067	1.819	7.070	566.76 (0.00)	−6.79 [1]	−7.13 [27]
ASSET_TURN	0.784	0.644	0.350	0.619	1.00	1.659	6.139	6.13 (0.00)	9.11 [1]	−17.01 [22]
TOBINSQ	1.667	1.214	0.863	1.349	2.111	1.547	6.125	388.85 (0.00)	−7.01 [0]	−11.02 [11]

Panel B: BDS test results for alternative models					
Regression model	2	3	4	5	6
$\text{TE}_{it} = \alpha + \beta STRT_{it} + \gamma X_{it-1} + Industry_k + Year_t + \epsilon_{it}$	0.11	0.27	0.39	0.26	0.13
$\text{DE}_{it} = \alpha + \beta STRT_{it} + \gamma X_{it-1} + Industry_k + Year_t + \epsilon_{it}$	0.19	0.25	0.17	0.14	0.22
$\text{INE}_{it} = \alpha + \beta STRT_{it} + \gamma X_{it-1} + Industry_k + Year_t + \epsilon_{it}$	0.41	0.21	0.37	0.29	0.12

Note: The *p*-values of the Jarque–Bera statistic are in parentheses. Additionally, the number of lags in the ADF test (square bracketed) is suggested by the Akaike information criterion (AIC), while the bandwidth for the PP test is selected automatically by the Newey–West bandwidth (in parentheses) using the Bartlett kernel spectral estimation method.
The distance value of the test is 0.7. For the details of the BDS test, please see Broock et al. (1996) and Ozcelebi and Izgi (2023). All variable definitions are in Appendix A.

TABLE 3 Correlation matrix.

Variable(s)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
TE (1)	1.0								
DE (2)	0.93*	1.0							
INE (3)	0.76*	0.65*	1.0						
STRT (4)	0.42*	0.29*	0.27*	1.0					
SIZE (5)	−0.33*	−0.24*	−0.39*	−0.10*	1.0				
ROA (6)	0.24*	0.19*	0.33*	0.17*	−0.30*	1.0			
CAPX (7)	0.42*	0.44*	0.12*	0.16*	0.06*	−0.05*	1.0		
ASSET_TURN (8)	−0.24*	0. 18*	0.38*	0.04*	−0.35*	0.36*	−0.29*	1.0	
TOBINSQ (9)	0.04*	0.01	0.15*	−0.15	−0.31*	0.68*	−0.16*	0.19*	1.0

Note: All variable definitions are in Appendix A.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level (two-tailed tests).

Conversely, return on assets (*ROA*), capital expenditure (*CAPX*) and assets turnover (*ASSET_TURN*) exhibit a positive significant relationship with carbon emissions. Finally, Tobinsq (*TOBINSQ*) is negatively related to carbon emissions. No serious multicollinearity issues are observed, with the strong correlation between *TE*, *DE* and *INE* attributed to their shared total carbon emissions calculations.

4.2 | Main results

To find the association between carbon emissions and business strategy (H_1), we focus on the coefficient of *STRT* in Columns (1) to (3) in Table 4. We utilise three proxies for carbon emissions: total carbon emissions (Scope 1 and 2, *TE*), direct carbon emissions (Scope 1, *DE*) and indirect carbon emissions (Scope 2, *INE*). According to Table 4, the coefficients on *STRT* are positive and significant for total carbon emissions (0.425, $p < 0.10$) and direct carbon emission (0.594, $p < 0.05$), but not for indirect carbon emissions (0.257, $p > 0.10$).

The effect of business strategy on direct carbon emissions is more pronounced compared to indirect carbon emissions. In economic terms, a one standard deviation change in strategy scores (4.120) is associated with a 1.751 (= 4.120 × 0.425) percent increase in total carbon emissions (Column 1) and in Column (2) a 2.447 (= 4.120 × 0.594) percent increase in direct carbon emissions. Table 4 Panel B presents the lagged effect to address the potential endogeneity issues in Columns (4) to (6). The coefficients of *STRT* in the previous year are also positive and economically significant for total and direct carbon emissions (0.457, $p < 0.10$, 0.657, $p < 0.05$) but not for indirect carbon emission (0.224, $p > 0.10$). In economic terms, a one standard deviation change in strategy scores (4.120) is linked to a 1.882 (= 4.120 × 0.457) percent rise in total carbon emissions (Column 4) and in Column (5) a 2.706 (= 4.120 × 0.657) percent increase in direct carbon emissions. This suggests that prospector firms exhibit higher carbon emissions, aligning with the idea that prospectors prioritise environmental concerns less and behave opportunistically (Liu & Kong, 2021; Maniora, 2018). Consequently, these results align with the prediction of the hypothesis.

We also observe significant relationships between control variables and firm-level carbon emissions in both contemporaneous and lagged models. *SIZE* (*Coefficient* = −0.188, −0.084 and −0.143) and *TOBINSQ* (*Coefficient* = −0.291, −0.292 and −0.178) exhibit a negative association with carbon emissions. Conversely, *ROA*

TABLE 4 Main results: business strategy and carbon emissions.

Variable(s)	Panel A: contemporaneous effect			Panel B: one-year lagged effect		
	Column 1 TE Coeff. (*t*-value)	Column 2 DE Coeff. (*t*-value)	Column 3 INE Coeff. (*t*-value)	Column 4 TE Coeff. (*t*-value)	Column 5 DE Coeff. (*t*-value)	Column 6 INE Coeff. (*t*-value)
CONSTANT	4.119***	1.794***	2.847***	3.989***	1.334***	2.197***
	(15.46)	(4.98)	(11.25)	(11.89)	(3.17)	(6.20)
STRT	0.425*	0.594**	0.257	0.457*	0.657**	0.224
	(1.82)	(2.37)	(1.42)	(1.81)	(2.22)	(0.92)
SIZE	−0.188***	−0.084**	−0.143***	−0.184***	−0.057	−0.119***
	(−8.12)	(−2.62)	(−5.27)	(−7.17)	(−1.55)	(−3.62)
ROA	1.887***	1.771**	1.841***	4.5101***	4.124***	3.845***
	(3.89)	(2.55)	(3.24)	(8.24)	(5.45)	(6.88)
CAPX	3.154***	2.352***	3.427***	3.142***	2.234***	3.897***
	(7.29)	(3.92)	(8.12)	(7.14)	(3.57)	(6.12)
ASSET_TURN	0.901***	1.101***	0.945***	0.854***	1.025***	0.987***
	(11.52)	(13.12)	(12.54)	(11.47)	(10.99)	(10.01)
TOBINSQ	−0.291***	−0.292***	−0.178***	−0.347***	−0.342***	−0.221***
	(−8.13)	(−6.87)	(−5.88)	(−9.19)	(−6.12)	(−6.29)
INDUSTRY_FE	Yes	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.724	0.747	0.658	0.792	0.814	0.694
F-stat	62.79***	39.19***	55.17***	57.14***	32.69***	46.39***
N	2,241	2,178	2,178	1,891	1,698	1,698

Note: Table 4 reports the regressions result of testing the relationship between business strategy and carbon emission. The dependent variable, carbon emissions, takes three measures: *TE* (total carbon emissions); *DE* (direct carbon emissions); and *INE* (indirect carbon emissions). In Panel B one year lagged all independent and control variables. All variable definitions are in Appendix A. Heteroscedasticity-robust standard errors clustered at the firm-level are shown in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level (two-tailed tests).

(*Coefficient* = 1.887, 1.771 and 1.841), *CAPX* (*Coefficient* = 3.154, 2.352 and 3.427) and *ASSET_TURN* (*Coefficient* = 0.901, 1.101 and 0.945) exhibit a positive association with carbon emissions. These control variable findings are consistent with those reported in previous studies (e.g., Bui et al., 2020; Safiullah et al., 2023).

4.3 | Additional analysis

4.3.1 | Intensive vs non-intensive carbon firms

In line with Bui et al. (2020) and Safiullah et al., 2021; Safiullah et al., 2023), Table 5 Panels A and B present the results of business strategy and carbon emissions for intensive firms and non-intensive firms, respectively. The coefficients for *STRT* are not significant in Panel A (Columns 1 to 3). Conversely, the *STRT* variable in Panel B is significant and positive in Columns 4 and 5 but not in Column 6. This result suggests that the influence of business strategy is more pronounced among non-intensive carbon firms. The findings of the control variables are in general in line with previous findings.

4.3.2 | Additional carbon emissions measures

Table 6, Panel A, shows the findings of additional carbon emissions measures, i.e., the natural logarithm of carbon emissions divided by sales, aligning with Safiullah et al. (2023). The *STRT* coefficients are significant and positive for total carbon emissions (*TE*, *Coefficient* = 0.319, $p < 0.10$) and direct carbon emission (*DE*, *Coefficient* = 0.554, $p < 0.05$), but not for indirect carbon emissions (*INE*, *Coefficient* = 0.231, $p > 0.10$). This finding indicates an association between a prospector business strategy and both total emissions and direct emissions, with no discernible connection to indirect emissions. Overall, our findings provide evidence that prospector business strategy increases carbon emissions, confirming the predictions of our hypothesis.

TABLE 5 Business strategy and carbon emissions: carbon-intensive vs. carbon non-intensive firms.

	Panel A: carbon-intensive firms			Panel B: carbon non-intensive firms		
Variable(s)	Column 1 TE Coeff. (*t*-value)	Column 2 DE Coeff. (*t*-value)	Column 3 INE Coeff. (*t*-value)	Column 4 TE Coeff. (*t*-value)	Column 5 DE Coeff. (*t*-value)	Column 6 INE Coeff. (*t*-value)
CONSTANT	5.187***	4.114**	2.412	6.589***	4.126***	4.887***
	(3.22)	(2.12)	(1.49)	(8.12)	(4.91)	(6.17)
STRT	0.578	0.698	−0.657	0.291*	0.572**	0.247
	(0.60)	(0.62)	(−0.69)	(1.67)	(2.29)	(1.31)
SIZE	0.267**	0.355**	0.441***	−0.175***	−0.031	−0.121***
	(2.41)	(2.62)	(3.79)	(−7.88)	(−1.17)	(−4.18)
ROA	2.418	2.298	0.774	4.257***	4.117***	3.798***
	(1.31)	(0.95)	(0.45)	(9.12)	(6.39)	(6.98)
CAPX	0.587	0.297	1.051	4.145***	3.072***	5.549***
	(0.69)	(0.29)	(1.19)	(7.89)	(3.71)	(8.10)
ASSET_TURN	−0.109	−0.051	0.128	0.861***	1.024***	0.819***
	(−0.17)	(−0.09)	(0.17)	(12.98)	(11.41)	(12.71)
TOBINSQ	−0.582**	−0.789***	−0.084	−0.292***	−0.291***	−0.251***
	(−2.61)	(−2.82)	(−0.39)	(−9.92)	(−6.95)	(−6.52)
INDUSTRY_FE	Yes	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.318	0.391	0.487	0.811	0.819	0.761
F-stat	3.55***	4.79***	7.62***	101.11***	93.11***	66.61***
N	313	313	313	1,928	1,865	1,865

Note: Table 5 reports the regressions result of testing the relationship between business strategy and carbon emission. The dependent variable, carbon emissions, takes three measures: *TE* (total carbon emissions); *DE* (direct carbon emissions) and *INE* (indirect carbon emissions). All variable definitions are in Appendix A. Heteroscedasticity-robust standard errors clustered at the firm-level are shown in parentheses.

***Statistical significance at the 1% levels.

**Statistical significance at the 5% level.

*Statistical significance at the 10% level (two-tailed tests).

TABLE 6 Business strategy and carbon emissions: additional carbon emissions measures.

	Panel A: carbon emissions divided by sales			Panel B: carbon emissions divided by outstanding common share		
Variable(s)	Column 1 TE Coeff. (*t*-value)	Column 2 DE Coeff. (*t*-value)	Column 3 INE Coeff. (*t*-value)	Column 4 TE Coeff. (*t*-value)	Column 5 DE Coeff. (*t*-value)	Column 6 INE Coeff. (*t*-value)
CONSTANT	4.879***	2.487***	3.421***	6.478***	3.425***	4.145***
	(18.45)	(7.24)	(12.59)	(17.62)	(7.25)	(12.29)
STRT	0.319*	0.554**	0.231	0.478**	0.687**	0.261
	(1.79)	(2.42)	(1.17)	(2.14)	(2.41)	(1.19)
SIZE	−0.090***	0.017	−0.030	0.078***	0.179***	0.147***
	(−4.31)	(0.61)	(−1.27)	(2.81)	(5.23)	(5.69)
ROA	0.297	−0.037	−0.049	2.581***	2.517***	1.821***
	(0.57)	(−0.09)	(−0.14)	(3.84)	(3.29)	(2.78)
CAPX	3.719***	2.785***	4.011***	3.782***	2.924***	3.697***
	(8.98)	(5.27)	(10.24)	(7.22)	(4.87)	(7.11)
ASSET_TURN	−0.049	0.164*	−0.031	0.927***	1.041***	0.947***
	(−0.82)	(1.92)	(−0.48)	(11.11)	(10.29)	(11.11)
TOBINSQ	−0.257***	−0.321***	−0.242***	−0.587***	−0.597***	−0.414***
	(−8.87)	(−8.12)	(−7.27)	(−13.88)	(−11.11)	(−11.41)
INDUSTRY_FE	Yes	Yes	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.767	0.765	0.531	0.724	0.747	0.514
F-stat	46.21***	23.71***	36.17***	74.11***	53.11***	57.42***
N	2,241	2,178	2,178	2,241	2,178	2,178

Note: Table 6 reports the regressions results of testing the relationship between business strategy and carbon emission. In Panel A the dependent variable, carbon emissions, take three measures scaled by sales: *TE* (total carbon emissions); *DE* (direct carbon emissions) and *INE* (indirect carbon emissions). In Panel B the dependent variable is carbon emissions takes three measures scaled by outstanding common share: *TE* (total carbon emissions); *DE* (direct carbon emissions); and *INE* (indirect carbon emissions). All variable definitions are in Appendix A. Heteroscedasticity-robust standard errors clustered at the firm-level are shown in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level (two-tailed tests).

Following He et al. (2021) and Safiullah et al. (2023), Table 6 Panel B reports findings utilising an additional measure of carbon emissions, i.e., carbon emissions divided by outstanding common shares. The *STRT* coefficients are significant and positive for total carbon emissions (*TE*, *Coefficient* = 0.478, $p < 0.05$) and direct carbon emission (*DE*, *Coefficient* = 0.687, $p < 0.05$), but not for indirect carbon emissions (*INE*, *Coefficient* = 0.261, $p > 0.10$). These findings align with the main results (Table 4) and Table 6 Panel A. In summary, these findings are consistent with additional measures and support the hypothesis.

5 | CONTROLLING FOR ENDOGENEITY ISSUES

There are three sources of endogeneity that may arise when examining the impact of strategy on firm performance. These include unobserved heterogeneity, simultaneity and dynamic endogeneity (Ullah et al., 2018, 2021). Failure to correct for endogeneity leads to incorrect estimations, interpretations and generalisations. We carry out the following additional analysis to control for endogeneity.

5.1 | Change analysis

Change analysis captures the impact of changes in the business strategy variable on carbon emissions, addressing limitations in the preceding section's levels analysis (Ham & Koharki, 2016). Table 7 shows that changes in business strategy play a predictive role in changing carbon emissions. In particular, changes in business strategy (ΔSTRT) exhibit a positive and significant association with carbon emissions, consistently observed across all models (Δ*TE*, *Coefficient* = 0.894,

TABLE 7 Business strategy and carbon emissions: change analysis.

Variable(s)	Model 1 ΔTCE Coeff. (*t*-value)	Model 2 ΔDCE Coeff. (*t*-value)	Model 3 ΔINCE Coeff. (*t*-value)
CONSTANT	−0.069***	−0.227***	−0.297***
	(−5.19)	(−7.47)	(−12.21)
ΔSTRT	0.894***	1.318**	1.118***
	(3.78)	(2.31)	(2.98)
ΔSIZE	−0.059	−0.249	−0.392**
	(−0.69)	(−1.11)	(−2.61)
ΔROA	2.921***	3.215***	2.478***
	(9.52)	(3.54)	(4.39)
ΔCAPX	0.487	−1.218	0.049
	(1.62)	(−1.51)	(0.10)
ΔASSET_TURN	−0.089	−0.747**	−0.574***
	(−0.79)	(−2.47)	(−2.79)
ΔTOBINSQ	−0.128***	0.081	0.041
	(−3.71)	(0.99)	(0.69)
INDUSTRY_FE	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes
R^2	0.148	0.291	0.491
F-stat	22.39***	5.21***	5.11***
N	1,499	1,391	1,391

Note: Table 7 reports the regressions results of testing the relationship between business strategy and carbon emission. The dependent variable is change in carbon emissions takes three measures: *ΔTCE* (change in total carbon emissions); *ΔDCE* (change in direct carbon emissions); and *ΔINCE* (change in indirect carbon emissions). All variable definitions are in Appendix A. Heteroscedasticity-robust standard errors clustered at the firm-level are shown in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level (two-tailed tests).

TABLE 8 Business strategy and carbon emissions: firm fixed effects analysis.

Variable(s)	Column 1 TE Coeff. (*t*-stat)	Column 2 DE Coeff. (*t*-stat)	Column 3 INE Coeff. (*t*-stat)
CONSTANT	6.178***	4.841***	4.919***
	(8.12)	(6.19)	(6.71)
STRT	0.391*	0.586**	0.647***
	(1.82)	(2.41)	(2.92)
SIZE	−0.337***	−0.372***	−0.281***
	(−4.12)	(−4.69)	(−3.92)
ROA	3.164***	3.427***	2.139***
	(8.52)	(9.21)	(6.42)
CAPX	0.347	0.336	0.541*
	(1.01)	(0.98)	(1.69)
ASSET_TURN	0.019	0.062	0.023
	(0.19)	(0.62)	(0.24)
TOBINSQ	−0.179***	−0.141***	−0.082***
	(−4.89)	(−4.29)	(−2.84)
INDUSTRY_FE	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes
FIRM_FE	Yes	Yes	Yes
$_R2$	0.841	0.864	0.871
F-stat	19.81***	18.12***	10.18**
N	2,241	2,178	2,178

Note: Table 8 reports the regressions result of testing the relationship between business strategy and carbon emission. The dependent variable, carbon emissions, takes three measures: *TE* (total carbon emissions); *DE* (direct carbon emissions) and *INE* (indirect carbon emissions). All variable definitions are in Appendix A. Heteroscedasticity-robust standard errors clustered at the firm level are shown in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level (two-tailed tests).

$p < 0.01$; *ΔDE*, *Coefficient* = 1.318, $p < 0.05$; *ΔINE*, *Coefficient* = 1.118, $p < 0.01$). In summary, this result aligns with H_1, that the prospector business strategy increases carbon emissions.

5.2 | Firm fixed effects analysis

We address the omitted variable bias using firm fixed effects regressions. Table 8 shows that prospector business strategy increases total carbon emissions (*TE*, *Coefficient* = 0.391, $p < 0.10$), direct carbon emissions (*DE*, *Coefficient* = 0.586, $p < 0.05$), and indirect carbon emissions (*INE*, *Coefficient* = 0.647, $p < 0.01$). This result confirms that endogeneity issues do not influence our findings. In essence, the findings are more significant in comparison to our primary results. The results of the control variables are in line with earlier findings.

5.3 | 2SLS instrumental variable approach

In line with Sun et al. (2020), we adopt the industry mean business strategy (*STRT_IND*) as an instrument to control for potential endogeneity concerns. The selection of this instrument is appropriate considering that business strategies at the industry level can impact strategies at the firm level. Nevertheless, the impact of industry-level business strategy on a company's carbon emissions remains unclear. Table 9 Panel A, the first stage model, indicates that *STRT_IND* is positively and significantly associated with *STRT* (Coff. = 0.817, $p < 0.01$). In the second stage, we utilise the predicted value of business strategy (*STRT_P*) as the variable of interest in Columns (1) to (3). Our results confirm the positive influence of business strategy on carbon emissions. These findings further reinforce our earlier conclusion that business strategy significantly contributes to explaining heightened carbon emissions.

TABLE 9 The effect of business strategy on carbon emissions: instrumental variable (IV) analysis.

Variable(s)	Panel A 1st stage STRT Coeff. (*t*-value)	Panel B 2nd stage Column 1 TE Coeff. (*t*-value)	Column 2 DE Coeff. (*t*-value)	Column 3 INE Coeff. (*t*-value)
CONSTANT	0.021	3.885***	1.924***	0.981**
	(0.62)	(12.11)	(3.98)	(2.94)
STRT_P		0.691***	3.998***	0.277
		(2.71)	(8.97)	(0.79)
STRT_IND	0.817***			
	(9.12)			
SIZE	0.005	−0.158***	−0.324***	−0.016
	(1.49)	(−6.12)	(−7.47)	(−0.45)
ROA	0.159**	4.107***	4.997***	2.988***
	(2.41)	(8.21)	(4.24)	(3.98)
CAPX	−0.041	2.811***	11.791***	1.817***
	(−0.89)	(6.78)	(21.62)	(2.81)
ASSET_TURN	−0.017	0.807***	0.997***	0.947***
	(−1.59)	(10.98)	(10.33)	(9.17)
TOBINSQ	0.007	−0.342***	−0.267***	−0.261***
	(1.39)	(−11.01)	(−4.17)	(−5.24)
INDUSTRY_FE	Yes	Yes	Yes	Yes
YEAR_FE	Yes	Yes	Yes	Yes
R^2	0.419	0.764	0.399	0.717
F-stat	21.81***	67.12***	167.47***	24.14***
N	2,241	2,241	2,178	2,178

Note: Panel A reports the results on the first stage of an instrumental variable using STRT as a dependent variable. Panel B shows the second stage results (Column 1–3) on the effect of business strategy on carbon emissions, controlling for the predicted business strategy score obtained in Panel A. All variable definitions appear in Appendix A. Heteroscedasticity-robust standard errors clustered at the firm-level are shown in parentheses.

***Statistical significance at the 1% level.

**Statistical significance at the 5% level.

*Statistical significance at the 10% level (two-tailed tests).

6 | CONCLUSIONS

The purpose of this study is to empirically investigate the association between business strategy and carbon emissions in U.S. firms. This investigation is important because the reduction of carbon emissions is vital for environmental sustainability and climate change, and business firms are one of the major contributors to high levels of carbon emissions. Therefore, this study utilises the CDP database (for carbon emissions) and COMPUSTAT (for financial data) for U.S. firms only, from 2007 to 2020. This study considers two broad types of firms with regard to strategy, that is, prospectors and defenders, by using Bentley et al.'s (2013) adaptation of Miles and Snow (1978, 2003) strategic typology. Three different types of carbon emissions are considered, that is, total emissions, direct emissions and indirect emissions. The results show a significant association between business strategy and total carbon emissions as well as direct carbon emissions. The relationship with indirect emissions is insignificant. The results highlight that prospector firms display higher levels of carbon emissions as compared to defender firms. According to additional analysis, the impact of business strategy is more pronounced for non-intensive carbon firms. The findings of this study demonstrate that business strategy is a determinant of total, as well as direct, carbon emissions.

The primary contributions of this study are as follows. This study shows that strategic orientation (prospector or defender) is pivotal in shaping carbon emissions. It also adds to the literature on firm-level business strategy and corporate sustainability. This aspect has generally been less explored in the sustainability literature (e.g., an exception is Bui et al., 2022), however, Bui et al. (2022) use a different typology of strategy (proactive and reactive strategies) and their primary focus is on carbon accounting systems and carbon emissions. Further, this study contributes to the ongoing debate that examines whether prospectors or defenders are more environmentally friendly (Kong et al., 2020; Liu & Kong, 2021; Yuan et al., 2020). The results indicate that prospectors in the U.S. are more likely to have higher carbon emissions as compared to defenders. This could be viewed from two angles. First, prospectors may be inclined towards unethical practices and exploit carbon emissions opportunistically by misreporting or mismanaging sustainability matters (Maniora, 2018). Second, prospectors may not have appropriate alignment between business strategy and organisational structures and processes (Miles et al., 1978). Finally, this study suggests that developed economies need to pay high attention to striking a balance between economic and environmental considerations and we need to consider all economies in the struggle against environmental and sustainability problems (Liu & Kong, 2021; Maniora, 2018).

The study has policy implications for regulators, investors and other stakeholders as it informs them about the significance of business strategies in achieving a reduction in carbon emissions. These stakeholders could take different responses to influence business strategies to attain a reduction in carbon emissions and improve environmental sustainability. Further, the results are also relevant because carbon emissions are a global concern and there is pressure on firms from investors, regulators, creditors and other stakeholders, to reduce carbon emissions.

This study has some limitations. Firstly, its reliance on the CDP database restricts the results generalisability to data reported in other databases not captured by the CDP. Secondly, the emissions data are reported voluntarily to the CDP and may not be 100% accurate. Thirdly, we investigate only firms that responded to the CDP from 2007 to 2020 and do not reflect changes over a longer period of time. Longitudinal studies may investigate changes over time. Fourthly, this study only considers U.S. firms. Future studies could address these limitations by including different time periods, firms and countries, and considering other variables like carbon accounting systems and circular economy practices (e.g.; Cheffi et al., 2023).

Future studies can use multiple ESG ratings to establish a relationship between ESG scores and carbon emissions. Additionally, investigating the influence of corporate governance mechanisms such as CEO characteristics, cross-listings, gender diversity and compliance with governance codes on carbon emissions could provide valuable insights. Finally, future studies can examine whether early adopters of IFRS S1 have lower levels of carbon emissions disclosure.

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APPENDIX A

A.1 | Variable definitions

Variable name	Symbol	Descriptions	Source
Total carbon emissions	TE	Following Bose et al. (2021) and Safiullah et al. (2023), TE is measured as log of (Scope 1&2)/assets total	CDP
Direct carbon emissions	DE	DE is measured as log of (scope 1/assets total	CDP
Indirect carbon emissions	INE	INE is measured as log of (scope 2/assets total	CDP
Business strategy	STRT	Strategy scores at firm level following Bentley et al. (2013). A composite strategy score is created for each firm-year using the following steps. First, from the COMPUSTAT database we collected data on the six strategy-related variables that make up the overall strategy score on a firm-year basis. These variables, as defined in Appendix B, are *R&D_S5*, *EMP_S5*, *REV_S5*, *SGA_S5*, *σ (EMP_S5)* and *CAP_S5*. Each of the variables was measured at firm-year level as the rolling prior five-year average to reduce time-based variation. Second, all the observations on each variable were classified into industry categories based on 2-digit SIC codes. Third, each observation was divided into five quintiles and, except for the case of observations on *CAP_S5*, assigned a score of 1 for those falling in the lowest quintile (representing the traits of a defender) to 5 for those falling in the highest quintile (representing the traits of a prospector). The industry-adjusted observations on *CAP_S5* were reverse-scored so that observations in the lowest (highest) quintile received a score of 5 (1). Finally, we computed a composite firm-year strategy score, *STRATEGY*, by adding the scores for each firm-year across the six variables. Therefore, our strategy scores could have a maximum value of 30 and a minimum value of 6. From *STRATEGY* scores, firm-years were categorized into different strategies based on the following criterion: defenders (6–12), analysers (13–23), and prospectors (24–30). Because analysers exhibit some traits of both defenders and prospectors, we focus on the defenders and prospectors and use the analysers as the benchmark for the other two categories.	COMPUSTAT
Firm size	FIRM SIZE	Natural logarithm of total assets.	COMPUSTAT
Return on assets	ROA	Net income scaled by assets total.	COMPUSTAT
Capital expenditure	CAPX	Capital expenditure scaled by total assets.	COMPUSTAT
Assets turnover	ASSET_TURN	Sales divided by total assets.	COMPUSTAT
Tobin's Q	TOBINSQ	Sum of the market value of equity plus the book value of total debt scaled by total assets	COMPUSTAT

APPENDIX B

B.1 | Component Variables for Strategy Scores

Variable	Description	Measure
Ratio of research and development to sales (R&D_S5)	Inclination to search new products and services	Ratio of R & D expenditure to sales which is calculated over a rolling prior five-year average.
Ratio of employee to sales (EMP_S5)	Effective utilisation of resources	Ratio of the number of employees to sales which is computed over a rolling prior five-year average.
Change in total revenue (REV_S5)	Historical growth or investment opportunities	One-year percentage change in total sales computed over a rolling prior five-year average.
Marketing to sales (SGA_S5)	Exploiting new products and services	Selling, general and administrative expenses to sales ratio which is computed over a rolling prior five-year average.
Employee fluctuations (σ (EMP_S5))	Organisational stability	Standard deviation of the ratio of employees to sales
Capital intensity (CAP_S5)	Efficiency of technology	Capital intensity is measured as net property, plant and equipment to total assets and is computed over a rolling five-year average.