

Carbon performance and corporate financial performance during crises

Evidence from the COVID-19 pandemic and the Global Financial Crisis

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Abstract

Economic crises offer a valuable perspective on the relationship between carbon performance and corporate financial performance (CFP). Crises test corporate performance and challenge the allegedly universal synergies that developed under “normal” circumstances. However, the current research in this area is limited and has often yielded insignificant results. Drawing from a global dataset spanning 15 years, we investigate the moderating influences of two distinct crises on the interplay between carbon emission intensity and CFP. Employing fixed-effects regression analysis, we dissect these critical periods, offering nuanced insights into their distinct impacts. The contrasting nature of the Global Financial Crisis (GFC) and the COVID-19 pandemic is central to this study. The COVID-19 pandemic, characterized by *operational* disruptions and natural resource scarcities (supply-side shock), significantly amplified the benefits of carbon reduction strategies, highlighting the value of efficient processes and cost efficiencies. In contrast, the GFC did not exhibit a significant impact on the carbon–CFP relationship. This differentiation is attributed to the GFC’s *finance*-driven nature (demand-side shock), and the resultant evolution in stakeholder preferences and organizational structures. This study extends beyond the debated territory of environmental, social, and governance (ESG) scores. It also provides a nuanced understanding of carbon performance’s role subject to the unique characteristics of a crisis.

KEYWORDS

carbon disclosure, carbon performance, corporate financial performance, corporate social responsibility, corporate sustainability, scope 1 emissions

1 | INTRODUCTION

Carbon emissions have assumed a central role in the discourse on climate change, as underscored by the Paris Agreement’s call for substantial emission reduction (IPCC, 2018). This imperative has gained further relevance in the face of increased regulatory efforts and heightened stakeholder pressure on carbon performance (Busch, Bassen et al., 2022)—the Volkswagen “Dieselgate” scandal, for example, illustrates the significance of emission disclosure and performance (Bouzzine & Lueg, 2020). A substantial body of academic literature has emerged that examines carbon

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performance. One focus within this domain is the relationship between carbon performance and corporate financial performance (CFP). Existing studies predominantly suggest a positive link (comprehensive reviews of the field; Busch & Lewandowski, 2018; Velte et al., 2020) with some notable exceptions (Busch, Bassen et al., 2022; Delmas et al., 2015).

However, existing theoretical frameworks present two opposing views on how corporate sustainability, in general, enhances or impairs performance in times of economic crisis. One perspective posits that crises exert significant pressure on firms, leading decision-makers to adopt more conservative and defensive strategies (Muhammad et al., 2015). This approach might compel firms to curtail emission reduction initiatives as a cost-saving measure to mitigate financial shocks (Gallego-Álvarez et al., 2015; Petitjean, 2019). Consequently, firms often face the challenge of how to reconcile sustainable practices with financial performance, grappling with the dilemma of “doing good” versus “doing well” in turbulent times (Marsat et al., 2021). In contrast, another viewpoint suggests that navigating financial crises and adhering to sustainability principles share common necessities, particularly the need for innovation to secure long-term corporate survival (Lopatta & Kaspereit, 2014). In this light, effective carbon management plays a key role in enhancing social capital and building trust in firms (Nirino et al., 2022). These assets take on enhanced importance during crises, a time when trust in firms and markets typically wanes (Demers et al., 2021; Lins et al., 2017).

Our empirical study follows up on these argumentations on the relationship between carbon performance and CFP during crises. The majority of existing research focuses on corporate sustainability, often assessed using debated and opaque ESG scores (Demers et al., 2021; Dobrick et al., 2023). Our study addresses the notable scarcity of studies that specifically concentrate on precisely measured carbon emission intensity (The Economist, 2022; Velte et al., 2020). Moreover, studies predominantly examine the Global Financial Crisis (GFC) period and report a negligible impact on CFP (Gallego-Álvarez et al., 2014; Hoang et al., 2020; Petitjean, 2019). Our research aims to provide clarity on this issue, positioning the study around the research question: *How does carbon performance influence CFP in times of crisis?*

Thereby, our study is the first to demonstrate the crisis-specific effects of carbon performance on CFP during the two most significant global crises in recent history. Our research employs fixed-effects regression analysis over 15 years from 2007 to 2021, utilizing an international sample from major developed markets, and investigates the nuanced impacts of relative carbon emissions (The Economist, 2022). Our analyses separately test for possibly different moderating effects of the recent COVID-19 pandemic and the GFC of 2008/2009. Specific effects of each crisis may not be obvious as both crises have similar (e.g., economic recessions) as well as distinct characteristics (e.g., the specific supply and demand effects).

Our results indicate that firms with lower carbon emission intensity generally exhibit higher CFP. Notably, the particular characteristics of the economic crisis moderate this relationship. During the COVID-19 pandemic, low-emission strategies significantly enhanced CFP by being particularly responsive to the operational challenges and resource shortages characteristic of this crisis. In contrast, the financial nature of the GFC did not have a similar moderating effect. Our findings on carbon emissions expand on the pioneering work of Lu et al. (2022), who used ESG scores instead of emissions, by providing confirmatory evidence that is not subject to the size biases inherent in the commonly used ESG scores (Dobrick et al., 2023; Drempetic et al., 2019). As well as confirming the widely examined CFP-improving effect of carbon performance, we expand on the extant literature that is limited to analyses on the individual crisis level. By comparing and contrasting the effects of the COVID-19 pandemic with those of the GFC, our study makes four contributions.

First, our study provides pioneering insights into the carbon–CFP link during the COVID-19 pandemic, highlighting that firms with lower carbon emission intensity outperformed their counterparts even more significantly than under normal conditions. In line with the Natural-Resource-Based View of the Firm (NRBV) (Hart, 1995), we contend that strategies focused on low carbon emissions cultivate resources through efficient processes and cost reductions, leading to an even more pronounced competitive advantage in times of crisis.

Second, we explain the differing results of the GFC based on the nature of the crisis and time effects. Although low-emission firms were able to mitigate the reduced supply and resource constraints arising from lockdowns and travel restrictions during the COVID-19 pandemic through their efficient production capabilities (Jebabli et al., 2022), these proved less effective during the GFC.

Third, our analysis employs a different research design than previous studies on the GFC, but corroborates their findings on the link between carbon performance and financial performance (Gallego-Álvarez et al., 2014; Hoang et al., 2020; Petitjean, 2019). This indicates that carbon measures might be more reliable across providers than the broader and opaque ESG scores (Berg et al., 2022; Chatterji et al., 2016; The Economist, 2022).

Fourth, the aftermath of the GFC led to regulatory changes, alongside shifting stakeholder preferences toward sustainability (Lopatta & Kaspereit, 2014). However, the organizational structures and sustainability strategies at the time were not fully developed, limiting their effectiveness in crises. This pattern suggests that the advantageous effects of carbon reduction strategies are more evident in crises following the GFC. Our findings, particularly the performance observed during the COVID-19 pandemic, underscore the strategic value of reducing carbon emission intensity to mitigate the impact of future economic crises.

2 | THEORETICAL FOUNDATION

2.1 | Definitions of key terms

2.1.1 | Corporate financial performance

CFP is a reflection of firm performance that “shows the financial return the company receives in each year of operation” (Gallego-Álvarez et al., 2014, p. 365) and is approached from both a market and an accounting perspective. Hamann et al. (2013) categorize performance indicators into the four different dimensions of stock market performance, firm growth, and the accounting-based measures of profitability and liquidity. We refer to CFP in terms of the two categories of stock market performance and profitability as these are the two predominantly used in empirical research (Busch & Lewandowski, 2018). We do not consider the firm growth category as a CFP indicator since growth is already accounted for in our carbon emission intensity variable (see Section 3.2.2). We omit liquidity measures as these tend to be short-term oriented, volatile in times of crises, and dependent on unused, and thus difficult to assess, credit lines that conceal the full extent of liquidity of a firm (Lang & Maffett, 2011; Lins et al., 2010). Comprising investors’ views on present and future benefits, market-based measures incorporate a long-term horizon and have the advantage over accounting-based indicators of being less easily influenced by managers (Velte et al., 2020). Profitability ratios are also a powerful tool commonly used in practice and research. Displaying a firm’s profit-generating ability relative to revenue, assets, or equity, profitability measures hold predictive power regarding corporate well-being or distress and failure (Secinaro et al., 2020).

2.1.2 | Carbon performance

Carbon performance is a “firm’s level of GHG emissions and management strategies that address climate change” (Busch & Hoffmann, 2011, p. 238). Our study specifically defines carbon performance as carbon emission intensity in order to assess carbon emissions *relative* to the produced output (i.e., *total amount of direct CO₂ and CO₂ equivalent emissions*, divided by *revenue*). Beyond ethics and regulations, the NRBV (Hart, 1995) suggests that firms have the incentive of increased CFP when reducing carbon emissions (De Stefano et al., 2016; Russo & Fouts, 1997). The first mechanism supporting this relationship is pollution prevention, which reduces the costs of regulatory compliance and waste disposal (Hart & Dowell, 2011; Porter & van der Linde, 1995). Second, efficient carbon performance enhances production efficiency by reducing required inputs, simplifying processes, and lowering compliance and liability costs (Hart & Dowell, 2011; Weinhofer & Hoffmann, 2010). These improvements lead to cost savings and optimized workflows, resulting in lower scrap rates (Lopatta & Kaspereit, 2014; Marsat et al., 2021). Third, low carbon emission reduces environmental risks and associated costs, building resources that create a strategic advantage over competitors reliant on inefficient resource use (Busch & Hoffmann, 2011).

2.1.3 | Crisis

Most definitions of *crisis* focus on the impact of disadvantageous events on firms (Ulmer & Sellnow, 2000). Three elements are considered fundamental to constitute a crisis: a triggering event causing or being likely to cause substantial change, a feeling of managerial inability to handle this change, and the severity of the trigger threatening firm survival (Keown-McMullan, 1997). Accordingly, a crisis can be defined as “a specific, unexpected, and non-routine event or series of events that create high levels of uncertainty and threaten or are perceived to threaten an organization’s high priority goals” (Ulmer & Sellnow, 2000, p. 144). Corresponding to this definition, crisis is referred to in this study in terms of the two major *global* economic crises of the past decades, the COVID-19 pandemic and the GFC of 2008/2009. We focus on these two crises because the World Bank notes that they are, by far, the most similar, and unmatched in their global reach, the depth of their economic recession, and the magnitude of the policy responses they triggered since World War II (Kose & Sugawara, 2020). At the same time, these crises differ significantly in their impact on industrial production and, thereby, carbon emissions (Bersalli et al., 2023; Jalles, 2019; Li et al., 2022; Yang et al., 2022). This provides a valuable setting for a differentiated examination of the relationship between CFP and carbon performance in times of crises.

2.2 | Hypotheses development

2.2.1 | Carbon emissions and financial performance during crises

Various theoretical approaches imply that sustainability becomes a secondary concern for firms striving to survive during economic downturns. Muhammad et al. (2015) suggest that crises pressure firms to adopt cost-saving measures, such as curtailing emission reduction initiatives.

Gallego-Álvarez et al. (2015) and Petitjean (2019) emphasize the challenge firms face in balancing sustainable practices with financial performance during turbulent times. Ducassy (2013) relies on principal-agent theory to propose that managers prioritize short-term financial stability over long-term environmental goals during crises. Hoang et al. (2020) reference stakeholder theory, and similarly argue that stakeholders demand financial prudence during economic turmoil, often at the expense of ESG commitments. Gallego-Álvarez et al. (2014) show that during COVID-19, firms with high leverage deprioritized ESG spending to ensure financial solvency. Engelhardt et al. (2021) argue that during crises, risk-averse investors may penalize firms with significant ESG expenditures because they view these expenses as diverting resources away from immediate financial performance. Corporate social responsibility (CSR) theories suggest that related CSR activities are seen as non-essential during crises: Demers et al. (2021) find that firms with higher CSR ratings did not necessarily perform better during the COVID-19 crisis. Broadstock et al. (2021) document that firms with substantial ESG investments faced greater financial constraints, leading to the postponement or reduction of these initiatives during economic downturns.

Opposed to these arguments—and consistent with the rationale of the NRBV—Busch and Lewandowski's (2018) meta-analysis and Velte et al.'s (2020) systematic literature review support the view that carbon performance, in particular, generally correlates positively with CFP, albeit with some exceptions (Busch, Bassen et al., 2022; Delmas et al., 2015). However, neither review finds enough evidence concerning carbon emissions and financial performance to address whether this relationship persists during economic crises. To bridge this gap, we conducted a literature review encompassing CFP during significant crises, extending beyond carbon emissions to include the broader fields of CSR, corporate sustainability (CS), and ESG scores. Table 1 presents a scoping review (Booth et al., 2021) of the existing literature, indicating that superior CSR/CS/ESG practices, as well as carbon performance, are generally associated with enhanced CFP.

Despite the somewhat tangential relationship between carbon emissions and CSR/CS/ESG, the findings in Table 1 provide a preliminary basis for our first investigation. We propose:

H1: Carbon performance has a positive influence on CFP which is strengthened during economic crises.

2.2.2 | Carbon emissions and financial performance during the COVID-19 pandemic

The COVID-19 pandemic and the GFC exhibit major similarities, such as uncertainty, stock market crashes, and economic recession (Giakoumelou et al., 2022; Lu et al., 2022). Tangential studies employing ESG scores, resource use scores, and CSR practices suggest that better performance in these areas had a more favorable effect on CFP during the COVID-19 pandemic (Albuquerque et al., 2020; Broadstock et al., 2021; Díaz et al., 2021; Ding et al., 2021; Engelhardt et al., 2021; Garel & Petit-Romec, 2021; Lu & Khan, 2023; Lu et al., 2022; Ullah et al., 2022; Yoo et al., 2021). Only a very few exceptions with mixed (Nirino et al., 2022) and insignificant findings (Bae et al., 2021; Demers et al., 2021) exist. We formulate specific hypotheses on carbon performance, since, first, the relationship between carbon performance and CSR/CS/ESG is only tangential, and, second, the two crises differ in several aspects. Unlike the regulatory compliance and short-term liquidity issues of the GFC, the pandemic was a supply-side shock, followed by quick policy responses that addressed broader, long-term stakeholder expectations.

While no extant study specifically examines the relationship between carbon performance and CFP during the COVID-19 pandemic, there are several conceptual reasons to believe that better carbon performance should be associated with higher CFP during this crisis. The economic crisis triggered by the pandemic was an exogenous event. The COVID-19 outbreak led to lockdowns and travel restrictions that first affected the real economic sector before spreading to the financial sector (Jebabli et al., 2022). This *supply-side*-induced crisis resulted in a shock of limited resources and materials (Lu et al., 2022), which could not be offset even by the unprecedented government subsidies provided in many countries.

Firms with low carbon emission intensity were able to play to their strength during the pandemic: they could produce similar levels of outputs as their competition while using a lower level of carbon-related resources (Bertram et al., 2021; Guérin & Suntheim, 2021). Thereby, their outputs were both cheaper and less reliant on disrupted global supply chains. Moreover, investors see a favorable relationship between low carbon emissions and technical innovativeness, agility, and business model innovation (Fernández et al., 2018). Because a low-carbon strategy enables resource-efficient production processes in line with the NRBV, firms with low carbon emission intensity were able to cope with the inherent economic problem of the pandemic. We hypothesize:

H1a: Carbon performance has a positive influence on CFP which was substantially strengthened during the COVID-19 pandemic.

2.2.3 | Carbon emissions and financial performance during the Global Financial Crisis

The nature of the GFC substantially differed from the COVID-19 pandemic and warrants its own theorization. We can see in Table 1 that the majority of studies agree that better CSR/CS/ESG performance was associated with better CFP during the GFC. Empirical research on carbon

TABLE 1 Overview of the extant literature on corporate sustainability and corporate financial performance during crises.

Year	Author	CS measure	CFP measure	Crisis measure	Results
Panel A: COVID-19 pandemic and GFC					
2022	Lu et al.	ESG Score—Average of E/S (Refinitiv)	ROA & ROE	Moderator—Crisis year-dummies	Mixed effects: - Unfavorable effect of CS during the GFC (–) - Favorable effect of CS during the COVID-19 pandemic (+)
Panel B: COVID-19 pandemic					
2023	Lu and Khan	ESG; E- and S-score, Average of E/S (Refinitiv)	ROA & ROE	Moderator—Dummy 1 for 2020/2021	Favorable effect (+)
2022	Nirino et al.	E- and S-score (Refinitiv)	Stock returns	Separate regressions for crisis- and post-crisis-returns (based on Lins et al., 2017)	Mixed effects: - Insignificant results for E-Score (0) - Unfavorable effect for S-Score (–)
2022	Ullah et al.	Resource Use score (Refinitiv)	Stock price performance	Recovery time of daily stock prices to pre-crisis level (i.e., December 17, 2020)	Favorable effect (+)
2021	Bae et al.	CSR categories: community, diversity, employee relations, environment, human rights (MSCI ESG Stats); average of E- and S-score (Refinitiv)	Cumulative weekly stock return (raw and abnormal)	Separate regressions for crisis- and post-crisis-returns (based on Lins et al., 2017)	Insignificant results (0)
2021	Broadstock et al.	ESG scores (SynTao Green Finance)	Stock returns	Separate regressions for inside-crisis- and post-crisis-returns	Favorable effect (+)
2021	Demers et al.	ESG scores (Refinitiv and MSCI)	Abnormal stock returns	Returns regressions for Q1 2020 crisis period and full year of 2020	Insignificant results (0)
2021	Díaz et al.	ESG scores (Sustainalytics)	Portfolio stock returns	Returns regressions for daily data from January to April 2020	Favorable effect (+)
2021	Ding et al.	ESG scores (Refinitiv)	Stock returns	Moderator: interaction of ESG score and weekly growth rate of confirmed COVID-19 cases	Favorable effect (+)
2021	Engelhardt et al.	ESG scores (Refinitiv)	Cumulative stock return (raw and abnormal)	Returns regressions for the period from February 3, 2020 to March 23, 2020	Favorable effect (+)
2021	Garel and Petit-Romec	E-score and E-subscores (Refinitiv)	Stock returns	Returns regressions for the period from February to March 2020	Favorable effect (+)
2021	Yoo et al.	E-, S-, and G-scores (Arbesque S-Ray)	Stock returns (raw and abnormal) and volatility	Moderator—Dummy 1 for 2020	Favorable effect (+)
2020	Albuquerque et al.	ESG Score—Average of E/S (Refinitiv)	Abnormal returns, return volatility, operating performance (ROA, OPM, asset turnover)	Regressions for crisis period Q1/2020; Moderator regression: COVID dummy 1 for February 24–March 31, 2020, Policy Response dummy 1 for March 18–March 31, 2020	Favorable effect (+)

(Continues)

TABLE 1 (Continued)

Panel C: GFC				
2021	Berkman et al.	ESG Score (KLD & Refinitiv)	Cumulative stock returns Return regression for the period from August 2008 to March 2009	Insignificant results (0)
2020	Hoang et al.	Environmental performance: GHG emissions, water use, waste disposal (Bloomberg)	ROA, ROCE, MB, PE	Two subsamples (pre- and post-crisis) Insignificant results for carbon emissions (0)
2020	Marsat et al.	E-Score (Refinitiv)	Duration for firm's weekly market price to recover to pre-crisis level	Return regressions for the crisis period from October 2007 to October 2011 Unfavorable effect (-)
2019	Petitjean	ESG score, E/S/G-scores, E-subscores (e.g., GHG emissions) (Bloomberg)	Profit margin, ROA, EPS, price to book value, stock returns	Moderator—Dummy 1 for 2008/09 Insignificant results for carbon emissions (0)
2017	Lins et al.	CSR categories: community, diversity, employee relations, environment, human rights (MSCI ESG Stats)	Stock returns (raw and abnormal)	Separate regressions for inside-crisis- and post-crisis-returns Favorable effect (+)
2017	Manrique and Marti-Ballester	E-Score (Refinitiv)	ROA & Tobin's Q	Research period from 2008 to 2015 to imply findings for GFC Favorable effect (+)
2016	Li et al.	Green Sustainability Program adoption (text analysis of annual reports)	Net income, inventory turnover, ROA	Two subsamples (pre- and post-crisis) Favorable effect (+)
2016	Cornett et al.	ESG Score (MSCI ESG Stats)	ROE	Two subsamples (pre- and post-crisis) Favorable effect (+)
2015	Muhammad et al.	Weighted Toxicity Score (Australian Pollutant Release and Transfer Registers)	ROA and Tobin's Q	Two subsamples (pre- and post-crisis) Insignificant results (0)
2014	Gallego-Álvarez et al.	Emission intensity (total CO ₂ emissions/revenue) (Carbon Disclosure Project)	ROA	Moderator—Dummy 1 for 2008/2009 Insignificant results for carbon emissions (0)
2014	Lopatta and Kasperit	Sustainability ratings (GES)	Market value of equity	Moderator - Dummy 1 for post-crisis periods (from end of 2008) Favorable effect (+)
2013	Ducassy	Corporate social performance (CFIE rating)	Information ratio (Excess stock returns over benchmark divided by benchmark's tracking error)	Returns regressions for 6-month periods around July 18, 2007 Mixed effects: - Favorable effect for early stage (+) - Insignificant results before crisis and in later crisis-stages (0)

Note: This table provides an overview of the current state of extant literature on CS and CFP during times of crisis. Based on the examined crises, studies are divided into three panels. In Panel C, three papers with special importance for our research are highlighted in bold because they explicitly analyze carbon emissions as opposed to the remaining studies that focus on more general examinations of higher-level CS constructs. Within the panels, studies are sorted in descending order by year and author. For a quick overview of obtained results in the last column, (+) refers to a CFP-improving effect of CS during the crisis, (-) refers to an unfavorable CS impact during the crisis and (0) refers to an insignificant relationship between CS and CFP during the crisis. It becomes apparent that the majority of studies identify a positive effect of CS on CFP during the crisis. While this tentative consensus is particularly evident during the COVID-19 pandemic, some insignificant results are also found for the GFC and in all three papers that focus on carbon emissions.

performance during crises is scarce and has produced only insignificant results for the GFC (Gallego-Álvarez et al., 2014; Hoang et al., 2020; Petitjean, 2019).

The GFC was an endogenous crisis, triggered by tumbling US subprime mortgages. Thus, as Bouri et al. (2021) show, the financial sector was impaired through a shortage of capital and rising interest rates before real economic activities were affected—this demand-side-induced crisis caused reduced demand for goods and services. Government guarantees and subsidies primarily supported banks—rather than consumers, and were smaller and enacted more slowly than during the pandemic (Lu et al., 2022).

Firms with low carbon emission intensity could not play to their strengths during the GFC: there is no evidence that firms with better carbon performance had systematically better access to capital during this crisis. In fact, the struggle to cope with low liquidity led to aggressive cost-cutting measures that postponed non-immediately essential investments, such as carbon reductions (Campello et al., 2010). Firms engaged in long-term, green investments faced difficulties in providing ready-to-liquidate collaterals to their creditors and satisfying investors' contemporary preference for immediate returns and curbed risks (Schoenmaker & Schramade, 2019). Specifically, the GFC affected real estate disproportionately, especially expensive, low-emission buildings which already struggle to maintain their realistic market values during normal economic downturns (Andrews et al., 2016). In parallel, regulatory support for low-carbon initiatives was weakened or delayed after the GFC (Campiglio et al., 2017). We hypothesize:

H1b: Carbon performance has a positive influence on CFP which was weakly strengthened during the GFC.

3 | RESEARCH DESIGN

3.1 | Sample

The study analyzes an international sample from developed economies, including firms listed in major indices (S&P 500; STOXX Europe 600; Nikkei 225; and S&P/TSX60), over 15 years from 2007 to 2021. This period covers significant events including the GFC and the COVID-19 pandemic. Data were sourced from the Refinitiv Datastream database. The initial sample of over 1300 firms was refined by excluding financial sector firms and underrepresented countries. Table 2 presents the sample by country and industry. The initial number of possible firm-year observations (16,605, as shown in the table) was reduced in the analysis due to missing data points because the study deals with unbalanced panel data; this still results in a substantial dataset of at least 5751 firm-year observations for analysis, despite some data gaps in early years' carbon emissions.

3.2 | Variables

3.2.1 | Corporate financial performance

The study evaluates CFP using both accounting-based and market-based measures. Return on assets (ROA) and Tobin's Q are the primary metrics used (Busch & Lewandowski, 2018). ROA assesses a firm's profitability by comparing net income to total assets, while Tobin's Q measures market valuation by dividing a firm's enterprise value by its book value of assets. These measures align with established literature and provide a comprehensive view of a firm's financial health and market performance (e.g., Manrique & Martí-Ballester, 2017; Muhammad et al., 2015).

3.2.2 | Carbon performance

We opted for carbon emission intensity in our main analysis due to its effectiveness in capturing operational efficiency (Busch & Lewandowski, 2018, p. 748) as the "quantity of carbon emissions necessary to generate one monetary unit of the chosen business metric" (p. 748) as well as for the methodological reasons described in Section 1. Emission intensity was calculated with EIKON data as the *total amount of direct CO₂ and CO₂ equivalent emissions in metric tons*, divided by *revenue in thousand USD* (Table 3). We complemented our analysis with a robustness test using absolute emissions. Our measurement of carbon emissions used direct scope 1 emissions, which we logarithmized against revenue to align with other model variables (Busch & Hoffmann, 2011).

3.2.3 | Moderating crisis effect

We included dummy variables in the regressions as moderators. The COVID-19-dummy is 1 in 2020 (Bae et al., 2021; Lu et al., 2022) and the GFC dummy is 1 in the years 2008/2009 (Gallego-Álvarez et al., 2014; Lins et al., 2017). The selection of year-dummies was based on extant literature and

TABLE 2 Sample distribution across countries and industry sectors.

Country	Industry							Total
	Construction	Manufacturing	Mining	Retail Trade	Services	Transportation and Public Utilities	Wholesale Trade	
United States	105	2775	195	465	1125	1050	195	5910
Japan	135	1995	30	75	285	360	90	2970
United Kingdom	105	570	105	210	240	225	75	1530
France	45	435	30	45	240	105	45	945
Germany	15	540	15	30	135	150	30	915
Sweden	15	465	0	30	120	45	15	690
Canada	0	105	150	120	75	195	15	660
Switzerland	0	465	15	30	75	60	15	660
Netherlands	0	240	0	15	120	15	15	405
Denmark	0	210	0	0	45	45	0	300
Italy	0	135	15	15	15	120	0	300
Spain	45	60	0	15	15	150	0	285
Ireland	0	165	0	0	60	15	30	270
Finland	15	135	0	15	15	30	0	210
Norway	0	120	30	0	0	15	15	180
Belgium	15	75	0	0	15	15	0	120
Luxembourg	0	30	0	30	15	30	0	105
Austria	0	75	0	0	0	15	0	90
Poland	0	15	15	30	0	0	0	60
Total	495	8610	600	1125	2595	2640	540	16,605

Note: This table shows the distribution of firm-year observations in total numbers by country of domicile and industry sector groups classified according to SIC Codes after preliminary data preparation and the exclusion of firms from the financial sector and countries with very few observations.

is in line with economic data. Over the last 20 years, the US GDP, as an indicator of financial distress and global recession and crisis periods, shows a severe decline only in 2008, 2009, and 2020 (U.S. Bureau of Economic Analysis, n.d.). Similarly, we observed a significant drop in the financial performance metrics of our study, especially ROA, in these three years. 2021 is not considered as a crisis year-dummy since the peak of the COVID-19 pandemic occurred in 2020. First vaccines had been introduced by December 2020. All included stock indices reached their pre-crisis levels in the course of late 2020 or early 2021 already. Leading indicators surveying business and consumer sentiment like the German ifo Business Climate Index (ifo Institute, 2024) or the US Consumer Confidence Index (The Conference Board, 2024) confirm our classification. Therefore, we argue that the years 2008, 2009, and 2020 marked the height of the respective crisis with the most severe effect on firms' performance.

3.3 | Control variables

We employed common control variables. Firm size (Lu et al., 2022; van Beurden & Gössling, 2008) is expressed in terms of the natural logarithm of total assets (Lu & Khan, 2023). The leverage ratio controls for the effect of capital structure and is calculated as total debt over common equity (Lee et al., 2016). R&D intensity is included to control for innovative capacity (Hoang et al., 2020). The effect of corporate governance is controlled for by board gender diversity and expressed as a percentage of female directors on the board (Lu et al., 2022). Table 3 lists all variable descriptions and their data sources.

3.4 | Regression model

The following fixed-effects model was applied, as suggested by the Breusch–Pagan–Lagrange multiplier test points and the Hausman test, with cluster-robust standard errors using the Huber–White sandwich estimator. Heckman corrections were conducted for every regression. Ramsey's

TABLE 3 Overview of variables.

Variable	Description	Source
ROA	Return on assets, $ROA = \frac{\text{Net income}}{\text{Total assets}}$, winsorized at 1% and 99% levels	WC08326
Tobin's Q	Tobin's Q = $\frac{\text{Enterprise value (EV)}}{\text{Total assets}}$, (EV = market capitalization + book value of net debt), winsorized at 1% and 99% levels	EV: 18100 Assets: WC02999
Emission intensity	Emission intensity = $\frac{\text{Total amount of direct CO}_2 \text{ and CO}_2 \text{ equivalent emissions in metric tons}}{\text{Revenue in thousand USD}}$ winsorized at 1% and 99% levels, logarithmized, 1-year lag	Emission: ENERDP024 Revenue: WC07240
Economic crises	Dummy variable for times of economic crisis that is 1 for the years 2008/2009/2020 and 0 otherwise	–
COVID-19	Dummy variable for the COVID-19 pandemic that is 1 for the year 2020 and 0 otherwise	–
GFC	Dummy variable for the GFC that is 1 for the years 2008/2009 and 0 otherwise	–
Firm size	Total assets in USD, winsorized at 1% and 99% levels, logarithmized, 1-year lag	WC07230
R&D intensity	Research & development intensity, $R\&D \text{ intensity} = \frac{\text{R\&D expenses}}{\text{Revenue}}$, winsorized at 1% and 99% levels, 1-year lag	R&D: WC01201 Revenue: WC01001
Leverage	Leverage ratio, $\text{Leverage} = \frac{\text{Total debt}}{\text{Total equity}}$, winsorized at 1% and 99% levels, 1-year lag	WC08231
Board diversity	Board gender diversity in terms of the percentage of female directors in the board of directors, 1-year lag	CGBSO03V
ROE	Return on equity, $ROE = \frac{\text{Net income}}{\text{Total equity}}$, winsorized at 1% and 99% levels, included as robustness test	WC08310
Absolute carbon emissions	Total amount of direct CO ₂ and CO ₂ equivalent emissions in metric tons, winsorized at 1% and 99% levels, logarithmized, 1-year lag, included as robustness test	ENERDP024

Note: In this table, all variables utilized in the analysis are outlined. Respective descriptions/formulas and data sources in Refinitiv Datastream are given for possible replication.

RESET test confirms a correct model specification:

$$CFP_{i,t} = \beta_0 + \beta_1 \text{Carbon performance}_{i,t-1} + \beta_2 \text{Crisis} + \beta_3 \text{Carbon performance}_{i,t-1} \times \text{Crisis} + \sum \text{Controls}_{i,t-1} + \sum \text{FFE} + \sum \text{YFE} + \varepsilon_{i,t}$$

4 | RESULTS

4.1 | Descriptives and correlation analysis

Summary statistics and a pairwise correlation matrix are presented in Table 4. It reveals a significant negative correlation at the 1% level between carbon emission intensity and both the CFP measures, ROA, and Tobin's Q. Based on the inverse measurement scale of emission intensity, low-carbon firms appear to be connected to higher CFP. Firm size and leverage show a significant negative correlation with the CFP proxies, whereas board diversity is positively related. Except for R&D intensity, all variables show the same direction of influence toward the two CFP measures.

4.2 | Main regression analysis

Regression results are presented in Table 5. In line with measuring CFP in terms of accounting- as well as market-based performance, the analysis is divided into an examination of ROA and Tobin's Q. To account for the influence of economic crises, three separate moderator analyses within fixed-effects regressions are performed: The carbon performance–CFP link in times of crisis overall (1), the relationship in times of the COVID-19 pandemic (2), and during the GFC (3).

The overall crisis effects (1) are determined by including a joint crisis proxy and suggest a statistically negative and highly significant general relationship between emission intensity and both performance measures—ROA ($\beta = -0.682, p < 0.01$) and Tobin's Q ($\beta = -0.153, p < 0.01$). More

TABLE 4 Descriptive statistics and correlation analysis.

Variables	N	Mean	Std. Dev.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) ROA	15,732	6.993	7.177	-17.6	33.67	1.000						
(2) Tobin's Q	15,431	1.674	1.547	0.294	9.506	0.554*	1.000					
(3) Emission intensity	8729	-3.721	2.396	-8.704	1.572	-0.249*	-0.322*	1.000				
(4) Firm size	15,742	16.04	1.49	11.917	19.338	-0.216*	-0.388*	0.225*	1.000			
(5) R&D intensity	10,370	0.053	0.071	0	0.405	-0.002	0.329*	-0.378*	-0.211*	1.000		
(6) Leverage	15,713	85.875	152.294	-623.11	867.46	-0.119*	-0.123*	0.122*	0.184*	-0.114*	1.000	
(7) Board diversity	13,873	17.233	13.234	0	75	0.116*	0.176*	-0.097*	0.104*	0.049*	0.027*	1.000

Note: This table presents summary statistics (number of firm-year observations, mean, standard deviation, minimum, and maximum) for the variables used in the regression analysis for the sample after preliminary data preparation and the exclusion of firms from the financial sector and from countries with very few observations. There are fewer observations in the regression analyses than in the correlation table since the dataset is an unbalanced panel. A time lag of 1 year is applied to all independent variables and control variables (*Emission intensity*, *Firm size*, *R&D intensity*, *Leverage*, and *Board diversity*). *Emission intensity* and *Firm size* (in terms of total assets) are logarithmized. All variables except *Board diversity* are winsorized at the 1% and 99% levels. This table also displays a pairwise correlation matrix among the variables outlined in the descriptive statistics. * $p < 0.01$.

specifically, a 1% increase in a firm's emission intensity is connected to a 0.00682% point decrease in the ROA, and a decrease of 0.00153 in the Tobin's Q. This indicates a higher CFP for firms with better carbon performance. The interaction effect of economic crises and emission intensity exhibits a significant negative relation with both ROA ($\beta = -0.241$, $p < 0.01$) and Tobin's Q ($\beta = -0.025$, $p < 0.05$). Consequently, the unmoderated negative effect of emission intensity is strengthened during times of crisis by the interaction term, resulting in an increased overall higher influence of carbon performance during a crisis ($\beta_{ROA} = -0.923/\beta_{Tobin's\ Q} = -0.178$) compared to non-crisis periods ($\beta_{ROA} = -0.682/\beta_{Tobin's\ Q} = -0.153$). More specifically, a 1% increase in a firm's emission intensity during a crisis is connected to a decrease in the ROA by 0.00923% points and a decrease of the Tobin's Q by 0.00178. This suggests the influence of carbon performance to be especially beneficial in times of crisis, with low-emission firms outperforming their less sustainable peers to a greater extent compared to normal circumstances. Thus, evidence is provided to support hypothesis H1.

To better understand this crisis effect, more fine-grained evidence is provided on the COVID-19 pandemic (2). Results confirm the overall CFP-improving effect of carbon emissions as emission intensity is significantly and negatively related to ROA ($\beta = -0.680$, $p < 0.01$) and Tobin's Q ($\beta = -0.150$, $p < 0.01$). The interaction effect is also in line with the findings of the joint crisis dummy as it exhibits significant negative results for ROA ($\beta = -0.517$, $p < 0.01$) as well as for Tobin's Q ($\beta = -0.081$, $p < 0.01$). Hence, the statistically negative influence of emission intensity is strengthened during the COVID-19 pandemic, which indicates carbon performance to be favorable for CFP in particular during the crisis, supporting hypothesis H1a.

Analysis of the GFC (3) yields differing findings compared to the pandemic. Other than consistent findings for the unmoderated emission intensity–CFP link ($\beta = -0.739$, $p < 0.01$ for ROA; $\beta = -0.162$, $p < 0.01$ for Tobin's Q), the moderating influence of the GFC does not show clear-cut results. There is only an insignificant positive effect for ROA ($\beta = 0.185$, $p > 0.1$), although a significant positive effect is identified for Tobin's Q ($\beta = 0.057$, $p < 0.01$). Thus, no strengthened effect of carbon performance on ROA is found, and the analysis of Tobin's Q even points to a weakened impact during the GFC. As these inconsistent results do not identify a clear moderating impact, it is suggested that the general favorable effect of carbon performance is not further strengthened during the GFC. Accordingly, our findings provide no support for hypothesis H1b.

Regarding the control variables employed, only firm size and R&D intensity exhibit a significant negative relation with ROA. Contrary to the assumed direction of influence, results suggest smaller and less research-intensive firms to be connected to better performance in terms of ROA. All regressions analyze a large amount of more than 5750 firm-year observations and almost 700 different firms. The explanatory power of the regressions is expressed by the adjusted coefficient of determination, R^2 -adjusted, providing results between 0.103 and 0.125. Since a minimum of 10.3% of the variation of CFP is explained by the model, explanatory power is deemed satisfactory and even higher than in comparable studies (Gallego-Álvarez et al., 2015; Lu et al., 2022).

4.3 | Robustness tests of the main regression

We performed several robustness checks. First, we used random effects to consider variation across entities (Wooldridge, 2013), which was consistent with our fixed-effects results. Second, we mitigated concerns of sample selection bias—as firms choose to disclose their emissions—by employing the Heckman (1979) two-step method. We first used a probit regression to estimate the probability of a firm's inclusion in our study,

TABLE 5 Emission intensity and corporate financial performance during crises.

	ROA			Tobin's Q		
	(1)	(2)	(3)	(1)	(2)	(3)
Emission intensity	−0.682*** (0.237)	−0.680*** (0.239)	−0.739*** (0.240)	−0.153*** (0.052)	−0.150*** (0.052)	−0.162*** (0.053)
Economic crises	−2.647*** (0.727)			0.047 (0.118)		
Economic crises × Emission intensity	−0.241*** (0.089)			−0.025** (0.012)		
COVID-19		−3.745*** (0.807)			−0.174 (0.121)	
COVID-19 × Emission intensity		−0.517*** (0.130)			−0.081*** (0.019)	
GFC			−2.515*** (0.690)			−0.212*** (0.078)
GFC × Emission intensity			0.185 (0.137)			0.057*** (0.020)
Firm size	−3.902*** (0.471)	−3.984*** (0.470)	−3.885*** (0.473)	−0.070 (0.094)	−0.085 (0.093)	−0.072 (0.094)
R&D intensity	−40.082*** (7.049)	−40.311*** (7.069)	−40.030*** (7.112)	−1.776 (1.510)	−1.816 (1.512)	−1.779 (1.498)
Leverage	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Board diversity	−0.017 (0.013)	−0.017 (0.013)	−0.018 (0.013)	0.002 (0.002)	0.002 (0.002)	0.002 (0.002)
CONSTANT	72.684*** (7.819)	74.030*** (7.794)	72.232*** (7.862)	2.299 (1.539)	2.543* (1.517)	2.295 (1.535)
Observations (N)	5751	5751	5751	5754	5754	5754
Number of firms	691	691	691	691	691	691
Year; Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean Variance Inflation Factor (VIF)	2.93	2.91	2.85	2.93	2.91	2.85
R ² -adjusted	0.104	0.108	0.103	0.120	0.125	0.122

Note: This table gives the results of the main regression analysis. There are fewer observations in the regression analyses than in the correlation table since the dataset is an unbalanced panel. Cluster-robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

focusing on whether a firm has a sustainability committee as an exclusion restriction variable (Lu et al., 2022). This variable is likely to increase carbon data availability but is not directly related to the dependent variable, CFP. When we re-estimated our initial regression with that parameter (Certo et al., 2016), the results were consistent (not tabulated). Third, we used a panel vector autoregression model to find that lagged carbon performance “Granger causes” higher CFP (measured either as ROA or Tobin's Q) (Abrigo & Love, 2016; Granger, 1969). As expected, a bidirectionality of this relationship cannot be excluded. Fourth, moderating effect analyses which re-test the main regressions with year-dummies outside crisis periods (i.e., 2007, 2010, 2019, and 2021) instead of with the crisis year-dummies presented in Section 3.2.3 (i.e., 2008, 2009, and 2020) is performed. Results confirmed the unique impact of the crises years 2008, 2009, and 2020 on carbon performance: No other year-dummy showed comparable significance to the COVID-19 pandemic effect. Fifth, we re-estimated our regressions using *absolute* carbon emissions. The results in Table 6 confirm the moderating crisis effects from the main regression, while differing dynamics are observed for the GFC with a negative impact on CFP. However, the analysis fails to demonstrate a significant unmoderated link, suggesting that low absolute emissions are not associated with higher CFP under “normal” circumstances.

Sixth, we re-estimated our regressions using return on equity (ROE) as a purely financial measure of CFP, while ROA also comprised operational performance aspects (Gallego-Álvarez et al., 2015). Table 7 confirms the main regression's findings for ROA and Tobin's Q.

TABLE 6 Absolute carbon emissions as the independent variable.

	ROA			Tobin's Q		
	(1)	(2)	(3)	(1)	(2)	(3)
Absolute carbon emission	−0.039 (0.220)	−0.046 (0.221)	−0.097 (0.220)	−0.044 (0.044)	−0.043 (0.044)	−0.055 (0.044)
Economic crises	1.118 (1.170)			0.426*** (0.161)		
Economic crises * Absolute carbon emission	−0.211*** (0.079)			−0.020* (0.012)		
COVID-19		4.548*** (1.568)			1.176*** (0.251)	
COVID-19 * Absolute carbon emission		−0.490*** (0.114)			−0.081*** (0.017)	
GFC			−6.640*** (1.886)			−1.475*** (0.341)
GFC * Absolute carbon emission			0.271** (0.129)			0.082*** (0.025)
Firm size	−3.837*** (0.512)	−3.951*** (0.511)	−3.841*** (0.517)	−0.034 (0.096)	−0.055 (0.094)	−0.042 (0.096)
R&D intensity	−41.290*** (7.074)	−41.310*** (7.075)	−40.968*** (7.167)	−2.038 (1.566)	−2.055 (1.562)	−1.981 (1.543)
Leverage	−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Board diversity	−0.020 (0.013)	−0.020 (0.013)	−0.019 (0.013)	0.001 (0.002)	0.001 (0.002)	0.002 (0.002)
CONSTANT	74.706*** (7.764)	76.622*** (7.754)	75.511*** (7.825)	2.832* (1.537)	3.159** (1.510)	3.106** (1.519)
Observations (N)	5751	5751	5751	5754	5754	5754
Number of firms	691	691	691	691	691	691
Year; Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean VIF	4.85	4.57	5.42	4.86	4.58	5.43
R ² -adjusted	0.100	0.105	0.099	0.112	0.120	0.117

Note: This table gives the results of the robustness test including absolute emissions as the independent variable. There are fewer observations in the regression analyses than in the correlation table since the dataset is an unbalanced panel. Cluster-robust standard errors are in parentheses. The standalone coefficients for COVID-19 are counterintuitively positive due to their multicollinearity with the interaction term COVID-19 * Absolute carbon emission. This multicollinearity causes estimation errors (seen in higher standard errors), so the standalone coefficients cannot not be interpreted in an economically sensible way (Wooldridge, 2013, p. 243). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5 | DISCUSSION

5.1 | Contributions to research

By showing that the nature of economic crises, specifically the COVID-19 pandemic and the GFC, influences the relationship between carbon performance and CFP differently, we make several contributions.

First, this is the first study documenting that the carbon–CFP link was strengthened during the COVID-19 pandemic, which is in line with previous evidence on the general CS–CFP link (see Table 1). Low-emission firms were not confronted with the dilemma of “doing good” versus “doing well” (Marsat et al., 2021) during the pandemic, but benefited from the synergies of carbon performance and CFP. Compared to the theories we

TABLE 7 Return on equity as dependent variable.

	ROE		
	(1)	(2)	(3)
Emission intensity	-2.158*** (0.831)	-2.157** (0.845)	-2.329*** (0.838)
Economic crises	-2.778 (2.493)		
Economic crises * Emission intensity	-0.761** (0.349)		
COVID-19		-5.924** (2.774)	
COVID-19 * Emission intensity		-1.565*** (0.499)	
GFC			-4.365** (2.196)
GFC * Emission intensity			0.475 (0.531)
Firm size	-12.960*** (1.784)	-13.243*** (1.796)	-12.916*** (1.798)
R&D intensity	-67.297*** (24.876)	-68.159*** (24.997)	-67.051*** (25.128)
Leverage	0.030*** (0.010)	0.030*** (0.010)	0.030*** (0.010)
Board diversity	-0.002 (0.047)	-0.001 (0.046)	-0.003 (0.046)
CONSTANT	225.126*** (29.056)	229.766*** (29.258)	223.878*** (29.304)
Observations (N)	5668	5668	5668
Number of firms	688	688	688
Year; Firm FE	Yes	Yes	Yes
Mean VIF	2.93	2.91	2.85
R ² -adjusted	0.087	0.090	0.086

Note: This table gives the results of the robustness test including ROE as the dependent variable. There are fewer observations in the regression analyses than in the correlation table since the dataset is an unbalanced panel. Cluster-robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

discussed above, these actual events and their results are best explained by the NRBV (Hart, 1995) since a low-emission strategy builds up strategic resources that increase CFP through more efficient operations (Marsat et al., 2021) and lower expenses (Muhammad et al., 2015). This competitive advantage acted as an insurance-like protection, helping firms to weather the COVID-19 pandemic (Lu & Khan, 2023).

Second, our analysis suggests that the effects of carbon performance on CFP depend on whether the nature of the crisis is an ineffectual demand-side shock (GFC) or an impactful supply-side shock (COVID-19). Just because the COVID-19 pandemic and the GFC exhibit major similarities such as uncertainty, stock market crashes, and economic recession (Giakoumelou et al., 2022; Lu et al., 2022), one may not simply assume that they affect the link between carbon performance and CFP in a similar manner.

Third, our analyses, based on the Refinitiv database, corroborate previous evidence on the carbon-CFP link during the GFC which relied on data from the Carbon Disclosure Project (Gallego-Álvarez et al., 2014) and Bloomberg (Hoang et al., 2020; Petitjean, 2019). This suggests that the divergence between providers of carbon measures appear to be smaller than between the broader, opaque, and often criticized ESG ratings (Berg et al., 2022; Chatterji et al., 2016; The Economist, 2022).

Fourth, our study explains the different circumstances under which the two crises occurred: societal attitudes and organizational structures. Post-GFC, there was a notable shift in *societal attitudes* toward sustainability and regulatory enforcement, as highlighted by Kemper and Martin

TABLE 8 Categorization of recommendations for future research.

Type	Issue	Possible research questions for future studies
A	Methodology	A1 Research sample <ul style="list-style-type: none"> How does carbon performance influence CFP during a crisis in developing markets? How does carbon performance influence CFP during a crisis in small- and medium-sized enterprises?
		A2 Proxy variables—carbon performance - (non-)financial performance <ul style="list-style-type: none"> What influence does the use of different carbon data providers have on the results? How do results shift when using reliable sources for scope 2 and 3 carbon emissions? How does the risk profile of a firm shift during crises when carbon performance is strong? How do perceptions of stakeholders on the firm change during crises when carbon performance is strong?
		A3 Moderator analysis with year-dummies <ul style="list-style-type: none"> How does carbon performance influence CFP, in terms of stock returns, during the COVID-19 pandemic and the GFC? (Event study design)
		A4 Endogeneity issues <ul style="list-style-type: none"> How far are carbon performance and CFP bidirectionally related in times of crisis? How do different stakeholders perceive the role of carbon performance during a crisis? (Qualitative study) Which factors could simultaneously drive carbon performance and CFP, for example, size, market power, or innovativeness? (Exploration of omitted variables)
B	Content-related	B1 Industry/country-specific analyses of the carbon performance link with CFP <ul style="list-style-type: none"> How do industry-specific characteristics (e.g., high-emission sectors) influence the link? How do country-specific characteristics (e.g., high-emission countries) influence the link? How does the regulatory context (e.g., common law vs. civil law) influence this link?
		B2 Extended research period <ul style="list-style-type: none"> What are the long-term implications of the strengthened influence of carbon performance during a crisis?
		B3 Focus on the type of crisis <ul style="list-style-type: none"> How does the type of crisis determine the link between carbon performance and CFP in different types of firms? How does the manner in which firms define a crisis affect the link between carbon performance and CFP? Does the link between carbon performance and CFP differ for firms (and their stakeholders) that are exposed only/mutually by physical risks of transition risk of carbon emissions?
		B4 Optimal level of carbon performance <ul style="list-style-type: none"> Can the link be described by a nonlinear relationship with an optimal level of carbon performance?
		B5 Organization-specific analyses <ul style="list-style-type: none"> How does firm size/complexity affect the carbon performance link to CFP during crises? How does firm size/visibility affect the carbon performance link to CFP during crises? How does the strategic orientation of a firm affect the carbon performance link with CFP during crises? (e.g., prospector vs. defender, innovativeness) How does the organizational structure of a firm affect the carbon performance link to CFP during crises? (e.g., agility or responsiveness)
		B6 Preferences of capital providers <ul style="list-style-type: none"> How do different investment horizons affect shareholders' carbon response strategies during crises? How do different investment intentions (e.g., strategic vs. financial) affect shareholders' carbon response strategies during crises? How does involvement in daily management activities affect shareholders' carbon response strategies during crises? (e.g., pension funds vs. private equity funds) How does family and/or founder ownership affect carbon response strategies during crises? How does the need for socio-emotional wealth affect carbon response strategies during crises? Which penalties do banks/bondholders impose on underperforming firms during crises? Which rewards do banks/bondholders award outperforming firms during crises?

Note: This table summarizes the avenues for future research that are described in Section 5.3. Being categorized into methodological (A) and content-related (B) issues, possible research questions for future studies are formulated for each issue. Besides this overview, please refer to the main text for more detailed elaborations.

(2010). This shift, as Lopatta and Kaspereit (2014) note, changed perceptions around profit maximization and increased stakeholder demands for CS disclosure and performance, even for shareholder-oriented firms (Wobst et al., 2023). Firms began aligning their carbon and related sustainability efforts with stakeholders' preferences, leading to a stronger link to CFP.

5.2 | Contributions to methodology

We advance this stream of literature methodologically by applying carbon emission intensity from the Refinitiv database instead of the often-applied but controversial ESG scores (see Table 1) (Demers et al., 2021). The underlying rationales for ESG scores lack agreement among different ESG rating agencies (Berg et al., 2022; Chatterji et al., 2016) and are subject to size bias (Dobrick et al., 2023; Drempetic et al., 2019), potentially applicable to the prior study by Lu et al. (2022). Even though Busch, Johnson et al. (2022) do not consider carbon performance to be free of data inconsistencies, it allows the analysis of a direct-outcome proxy for corporate environmental performance (Busch & Hoffmann, 2011; The Economist, 2022). Furthermore, carbon performance offers a more precise and easily comprehensible measure of environmental performance as it reduces the opaqueness of multidimensional constructs of (sustainable, social, or) environmental performance (Busch & Lewandowski, 2018; The Economist, 2022).

5.3 | Limitations and recommendations for future research

We list future research opportunities in Table 8 (methodologies: A1–A4 and topics: B1–B5). Our study is limited to large listed firms, so further exploration could extend to small- and medium-sized firms or developing markets, and consider the specific requirements and crisis impacts in these settings (Lu & Khan, 2023). These include limited data availability and accuracy of carbon emission data (Mukherjee et al., 2013), austere instead of expansive fiscal policy, as well as restricted access and exposure to global financial markets (Bhattacharya & Dasgupta, 2012) (A1). Our study's reliance on scope 1 emissions for carbon performance limits its generalizability (Nirino et al., 2022); there is a need for more research to explore broader CS measures and alternative data sources (Busch, Johnson et al., 2022) for a more comprehensive assessment. Future studies may also expand the view of performance beyond financial performance, investigating shifts in risk or stakeholder perceptions (A2). Using crisis year-dummies simplifies the duration of economic crises, suggesting subsequent research may use daily stock market data (e.g., Díaz et al., 2021; Lins et al., 2017) (A3). Since the Granger causality test does not point to a unidirectional relation, future research might search for bidirectional effects (Lu et al., 2022), as well as an exploration of omitted variables (A4). As this study deals with global crises, conducting industry- or country-specific investigations could be of interest (Engelhardt et al., 2021; Lu et al., 2022). Shedding more light on the regulatory context (common law vs. civil law) might yield surprising results (Ioannou & Serafeim, 2012; Lueg et al., 2014): firms in civil law settings tend to lean more toward stakeholder orientation and sustainability, and should exhibit the link between carbon performance and financial performance (Hörisch et al., 2017). Yet, firms in more shareholder-oriented common law regimes might find it easier to reduce their generally higher carbon emissions and quickly reap the financial low-hanging fruit (Flammer, 2013) (B1). Examining the post-pandemic period has the potential to reveal the long-term implications of carbon performance after the crisis (Garel & Petit-Romec, 2021; Yoo et al., 2021) (B2). Future research should delve deeper into the nuanced dynamics of how different types of crises distinctly affect firms. Specifically, it would be of interest if the link between carbon performance and CFP differs depending on whether the firm and its stakeholders face immediate physical risks or indirect transition risks from a crisis (Teutrine et al., 2024) (B3). We also recommend evaluating an optimal level of carbon performance in terms of a possible nonlinear relationship (Lopatta & Kaspereit, 2014) against the background of a decreasing marginal benefit of CS (Flammer, 2013) (B4). Future research could examine organizational factors that influence the relationship between carbon performance and CFP during crises, for example, a firm's size, complexity, and visibility (Läger et al., 2021; Loughran & McDonald, 2023), or its strategic orientation, for example, in terms of prospector versus defender, agility and responsiveness, or innovativeness (B5). Additional research could also investigate the role of the providers of capital to a firm. Shareholders might prefer different response strategies depending on their involvement in daily management activities, their investment intentions, their investment horizons (Barroso Casado et al., 2016), or the amount of socio-emotional wealth they desire, for example, as family/founding owners (Wobst et al., 2023). Banks and bondholders could impose penalties by demanding higher yields or withholding credit during crises for underperforming firms, or conversely, only reward outperformers with favorable lending terms (Bae et al., 2018) (B6).

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data subject to third party restrictions. The data that supports the findings of this study are available from Thomson Reuters Eikon. Restrictions apply to the availability of these data, which were used under license for this study.

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