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Indirect Emissions, Direct Financial Impact?

A Quantitative Analysis of Scope 3 Emissions Effect on Financial Performance

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Abstract

This thesis examines whether lower Scope 3 emissions are associated with improved corporate financial performance among publicly listed EU and US firms. Using panel data and fixed effects regression models, the study analyzes the relationship between Scope 3 carbon intensity and both accounting-based and market-based financial performance, measured through ROA and Tobin's Q. The findings indicate that lower Scope 3 carbon intensity tends to be associated with higher ROA, while no significant relationship is observed for Tobin's Q. In addition, no significant effects are identified for short-term changes in carbon intensity. The results also show no significant differences between firms in the European Union and the United States. By focusing specifically on Scope 3 emissions and applying a PCAF-based data quality filter, the study contributes new evidence to the growing literature on the financial implications of corporate decarbonization and highlights the importance of reliable emissions reporting.

Keywords: Corporate carbon performance, corporate financial performance, scope 3 emissions, carbon intensity.

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Key Definitions

Term	Definition
Corporate carbon performance (CCP)	A firm's performance related to greenhouse gas emissions. In this study, CCP is operationalized using Scope 3 carbon intensity and changes in Scope 3 carbon intensity.
Corporate financial performance (CFP)	A firm's financial performance. In this study, CFP is operationalized using return on assets (ROA) and Tobin's Q.
Scope 3 emissions	Indirect greenhouse gas emissions occurring throughout a firm's value chain, excluding direct operations and purchased energy.
Carbon intensity (CI)	Scope 3 emissions divided by firm revenue. Lower carbon intensity reflects higher corporate carbon performance.
Change in carbon intensity (ΔCI)	Year-over-year percentage change in carbon intensity.
Return on assets (ROA)	Accounting-based measure of financial performance calculated as EBIT divided by total assets.
Tobin's Q	Market-based measure of financial performance calculated as enterprise value divided by total assets.
PCAF score	Weighted data quality score developed by the Partnership for Carbon Accounting Financials (PCAF), where lower scores indicate higher emissions data quality.
Firm-year observation	One observation for a specific firm in a specific fiscal year.
Fixed effects model	Panel regression model controlling for unobserved time-invariant firm characteristics and year-specific effects.

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1 | Introduction

Corporate greenhouse gas emissions are commonly divided into Scope 1, Scope 2, and Scope 3 emissions. Scope 1 emissions refer to direct emissions from sources owned or controlled by the firm, while Scope 2 emissions refer to indirect emissions from purchased energy. Scope 3 emissions capture other indirect emissions from upstream and downstream activities in the firm's value chain or product life cycle, such as purchased goods, transportation, product use, and end-of-life treatment (WBCSD & WRI, 2011; LSEG, 2025).

The practical relevance of Scope 3 emissions can be seen in corporate climate strategies. For example, Walmart's Project Gigaton targets emissions reductions across its supply chain, while H&M Group reports Scope 3 reduction targets as part of its broader climate strategy (Sturcken, 2024; H&M Group, 2026). These examples illustrate that large firms increasingly address emissions beyond their own operations. However, they do not answer whether stronger Scope 3 carbon performance is financially rewarded. This thesis therefore examines whether Scope 3 corporate carbon performance is associated with corporate financial performance.

Scope 3 emissions are especially important because they often represent the largest share of corporate emissions and are harder to control than Scope 1 and Scope 2 emissions. They include upstream and downstream activities such as purchased goods, logistics, product use, and end-of-life treatment (WBCSD & WRI, 2011). This makes Scope 3 a broader measure of a firm's environmental footprint, but also a more complex and uncertain one. As regulation and investor attention increase, the key question is whether stronger Scope 3 performance is financially rewarded.

Empirical evidence on the relationship between carbon performance and financial performance remains mixed. Some studies suggest that emission reductions improve efficiency, reduce risk, and strengthen profitability (Russo & Fouts, 1997; Busch & Lewandowski, 2018). Others find weaker, non-linear, or insignificant effects, especially when carbon reduction requires costly investment or when markets struggle to price environmental information (Trumpp & Guenther, 2017; Kayser et al., 2026). Importantly, most prior research focuses on Scope 1 and Scope 2 emissions. Scope 3 has received less attention, despite often dominating firms' total climate footprint.

This thesis contributes to existing research in two main ways. First, it extends the limited literature on the relationship between Scope 3 corporate carbon performance and corporate financial performance. Prior research has primarily focused on Scope 1 and Scope 2 emissions and has often reported mixed or insignificant findings for Scope 3. The study also formally tests whether this relationship differs between EU- and US-incorporated firms, which prior studies have not directly examined. Second, the study addresses key data quality limitations in earlier Scope 3 research. By using more recent firm-level data, the study captures the increasing availability of Scope 3 disclosures following heightened regulatory pressure and reporting requirements. In addition, the application of a PCAF-based quality filter excludes lower-quality emission estimates, improving the reliability of the remaining observations and reducing measurement noise that may otherwise obscure empirical relationships.

1.1 | Purpose

This thesis aims to determine whether Scope 3 corporate carbon performance is associated with corporate financial performance, and whether this association differs between firms incorporated in the European Union and the United States. The study addresses the following research question:

Is there a relationship between Scope 3 corporate carbon performance and corporate financial performance, and does this relationship differ between firms incorporated in the European Union and the United States?

To answer this question, the study uses panel data on firms reporting Scope 3 emissions from 2020 to 2026. Corporate carbon performance is measured by Scope 3 carbon intensity and its year-over-year change. Corporate financial performance is measured by return on assets (ROA) and Tobin's Q, which represent accounting- and market-based performance, respectively. The relationship is tested using panel regression models with an interaction term for EU incorporation. The sample is limited to firms whose Scope 3 disclosures have a PCAF data-quality score of three or lower, where PCAF refers to the Partnership for Carbon Accounting Financials and lower scores indicate higher-quality emissions data. This threshold is used to reduce measurement error.

1.2 | Main Findings

The findings indicate that Scope 3 carbon intensity is negatively associated with ROA. This suggests that firms with lower carbon intensity tend to exhibit stronger accounting-based performance. In contrast, Scope 3 carbon intensity is not significantly associated with Tobin's Q, indicating that markets do not price Scope 3 performance in the same way within the sample. Year-on-year changes in Scope 3 carbon intensity are not significantly associated with either ROA or Tobin's Q. The interaction term for EU incorporation is also insignificant, suggesting that the relationship between Scope 3 carbon performance and financial performance does not differ substantially between EU- and US-incorporated firms.

2 | Literature Review & Theoretical Background

Corporate greenhouse gas emissions have become an increasingly important focus in both sustainability research and corporate strategy. Firms are under growing pressure from regulators, investors, and consumers to measure, report, and reduce their emissions. As a result, understanding how corporate carbon performance relates to firms' financial outcomes has become an important research topic. In this literature review, we first explain how corporate emissions are defined and measured, with particular attention to the different emission scopes. We then review the theoretical mechanisms through which corporate carbon performance may influence financial performance, followed by empirical findings as well as regional and regulatory factors that may shape this relationship.

2.1 | Carbon Emissions

This section outlines the definitions, measurement approaches, and the classification of corporate greenhouse gas emissions into Scopes 1, 2, and 3. It subsequently examines the significance of Scope 3 emissions for evaluating corporate climate impact, while acknowledging the associated measurement and comparability challenges.

2.1.1 | Defining and Measuring Corporate Emissions

Greenhouse gases (GHGs) trap heat in the atmosphere, driving global warming. The Kyoto Protocol lists several regulated GHGs, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons ($HFCs$), perfluorocarbons ($PFCs$), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) (Eurostat, n.d.). Emissions are measured in carbon dioxide equivalents ($CO_2 - e$), which use Global Warming Potentials to compare each gas's warming impact to CO_2 (Eurostat, n.d.).

The GHG Protocol categorizes corporate emissions into three scopes based on source and control. Scope 1 includes direct emissions from owned sources like facilities and vehicles. Scope 2 covers indirect emissions from purchased electricity, steam, heat, and cooling. Scope 3 encompasses all other indirect emissions across the value chain, such as from purchased goods, transportation, product use, and end-of-life of sold products (WBCSD & WRI, 2004, 2011). Firms typically report emissions in either absolute or intensity-based terms. Because firm size significantly affects absolute figures, intensity measures, emissions relative to revenue or production, are widely adopted to facilitate cross-firm comparisons (Busch & Lewandowski, 2018; WBCSD & WRI, 2004).

2.1.2 | Scope 3 Emissions and Reporting Challenges

The distribution of emissions across each scope differs by industry, but generally, scope 3 makes up the largest part of a company's carbon footprint. Scope 3 reporting includes emissions from suppliers, logistics, product use, and disposal, pointing out sources not covered by Scope 1 or Scope 2. This data is essential for creating successful decarbonization plans throughout the value chain (Hettler & Graf-Vlachy, 2024).

Measuring Scope 3 emissions presents considerable methodological challenges because they occur outside a company's direct control. Their estimation relies on supplier data, activity records, and emission factors (Fouret et al., 2024). Variations in reporting boundaries, calculation methods, and estimation techniques across companies make comparisons difficult (Klaaßen & Stoll, 2021). Additionally, many companies report only a subset of Scope 3 emission categories due to data constraints and the complexities of obtaining information from external value-chain actors (Fouret et al., 2024).

Industry context determines where emissions arise across the value chain, so the relative importance of Scope 1, 2, and 3 emissions varies by sector. For example, retail and wholesale firms often have a particularly large share of emissions in Scope 3, as much of their climate impact stems from suppliers' production and distribution and from product use rather than from direct operations (Adelfang et al., 2024).

2.2 | Carbon Emissions and Financial Performance

In the following sections, we discuss theoretical and empirical links between corporate carbon performance and financial performance. The discussion distinguishes between accounting-based mechanisms related to operational performance and profitability, and market-based mechanisms related to investor perceptions, risks, and firm valuation. Within both perspectives, carbon performance may either create or destroy value.

2.2.1 | Accounting-based CFP

Value creating mechanisms

A central value-creation mechanism in the environmental performance literature is improved efficiency and lower operating costs. Environmental harm is often inefficient use of inputs, meaning that reductions in emissions, waste, and resource consumption may also improve business performance. Firms may therefore create value by using fewer environmental resources per unit of output and by increasing resource efficiency relative to competitors. Figge and Hahn (2012) argue that environmental value arises when firms use environmental resources more efficiently than the market benchmark, while Clarkson et al. (2011) describe pollution as wasted input caused by inefficiencies in product design, input choice, or production processes. From this perspective, proactive environmental strategies may enhance firm performance through process improvements. This argument is consistent with the resource-based view, which suggests that environmental capabilities can become strategic resources that improve competitiveness and profitability (Russo & Fouts, 1997). Prior studies further support this mechanism by showing that environmental initiatives may generate cost savings through lower energy use, waste reduction, and operational improvements (Ambec & Lanoie, 2008; Bendig et al., 2023).

Consumer demand for sustainable products represents another potential value-creation mechanism. If consumers prefer environmentally responsible products or are willing to pay price premiums for sustainable goods, firms with stronger environmental performance may benefit from increased sales, higher margins, stronger brand equity, and improved market positioning (Russo & Fouts, 1997; Trumpp & Guenther, 2017). Empirical research generally shows positive consumer attitudes and purchase intentions toward sustainable products, particularly when sustainability claims are credible and supported by strong brand reputation or certification labels (Nguyen et al., 2019; Kumar et al., 2021; Fatemi et al., 2023).

Innovation represents another mechanism through which carbon performance may create value. Efforts to reduce emissions often require firms to rethink production processes and adopt new technologies. Trumpp and Guenther (2017) argue that environmental initiatives may stimulate process innovation and the development of new capabilities. Similarly, Figge and Hahn (2012) suggest that environmental challenges can encourage firms to redesign products and production systems in more sustainable ways. Ambec and Lanoie (2008) also highlight that environmental pressures and regulations may stimulate technological innovation. More recent empirical evidence supports this mechanism. Acheampong and Wang (2025) finds that firms engaging in carbon reduction initiatives exhibit higher levels of innovation and firm value, suggesting that sustainability strategies may stimulate technological development and strengthen competitive positioning.

Value destroying mechanisms

While environmental strategies may generate value, the literature also identifies mechanisms through which carbon emission reduction may destroy value. One key concern is the investment and compliance costs associated with environmental initiatives. Implementing carbon reduction strategies often requires investments in cleaner technologies, renewable energy sources, and new production processes, which may increase operational costs and reduce profitability in the short term. Figge and Hahn (2012) argue that environmental improvements frequently require technological investments and process adjustments as well as compliance with environmental regulation, all of which may increase costs. Similarly, Bendig et al. (2023) note that achieving ambitious carbon reduction targets may involve substantial organizational changes, including investments in renewable energy, process changes, and supply chain redesign. Ambec and Lanoie (2008) likewise emphasize that environmental initiatives may reduce firm value when investment costs exceed efficiency gains.

The literature also highlights operational trade-offs associated with environmental engagement. According to the trade-off hypothesis, investments in environmental performance may divert resources from core business activities, weakening financial performance when costs exceed benefits. Trumpp and Guenther (2017) argue that improving environmental performance may shift resources away from profit-generating activities and increase production costs, particularly when firms rely on reactive or end-of-pipe technologies to meet regulatory requirements.

Finally, carbon reduction initiatives may fail to generate financial benefits if consumer demand does not materialize as expected. Although consumers often express positive attitudes toward sustainable products, actual purchasing behavior frequently does not align with these attitudes. This attitude–behavior gap implies that firms may invest in sustainability initiatives without realizing corresponding increases in sales or price premiums. Nguyen et al. (2019) show that consumers may report strong environmental intentions but fail to translate these attitudes into consistent purchasing behavior. This can derive from consumers not finding sustainable alternatives or being sensitive towards higher prices.

Overall, the literature suggests that carbon emission reduction may destroy value when firms incur substantial investment and compliance costs, experience operational trade-offs from reallocating resources toward environmental initiatives, or fail to capture sufficient market demand to offset these costs.

2.2.2 | Market-based CFP

Value creating mechanisms

While the previous section outlined accounting-based mechanisms, these effects are not isolated from capital markets. Improvements in profitability, efficiency, or risk exposure are incorporated into investors' expectations regarding future cash flows and firm value. Consequently, accounting-based performance is indirectly reflected in market-based measures such as Tobin's Q. However, beyond these indirect effects, the literature also identifies several distinct market-based mechanisms through which corporate carbon performance (CCP) may influence firm valuation. A central market-based mechanism concerns risk reduction and access to capital. Firms with stronger carbon performance are generally perceived as less exposed to climate-related, regulatory, and reputational risks, reducing uncertainty surrounding future cash flows and improving financing conditions (Giordino et al., 2026). Carbon performance increasingly functions as a signal of firms' preparedness for future climate regulation and transition risks, making low-emission firms more attractive to investors and potentially contributing to higher market valuations.

Investor demand and capital allocation further reinforce this relationship. Institutional investors increasingly integrate sustainability and carbon-related factors into portfolio allocation decisions and may reward firms that actively manage emissions and environmental risks (Velte, 2023; Giordino et al., 2026). This development reflects both growing sustainability mandates and the perception that firms with stronger carbon performance may be better positioned to manage long-term climate-related challenges. Increased investor demand for environmentally responsible firms may therefore contribute to higher firm valuations.

The literature also highlights signalling effects and reductions in information asymmetry as important market-based mechanisms. Transparent carbon disclosure and proactive sustainability initiatives may signal effective environmental risk management and long-term strategic orientation, allowing investors to better assess firms' future prospects (Alsaifi et al., 2020). Higher-quality carbon disclosure may therefore strengthen investor confidence and improve market valuation by reducing uncertainty regarding firms' exposure to climate-related risks.

In addition, legitimacy and stakeholder alignment may positively influence market value. Firms that align with societal expectations regarding climate responsibility may strengthen their legitimacy and reputation among investors and other stakeholders. This effect may be particularly relevant in institutional environments where sustainability is strongly embedded in regulatory frameworks and investor expectations, such as the European market (Giordino et al., 2026).

Value destroying mechanisms

The literature also identifies several channels through which improvements in carbon performance may reduce or fail to increase market value. From a neoclassical and shareholder theory perspective, environmental investments may divert resources from profit-maximizing activities and create additional financial burdens for firms (Bendig et al., 2024). Investors may perceive emission reduction initiatives as costly, uncertain, or difficult to monetize, particularly when benefits are long term or hard to quantify. As a result, decarbonization efforts may weaken market expectations regarding future profitability and cash flows, especially in the short term.

The literature further highlights a cost-risk trade-off that may create ambiguity in market reactions. While lower emissions may reduce exposure to regulatory and transition risks, achieving these reductions frequently requires costly organizational transformations. As a result, two opposing effects may emerge simultaneously: a positive effect through reduced long-term risk exposure and a negative effect through increased short-term costs. If investors cannot clearly determine which effect dominates, the overall impact on market valuation may remain weak or statistically insignificant (Bendig et al., 2024).

Short-term market pressures and differences between accounting-based and market-based performance measures may further weaken market-based effects. Even if carbon reduction initiatives generate long-term operational or strategic benefits, financial markets may place greater emphasis on future expectations, risk assessments, and near-term financial performance (Bendig et al., 2023). Consequently, firms may experience situations where improved carbon performance contributes positively to accounting-based financial performance through operational efficiency gains, while failing to generate corresponding increases in market valuation (Bendig et al., 2023).

Finally, uncertainty and measurement challenges may reduce the usefulness of carbon performance as a market signal, particularly for Scope 3 emissions. Compared to Scope 1 and Scope 2 emissions, Scope 3 emissions are more difficult to measure reliably due to their dependence on external actors, complex value chains, and estimated data sources (Kayser et al., 2026; Busch & Lewandowski, 2018). These characteristics create greater uncertainty regarding reported Scope 3 performance and may weaken investor confidence in the reliability of disclosed emissions data, thereby limiting its effect on firm valuation (Kayser et al., 2026).

2.2.3 | Financial Implications of Different Emission Scopes

The relationship between CCP and CFP may differ across emission scopes because Scope 1, Scope 2, and Scope 3 emissions vary substantially in terms of controllability, measurement reliability, operational complexity, and stakeholder visibility (Kayser et al., 2026). Prior literature therefore emphasizes the importance of distinguishing between the individual emission scopes rather than treating corporate emissions as a single aggregated measure.

Scope 1 and Scope 2 emissions originate from firms' own operations and purchased energy and are therefore generally more directly controllable by management. Reductions in these emissions may improve operational efficiency through lower energy consumption, reduced waste, process optimization, and cleaner production technologies. In addition, Scope 1 and Scope 2 emissions are typically easier to measure and verify, increasing the credibility and comparability of reported emissions data (Lewandowski, 2017).

In contrast, Scope 3 emissions arise from upstream and downstream value chain activities and depend heavily on external actors such as suppliers, logistics partners, distributors, and consumers (Kayser et al., 2026). As a result, firms have more limited direct control over these emissions, and reductions often require complex coordination across supply chains. At the same time, firms may still exert indirect influence over Scope 3 emissions through supplier selection, procurement requirements, sustainability standards, and collaboration with value chain partners. However, implementing such changes may involve switching suppliers, restructuring supply chains, or engaging in costly coordination processes, which can increase operational complexity and implementation costs. Scope 3 emissions are also more difficult to measure reliably because they frequently rely on estimates and external data sources, resulting in greater uncertainty and lower data quality (Lewandowski, 2017). These characteristics may make the financial effects of Scope 3 emission reductions more uncertain and more difficult to realize in the short term.

At the same time, stakeholder and legitimacy perspectives suggest that Scope 3 emissions may become increasingly financially relevant due to growing regulatory pressure and rising stakeholder expectations regarding value chain sustainability (Giordino et al., 2026). Because Scope 3 emissions often represent the largest share of firms' total carbon footprint, stakeholders may increasingly view Scope 3 management as an indicator of broader corporate sustainability capabilities and long-term climate strategy (Kayser et al., 2026).

2.2.4 | Empirical Findings

Empirical research examining the relationship between corporate carbon performance (CCP) and corporate financial performance (CFP) has produced mixed findings. Early evidence suggests that stronger environmental performance may contribute to competitive advantage and improved financial outcomes. For example, Russo and Fouts (1997) find that firms with stronger environmental performance tend to achieve higher profitability and growth.

More recent meta-analytical evidence also points toward a generally positive relationship between environmental and financial performance, although results vary across contexts and measurement approaches. Albertini (2013) finds a predominantly positive relationship between environmental performance and financial outcomes, while Busch and Lewandowski (2018) conclude that the overall relationship between carbon performance and financial performance is generally positive but depends on factors such as the emission scope examined, the financial performance measure applied, and methodological differences across studies.

More recent research has increasingly distinguished between different emission scopes, particularly Scope 1, Scope 2, and Scope 3 emissions. Several studies report that lower carbon intensity or emission reductions are positively associated with accounting-based financial performance, particularly for operational emissions (Scope 1 and Scope 2). Lewandowski (2017) finds that emission reductions linked to operational efficiency improvements can enhance accounting-based financial performance. Similarly, Kayser et al. (2026) show that lower Scope 1 and Scope 2 carbon intensity is associated with higher ROA, whereas the relationship between Scope 3 emissions and financial performance is weaker and statistically insignificant. Consistent with these findings, Wang et al. (2026) highlight substantial inconsistencies in Scope 3 accounting methodologies, data transparency, and verification standards.

Evidence regarding market-based financial performance measures, such as Tobin's Q, is less consistent. Matsumura et al. (2014) find that firms with higher carbon emissions tend to receive lower market valuations. However, other studies report weaker or insignificant relationships between carbon performance and market-based measures, particularly for Scope 3 emissions. For example, Kayser et al. (2026) find only partial support for a relationship between operational emissions and Tobin's Q, while no robust relationship is identified for Scope 3 emissions.

Overall, the empirical literature suggests that positive relationships between carbon performance and financial performance appear more consistently for operational emissions and accounting-based performance measures such as ROA, whereas evidence regarding Scope 3 emissions remains relatively limited and inconclusive.

2.2.5 | Hypothesis 1

The literature identifies both value-creating and value-destroying mechanisms linking CCP to CFP. Since lower emissions and lower carbon intensity reflect stronger CCP, emission reductions are generally interpreted as improvements in corporate carbon performance. On the one hand, emission reductions may improve operational efficiency, stimulate innovation, strengthen stakeholder relationships, and enhance legitimacy among consumers and investors (Russo & Fouts, 1997; Trumpp & Guenther, 2017). On the other hand, carbon reduction initiatives may require substantial investments, create operational trade-offs, and involve implementation costs that may weaken profitability, particularly in the short term (Ambec & Lanoie, 2008; Bendig et al., 2023).

Although prior empirical findings remain mixed, the overall literature suggests a predominantly positive relationship between environmental performance and financial performance (Albertini, 2013; Busch & Lewandowski, 2018). Positive effects appear particularly consistent for accounting-based performance measures such as ROA, where improved efficiency and resource utilization may directly affect profitability (Lewandowski, 2017). At the same time, empirical evidence regarding Scope 3 emissions remains more limited and inconclusive, partly due to historical challenges related to measurement reliability and data quality (Kayser et al., 2026).

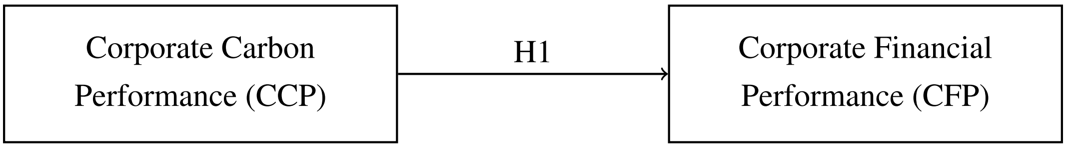
Despite these challenges, several developments suggest that Scope 3 carbon performance may become increasingly financially relevant. Scope 3 emissions often represent the largest share of firms' total carbon footprint and are receiving growing attention from regulators, investors, and consumers. In addition, increasing sustainability disclosure requirements and improved reporting practices may reduce information uncertainty and strengthen the credibility of Scope 3 data over time. Firms that successfully manage Scope 3 emissions may therefore benefit from improved stakeholder trust, stronger supply chain positioning, and enhanced long-term competitiveness.

Overall, while Scope 3 emission reductions may involve substantial implementation costs and coordination challenges, the literature suggests that the potential benefits associated with efficiency improvements, stakeholder alignment, legitimacy, and strategic positioning are expected to outweigh these costs over time. Based on these arguments, the following hypothesis is formulated:

H1: There is a positive relationship between Scope 3 CCP and CFP.

An overview of the research model for hypothesis 1 is presented in Figures 1.

FIGURE 1 | Research Model for H1



2.3 | Regional Differences in the CCP–CFP Relationship

In this section, we review how institutional differences between the European Union and the United States may influence the relationship between corporate carbon performance and corporate financial performance. We focus specifically on differences in sustainability reporting requirements, carbon regulation, and prior empirical findings.

2.3.1 | Regulatory Differences Between the European Union and the United States

The European Union has gradually moved from broad non-financial disclosure toward mandatory and standardised sustainability reporting. The Non-Financial Reporting Directive (NFRD), introduced in 2014, required large public-interest entities to disclose non-financial information, including environmental matters. However, it allowed firms considerable discretion in choosing reporting frameworks (European Parliament & Council, 2014). The Corporate Sustainability Reporting Directive (CSRD), adopted in 2022, expanded this regime. In-scope firms must now report under the European Sustainability Reporting Standards (ESRS). The CSRD also introduced the principle of double materiality. Under this principle, firms must disclose both their impacts on people and the environment and the financial risks that sustainability matters pose to the firm itself (European Parliament & Council of the European Union, 2022; European Commission, 2023). Double materiality, therefore formalizes the view that sustainability performance has financial implications for firms. The first wave of CSRD-affected firms applies the rules for financial year 2024, with reports published in 2025.

The United States has not established a comprehensive, mandatory sustainability reporting system across the entire economy at the federal level. The Securities and Exchange Commission clarified in 2010 that climate-related risks might need to be disclosed if they are material to investors, based on existing reporting rules (SEC, 2010). At the state level, several states have introduced mandatory carbon-pricing schemes; for example, the Regional Greenhouse Gas Initiative (RGGI) has operated a market-based program to cut carbon emissions from the power sector in northeastern states since 2009, and California implemented an economy-wide cap-and-trade program in 2013. These policies cover only certain firms and sectors, making their scope different from the EU's broader regulatory approach.

Voluntary initiatives such as CDP, the Science Based Targets initiative (SBTi), and reporting based on the Task Force on Climate-related Financial Disclosures (TCFD), now incorporated into the IFRS S2 climate disclosure standard, remain relevant in both regions. These initiatives, however, do not generate the same mandatory and standardised reporting pressure as EU regulation.

2.3.2 | Empirical Findings

Mandatory and voluntary reporting regimes differ in the extent to which they shape the credibility and comparability of carbon information. Mandatory reporting can reduce selective disclosure and improve cross-firm comparability, whereas voluntary reporting may leave more room for boilerplate disclosure and impression management. Christensen et al. (2021) argue that sustainability reporting mandates can affect capital markets, stakeholders, and firm behaviour, but that their effects depend on enforcement, materiality definitions, and broader institutional context. This distinction is relevant for an EU–US comparison because the European Union relies more heavily on mandatory sustainability reporting, while the United States has historically relied more on investor materiality and voluntary disclosure.

Empirical evidence supports the relevance of this institutional difference. Cicchiello et al. (2023) compare EU firms affected by the NFRD with US firms during 2015–2020 and find that mandatory EU non-financial disclosure regulation is associated with significantly higher ESG scores. The authors interpret this as evidence that the NFRD improved firms' disclosure commitment and effectiveness, suggesting that mandatory regulation can strengthen sustainability practices. This finding is consistent with the view that EU regulation may increase the visibility and relevance of carbon performance compared with the current US setting.

Voluntary disclosure is, however, not necessarily uninformative. In a US setting, Datt et al. (2018) find that better carbon performers disclose more carbon information through CDP, consistent with signalling theory, which suggests that strong performers may use voluntary disclosure to distinguish themselves from weaker performers. At the same time, the reliability of voluntary disclosure remains a concern, as managers may selectively disclose favourable information or use environmental reporting for impression management.

Direct evidence on regional differences in the CCP–CFP relationship remains limited. Busch et al. (2022) extend a US sample to include EU firms and report subsample results indicating broadly similar patterns across the two regions, although they do not formally test whether the regional coefficients differ from each other. Kayser et al. (2026) similarly find no significant divergence between EU and US subsamples in their analysis of firms with science-based targets. Taken together, prior research does not conclusively demonstrate that one region exhibits a stronger CCP–CFP relationship than the other, and the literature therefore supports a theoretically motivated regional hypothesis that has not yet been empirically settled.

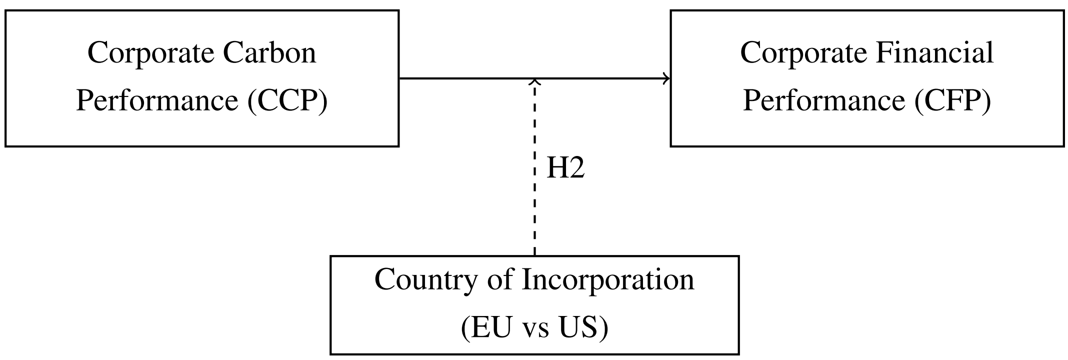
2.3.3 | Hypothesis 2

The European Union and the United States employ distinct approaches to regulating and disclosing carbon performance. The European Union has implemented mandatory and standardized sustainability reporting, supported by carbon-pricing instruments that impose direct costs on emissions. In contrast, the United States has historically relied on voluntary disclosure practices focused on investor materiality, resulting in less standardized carbon information across firms. Although empirical evidence regarding regional differences in the CCP–CFP relationship remains inconclusive, the institutional context suggests that stakeholder pressure and the financial relevance of carbon performance may be more pronounced in Europe. As outlined in the previous section, efficiency gains, reputational benefits, and reduced cost of capital are contingent upon emissions being observable and comparable to investors, regulators, and customers. This suggests that these mechanisms may be more robust in the European context. Based on these considerations, the second hypothesis is proposed as follows:

H2: The positive relationship between CCP and CFP is stronger for firms incorporated in the European Union than for firms incorporated in the United States.

An overview of the research model for hypothesis 2 is presented in Figures 2.

FIGURE 2 | Research Model for H2



3 | Method

In this section, we present the empirical methodology, including the research design, sample selection, variable construction, and model specification.

3.1 | Research Design

We apply a quantitative empirical research design to analyze the relationship between Scope 3 corporate carbon performance and financial performance. The analysis is based on secondary firm-level data from LSEG Workspace covering publicly listed firms. The dataset consists of firm-year observations, creating a panel structure that allows us to examine changes in emissions and financial performance over time. We estimate regression models where financial performance indicators serve as dependent variables and Scope 3 carbon performance measures constitute the main independent variables. Control variables are included to account for firm characteristics that may influence financial performance.

3.2 | Sample Selection

We used a dataset retrieved from LSEG Workspace, which provides standardized financial and ESG-related data for publicly listed firms. The initial sample construction was conducted using the LSEG screener, and the process is summarized in Table 1.

First, we selected publicly listed firms incorporated in either the European Union or the United States. We then restricted the sample to firms reporting Scope 3 emissions greater than zero over the last three fiscal years to ensure the availability of emissions data necessary for the analysis of carbon intensity and changes in carbon intensity over time.

To improve the reliability of the emissions data, we retained only firms with a PCAF Scope 3 weighted quality score of three or lower over the same period. Under the PCAF methodology, lower scores indicate higher data quality. Scores of 1 and 2 are based on reported emissions data, either audited or non-audited, while score 3 is based on physical activity data combined with specific emission factors. In contrast, scores of 4 and 5 rely increasingly on sector averages, proxy data, and high-level estimates. This threshold therefore ensures that the sample primarily includes firms with relatively higher-quality and more reliable Scope 3 emissions data. Prior research emphasizes the importance of data quality in carbon performance studies, as emissions data may be self-reported, estimated, or externally verified. For example, Bendig et al. (2024) show that verified emissions data is more accurate than self-reported data, which in turn is more accurate than estimated data. By excluding observations with lower-quality estimates, we aim to reduce measurement error in Scope 3 emissions.

The dataset consists of firm-level accounting, market, and emissions variables retrieved from LSEG Workspace. Extracted variables include Scope 3 emissions, revenue, total assets, enterprise value, EBIT, capital expenditures, and country of incorporation. Most accounting and market variables are standardized by LSEG based on firm-reported financial statements, while Scope 3 emissions may consist of either directly reported or model-estimated values depending on disclosure availability.

Several variables used in the analysis were further constructed from the extracted data. Specifically, carbon intensity was calculated as Scope 3 emissions divided by revenue, while Tobin's Q was calculated as enterprise value divided by total assets. Additional transformations include logarithmic scaling, lagged variables, and year-over-year change measures. A detailed overview of all variables, data sources, and variable constructions is provided in Appendix X.

After applying the screening criteria in LSEG Workspace, the dataset was exported and further processed in Python. Additional data preparation steps included winsorization, logarithmic transformations, and the construction of lagged and year-over-year change variables. To ensure consistency across all regression analyses, observations with missing values for any regression variable were removed prior to estimation. This includes missing values for ROA, Tobin's Q, carbon intensity, change in carbon intensity, firm size, sales growth, and capital intensity, as well as the lagged values required for the panel regressions. Consequently, the same firm-year observation set is maintained throughout the main analyses.

While Table 1 reports the number of firms remaining after each screening step, the regression analyses are conducted at the firm-year level. The final dataset therefore consists of an unbalanced panel of 634 firms and 2,654 firm-year observations.

TABLE 1 | Sample selection process

Selection step	Criterion	Firms	Firm-year observations
Initial publicly listed firms	Firms available in LSEG Workspace	67,700	–
Geographic restriction	Firms incorporated in the EU or US	14,619	–
Scope 3 emissions availability	Scope 3 combined emissions $>$ 0 during the last three fiscal years	3,796	–
PCAF data quality filter	PCAF Scope 3 weighted quality score ≤ 3 during the last three fiscal years	733	–
Fiscal year availability	Non-missing latest fiscal year information	636	4,452
PCAF data availability	Removal of missing PCAF observations	636	3,371
Regression sample	Non-missing values for all regression variables	634	2,654

Notes: The unit of analysis in the regression models is firm-year observations. The final dataset constitutes an unbalanced panel. Observations are reduced throughout the sample selection process due to missing emissions, financial, and control variable data, as well as the construction of lagged and change variables.

3.3 | Variables

This section describes the variables used in the empirical analysis. Following prior research, we lag all independent and control variables by one year to mitigate concerns about reverse causality and ensure that explanatory variables precede financial outcomes (Bendig et al., 2023).

3.3.1 | Dependent Variable

Corporate financial performance can be measured using both accounting-based and market-based indicators, reflecting different dimensions of value creation. Accounting-based measures capture firms' internal operational performance, while market-based measures reflect how investors value firms and their future prospects. Because environmental initiatives may affect operational efficiency and market valuation differently, we include both dimensions when examining the relationship between corporate carbon performance and financial performance.

Accordingly, we measure CFP using both return on assets (ROA) and Tobin's Q. ROA serves as the accounting-based measure and captures how efficiently a firm generates profits from its asset base. In contrast to Kayser et al. (2026), who operationalize ROA as net income divided by total assets, we measure ROA as earnings before interest and taxes (EBIT) divided by total assets. This approach allows us to focus more directly on operating performance independent of firms' financing structures and tax environments.

In addition, we employ Tobin's Q as a market-based measure of CFP. Tobin's Q captures the market valuation of a firm relative to its asset base and reflects investors' expectations regarding future performance. It is calculated as enterprise value divided by total assets. Compared to accounting-based measures, Tobin's Q incorporates forward-looking information and may therefore capture how financial markets evaluate firms' environmental performance and associated risks or opportunities.

By incorporating both ROA and Tobin's Q, we provide a broader assessment of whether improvements in corporate carbon performance are associated with operational performance, market valuation, or both.

3.3.2 | Independent Variables

The key independent variable in this study is corporate carbon performance (CCP). In this study, CCP is operationalized using Scope 3 carbon intensity and changes in Scope 3 carbon intensity. Scope 3 emissions are retrieved from LSEG Workspace using the aggregated Scope 3 emissions variable, reported in tonnes of carbon dioxide equivalent (tCO2e). The variable covers indirect emissions from both upstream and downstream activities in a firm's value chain or product life cycle. According to LSEG, Scope 3 upstream and downstream emissions are modelled separately, while the aggregated Scope 3 variable combines these components. The data may consist of company-reported values, CDP-reported values, or LSEG-estimated values, depending on data availability and LSEG's quality checks (LSEG, 2025). To reduce measurement error, the sample is restricted to observations with a PCAF Scope 3 data quality score of three or lower.

Prior literature distinguishes between several approaches to measuring carbon performance, including absolute carbon usage, carbon intensity, and carbon assessment (Bendig et al., 2024). Carbon usage measures total emissions in absolute terms but is strongly influenced by firm size, making comparisons across firms difficult. Carbon intensity improves comparability by relating emissions to economic activity, such as revenue, but it may still be affected by changes in firm scale rather than actual improvements in environmental performance. At the same time, carbon intensity decreases and corporate carbon performance improves when firms reduce their absolute emissions relative to their level of economic activity.

To complement carbon intensity measures, recent research has increasingly incorporated carbon assessment measures that capture changes in carbon performance over time. Bendig et al. (2024) argue that such measures provide additional insight into improvements in emissions efficiency by focusing on changes in environmental performance rather than emission levels alone.

Consistent with prior literature, the analysis employs both carbon intensity and changes in carbon intensity as measures of corporate carbon performance (Kayser et al., 2026). Carbon intensity captures firms' emissions efficiency relative to their level of economic activity, while changes in carbon intensity reflect improvements or deteriorations in carbon performance over time. Carbon intensity is calculated as:

$$CI_{i,t} = \frac{\text{Scope 3 emissions}_{i,t}}{\text{Revenue}_{i,t}}$$

where carbon emissions are scaled by firm revenue to improve comparability across firms. Consistent with prior literature, a logarithmic transformation is applied to the carbon intensity variable to reduce skewness in the data and improve the distributional properties of the variable (Kayser et al., 2026; Bendig et al., 2023).

In addition, to capture changes in carbon performance over time, the analysis also employs a past-related carbon assessment measure operationalized as the percentage change in carbon intensity. Following prior studies (Kayser et al., 2026), the change in carbon intensity is calculated as:

$$\Delta CI_{i,t} = \frac{CI_{i,t} - CI_{i,t-1}}{CI_{i,t-1}}$$

This measure captures the percentage change in carbon intensity from one year to the next, where negative values indicate reductions in carbon intensity and positive values indicate increases.

By examining both the level and change in Scope 3 carbon intensity, we capture not only firms' current value-chain carbon efficiency but also their progress in managing and reducing these emissions over time.

We focus specifically on Scope 3 emissions, which capture indirect emissions across firms' value chains. However, Scope 3 data is subject to considerable measurement challenges because it often relies on estimates, assumptions, and third-party information. To mitigate these concerns, we restrict the sample to firms with higher-quality Scope 3 data by applying a PCAF quality score threshold. By excluding observations with lower-quality estimates, we aim to reduce measurement error and improve the reliability of the carbon performance measures.

3.3.3 | Control Variables

To isolate the relationship between corporate carbon performance and financial performance, we include several firm-level control variables in the regression models. Following prior research examining environmental performance and financial outcomes (e.g., Kayser et al., 2026), we control for firm size, sales growth, and capital intensity. These variables account for firm characteristics that may influence financial performance independently of carbon performance.

We include firm size because larger firms may benefit from economies of scale, stronger market positions, and greater access to resources. Firm size is operationalized as the natural logarithm of total assets. Among publicly listed firms, larger firms often exhibit more mature business structures and lower growth opportunities, while also facing increased organizational complexity and coordination costs, which may negatively affect both accounting-based and market-based financial performance. Sales growth captures firm expansion and is measured as the annual percentage change in revenue. Firms with higher sales growth may exhibit stronger financial performance due to increasing demand or successful market strategies. Capital intensity captures differences in firms' investment intensity and production structures and is measured as the ratio of capital expenditures to revenue.

We initially included leverage as a control variable following prior literature. However, due to substantial data limitations leading to a significant reduction in sample size, and because its inclusion did not materially affect the estimated coefficients of interest, we excluded leverage from the baseline specification to preserve statistical power.

3.4 | Research Model

To examine the relationship between CCP and CFP, panel regression models are estimated. CFP is measured using both an accounting-based indicator (return on assets, ROA) and a market-based indicator (Tobin's Q), while CCP is captured using both carbon intensity and the change in carbon intensity.

We estimate a panel regression model with firm and year fixed effects. Firm fixed effects control for time-invariant firm characteristics, while year fixed effects account for macroeconomic shocks common across firms. All independent and control variables, except sales growth, are lagged by one year to mitigate reverse causality concerns. To address heteroscedasticity and within-firm correlation, robust standard errors clustered at the firm level are applied.

The baseline model for hypothesis 1 is specified as follows:

$$\begin{aligned} CFP_{i,t} = \alpha_0 + \beta_1 CCP_{i,t-1} + \beta_2 FirmSize_{i,t-1} + \beta_3 SalesGrowth_{i,t} \\ + \beta_4 CapitalIntensity_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t} \end{aligned}$$

$$\begin{aligned} CFP_{i,t} = \alpha_0 + \beta_1 \Delta CCP_{i,t-1} + \beta_2 FirmSize_{i,t-1} + \beta_3 SalesGrowth_{i,t} \\ + \beta_4 CapitalIntensity_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t} \end{aligned}$$

where $CFP_{i,t}$ represents corporate financial performance for firm i in year t, measured as ROA or Tobin's Q. $CCP_{i,t-1}$ denotes corporate carbon performance measured as Scope 3 carbon intensity, while $\Delta CCP_{i,t-1}$ captures the change in carbon intensity. μ_i represents firm fixed effects, λ_t year fixed effects, and $\varepsilon_{i,t}$ the error term.

Consistent with prior literature (Bendig et al., 2023; Kayser et al., 2026), the models using ΔCCP examine the relationship between changes in carbon intensity and the absolute levels of ROA and Tobin's Q rather than changes in financial performance. This approach is based on the assumption that improvements in corporate carbon performance, reflected through reductions in carbon intensity, may contribute positively to firms' financial performance in the following year. However, to further test robustness and better match changes in carbon performance with changes in financial performance, additional robustness models are estimated using changes in both CCP and CFP measures.

To test whether the relationship between CCP and CFP differs across regions, the baseline model is extended by including an interaction term between CCP and a regional dummy variable indicating whether a firm is headquartered in EU for hypothesis 2:

$$CFP_{i,t} = \alpha_0 + \beta_1 CCP_{i,t-1} + \beta_2 \left(CCP_{i,t-1} \times EUDummy_i\right)$$
$$+\beta_3 FirmSize_{i,t-1} + \beta_4 SalesGrowth_{i,t} + \beta_5 CapitalIntensity_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

$$CFP_{i,t} = \alpha_0 + \beta_1 \Delta CCP_{i,t-1} + \beta_2 \left(\Delta CCP_{i,t-1} \times EUDummy_i\right)$$
$$+\beta_3 FirmSize_{i,t-1} + \beta_4 SalesGrowth_{i,t} + \beta_5 CapitalIntensity_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

where $EUDummy_i$ equals 1 if the firm is headquartered in the European Union and 0 if it is based in the United States. The interaction term captures whether the relationship between corporate carbon performance and financial performance differs between the two regions. A negative and statistically significant coefficient for the interaction term would indicate that the relationship is stronger for EU firms, thereby providing support for the second hypothesis.

Table 2 provides an overview of the estimated regression specifications for hypotheses 1 and 2.

TABLE 2 | Regression model overview

Model	Hypothesis	Independent variable	Dependent variable
Model 1a	H1	Carbon intensity (CI)	ROA
Model 1b	H1	Change in carbon intensity (ΔCI)	ROA
Model 1c	H1	Carbon intensity (CI)	Tobin's Q
Model 1d	H1	Change in carbon intensity (ΔCI)	Tobin's Q
Model 2a	H2	CI × EU dummy	ROA
Model 2b	H2	ΔCI × EU dummy	ROA
Model 2c	H2	CI × EU dummy	Tobin's Q
Model 2d	H2	ΔCI × EU dummy	Tobin's Q

Notes: CI = Scope 3 carbon intensity, measured as Scope 3 emissions divided by total revenue. ΔCI = annual percentage change in Scope 3 carbon intensity. ROA = return on assets, measured as EBIT divided by total assets. Tobin's Q = enterprise value divided by total assets. EU dummy = binary variable equal to 1 for firms incorporated in the European Union and 0 otherwise.

Table 3 summarizes the variables included in the regression models and their expected relationships with financial performance. Carbon intensity and changes in carbon intensity are expected to have negative relationships with ROA and Tobin's Q, as lower carbon intensity reflects higher CCP. The interaction terms are also expected to be negative, reflecting a stronger CCP–CFP relationship for EU firms.

TABLE 3 | Variables and expected signs

Variable	Expected effect on ROA	Expected effect on Tobin's Q
Carbon Intensity (CI)	-	-
Change in Carbon Intensity (ΔCI)	-	-
Interaction between CI and EU dummy (CCP × EU)	-	-
Interaction between ΔCI and EU dummy (ΔCCP × EU)	-	-
Total assets (firm size)	-	-
Sales growth	+	+
Capital intensity	-	-

Notes: Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue.

3.5 | Statistical Considerations

To ensure the validity and reliability of the empirical results, we apply several statistical procedures and robustness checks.

First, to mitigate the influence of extreme values, we winsorize all continuous variables at the 1st and 99th percentiles, consistent with prior literature. This approach reduces the impact of outliers without excluding observations from the sample.

Second, we address potential heteroscedasticity and within-firm correlation by applying robust standard errors clustered at the firm level. This is particularly relevant in panel data settings, where error terms may not be independent across time within firms.

Third, we assess multicollinearity using variance inflation factors (VIF). All VIF values remain below conventional thresholds, indicating that multicollinearity does not pose a concern for the estimation results. Given the panel structure and large sample size, the assumption of normally distributed residuals is not considered critical for statistical inference.

Finally, we conduct several robustness tests to validate the stability of the results. These include (i) using alternative measures of financial performance, (ii) applying alternative specifications of carbon performance, (iii) conducting subsample analyses based on geographic regions (EU versus US firms), and (iv) restricting the sample to firms with higher-quality emissions data based on PCAF scores. The results remain consistent across these alternative specifications, supporting the robustness of the main findings.

As additional robustness tests, supplementary model specifications are estimated.

First, Robustness Models R1a and R1b extend baseline Models 1a and 1b by including lagged return on assets. This specification accounts for earnings persistence, as current profitability may partly be explained by prior firm performance. By including $ROA_{i,t-1}$, the analysis tests whether the estimated relationship between corporate carbon performance and current profitability remains after controlling for prior profitability. Given the short panel dimension, these models are treated as supplementary robustness tests rather than the primary model specification.

Second, Robustness Models R2a and R2b regress changes in financial performance on changes in corporate carbon performance. Specifically, ΔROA and $\Delta Tobin's\ Q$ are regressed on Δ carbon intensity to assess whether short-term improvements in corporate carbon performance are associated with contemporaneous improvements in financial performance. This extends prior research by Bendig et al. (2023) and Kayser et al. (2026), which examine changes in carbon intensity but do not match them with changes in financial performance measures. By using change variables on both sides of the regression, these models provide a stricter test of whether year-over-year improvements in Scope 3 carbon performance are associated with simultaneous financial performance improvements.

TABLE 4 | Robustness model overview

Model	Independent variable	Additional specification	Dependent variable
R1a	Carbon intensity (CI)	Lagged ROA included	ROA
R1b	Change in carbon intensity (ΔCI)	Lagged ROA included	ROA
R2a	Change in carbon intensity (ΔCI)	Change specification	ΔROA
R2b	Change in carbon intensity (ΔCI)	Change specification	ΔTobin's Q

Notes: ROA = return on assets. Tobin's Q = enterprise value divided by total assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity.

4 | Empirical Results

In this section, we present the empirical findings of the study. We begin with descriptive statistics and correlation analysis to provide an overview of the data and relationships between variables. We then report the regression results used to test the hypotheses, followed by robustness checks to assess the stability of the findings.

4.1 | Descriptive Statistics and Correlation Matrix

Table 5 presents the descriptive statistics for all variables included in the empirical analysis. Overall, the results indicate that firms in the sample are, on average, profitable and exhibit substantial variation across both financial and carbon-related variables.

Starting with financial performance, the mean ROA is 9.3%, suggesting that firms generate positive returns on their assets on average. Similarly, the mean Tobin's Q is 1.68, exceeding unity, which implies that the market valuation of firms is, on average, higher than the book value of their assets. However, the relatively high standard deviation and wide range indicate substantial heterogeneity in market valuations across firms.

Regarding corporate carbon performance, the mean carbon intensity (CI) is negative (-7.78), reflecting the logarithmic transformation applied to the variable. In contrast, the change in carbon intensity (ΔCI), measured as the percentage year-over-year change in carbon intensity, exhibits substantial variability, with a very large standard deviation and wide range. This indicates considerable volatility in annual changes in emissions intensity across firms. The large dispersion is partly driven by firms with very low initial carbon intensity levels, where relatively small absolute changes may generate extremely large percentage changes. This pattern is consistent with prior research highlighting the measurement challenges and variability associated with Scope 3 emissions (Kayser et al., 2026).

Turning to the control variables, firm size shows relatively limited dispersion, indicating a homogeneous sample in terms of scale. Sales growth varies across firms, while capital intensity exhibits substantial heterogeneity, suggesting differences in production structures and asset intensity within the sample.

Overall, the descriptive statistics reveal considerable heterogeneity across firms, particularly for market-based performance and changes in carbon intensity, supporting the need to account for outliers and skewness in the regression analysis.

TABLE 5 | Descriptive statistics

	Dependent variables		Independent variables		Control variables		
	ROA	**Tobin's Q**	**CI**	**ΔCI**	**Total assets**	**Sales growth**	**Capital intensity**
N	2,654	2,654	2,654	2,654	2,654	2,654	2,654
Mean	9.3%	1.68	-7.78	15.32	23.29	0.08	0.10
Std. Dev.	6.7%	1.73	1.59	116.99	1.60	0.17	0.20
Min	-5.9%	0.00	-12.81	-81.58	17.95	-0.41	0.00
P25	4.8%	0.71	-8.90	-19.42	22.24	-0.02	0.03
Median	7.9%	1.05	-7.74	-5.69	23.29	0.07	0.05
P75	12.1%	1.94	-6.72	11.69	24.42	0.16	0.10
Max	32.5%	9.86	-3.53	1,103.07	27.85	0.83	2.83

Notes: ROA = return on assets. Tobin's Q = enterprise value divided by total assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity. Total assets = natural logarithm of total assets. Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue.

Table 6 presents the Pearson correlation coefficients for all variables included in the analysis. Overall, the correlations indicate limited risk of multicollinearity, as most coefficients are relatively low in magnitude.

ROA and Tobin's Q are positively correlated (0.672), suggesting that firms with higher operational profitability also tend to exhibit higher market valuations. Regarding corporate carbon performance, carbon intensity (CI) is negatively correlated with both ROA (-0.209) and Tobin's Q (-0.314), indicating that firms with higher emissions intensity tend to exhibit lower financial performance. In contrast, ΔCI shows only very weak and statistically insignificant correlations with both ROA (-0.033) and Tobin's Q (-0.023), suggesting that short-term changes in carbon intensity are not strongly associated with financial outcomes at the descriptive level.

Among the control variables, sales growth is positively correlated with both financial performance measures, while capital intensity is negatively correlated with both ROA (-0.262) and Tobin's Q (-0.128). Firm size is negatively correlated with both ROA (-0.082) and Tobin's Q (-0.117), whereas leverage displays relatively weak negative correlations with the financial performance measures.

All coefficients remain well below commonly cited multicollinearity thresholds. The highest correlation is observed between ROA and Tobin's Q (0.672), while the correlations among the independent and control variables remain relatively modest. Overall, the correlation structure suggests that multicollinearity is unlikely to pose a significant issue in the regression analysis.

TABLE 6 | Correlation matrix

Variable	ROA	Tobin's Q	CI	ΔCI	Size	Growth	Lev.	Cap. int.
ROA	1.000							
Tobin's Q	0.672***	1.000						
	(0.000)							
Carbon intensity	-0.209***	-0.314***	1.000					
	(0.000)	(0.000)						
Δ Carbon intensity	-0.033	-0.023	0.186***	1.000				
	(0.147)	(0.321)	(0.000)					
Firm size	-0.082***	-0.117***	0.150***	-0.031	1.000			
	(0.000)	(0.000)	(0.000)	(0.166)				
Sales growth	0.138***	0.182***	-0.025	0.023	-0.027	1.000		
	(0.000)	(0.000)	(0.270)	(0.303)	(0.238)			
Capital intensity	-0.262***	-0.128***	0.081***	-0.017	0.104***	0.055**	0.189***	1.000
	(0.000)	(0.000)	(0.000)	(0.441)	(0.000)	(0.015)	(0.000)	

Notes: p-values are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. ROA = return on assets. ROA = return on assets. Tobin's Q = enterprise value divided by total assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity. Total assets = natural logarithm of total assets. Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue.

4.2 | Empirical Analysis

We first present the baseline regression results (H1), followed by tests of regional differences between EU and US firms (H2) and robustness checks.

4.2.1 | Hypothesis 1 Results

Table 7 reports the fixed effects regression results examining the relationship between corporate carbon performance (CCP) and corporate financial performance (CFP), operationalized using multiple financial and carbon performance measures.

When CCP is measured using Scope 3 carbon intensity (CI) and CFP is measured using ROA, the results show a negative and statistically significant relationship ($\beta = -0.0072$, $p < 0.01$). Since lower carbon intensity reflects higher CCP, the negative coefficient indicates a positive association between CCP and accounting-based financial performance, providing support for H1 when CFP is operationalized as ROA. The coefficient implies that a 1% reduction in carbon intensity is associated with an increase in ROA of approximately 0.0072 percentage points. These results suggest that improvements in Scope 3 carbon performance are associated with economically meaningful, although relatively modest, improvements in accounting-based financial performance.

In contrast, when CFP is operationalized using Tobin's Q, the relationship between carbon intensity and financial performance is negative but not statistically significant ($\beta = -0.0439$, p = 0.1922). While the coefficient direction is consistent with H1, the lack of statistical significance suggests no clear evidence of a relationship between CCP and market-based financial performance.

When CCP is measured using changes in carbon intensity (ΔCI), no statistically significant relationship is observed for either operationalization of CFP. Specifically, the relationship between ΔCI and ROA is statistically insignificant (p = 0.1257), as is the relationship between ΔCI and Tobin's Q (p = 0.9305). The coefficients are close to zero in both models, indicating that short-term changes in carbon intensity are not associated with financial performance within the observed time horizon.

The control variables display relatively consistent patterns across all specifications. Sales growth is positive and highly significant in all models, indicating that firm growth is an important driver of financial performance. Firm size, measured as the natural logarithm of total assets, is negatively and significantly related to both ROA and Tobin's Q, suggesting lower financial performance for larger firms within the fixed effects framework. Capital intensity is negatively and significantly associated with ROA but not statistically significant for Tobin's Q.

All models include firm and year fixed effects and are based on 2,654 firm-year observations. The within R^2 ranges from 0.0469 to 0.0927, which is in line with prior fixed effects panel studies examining the relationship between CCP and CFP (Bendig et al., 2023; Kayser et al., 2026). In fixed effects models, the within R^2 is the most relevant measure of explanatory power, as it captures the extent to which the models explain variation within firms over time after controlling for unobserved time-invariant firm characteristics.

In contrast, the overall R^2 may become negative in fixed effects panel models. This is not uncommon and does not indicate model misspecification or invalid results. Since fixed effects estimation focuses on within-firm variation and removes firm-specific averages, the overall fit measure may perform poorly when evaluated against the total variation in the data. Prior fixed effects studies in the CCP–CFP literature have similarly emphasized the within R^2 rather than the overall R^2 for this reason (Bendig et al., 2023; Kayser et al., 2026).

Overall, the results provide partial support for H1. A positive relationship between CCP and CFP is observed only when CCP is measured using carbon intensity and CFP is measured using the accounting-based performance measure ROA. No statistically significant relationship is observed for Tobin's Q or for models using changes in carbon intensity as the operational measure of CCP.

TABLE 7 | Regression results: CCP's effect on CFP (H1)

	Model 1a (ROA)		Model 1b (ROA)		Model 1c (Tobin's Q)		Model 1d (Tobin's Q)	
Variable	**Coef.**	**p**	**Coef.**	**p**	**Coef.**	**p**	**Coef.**	**p**
Constant	0.7986***	0.0001	0.8128***	0.0002	15.3387***	0.0003	15.4494***	0.0004
CI	-0.0072***	0.0006			-0.0439	0.1922		
ΔCI			-0.0000	0.1257			0.0000	0.9305
Total assets	-0.0327***	0.0002	-0.0309***	0.0008	-0.6040***	0.0012	-0.5940***	0.0015
Sales growth	0.0462***	0.0000	0.0438***	0.0000	0.4050***	0.0008	0.3907***	0.0009
Capital intensity	-0.0468***	0.0041	-0.0489***	0.0040	0.1252	0.4052	0.1103	0.4700
Observations	2,654		2,654		2,654		2,654	
R squared	-0.4610		-0.3978		-0.1840		-0.1920	
R squared within	0.0927		0.0829		0.04685		0.0469	
Firms FE	YES		YES		YES		YES	
Year FE	YES		YES		YES		YES	

Notes: ROA = return on assets. ROA = return on assets. Tobin's Q = enterprise value divided by total assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity. Total assets = natural logarithm of total assets. Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue.

4.2.2 | Hypothesis 2 Results

Table 8 reports the fixed effects regression results including interaction terms to assess whether the relationship between corporate carbon performance (CCP) and corporate financial performance (CFP) differs between EU and US firms.

Consistent with the baseline results, when CCP is measured using lagged Scope 3 carbon intensity (CI) and CFP is measured using ROA, the relationship remains negative and weakly statistically significant ($\beta = -0.0060$, p = 0.0510). Since lower carbon intensity reflects higher CCP, the negative coefficient indicates that higher CCP is associated with stronger accounting-based financial performance. The coefficient implies that a 1% reduction in carbon intensity is associated with an increase in ROA of approximately 0.006 percentage points. This provides continued, although weaker, support for H1 when CFP is operationalized using ROA.

In contrast, when CFP is operationalized using Tobin's Q, the coefficient for carbon intensity remains negative but statistically insignificant ($\beta = -0.0491$, p = 0.3746), suggesting no statistically significant relationship between CCP and market-based financial performance.

The interaction term between carbon intensity and the EU dummy variable is not statistically significant for either operationalization of CFP. Specifically, the interaction term is insignificant for ROA (p = 0.5752) and for Tobin's Q (p = 0.8773). These results indicate that the relationship between CCP, measured through carbon intensity, and CFP does not differ significantly between EU and US firms.

When CCP is operationalized using changes in carbon intensity (ΔCI), the results remain statistically insignificant across all specifications. The relationship between ΔCI and ROA is insignificant (p = 0.1037), as is the relationship between ΔCI and Tobin's Q (p = 0.6318). Similarly, the interaction term between ΔCI and the EU dummy variable is not statistically significant for either ROA (p = 0.2944) or Tobin's Q (p = 0.4238). This suggests no regional differences in the relationship between short-term changes in carbon performance and financial performance.

The control variables display patterns consistent with the baseline models. Sales growth is positive and highly significant across all specifications, while firm size, measured as the natural logarithm of total assets, is negatively and significantly associated with both ROA and Tobin's Q. Capital intensity is negatively and significantly related to ROA but remains statistically insignificant for Tobin's Q.

All models include firm and year fixed effects and are based on 2,654 firm-year observations. The within R^2 ranges from 0.0468 to 0.0930, similar to the baseline models, indicating that the inclusion of regional interaction terms does not materially improve explanatory power.

Overall, the results provide continued partial support for H1, as a positive relationship between CCP and CFP is observed only when CCP is measured using carbon intensity and CFP is measured using the accounting-based performance measure ROA. However, no support is found for H2, as the interaction terms between the operational measures of CCP and EU incorporation are consistently statistically insignificant, suggesting that the CCP–CFP relationship does not differ significantly between EU and US firms.

TABLE 8 | Regression results: Regional differences (H2)

	Model 2a (ROA)		Model 2b (ROA)		Model 2c (Tobin's Q)		Model 2d (Tobin's Q)	
Variable	**Coef.**	**p**	**Coef.**	**p**	**Coef.**	**p**	**Coef.**	**p**
Constant	0.7983***	0.0001	0.8168***	0.0001	15.3397***	0.0003	15.5050***	0.0003
Scope 3 carbon intensity (lag)	-0.0060*	0.0510			-0.0491	0.3746		
Δ Scope 3 carbon intensity (lag)			-0.0000	0.1037			-0.0001	0.6318
CCP × EU	-0.0023	0.5752			0.0098	0.8773		
ΔCCP × EU			0.0000	0.2944			0.0001	0.4238
Firm size (lag)	-0.0327***	0.0002	-0.0311***	0.0008	-0.6040***	0.0012	-0.5964***	0.0013
Sales growth	0.0463***	0.0000	0.0439***	0.0000	0.4045***	0.0009	0.3923***	0.0009
Capital intensity (lag)	-0.0464***	0.0048	-0.0490***	0.0038	0.1237	0.4076	0.1087	0.4749
Observations	2,654		2,654		2,654		2,654	
R squared	-0.5916		-0.4052		-0.1654		-0.1950	
R squared within	0.0930		0.0837		0.0468		0.0472	
Firms FE	YES		YES		YES		YES	
Year FE	YES		YES		YES		YES	

Notes: ROA = return on assets. ROA = return on assets. Tobin's Q = enterprise value divided by total assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity. Total assets = natural logarithm of total assets. Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue.

4.2.3 | Robustness Tests

The inclusion of lagged return on assets confirms the presence of earnings persistence, as past profitability is strongly associated with current performance. Importantly, the negative relationship between Scope 3 carbon intensity and ROA remains statistically significant, suggesting that the baseline findings are not solely driven by prior firm performance. In contrast, the coefficient for the change in carbon intensity remains statistically insignificant and economically small, indicating limited evidence that short-term changes in Scope 3 carbon intensity are associated with contemporaneous accounting-based financial performance.

TABLE 9 | Regression results: Robustness test with lagged ROA

	Model R1a (ROA)		Model R1b (ROA)	
Variable	**Coef.**	**p**	**Coef.**	**p**
Scope 3 carbon intensity (lag)	-0.0040**	0.0259		
Δ Scope 3 carbon intensity			-0.0000	0.2955
Firm size (lag)	-0.0245***	0.0001	-0.0232***	0.0003
Sales growth	0.0639***	0.0000	0.0630***	0.0000
Capital intensity (lag)	-0.0382***	0.0046	-0.0393***	0.0044
Lagged ROA	0.3077***	0.0000	0.3181***	0.0000
Observations	2,650		2,650	
R squared	-26.7367		-26.7573	
R squared within	0.1861		0.1835	
Firms FE	YES		YES	
Year FE	YES		YES	

Notes: ROA = return on assets. ROA = return on assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity. Total assets = natural logarithm of total assets. Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue. Lagged ROA = previous year's return on assets.

As an additional robustness analysis, we examined whether changes in financial performance are associated with changes in Scope 3 carbon intensity by regressing ΔROA and ΔTobin's Q on Δ carbon intensity. This extends prior research by Kayser et al. (2026) and Bendig et al. (2023), which analyzed changes in carbon intensity without matching them to changes in financial performance measures. By using change variables on both sides of the regression, the analysis provides a stricter test of whether short-term improvements in corporate carbon performance are reflected in contemporaneous financial improvements.

The results show no statistically significant relationship between changes in Scope 3 carbon intensity and either ΔROA or ΔTobin's Q. In addition, the estimated coefficients are relatively small in magnitude, suggesting limited short-term financial effects associated with year-over-year changes in Scope 3 carbon intensity within the sample period. While these findings do not provide evidence of immediate financial improvements from short-term emission reductions, the coefficient directions remain broadly consistent with the baseline results. This may indicate that potential financial effects of Scope 3 improvements materialize gradually rather than within the short time horizon captured by the change models.

TABLE 10 | Regression results: Robustness test with change in ROA and Tobin's Q

	Model R2a (ΔROA)		Model R2b (ΔTobin's Q)	
Variable	**Coef.**	**p**	**Coef.**	**p**
Constant	0.5475	0.0142	-22.0353	0.0912
Δ Scope 3 carbon intensity	-0.0000	0.8838	0.0001	0.6457
Firm size (lag)	0.0019	0.0001	0.9441*	0.0921
Sales growth	0.1048***	0.0000	0.5152	0.0012
Capital intensity (lag)	-0.0248	0.0046	-0.4171	0.1556
Observations	2,020		2,650	
R squared	0.1242		-4.3872	
R squared within	0.1373		0.0285	
Firms FE	YES		YES	
Year FE	YES		YES	

Notes: ROA = return on assets. ROA = return on assets. Tobin's Q = enterprise value divided by total assets. CI = Scope 3 carbon intensity measured as Scope 3 emissions divided by revenue. ΔCI = percentage change in Scope 3 carbon intensity. Total assets = natural logarithm of total assets. Sales growth = annual percentage change in revenue. Capital intensity = ratio of capital expenditures to revenue.

4.3 | Summary of Results

The results provide partial support for H1. Lower Scope 3 carbon intensity is associated with higher ROA, indicating a positive relationship between corporate carbon performance and accounting-based financial performance. The estimated effect is economically modest, with a 10% reduction in carbon intensity corresponding to an increase in ROA of approximately 0.072 percentage points. However, no significant relationship is found for Tobin's Q.

No significant effects are observed for changes in carbon intensity, suggesting that short-term improvements are not associated with financial performance within the observed period.

Finally, no support is found for H2, as the interaction terms are insignificant, indicating that the relationship does not differ between EU and US firms.

5 | Discussion

The purpose of this thesis was to examine whether Scope 3 corporate carbon performance is associated with corporate financial performance, and whether this relationship differs between firms incorporated in the European Union and the United States. The results provide partial support for these questions. Lower Scope 3 carbon intensity is associated with higher ROA, but not with higher Tobin's Q. Neither the level nor year-on-year changes in carbon intensity show a different relationship with financial performance between EU and US firms. A common thread runs through these results: Scope 3 performance may carry financial relevance, but only through a channel that does not yet depend on how markets interpret or price the information.

5.1 | What the results suggest about the Scope 3-financial performance relationship

The significant negative relationship between carbon intensity and ROA may reflect a connection between lower emissions and broader operational efficiency. Firms that manage their supply chains and procurement carefully tend to use inputs more efficiently and generate less waste. If lower Scope 3 intensity is partly a marker of this kind of operational discipline, it could explain why it is associated with higher profitability even where no deliberate climate strategy is in place. Under this interpretation, what the ROA result picks up may be less about sustainability specifically and more about what well-run firms tend to look like when measured through their emissions profile.

The absence of a significant relationship with Tobin's Q may reflect that the same signal does not translate easily to markets. Even if lower carbon intensity reflects operational efficiency, investors would need Scope 3 data that is consistent and comparable across firms to price it into valuations. Firms define which emissions to include and how to calculate them differently, which makes cross-firm comparisons difficult. An investor who cannot tell whether an improvement reflects a genuine operational change or a shift in how emissions are calculated may have limited basis for adjusting a firm's valuation on that basis alone. It is also possible that for the large, listed firms in this sample, broad sustainability expectations are already reflected in market prices in a general way, meaning specific improvements in Scope 3 carbon intensity may not move valuations further.

The costs of achieving reductions offer a further possible explanation for the absent market response. Reducing value chain emissions requires supplier coordination and supply chain restructuring, both of which involve near-term costs before any efficiency gains appear. If investors weigh both the potential long-run benefit of lower emissions and the transition costs required to achieve them, these effects may partially offset each other, producing no significant change in market valuation. This argument also connects to the null result for year-on-year changes in carbon intensity. A firm actively reducing its emissions is likely still absorbing restructuring costs, while a firm with persistently low intensity may have already been through that process. Any financial benefit from Scope 3 reductions may therefore take several years to emerge, which a one-year window is unlikely to capture.

5.2 | What the results suggest about the role of data quality and disclosure

The ROA result diverges from the limited prior research on Scope 3, which has generally found weak or null results. One possible explanation for this divergence is data quality. Earlier studies did not apply a quality filter comparable to the PCAF threshold used here. Low-quality Scope 3 estimates may introduce noise that suppresses regression coefficients, and removing the poorest-quality observations could make an otherwise undetectable relationship visible. The prior null findings may therefore reflect a measurement problem rather than the absence of a relationship, though this cannot be confirmed without replicating those studies under similar data quality conditions. This also has implications for how the mixed results in the broader CCP-CFP literature may be interpreted. Scope 3 emissions are inherently more difficult to measure than Scope 1 or Scope 2, as they depend on supplier-provided data and external estimates. Studies that include all emission scopes without accounting for differences in data reliability may risk underestimating the financial relevance of value chain emissions specifically.

The insignificant EU-US interaction is consistent with this picture. Even if EU regulation creates stronger pressure to manage and disclose Scope 3 emissions, it does not resolve the data comparability problem that may prevent markets from pricing carbon performance in the first place. A more direct explanation is timing. The CSRD first applies mandatorily to the 2024 financial year. For most of the sample period, mandatory EU disclosure had therefore not yet come into force, which may explain why no regional difference is detectable.

There is also reason to consider who chooses to report voluntarily. Firms may be more likely to disclose sustainability information when their performance is favorable, since disclosure can function as a positive signal to investors. In the US, where Scope 3 disclosure is voluntary, firms that report their data may therefore tend to be those with stronger carbon performance. In the EU, all qualifying firms must report regardless of their performance level. This means the EU sample may include a wider range of performers than the US sample, which could partially offset any credibility advantage of mandatory reporting. The insignificant result may therefore not mean that regulation is irrelevant, but rather that these forces may work against each other within this particular sample and time period.

5.3 | Practical implications

These results carry different implications depending on the stakeholder group. For managers, the null result for year-on-year changes suggests that the financial effects of Scope 3 reductions are unlikely to appear within a single year. Since supply chain restructuring involves upfront costs that take time to recover, evaluating Scope 3 initiatives against annual profitability targets may not be appropriate. A longer time horizon is likely more relevant for assessing whether these investments pay off.

For investors, the data comparability challenges described above suggest that Scope 3 metrics may not yet function as reliable valuation inputs. At the same time, the ROA result suggests that carbon intensity may carry information about operational efficiency that is not fully reflected in market prices. Developing the capacity to assess Scope 3 data quality may therefore become increasingly relevant as disclosure standards improve under CSRD.

For policymakers, the results point to data standardization as an important condition. The ROA relationship only became detectable after removing the lowest-quality observations, which suggests that improving the comparability and reliability of Scope 3 disclosures could make the financial relevance of Scope 3 performance more visible to market participants who cannot apply their own quality filters.

6 | Conclusions

This study contributes to the literature in two main ways. First, it extends the still limited literature examining the relationship between Scope 3 corporate carbon performance and corporate financial performance. Prior research has largely focused on Scope 1 and Scope 2 emissions, while empirical evidence on Scope 3 emissions remains relatively scarce and inconclusive. This study instead finds that lower Scope 3 carbon intensity is significantly associated with higher accounting-based financial performance, measured through ROA. In contrast, no significant relationship is identified for market-based financial performance measured through Tobin's Q. The findings therefore provide new evidence suggesting that Scope 3 carbon performance may be financially relevant, but that this relevance depends on the financial performance measure considered.

Second, the study contributes methodologically by addressing key limitations in prior Scope 3 research related to data quality and measurement reliability. Because Scope 3 emissions are inherently more difficult to estimate and verify due to their dependence on complex value chains and external actors, earlier research has been subject to substantial measurement uncertainty. By using more recent firm-level data collected during a period of improving sustainability disclosure practices and by applying a PCAF-based quality filter, the study reduces the influence of low-quality emissions estimates that may previously have obscured empirical relationships. The study therefore demonstrates how improved disclosure quality and more reliable Scope 3 data can affect empirical findings within the CCP–CFP literature.

Limitations

This study has three main limitations. First, although the independent variables are lagged, the analysis cannot fully rule out reverse causality or broader endogeneity concerns. More profitable firms may have greater financial and organizational capacity to reduce Scope 3 carbon intensity. The results should therefore be interpreted as associations rather than causal effects.

Second, the study is limited by the short time period for which reliable Scope 3 data is available. This is particularly relevant for the models using year-over-year changes in carbon intensity. Scope 3 reductions may require supplier coordination, supply chain restructuring, product redesign, or operational investments. These initiatives may create short-term costs before any financial benefits become visible.

Third, Scope 3 emissions remain difficult to measure consistently across firms. Even though the study applies a PCAF-based quality filter, Scope 3 data may still differ in reporting boundaries, estimation methods, and category coverage. This limits comparability and may partly explain why the market-based results are insignificant.

Suggested future research

Future research should first examine the causal direction between Scope 3 carbon performance and financial performance. Stronger identification strategies, such as natural experiments, difference-in-differences designs, or instrumental variable approaches, could help determine whether lower Scope 3 carbon intensity improves financial performance or whether financially stronger firms are simply better able to reduce emissions.

Second, future studies should examine longer time horizons and alternative lag structures. The insignificant results for changes in carbon intensity may reflect that Scope 3 improvements take time to affect profitability or market valuation. Multi-year changes in carbon intensity could therefore better capture delayed financial effects than year-over-year changes.

Third, future research should examine heterogeneity within Scope 3 emissions. Scope 3 consists of several categories, including purchased goods and services, transportation, product use, and end-of-life treatment. These categories differ in managerial control, operational relevance, and financial implications. Studying specific Scope 3 categories, preferably within industry-specific samples, could provide a clearer understanding of when and how Scope 3 carbon performance becomes financially relevant.

Reference List

Acheampong, A., & Wang, Y. (2025). Carbon reduction initiatives, firm innovation and firm value. Economics Letters, 256, 112613.

Albertini, E. (2013). Does Environmental Management Improve Financial Performance? A Meta-Analytical Review. Organization & Environment, 26(4), 431-457.

Alsaifi, K., Elnahass, M., & Salama, A. (2020). Carbon disclosure and financial performance: UK environmental policy. Business Strategy and the Environment, 29(2), 711–726.

Ambec, S., & Lanoie, P. (2008). Does it pay to be green? A systematic overview. Academy of Management Perspectives, 22(4), 45–62.

Bendig, D., Schulz, C., Erbar, F., & Heubeck, T. (2024). Apples to apples: Accurately assessing corporate carbon performance. Journal of Cleaner Production, 486, 144338.

Bendig, D., Wagner, A., & Lau, K. (2023). Does it pay to be science-based green? The impact of science-based emission-reduction targets on corporate financial performance. Journal of Industrial Ecology, 27(1), 125–140.

Busch, T., & Lewandowski, S. (2018). Corporate carbon and financial performance: A meta-analysis. Journal of Industrial Ecology, 22(4), 745–759.

Busch, T., Bassen, A., Lewandowski, S., & Sump, F. (2022). Corporate carbon and financial performance revisited. Organization & Environment, 35(1), 154–171.

Christensen, H. B., Hail, L., & Leuz, C. (2021). Mandatory CSR and sustainability reporting: Economic analysis and literature review. Review of Accounting Studies, 26(3), 1176–1248.

Cicchiello, A. F., Marrazza, F., & Perdichizzi, S. (2023) Non-financial disclosure regulation and environmental, social, and governance (ESG) performance: The case of EU and US firms. Corporate Social Responsibility and Environmental Management, 30(3), 1121–1128

Clarkson, P. M., Li, Y., Richardson, G. D., & Vasvari, F. P. (2011). Does it really pay to be green? Determinants and consequences of proactive environmental strategies. Journal of Accounting and Public Policy, 30(2), 122–144.

Datt, R. R., Luo, L., & Tang, Q. (2019). Corporate voluntary carbon disclosure strategy and carbon performance in the USA. Accounting Research Journal, 32(3), 417–435.

European Commission. (2023). Commission Delegated Regulation (EU) 2023/2772 establishing the European Sustainability Reporting Standards (ESRS).

European Parliament & Council of the European Union. (2014). Directive 2014/95/EU on disclosure of non-financial and diversity information. European Parliament & Council of the European Union. (2022). Directive (EU) 2022/2464 on corporate sustainability reporting.

Fatemi, H., Leijerholt, U., Rezvani, Z., & Schnittka, O. (2023). Consumer responses to sustainable product branding strategies: A literature review and future research agenda. Baltic Journal of Management, 18(4), 525–542.

Figge, F., & Hahn, T. (2012). Is green and profitable sustainable? Assessing the trade-off between economic and environmental aspects. International Journal of Production Economics, 140(1), 92–102.

Fouret, F., Haalebos, R., Olesiewicz, M., Simmons, J., Jain, M., & Kooroshy, J. (2024). Scope for improvement: Solving the Scope 3 conundrum. FTSE Russell.

Giordino, D., Panero, M., Alshaghdali, N. O., & Koltai, J. P. (2026). Exploring the interrelationships among supply chain emissions, financial performance, market value, and board sustainability: An exploration of the European landscape. Corporate Social Responsibility and Environmental Management. Advance online publication.

Hettler, M., & Graf-Vlachy, L. (2024). Corporate Scope 3 carbon emission reporting as an enabler of supply chain decarbonization: A systematic review and comprehensive research agenda. Business Strategy and the Environment, 33(2), 263–282.

Kayser, C., Schüder, M., Retsch, B. T., & Zülch, H. (2026). What Role Do Scope 3 Emissions Play in the Carbon Financial Performance Context? Evidence From Disentangling of Scopes 1, 2, and 3 Emission Performance Within the Science-Based Targets Initiative Setting. Business Strategy and the Environment, 35(1), 1426–1455.

Klaaßen, L., & Stoll, C. (2021). Harmonizing corporate carbon footprints. Nature Communications, 12(1), 6149-13.

Kumar, A., Prakash, G., & Kumar, G. (2021). Does environmentally responsible purchase intention matter for consumers? A predictive sustainable model developed through an empirical study. Journal of Retailing and Consumer Services, 58, 102270.

Lewandowski, S. (2017). Corporate Carbon and Financial Performance: The Role of Emission Reductions. Business Strategy and the Environment, 26(8), 1196–1211.

Matsumura, E. M., Prakash, R., & Vera-Muñoz, S. C. (2014). Firm-value effects of carbon emissions and carbon disclosures. The Accounting Review, 89(2), 695–724.

Nguyen, H. V., Nguyen, C. H., & Hoang, T. T. B. (2019). Green consumption: Closing the intention-behavior gap. Sustainable Development, 27(1), 118–129.

Russo, M. V., & Fouts, P. A. (1997). A resource-based perspective on corporate environmental performance and profitability. Academy of Management Journal, 40(3), 534-559.

Trumpp, C., & Guenther, T. (2017). Too Little or too much? Exploring U-shaped Relationships between Corporate Environmental Performance and Corporate Financial Performance. Business Strategy and the Environment, 26(1), 49–68.

Velte, P. (2023). Which institutional investors drive corporate sustainability? A systematic literature review. Business Strategy and the Environment, 32(1), 42–71.

Wang, Z., Hubacek, K., Sun, X., & Ruzzenenti, F. (2026). Landscape of research on accounting Scope 3 emissions: A review of methodologies and data. Corporate Social Responsibility and Environmental Management, 1–17.

WBCSD & WRI. (2004). A Corporate Accounting and Reporting Standard. Greenhouse Gas Protocol. ISBN 1-56973-568-9.

WBCSD & WRI. (2011). Corporate Value Chain (Scope 3) Accounting and Reporting Standard. Greenhouse Gas Protocol. ISBN 978-1-56973-772-9

Electronic sources

Adelfang, S., Bedert, E., Bochkov, M., Delberghe, C., Dornheim, N., Liu, M., Münch, R., Pantusenko, V., Siemssen, S., & Soode, E. (2024) 'Net Zero Game Changer - Tackling the hidden footprint in European retail and wholesale value chains' Oliver Wyman & EuroCommerce. https://www.eurocommerce.eu/2024/06/net-zero-game-changer-tackling-the-hidden-carbon-footprint-in-european-retail-and-wholesale-value-chains/ [Accessed: 15.02.2026]

European Environment Agency. (2024). Greenhouse gas emissions in the upstream supply chain of EU-27 household consumption domains, million tonnes CO_2 equivalent, 2020. European Union. https://www.eea.europa.eu/en/analysis/maps-and-charts/greenhouse-gas-emissions-in-the-1?activeTab=6fbd444d-c422-4a78-8492-fd496bd61b7a [Accessed: 14.02.2026]

Eurostat (n.d.). "Glossary: Greenhouse gas (GHG)". European Union. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Greenhouse_gas_(GHG) [Accessed: 14.02.2026]

Eurostat (n.d.). "Glossary: Carbon dioxide equivalent". European Union. https://ec.europa.

eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_equivalent [Accessed: 14.02.2026]

H&M Group. (2026). H&M Group Annual & Sustainability Report 2025. H&M Group. https://hmgroup.com/wp-content/uploads/2026/03/HM-Group-Annual-and-sustainability-report-2025.pdf [Accessed: 08.05.2026]

Sturcken, E. (2024) Walmart's Project Gigaton win shows how to cut emissions with speed and scale. Enviromental Defense Fund. https://business.edf.org/insights/walmart-project-gigaton-win-shows-how-to-cut-emissions-with-speed-scale/ [Accessed: 08.05.2026]

SEC (2010). Commission Guidance Regarding Disclosure Related to Climate Change. U.S. Securities and Exchange Commission. https://www.sec.gov/rules-regulations/2010/02/commission-guidance-regarding-disclosure-related-climate-change [Accessed: 02.05.2026]

Appendix

APPENDIX 1 | Data collection and variable construction

Final variable	Underlying LSEG variable(s)	Data type	Construction / transformation
ROA	EBIT (USD), Total Assets (USD)	Reported and standardized by LSEG	Calculated as EBIT divided by total assets.
Tobin's Q	Enterprise Value (USD), Total Assets (USD)	Reported and standardized by LSEG	Calculated as enterprise value divided by total assets.
Scope 3 carbon intensity (CI)	Scope 3 combined emissions (tCO_2e), Total Revenue (USD)	Emissions reported or estimated by firms and standardized by LSEG	Calculated as Scope 3 emissions divided by revenue. Natural logarithm applied in regression models.
Change in carbon intensity (ΔCI)	Constructed from CI	Self-calculated	Calculated as $(CI_t - CI_{t-1})/CI_{t-1}$.
Firm size	Total Assets (USD)	Reported and standardized by LSEG	Measured as the natural logarithm of total assets.
Sales growth	Total Revenue (USD)	Reported and standardized by LSEG	Calculated as annual percentage change in revenue.
Capital intensity	Capital Expenditures (USD), Total Revenue (USD)	Reported and standardized by LSEG	Calculated as capital expenditures divided by revenue.
EU dummy	Country of incorporation	Reported by firms and standardized by LSEG	Dummy variable coded as 1 for firms headquartered in EU member states and 0 for firms headquartered in the United States.
Lagged ROA	Constructed from ROA	Self-calculated	One-period lag of ROA used in robustness models.
ΔROA	Constructed from ROA	Self-calculated	Calculated as $(ROA_t - ROA_{t-1})/ROA_{t-1}$.
ΔTobin's Q	Constructed from Tobin's Q	Self-calculated	Calculated as $(TQ_t - TQ_{t-1})/TQ_{t-1}$.

Notes: Financial and emissions data were retrieved from LSEG Workspace. LSEG standardizes firm-reported accounting, market, and emissions data across firms and reporting periods. Scope 3 emissions may include both directly reported and model-estimated values depending on firm disclosure availability. All continuous variables were winsorized at the 1st and 99th percentiles. Lagged variables were constructed at the firm-year level.

APPENDIX 2 | Sample period

Year	Observations	Firms	% of Observations
2020	18	18	0.68%
2021	353	353	13.30%
2022	462	462	17.41%
2023	612	612	23.06%
2024	631	631	23.78%
2025	572	572	21.55%
2026	6	6	0.23%

APPENDIX 3 | Country of Incorporation distribution

Country of Incorporation	Observations	Firms
United States	1,161	273
France	305	68
Sweden	223	61
Germany	194	45
Netherlands	125	31
Finland	122	29
Spain	118	28
Italy	105	26
Denmark	81	20
Ireland	55	13
Belgium	53	12
Portugal	37	9
Austria	32	7
Poland	19	6
Luxembourg	11	3
Greece	5	1
Hungary	5	1
Romania	3	1

APPENDIX 4 | Country of Incorporation – year distribution

Year	Region	Observations	Firms
2020	US	18	18
2021	EU	196	196
2021	US	157	157
2022	EU	252	252
2022	US	210	210
2023	EU	345	345
2023	US	267	267
2024	EU	360	360
2024	US	271	271
2025	EU	338	338
2025	US	234	234
2026	EU	2	2
2026	US	4	4

APPENDIX 5 | Descriptive statistics – Regions

	Mean		Std. dev.		Minimum		Maximum	
Variable	EU	US	EU	US	EU	US	EU	US
Average ROA	0.079	0.111	0.052	0.080	-0.060	-0.060	0.325	0.325
Tobin's Q	1.252	2.238	1.229	2.081	0.000	0.144	9.860	9.860
CI	-7.566	-8.063	1.448	1.722	-12.092	-12.813	-3.531	-3.531
ΔCI	33.028	28.152	480.590	292.774	-94.631	-97.526	13049.534	8028.689
Total assets	22.951	23.725	1.661	1.405	17.954	19.433	27.845	27.229
Sales growth	0.076	0.086	0.170	0.168	-0.408	-0.408	0.832	0.832
Capital intensity	0.085	0.126	0.130	0.254	0.001	0.002	1.997	2.832

APPENDIX 6 | Coefficient interpretation (H1)

Reduction in carbon intensity	Estimated change in ROA	Estimated ROA after change
No reduction	–	9.30%
1% reduction	+0.007 percentage points	9.31%
10% reduction	+0.072 percentage points	9.37%
50% reduction	+0.360 percentage points	9.66%

AI disclosure

We used generative AI tools as supportive tools during the thesis process. The tools we used were ChatGPT, Google Gemini, and Claude.

We primarily used ChatGPT to support selected parts of the research and writing process, including Python coding, troubleshooting error messages, improving sentence structure, and refining the academic language of the written text. We used Google Gemini mainly for coding-related tasks in Google Colab, particularly to assist with Python code, debugging, and interpreting coding errors. Claude was used as an additional supportive tool for text-related assistance, such as improving clarity, structure, and academic phrasing.

The use of these tools helped us work more efficiently, particularly in relation to programming, and linguistic refinement. AI-generated suggestions also helped us identify clearer ways of formulating certain sentences and structuring parts of the text. As a result, we were able to devote more time to the analysis, interpretation, and discussion of the empirical findings.

We were aware of several risks connected to the use of generative AI. One risk was that AI-generated suggestions could unintentionally change the intended meaning of the text. To manage this risk, we used specific prompts and carefully reviewed, revised, and adapted all AI-generated suggestions before including them in the thesis. Another risk was that AI tools could produce inaccurate, misleading, or fabricated information. To reduce this risk, we did not use AI tools as sources of factual information, theoretical claims, or academic references. All academic content, including theories, empirical findings, and references, was verified through peer-reviewed literature and our own data analysis.

Through the use of generative AI, we developed a better understanding of how to formulate precise prompts, critically evaluate AI-generated outputs, and use AI tools responsibly in an academic context. Overall, we used AI as a supportive tool, while all analytical decisions, interpretations, and final written content remained our own responsibility.