THE IMPACT OF CARBON EMISSIONS ON STOCK RETURNS AND FINANCIAL PERFORMANCE: ANALYZING REGIONAL VARIATIONS AND GOVERNANCE MECHANISMS IN ASIA, THE MIDDLE EAST, AND EUROPE

A Thesis

Submitted to the Master of Finance in Sustainable Finance Study Program at the Faculty of Economics and Business in partial fulfilment of the requirements for the Degree of

Master of Finance in Sustainable Finance (M.Fin.)

by:

Rashid Shabir Abbasi

03222320009

UNIVERSITAS ISLAM INTERNASIONAL INDONESIA
DEPOK
2025

THE IMPACT OF CARBON EMISSIONS ON STOCK RETURNS AND FINANCIAL PERFORMANCE: ANALYZING REGIONAL VARIATIONS AND GOVERNANCE MECHANISMS IN ASIA, THE MIDDLE EAST, AND EUROPE

A Thesis

Submitted to the Master of Finance in Sustainable Finance Study Program at the Faculty of Economics and Business in partial fulfilment of the requirements for the Degree of

Master of Finance in Sustainable Finance (M.Fin.)

by:

Rashid Shabir Abbasi

03222320009

UNIVERSITAS ISLAM INTERNASIONAL INDONESIA
DEPOK
2025

ABSTRACT

Rashid Shabir Abbasi
03222320009
rashid.abbasi@uiii.ac.id
Master of Sustainable Finance
Universitas Islam Internasional Indonesia

This research addresses a pertinent question in asset pricing: whether firms' carbon emissions affect their stock returns. To investigate this, the study conducts a comprehensive analysis of approximately five thousand firms across Asia, the Middle East, and Europe, employing robust econometric methods. The findings indicate that higher-emitting firms earn lower monthly returns in all these regions, although the strength of this relationship varies across regions. This negative return-emission relationship is further explained through the lens of financial performance. Additional analysis reveals that firms with higher carbon emissions also exhibit weaker financial fundamentals. These findings suggest that emissions are not only an environmental concern but also a proxy for broader operational inefficiencies, regulatory exposure, and reputational risk. High-emitting firms often face higher compliance costs, reduced demand from ESG-conscious investors, and lower stakeholder trust—factors that collectively deteriorate profitability. As financial performance declines, so do market expectations of future cash flows, thereby translating into lower stock returns. By controlling for industry and time-fixed effects and addressing potential issues of multicollinearity and serial correlation through two-way clustered standard errors, this study provides robust empirical evidence that carbon emissions are priced in financial markets, both directly through performance and indirectly through investor sentiment. The results have significant implications for investors, policymakers, and firms operating in increasingly sustainability-focused economies.

Keywords: *Carbon Emissions, Stock Returns, Asset Pricing, ESG, Climate Change*

ACKNOWLEDGEMENTS

This journey has been one of growth, learning, and gratitude, and it is only fitting that I begin by acknowledging the incredible people who have made it all possible.

First, I would like to give my sincere gratitude to Universitas Islam Internasional Indonesia who has given me the opportunity to pursue my studies further. The experience at this place has been nothing short of transformative and the people of Indonesia have been so welcoming and hospitable to make this journey even more memorable.

To my supervisors and the honored members of the Faculty of Economics and Business, it is your guidance and support that I was able to overcome each and every challenge. I am very grateful to your patience and professionalism.

A special, heartfelt thank you goes to the foundation of my life—my mother. I would not be what I am today without her sacrifices, resilience, and love that she offered unconditionally.

However, I owe most gratitude to my maternal grandparents- Muhammad Yousuf and Kaneez Fatima, Uncle Muhammad Nawaz and Aunt Samina Nawaz. From the very beginning, they have been the cornerstones of my life. I have lived under their roof since childhood, and they have not only nurtured me with love, but have also supported every step of my education. Their sacrifices, endless belief in my potential, and unwavering encouragement have shaped my path and made all of this possible. Their love is the reason I stand here today. In the face of challenges, they were the ones who pushed me forward, who believed in me when I doubted myself, and who gave me everything I needed to succeed. My grandparents, Uncle, and Aunt have been my mentors, my teachers, and my family in the truest sense.

This thesis is a reflection of their selflessness, their boundless support, and the incredible role they've played in shaping the person I am today. For their love, guidance, and sacrifices, I am forever grateful. Thank you for being the foundation upon which everything stands.

زندگی میں اک شجر ایسا لگانا چاہیے
جس کا سایہ دوسروں کے گھر پہ جانا چاہیے

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION DIRECTORY

CO2e	: *Carbon Dioxide Equivalent*
EBIT	: *Earnings Before Interest and Taxes*
EBITDA	: *Earnings Before Interest, Taxes, Depreciation and Amortization*
EPS	: *Earnings Per Share*
ESG	: *Environmental, Social and Governance*
ETS	: *Emissions Trading System*
EU	: *European Union*
G7	: *Group of Seven*
GHG	: *Greenhouse Gas*
GICS	: *Global Industry Classification Standard*
GPM	: *Gross Profit Margin*
LSEG	: *London Stock Exchange Group*
MDPI	: *Multidisciplinary Digital Publishing Institute*
NPM	: *Net Profit Margin*
RBV	: *Resource-Based View*
ROA	: *Return on Assets*
ROE	: *Return on Equity*
R-squared	: *Coefficient of Determination*

CHAPTER I
INTRODUCTION

1.1 Background

The global drive toward sustainability has fundamentally reshaped corporate priorities and investment strategies, with environmental, social, and governance (ESG) factors becoming central to decision-making. Among these, carbon emissions have emerged as a pivotal metric, reflecting a firm's environmental impact and exposure to climate-related risks. As climate change intensifies, governments, corporations, and investors are under increasing pressure to address these risks proactively. Regulatory measures such as carbon pricing, emission caps, and mandatory disclosures are not just policy tools; they are mechanisms that can redefine market dynamics and influence long-term financial performance. In parallel, societal awareness of environmental issues has surged, prompting stakeholders to scrutinize corporate behavior and demand greater accountability.

In this context, carbon emissions are no longer seen solely as a compliance issue but as a critical factor with financial implications. High-emission firms may face reputational damage, higher operating costs due to stricter regulations, and the risk of stranded assets, particularly in carbon-intensive industries. Conversely, firms that successfully reduce emissions or adopt sustainable practices may benefit from lower capital costs, enhanced market valuation, and greater investor trust. For sustainability to become an embedded corporate priority, it is essential that the financial performance of firms with low carbon emissions translates into a lower cost of capital. This creates a natural incentive for businesses to focus on reducing emissions while simultaneously reducing the reliance on regulatory bodies and government funding to transition to a low-carbon economy. And once this perfect market structure is achieved where sustainability efforts are completely reflected in firms stock prices, the transition to low-carbon economy would be exponential around the world.

Despite this increasing attention, the academic literature presents conflicting findings. Some studies suggest that firms with high carbon emissions are penalized by the market, reflecting investors' aversion to environmental risks. Others argue that such firms continue to perform well due to their entrenched market positions and the slower adoption of sustainability practices in certain sectors. Adding to this complexity, regional and industry-specific differences further complicate the relationship. Much of the existing research relies heavily on data from the United States and Europe, which limits its

applicability to regions with different regulatory environments, cultural attitudes, and market dynamics.

Asia, the Middle East, and Europe represent regions with significant variation in sustainability frameworks and financial markets. Asia is home to rapidly industrializing economies, many of which are heavily reliant on fossil fuels yet are also leading adopters of renewable energy technologies. The Middle East faces unique challenges, as its economies are deeply intertwined with the oil and gas sector, creating tensions between economic growth and sustainability goals. Europe, on the other hand, has been at the forefront of sustainability initiatives, implementing strict regulations and fostering green financial instruments. Examining these regions together provides an opportunity to capture the diversity of the emissions-financial performance relationship and uncover mechanisms that may be overlooked in single-region studies.

This research, therefore, seeks to address these gaps by systematically analyzing how carbon emissions influence stock returns across these regions. It also analyzes the mechanisms driving the financial outperformance of carbon-efficient firms and explores how governance structures, firm-specific characteristics, and regional factors mediate this relationship. By doing so, the study aims to contribute to the growing field of sustainable finance, offering insights into the financial implications of carbon emissions on a global scale.

1.2 Problem Statement

The global shift toward sustainability has created a pressing need for firms and investors to understand the financial implications of environmental practices, particularly carbon emissions. While carbon emissions are increasingly recognized as a critical factor influencing firm valuation and market performance, the evidence remains inconclusive and fragmented. Existing studies offer mixed findings, with some suggesting a negative relationship between emissions and stock returns due to growing investor preferences for sustainability, while others point to negligible or even positive correlations. These inconsistencies raise important questions about the true nature of this relationship and the factors driving it.

A significant limitation of prior research is its heavy focus on developed markets, particularly the United States and Europe, where regulatory frameworks and investor priorities differ significantly from those in emerging economies. This geographic bias limits the applicability of findings to regions like Asia and the Middle East, which have distinct challenges and opportunities in their transition to sustainability. For instance,

Asia's industrial growth often conflicts with sustainability goals, while the Middle East faces structural dependence on fossil fuels. Europe, despite its leadership in sustainability, presents its own complexities due to varying levels of economic development and regulatory enforcement across member states. These differences highlight the need for a more nuanced, region-specific understanding of the emissions-stock returns relationship.

Furthermore, while the concept of carbon efficiency and its potential to drive financial outperformance has gained traction, the underlying mechanisms remain underexplored. Governance structures, firm-specific characteristics, and external factors such as regional policies and cultural attitudes likely play a crucial role in shaping this dynamic, yet they are often overlooked in existing studies. This lack of clarity makes it challenging for firms to develop effective sustainability strategies and for investors to incorporate carbon-related risks into their decision-making processes.

This research addresses these gaps by analyzing the relationship between carbon emissions and stock returns in Asia, the Middle East, and Europe. It goes beyond correlation by investigating the mechanisms that enable carbon-efficient firms to achieve superior financial performance and examining how regional differences influence this relationship. By doing so, the study aims to provide actionable insights for firms, investors, and policymakers navigating the evolving landscape of sustainability and finance.

1.3 Research Questions

I. Do carbon emissions correlate with stock returns in Asia, the Middle East, and Europe? Why are results inconsistent across regions?
II. What mechanisms drive the financial outperformance of carbon-efficient firms in these regions?
III. How does governance quality mediate the emissions-returns relationship across different regulatory and cultural contexts?
IV. How do regional differences in regulations, cultural values, and economic structures affect how financial markets price carbon emissions?

1.4 Research Objectives

I. To examine whether carbon emissions and stock returns are correlated in Asia, the Middle East, and Europe, addressing the inconsistency in prior findings.
II. To analyze how carbon-efficient firms achieve superior financial performance, focusing on the role of reduced regulatory and operational risks.

III. To examine how governance quality influences the financial effects of carbon emissions, particularly in markets with strong regulatory enforcement.

IV. To provide insights into how regional differences in regulations, cultural attitudes, and economic contexts influence the pricing of carbon emissions in financial markets.

1.5 Hypotheses

I. H1: Carbon emissions are correlated with stock returns.

II. H2: The correlation between carbon emissions and stock returns varies by region and time due to differences in regulatory environments, data accuracy, and market maturity.

III. H3: Carbon-efficient firms outperform in stock markets due to reduced regulatory and operational risks and better governance practices.

IV. H4: Governance quality positively moderates the relationship between emissions and stock returns, particularly in markets with strong regulatory enforcement.

1.6 Significance of the Research

The study is of great value in the discussion of the crucial overlap between environmental sustainability and financial performance, especially in the framework of the changing world priorities. The dual challenge of climate change and economic growth have put corporate responsibility and environmental accountability under an unprecedented focus. This study helps to better understand the relationship between the financial performance and stock returns and carbon emissions, which is a factor that will help to better understand how environmental practices of firms affect their market valuation and financial performance as a whole.

Among the most important contributions of the research is the fact that it dwells upon regional differences and governance processes which are less explored in the literature. Whereas most of the previous studies have focused on developed markets especially in the United States and Europe, this paper extends the study area to Asia and the Middle East. These areas are not only fast becoming industrialized but also have special environmental and regulatory issues. The dynamics that exist in such varied contexts are important in coming up with a global view of how carbon emissions affect financial performance and the behavior of investors.

Another important gap in the literature that is being filled by the study is the moderating factors that affect the relationship between carbon emissions and financial performance. Regulatory frameworks, governance structure and the characteristics of firms

(e.g. size, industry and market positioning) are likely to be key determinants of this relationship. The determination of these moderating factors will offer practical information to policymakers, investors, and corporate leaders, so that they can make informed decisions that will balance financial prosperity with sustainability targets.

1.7 Research Outline

This study is divided into a number of important chapters. The Literature Review (Chapter 2) is a critical synthesis of existing research on the topic and identifies important themes and gaps, as well as methodological approaches. It examines the direct and moderating effects between carbon emissions and stock returns and financial performance. The systematic approach to this research is described in Chapter 3, Methodology. It explains how the data was collected and that it was based on the articles found in such reputable databases as Scopus, MDPI, and Emerald, and on the criteria applied in the selection. The analytical framework, including quantitative methods to be employed to analyze the effect of carbon emissions on stock returns and financial performance, is also described in the chapter. The results of the analysis including the most important patterns and trends are provided in Chapter 4, Results and Discussion. The findings are critically presented in relation to available literature with special focus on the consistencies, divergences and their implication to theory and practice.

CHAPTER II
LITERATURE REVIEW

2.1 Introduction to the Literature

The relationship between carbon emissions, stock returns, and financial performance has become a topic of more and more interest over the past years, as the world is increasingly focused on the problem of climate change and sustainability, and how the two relate to financial markets. With the issue of the environment becoming increasingly urgent, more stakeholders are becoming interested in the way businesses deal with their environmental impact. Simultaneously, the financial markets are becoming more sustainable with investors requiring more disclosures on the environmental performance of firms. It is against this background that carbon emissions have become one of the most important topics of interest not only as a gauge of the environmental impact but also as a determinant of financial performance such as stock returns and profitability.

In order to comprehend this relationship better, I have performed a systematic review of the literature in the field. The review focused on articles published between 2000 and 2024, using the keywords "emissions," "financial performance," and "stock returns." The three large databases used to retrieve these articles were MDPI, Scopus, and Emerald. In total, I found 63 relevant papers on Scopus, 49 on MDPI, and 90 on Emerald. Notably, most of these articles were published after 2020, and a significant proportion of them focused on research from the United States and China. While the literature is extensive, only a small number of studies directly address the relationship between carbon emissions, financial performance, and stock returns. Even fewer explore the factors that might influence or moderate this relationship.

Existing studies have examined a variety of topics, such as the impact of mandatory emissions disclosure, the rise of green investments, and the financial benefits of reducing emissions. Much of this research is based on data from the United States and Europe, where regulatory frameworks and investor priorities have shaped corporate approaches to sustainability. These studies have helped shed light on whether firms' environmental performance affects their stock valuations and financial metrics. However, the findings are often inconsistent, with differing conclusions about the strength and direction of the relationships. This chapter aims to piece together these fragmented findings by focusing on three key areas: the direct relationship between carbon emissions, stock returns, and financial performance; the mechanisms that might mediate this connection; and the regional or industry-specific factors that influence outcomes. By synthesizing insights from

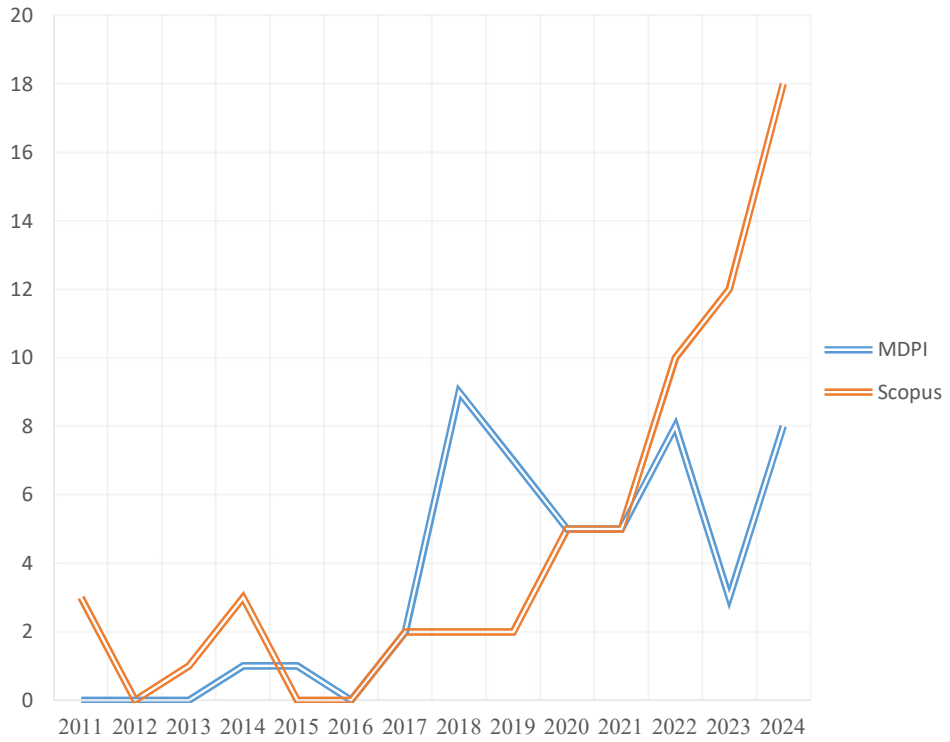

Figure 2.1. Publications by year.

Source: author's compilation.

the existing literature, this review provides a clearer picture of the current state of knowledge while highlighting areas where more research is needed. The discussion is structured into three main sections: theoretical frameworks, conceptual underpinnings, and a review of previous studies. These sections collectively provide a comprehensive understanding of the complex dynamics between environmental sustainability and financial outcomes.

2.2 Theoretical Framework

The relationship between carbon emissions, financial performance, and stock returns can be understood through several theoretical lenses, offering a structured understanding of the mechanisms at play. These frameworks guide empirical investigations by highlighting the dynamic interplay between environmental sustainability and financial outcomes, as discussed below in expanded detail.

2.2.1. Risk-Based Theory

Risk-based theory follows the assumption that the risk of high carbon emissions subjects the firms to different types of risks such as regulatory, reputational, operational risks which directly impact the financial performance and market valuation. Regulatory mechanisms such as carbon taxes and emissions trading schemes (e.g. the EU ETS) amplify these risks and firms must take positive action to manage their carbon footprints.

Regulatory risks are founded on the implementation of carbon pricing mechanism, emissions limits and compulsory reporting criteria. Firms which fail to comply with such regulations face financial penalties, restricted access to the market or they are closed. To illustrate, Downar et al. (2021) highlight the compulsory policy of emissions disclosure in the UK, according to which the companies reduced emissions by 14-18% despite the 9% growth in production costs. This drop indicates the pressure that the regulatory frameworks exert on the firms to concentrate on the control of emissions.

Reputational risks occur when stakeholders, such as consumers, investors and communities, view firms as environmentally irresponsible. Companies that have a high level of emissions may lose their market share to their competitors who are more in line with the societal demands of sustainability. Heinkel et al. (2001) state that this reputational challenge becomes more pronounced by the increasing focus on ethical investing, whereby green investors are increasingly shunning high-emission companies in their portfolio. This omission does not only increase the cost of capital but also leaves the polluting firms isolated with the long-term investors.

Operation risks are associated with supply chain interruptions, scarcity of resources, and climate-related catastrophes. These risks are especially dangerous to high-emission firms and may increase costs and decrease profitability. Scholtens and van der Goot (2014) studied the EU ETS and concluded that the involvement in the carbon pricing schemes could be quite expensive at first but it enhanced the regulatory alignment and minimized the long-term operational risks of the companies. All these findings reiterate the need to have firms actively deal with risks associated with emissions in order to protect their financial and market stability. This demonstrates how the mitigation of risk by regulatory compliance, reputational boosting can have long-term benefits even in expensive transitions.

2.2.2. Preference-Based Theory

The preference-based theory focuses on investor sentiment as the force behind the financial performance of sustainable firms. With sustainability emerging as an investor priority, companies that meet environmental, social, and governance (ESG) standards are receiving a competitive advantage in the capital markets. According to Pastor et al. (2021), this is referred to as a taste premium in which environmentally aware investors penalize high-emission companies by giving low-emission companies higher valuations and reduced capital costs.

Hartzmark and Sussman (2019) present empirical evidence of this theory using the flow of funds in the U.S. mutual fund market. They note that funds that are high-sustainability receive high inflows, which indicates investor confidence in the long-term worth of ESG-focused companies. In addition, Heinkel et al. (2001) observe that the increasing number of green investors will decrease the amount of capital available to high-emission companies, further increasing the financial disparity between sustainable and polluting organizations.

The preferences of investors are not homogenous, as it is stated by Bauer et al. (2022). They discovered that green stocks have always outperformed brown stocks in G7 markets in the last 10 years as the focus on sustainability grows. The trend was however reversed temporarily in the 2022 energy crisis when the global energy prices increased which increased the profitability of brown stocks in the oil and gas sectors. This short-term rotation highlights the interconnection between macroeconomic conditions and investor psychology and implies that although green stocks are popular in the long term, brown stocks may perform better in certain economic environments.

2.2.3. Resource-Based View

The resource-based view (RBV) gives an additional perspective through which the connection between carbon emissions and financial performance can be analyzed. RBV is based on strategic management and assumes that a firm can gain sustained competitive advantage through the use of unique resources and capabilities. Hart (1995) further elaborates this model with the natural-resource-based view in which he suggests that environmental practices like pollution prevention, resource efficiency, and sustainable development are the main sources of competitive advantage.

Pollution prevention measures allow companies to cut wastes and emissions, and this directly translates into savings. As an illustration, Sichigea et al. (2020) discovered that companies in extractive and healthcare sectors enjoyed the advantages of implementing

green technologies in terms of increased operational efficiencies and lower material costs. On the same note, Ambec and Lanoie (2008) point out that companies that utilize resource-efficient technology tend to gain twofold advantage, i.e. reduced costs of production and enhanced environmental compliance resulting in enhanced financial performance.

2.3 Conceptual Framework

The conceptual framework of the research is based on the idea of how carbon emissions relate to stock returns and the financial performance. In this section, the main concepts are defined, their implications are discussed, and the concepts are linked to theoretical insights, which forms a strong basis of the analysis.

2.3.1 Carbon Emissions

Carbon emissions represent a firm's contribution to greenhouse gases, serving as a critical indicator of its environmental impact. Such emissions are frequently divided into direct emissions (Scope 1), indirect emissions purchased energy (Scope 2), and other indirect emissions along the value chain (Scope 3). These emissions are necessary to be measured and reported accurately to comply with regulations and make strategic decisions.

Carbon emissions have financial implications in terms of regulation, the market, and operations. Regulatory systems such as the EU Emissions Trading Scheme (ETS) penalize high-emission companies with a financial penalty and provide an incentive to reduce through market-based systems. Market-wise, companies that are more emitting are exposed to reputational risks which influence investor perceptions and the share prices. According to Jangid and Sharma (2024), the companies that have implemented energy-efficient technologies in the Asia-Pacific region achieved competitive advantages both locally and globally. In addition, the emissions intensity measure, which normalizes emissions against firm size or revenue, provides a more detailed view of carbon efficiency. Aswani et al. (2024) argue that emissions intensity, rather than unscaled emissions, serves as a more relevant metric for assessing a firm's environmental performance and financial risk.

2.3.2 Stock Market and Financial Performance

The stock market serves as a barometer for investor sentiment and a reflection of firms' environmental practices. The relationship between stock returns and the emissions performance has drawn a lot of attention with inconsistent results in literature. Investors tend to choose green stocks, which have low emissions and good ESG results, as they have a low risk profile and respond to the trend of sustainability. According to Chakrabarti and

Sen (2021), brown stocks were resilient in times of high energy prices, as was the case during the 2022 energy crisis, when oil and gas companies recorded high returns. This cyclical performance shows the importance of macroeconomic factors on stock returns and the necessity of investors to achieve short-term gains and long-term sustainability objectives. The correlation between stock performance and emissions also has regional differences. The above insights show that stock returns are not only dependent on the emissions performance but are influenced by a mixture of regulatory, economic and market-specific conditions.

Financial performance is the measure of how well a company is performing in terms of profitability, efficiency and market value and is usually measured using indicators such as ROA, ROS, EBIT margin, EBITDA margin and Tobin Q. These measures assist in determining the effectiveness of a firm in managing its resources and making returns. Research indicates that organizations that implement carbon-efficient and sustainable operations, particularly, those in energy-intensive or extractive industries, tend to achieve gains in these measures as a result of cost savings and operational efficiencies. As an example, companies with energy-saving technology or emissions reduction measures are likely to have better ROA, ROS, and profit margins. In addition, firms that are strong in terms of sustainability tend to have a higher market value as indicated by a larger Tobin Q meaning that investors perceive them to be more valuable in the long run.

2.4 Previous Studies

An examination of the previous literature shows that there is a great potential in understanding the correlation between carbon emissions, financial performance, and stock returns. In this section, the most significant findings in each theme are synthesized in order to comprehend this relationship.

2.4.1 Emission Disclosure and Market Response

The significance of the compulsory disclosure of carbon emission in the establishment of corporate environmental sustainability and the financial performance has been projected as one of the key research areas. Emission reporting and transparency are also effective tools that investors can rely on to assess the environmental risk of companies and numerous studies have highlighted the effectiveness of such disclosures in causing operational shifts, market value, and stock market behavior alteration. The relationship between the disclosure of emission and financial performance is not straightforward because the companies incur expenses in their attempt to reduce emissions.

The implementation of compulsory emissions disclosure has proven to be especially effective in such jurisdictions as the European Union and the UK. A recent study by Downar et al. (2021) is a breakthrough study of mandatory emissions disclosure by listed companies in the UK with a difference-in-differences approach. They contrasted companies that had to report their greenhouse gas emissions, and those that did not have to do it. They found that although companies had cut their carbon footprints by an average of 14-18%, it did so at a heavy cost- production costs increased by about 9%. Notwithstanding this cost increase, the companies that managed to decrease the emissions saw an increase in the sales, so the overall financial performance did not worsen significantly. This paper proposes that though compulsory disclosure of emissions could raise the costs of operations, it can also drive consumer demand, as the stakeholders grow in attachment to sustainability initiatives. Similarly, Scholtens and van der Goot (2014) discussed the European Union Emissions Trading Scheme (ETS) that obliges carbon allowances to the companies in carbon-intensive industries including oil, gas, and cement. They discovered that companies in such sectors were facing a considerable volatility in the prices of stocks, not only driven by the regulatory cost of carbon allowances, but also by the market-based carbon pricing signals.

2.4.2 Investor Perception and Market Behavior

The effect of disclosure of emissions on the financial performance is highly influenced by the investor perceptions. We are seeing some evidence that investors are paying more attention to environmental issues in making investment decisions and are especially interested in emissions reporting and sustainability practices. It has been established that firms with transparent emissions reporting are typically perceived to be better able to deal with the environmental risks, which leads to higher valuations and improved stock returns. According to the study by Zhang and Kumar (2024) on the Asian market, the companies that disclosed their decreased emissions and sustainability practices were rated higher by the investors and had more significant stock returns in comparison with less transparent companies. These findings suggest that emissions disclosure is not only a regulatory requirement but an effective signal to investors, which enhances the reputation of the firm and enhances investor confidence.

2.4.3 The "Green" and "Brown" Stocks

As global sustainability efforts intensify, the financial markets have witnessed a growing differentiation between "green" and "brown" stocks. Green stocks are those businesses that

are green-minded and practice environmental-friendly activities, including cutting down on carbon emissions. Brown stocks, in turn, are linked with the companies of the carbon-intensive sectors that tend to have a less sustainable environmental performance. The argument on whether one form of stock offers better financial returns than the other is the core of determining the impact of carbon emissions on financial performance.

The idea that sustainability enhances financial performance has been supported by several researches, particularly those that have dwelled on the long-term returns of green stocks. Bauer et al. (2022) in their study analyzed the performance of green stocks in G7 countries within the past 10 years and they concluded that green stocks outperformed brown stocks in terms of stock returns and profitability. The green stocks trend was particularly sharp in the renewable energy sector, technology, and consumer goods where the environmental projects were deeply embedded in the business strategies. The long-term benefit of green investment including low operating cost, brand value, and availability of capital has been cited many times to explain such a positive relationship between sustainability and financial performance.

However, the study also pointed out a short-term deviation of the energy crisis of 2022, which led to massive returns on brown stocks in energy industries as energy prices skyrocketed. The story of the green stocks outperforming brown stocks is more complex as the brown stocks have rebounded, particularly during times of market stress. Brown stocks (the energy sectors in particular) can benefit greatly when there is a high energy price or a world supply shortage. This was captured in the 2022 energy crisis where the price of stocks of oil and gas companies has been rising due to supply chain and energy demand problems (Bauer et al., 2022). This means that the green stocks may be preferable in the long-term returns but the relative performance of the brown stocks is dependent on exogenous market shocks of energy price shocks and geopolitical events.

2.4.4 Carbon Emissions and Financial Sustainability

Financial sustainability is the capacity of a firm to achieve steady revenue along with control of environmental and financial risks, which is instrumental in the mediation process between emissions reductions and the financial performance. In some studies, it was found that companies that could afford to cope with the costs of cutting down carbon emissions and even utilize the programs to increase their future profits. Probohudono et al. (2024) conducted a study on the moderating effect of the financial sustainability of the relationship between emissions reduction and the firm performance in Indonesia. They found that the beneficiaries of the reductions in emissions were the firms with strong solvency positions

and low business risks as it led to an increase in the value of a firm. The advantages of green technologies and emission reduction can be paid by financially stable companies with positive financial outcomes at the end. This is more so in the case of larger companies which can access more capital since they can invest in cleaner technologies and emission reduction without jeopardizing their financial stability in general.

The other critical factor in the association between reduction of emissions and financial performance is the cost of capital of a firm. Moneva and Ortas (2010) assert that businesses with a lower capital are those that are environmentally productive like reducing emissions. There is also a higher probability that such firms will be perceived by investors as less risky leading to better access to finance on favorable terms. This will create a positive reinforcing loop where the firms which have already reduced their emissions can invest in other green technologies which will not only improve their environmental performance but also their financial performance.

2.5 Industry-Specific Dynamics of Carbon Performance

Financial consequences of the emissions reductions are not consistent across the industries. The industries that are more directly impacted by the emissions reduction and carbon pricing mechanisms are the carbon-intensive industries like energy, utilities, and manufacturing industries. Conversely, other industries like healthcare and technology are less directly affected financially by the reduction of emissions. In the study conducted by Jangid and Sharma (2024), the researchers examined the companies in the Asia-Pacific region and concluded that energy companies with lower carbon emissions performed better on the stock market. This was more so to the firms that adopted renewable energy technologies because they were considered to be better placed in terms of future growth and regulatory compliance. The decrease in emissions in the energy sector also assisted companies to guard against the risk of increasing carbon prices and regulatory fines, and further enhanced their financial performance. On the same note, Sichigea et al. (2020) discovered that companies in sectors like extractives and minerals processing and health care had a high financial gain due to emissions reductions, especially in cost savings in their operations and improved corporate image. But the study also indicated that the transition to greener technologies may be too expensive to smaller companies particularly those that do not have the financial strength to meet the initial requirements of the investments. Nevertheless, unlike the carbon-intensive industries, the health, and technology sectors do not have as much direct financial implication of emission reductions. Nevertheless, such companies are capable of enjoying better brand value and consumer

perception. According to Jangid and Sharma (2024), the financial effects of the emissions reductions might be less direct, but the sustainability initiatives can enhance the reputation of a firm, which can contribute to the customer loyalty and, eventually, to the stock prices.

2.6 Regional Variations in Carbon Emissions and Financial Performance

The association between carbon emissions and stock returns as well as financial performance is not consistent in all regions since industry-specific research also indicates divergent patterns. As mentioned above, carbon-intensive industries, including the power sector, tend to have an asymmetric reaction to the emissions disclosure (Da Silva et al., 2016), whereas the healthcare and extractives industries have a less significant correlation, which is also affected by the less intensive environmental impact (Sichigea et al., 2020). Chakrabarti and Sen (2021) have shown that green stocks were resilient in the course of an economic crisis, which made them appealing to investors who wanted stability. This resilience however is not universal, and depends on the sector and region, highlighting the need to analyze the context. Financial outcomes in geographical regions have different patterns due to various factors including regulatory, investor behavior and differences in sectors. This part looks at the effects of carbon emissions on financial performance and stock returns in various regions with special reference to Asia, Europe and Middle East.

European Union (EU) has been on the forefront in enforcing strict emissions cutting laws and carbon pricing policies. As argued in the previous section, the EU Emissions Trading Scheme (ETS) is one of the examples of a regulatory framework that affects corporate performance and stock price. Scholtens and van der Goot (2014) argue that due to the EU emissions reduction in the firms, the companies that participate in the emission reduction are usually perceived to be in a better position to bear the future regulatory costs, which results in better stock returns. On the same note, Downar et al. (2020) stated that well-performing firms in the EU have positive stock returns because regulatory stability and market forces promote investments that are sustainability-related. The Middle East, on the contrary, is a region that has a lot to do with oil and gas industries and hence the situation is different. Although other countries such as the United Arab Emirates and Saudi Arabia are paying more attention to the diversification of their economies and investment in sustainable projects (including the Saudi Vision 2030), the region was traditionally behind in terms of the reduction of carbon emissions. The response of the financial market in these areas is slower and the emissions reduction programs are less likely to be associated with the short-term stock returns.

In Asia, the heterogeneity of the regulatory environments generates both positive and negative results. According to the research by Probohudono et al. (2024) on Indonesian companies, the new markets often have the problem of striking the right balance between the cost of emission reductions and the necessity of industrial development. In other nations such as China and India, the rate of carbon emissions is high due to the rapid process of industrialization. But the efforts of governments like the carbon neutrality plan of China by 2060 and India to promote renewable energy are slowly altering the situation. According to Chen et al. (2024), the Chinese companies that decreased carbon emissions experienced an increase in the sentiment of investors, thus they received excess stock returns, indicating that the green investment is gaining popularity in such rapidly expanding markets. On the same note, Jangid and Sharma (2024) noted that carbon-efficient companies in the Asia-Pacific region had superior financial performance, especially in non-carbon-intensive sectors. Nevertheless, in those countries where enforcement mechanisms are weak, the incentives required to encourage firms to engage in sustainable practices are not always provided, which waters down the potential financial gains.

2.7 Future of Carbon Emissions, Financial Performance, and Stock Returns

With the global economy increasingly focusing on sustainability, the future of carbon emissions and its correlation to financial performance and stock returns will be determined by a number of trends. The section discusses the trends and future projections of the next ten years.

2.7.1 The Rise of Green Financing

Green financing, in the form of green bonds and sustainable investment funds, is likely to pick up pace over the next few years. The popularity of green bonds, which are employed to fund environmentally sustainable projects, is rising as a means of capital raising in both the developed and emerging markets. Bauer et al. (2022) argue that the emission of green bonds has grown exponentially, and the same is likely to persist in the future since investors and companies are keen to balance monetary investment with environmental objectives. The emergence of green financing is an immense opportunity to the companies that specialize in carbon emission reduction. Companies which are issuing green bonds or obtaining funds of sustainable investments will find that not only they will get money to make an emissions reduction project, but also a better stock performance due to the positive attitude of investors who are concerned about sustainability.

2.7.2 Technological Innovations and Emissions Reductions

New technology will be a key factor in determining future carbon emissions and financial performance. The cost of emissions reduction is expected to reduce as new technologies emerge to assist the firms in lowering their carbon footprint. This will help more firms particularly the carbon-intensive firms to go green without compromising on profitability. Renewable energy, energy efficiency technologies, and carbon capture and storage are the areas that could considerably lower the costs of operating in terms of emissions reduction, and firms could enhance their environmental and financial performance.

2.8 Mechanisms Mediating the Carbon-Financial Performance Nexus

The relationships between the carbon efficiency and the financial performance are not easy and direct. What matters is governance. Firms with good governance systems are better placed to manage the environmental risks and therefore, meet the expectations of investors and regulatory provisions. Transparency is also enhanced by good governance which is being increasingly valued within the markets where sustainability reporting is a priority. This is particularly the case in the research conducted by Helhel et al. (2024) who have found out that governance influenced positively the financial performance in the fast-moving consumer goods sector.

Mitigation of risks also matters. The low-emission firms are less vulnerable to regulatory penalties and reputational catastrophes, which is part of their lower cost base and higher profitability. Chava (2014) also added the fact that the environmentally sensitive firms are most likely to realize the lower costs of equity and debt capital which further elevates their financial position. One more aspect of this dynamic is the preference of investors. Hartzmark and Sussman (2019) have revealed that the sustainability labels influence the flow of funds significantly, which speaks of the general tendencies in the market of green investments.

The technological innovation and resource efficiency also forms the basis of financial outperformance of low-emission firms. Ambec and Lanoie (2008) state that some of the major drivers of improved financial performance are operational efficiencies such as savings of energy and reduction of waste. Moreover, a study by Bansal and Roth (2000) brought out the pressure being exerted on firms by competitive forces and legitimacy issues to achieve environmentally sustainable operations that leads to a higher long term value.

2.9 Critiques and Methodological Challenges

One criticism that has been repeated in the literature is that of inconsistent emissions data. Bajic et al. (2023) emphasized the major shortcomings of vendor-calculated emissions-related indicators, which do not always correlate with the information disclosed by firms. This inconsistency makes it hard to conduct empirical studies since unscaled and scaled emissions produce different correlations with the financial performance (Aswani et al., 2024). Moreover, the absence of uniform reporting systems contributes to such inconsistencies, which weakens the comparability of the studies.

The temporal variability of findings also brings into question the soundness of current models. Oestreich and Tsiakas (2015) highlighted the role of time in changing policy and investor preferences and affecting the relationship between emissions and returns. This variability is what requires more dynamic modeling techniques in order to model these changing trends effectively.

In addition, regional and industry-specific details are usually concealed in aggregated datasets. Aswani et al. (2024) called to further break down the analyses to distinguish between emissions intensity and absolute emissions since these two measures offer different views of corporate environmental and financial performance.

CHAPTER III
METHODOLOGY

In this chapter, the author describes the methodological strategy to analyze the connection between carbon emissions, stock returns, and the financial performance. The research methodology is quantitative, and the multiple regression models will be used to investigate these relationships taking into consideration the industry, regional, and time differences.

3.1 Research Design

The research design used in this study is quantitative based on the use of firm level unbalanced panel data to examine how carbon emissions affect stock returns and financial performance in Asia, the Middle East and Europe. The quantitative method provides the possibility of systematic hypothesis testing and provides empirical data on the correlation between carbon emissions, firm performance, and governance mechanisms, based on large-scale financial and ESG data. The choice of quantitative empirical study is informed by the nature of the research question which aims to quantify the financial implications of corporate carbon emissions and test the role of firm-specific governance factors in modifying the effects.

The study is structured around two core empirical objectives. First, it examines the direct relationship between firms' carbon emissions and both stock market performance and financial performance. Second, it investigates whether firm-level governance practices related to sustainability influence or moderate the effect of carbon emissions on firm outcomes. To address these objectives, the research employs cross-sectional panel regressions that utilize firm-month level data. The panel structure allows for controlling both firm-specific heterogeneity (via industry fixed effects) and time-specific shocks (via monthly fixed effects), thereby minimizing omitted variable bias that might arise from unobserved time-invariant firm characteristics or market-wide events. The dependent variables are divided into two main categories: (i) stock returns, to capture capital market reactions to firm carbon emissions, and (ii) financial performance metrics, which include profitability and operating efficiency indicators. Analyzing both market-based and accounting-based performance provides a more comprehensive picture of how carbon emissions influence firm value from both investor and operational perspectives.

The empirical analysis proceeds in three stages. The first stage evaluates the relationship between firms' carbon emissions and their monthly stock returns. The regression model controls for firm characteristics, while incorporating time (month-year) and industry fixed effects. In the second stage, the analysis investigates whether carbon

emissions are associated with differences in firms' internal financial performance. This analysis also includes firm-level controls and fixed effects to account for sectoral and temporal variations. In the third stage, the study incorporates interaction terms between carbon emissions and governance variables to assess whether firm-level sustainability governance influences the emissions-performance relationship. The interaction terms allow for testing whether these governance mechanisms mitigate or amplify the financial consequences of carbon emissions.

In this study, the standard errors are adjusted using two-way clustering to address potential correlation structures that are inherent in panel data. Since the dataset consists of repeated firm-level observations across time, there is a reasonable expectation that the error terms may be correlated both within firms over time and across firms within the same time period. Ignoring these correlations could lead to underestimated standard errors and overstatement of statistical significance. Clustering at the firm level controls for serial correlation that may exist within individual firms. Firms may experience persistent internal shocks, such as changes in management, long-term strategic decisions, or regulatory actions, which can affect their financial performance and emissions over multiple periods. These serial correlations violate the assumption of independent error terms, making conventional standard errors unreliable. By clustering at the firm level, the estimation accounts for such within-firm dependencies and produces more accurate standard errors. Besides the firm-level clustering, there is also time-level clustering that takes into consideration contemporaneous shocks that can impact on all the firms at a particular time. Macroeconomic events, changes in monetary policy, worldwide crises, or changes in investor sentiment can affect all the firms in the sample in the same month and are likely to be recorded in the financial markets. Such cross-sectional correlations not adjusted may also distort the inference. Thus, clustering at the time level will make sure that any common shocks which might happen at the same month are reflected in the estimation of standard errors in an appropriate manner. Firm-level and time-level clustering, also known as two-way clustering, enables the model to deal with both dimensions of the possible correlation at once. The strategy increases the reliability of the statistical inference and minimizes the chances of false results that may occur due to the failure to consider error dependencies.

To further strengthen the estimation strategy, the models include fixed effects for both time and industry. Time fixed effects absorb month-specific shocks that uniformly affect all firms, such as changes in global financial conditions, commodity prices, or monetary policy actions. Including time fixed effects removes the influence of these common shocks, allowing the model to focus on firm-level variation within each period.

Industry fixed effects control for unobserved heterogeneity across sectors that may systematically influence both carbon emissions and financial outcomes. Industries differ significantly in their environmental impact and financial structures. For example, energy-intensive sectors like oil and gas inherently produce higher emissions compared to service-oriented industries. By incorporating industry fixed effects, the analysis accounts for these sector-specific differences, ensuring that the estimated relationships are not confounded by the structural characteristics of particular industries. Hence, this combination of two-way clustered standard errors and fixed effects for time and industry provides a rigorous framework for obtaining unbiased and reliable estimates, which is particularly important given the complexity of the relationship between carbon emissions, stock returns, and financial performance.

3.2 Variables and Data Sources

3.2.1 Dependent Variables

I. **Stock Returns:** Monthly stock returns from 2000-2024 of publicly listed firms are used as the primary measure of market performance. These are sourced from Refinitiv database. After the monthly data is obtained, it is merged with emissions and other financial data based on calendar year basis to obtain firm-month-year data, following previous literature (e.g., Bolton & Kacperczyk, 2021). Stock returns provide a dynamic perspective on how the market prices a firm's sustainability practices.

II. **Financial Performance Indicators:**

a) **EBITDA Margin:** It is a measure of the performance of a firm in terms of efficiency and profitability in its operations but disregarding the impact of financing and accounting choices.

b) **EBIT Margin:** Indicating the earnings before interest and taxes as percentage of revenue, the variable shows the profitability of operations of a firm.

c) **Return on Equity (ROE):** This is the measurement of the efficiency of a firm in terms of revenue generation with the shareholders capital.

d) **Return on Assets (ROA):** ROA measures the profitability of a firm by measuring the net income against the total assets of a firm.

e) **Gross Margin:** This ratio measures how efficiently a firm manages its direct manufacturing costs relative to the revenue it generates.

f) **Net Margin:** This ratio measures how efficiently a firm is managing its expenses and converting revenue into profits.

3.2.2 Independent Variable:

The study uses comprehensive emissions data, encompassing both unscaled and scaled emissions:

I. **Scope 1 Emissions:** Direct greenhouse gas emissions from firm-owned or controlled sources, such as factories or company vehicles.
II. **Scope 2 Emissions**: Indirect emissions from the generation of purchased electricity, steam, heating, or cooling consumed by the firm.
III. **Scope 3 Emissions:** All other indirect emissions occurring across the value chain, including supplier and customer activities.

Emissions data are obtained from firm disclosures and vendor estimates provided by the Refinitiv database. These categories offer a holistic view of a firm's carbon footprint and its environmental impact. All of the variables are provided in Table 3.1.

Table 3.1. Variables Description

Variable	Definition
Return	Stock returns per month expressed as a percentage.
ROE	Ratio of net income to common equity capital expressed as a percentage.
ROA	Ratio of net income before discontinued operations to total assets expressed as a percentage.
EBIT margin	Ratio of earnings before interest and taxes divided by revenue from business activities expressed as a percentage.
EBITDA margin	Ratio of earnings before interest, taxes, depreciation and amortization divided by revenue from business activities as a percentage.
Gross margin	Ratio of gross profit divided by revenue from business activities expressed as a percentage.
Net margin	Ratio of income before discontinued operations and extraordinary items divided by revenue from business activities expressed as a percentage.
Actual total CO2e	Total CO2 and CO2 equivalent emissions in tonnes. Includes both scope 1 and scope 2.

Variable	Definition
Estimated total CO2e	The estimated CO2 and CO2 equivalent emissions in tonnes.
Scope 3	Total CO2 and CO2 scope 3 equivalent emissions in tonnes.
Scope 2	Total CO2 and CO2 scope 2 equivalent emissions in tonnes.
Scope 1	Total CO2 and CO2 scope 1 equivalent emissions in tonnes.
Scope 3 intensity	Total CO2 and CO2 scope 3 equivalent emissions in tonnes divided by revenue US dollars in million.
Scope 2 intensity	Total CO2 and CO2 scope 2 equivalent emissions in tonnes divided by revenue US dollars in million.
Scope 1 intensity	Total CO2 and CO2 scope 1 equivalent emissions in tonnes divided by revenue US dollars in million.
ESG Controversies Score	Measurement of a firm's exposure to environmental, social and governance controversies and negative events reflected in global media. Ranging from 1-100, where 100 indicates no controversy.
Environmental Restoration Initiatives	Binary variable indicating whether a firm reports environmental restoration initiatives, excluding restoration caused by its own operations.
Climate Change Risks and Opportunities Financial Planning	Binary variable indicating whether a company disclose the impact of climate change risks and opportunities on financial planning.
Policy Executive Compensation ESG Performance	Binary variable indicating whether executive compensation is linked to ESG or sustainability performance criteria.
Log size	Total market capitalization in natural log form.
Log employees	Total number of full and part time employees in natural log form.
Income before tax margin	Ratio of income before taxes divided by revenue from business activities expressed as a percentage.
Asset turnover	Ratio of total assets divided by total assets.
Current ratio	Ratio of total current assets divided by total current liabilities.
EPS diluted	Ratio of diluted net income to common shareholders excluding extraordinary items divided by diluted weighted average shares outstanding.

3.3 Empirical Models

To understand the relationship between carbon emissions and stock returns, this study employs the following cross-sectional regression:

$$\text{Return}_{it} = \beta_0 + \beta_1 \text{Emissions}_{it} + \beta_2 \text{Controls}_{it} + \varphi_{it} + \gamma_{industry} + \epsilon_{it} \quad (1)$$

Equation (1) above is the baseline model of this study. The dependent variable is monthly stock returns for firm *i* in month-year *t.* The dependent variable Emissions is logged form of scope 1, scope 2, scope 3, total actual CO2e, total estimated CO2e, including both their scaled and unscaled versions, depending on the model. All of the variables along with their definitions are provided in Table 3.1. To control for month-year and industry fixed effects, φ_{it} and $\gamma_{industry}$ respectively are included in equation (1). To account for multicollinearity and serial correlation, standard errors are two-wary clustered at the month-year and firm level.

To understand the relationship between carbon emissions and financial performance, this study employs the following cross-sectional regression:

$$\text{Fin. Performance}_{it} = \beta_0 + \beta_1 \text{Emissions}_{it} + \beta_2 \text{Controls}_{it} + \varphi_{it} + \gamma_{industry} + \epsilon_{it} \quad (2)$$

The definition of the financial performance variables along with other variables employed in equation (2) is provided in Table 3.1. All other specifications remain the same as per equation (1).

And finally, to understand how governance mechanisms mediate the emission-return relationship, this study employs following cross-sectional regression:

$$\text{Return}_{it} = \beta_0 + \beta_1 \text{Emissions}_{it} + \beta_2 Governance_{it} + \beta_3 \text{Emissions}_{it} \times Governance_{it} + \beta_4 \text{Controls}_{it} + \varphi_{it} + \gamma_{industry} + \epsilon_{it} \quad (3)$$

In equation (3), the governance variables include ESG Controversies Score, Environmental Restoration Initiatives, Climate Change Risks and Opportunities Financial Planning, and Policy Executive Compensation ESG Performance. The definitions of all these variables are provided in Table 3.1. All other variables are same as in equation (1).

CHAPTER IV
RESULTS AND DISCUSSION

A. Asia

4.1 Descriptive Statistics

This chapter presents empirical findings on the impact of carbon emissions on stock returns for firms across 14 countries in Asia (see Table 4.1a). Data collected from Refinitiv comprises observations from 3,337 firms, totaling 300,896 firm-month data points. The countries represented in the sample include Japan (96,119 observations), China (58,732), and India (40,573) comprising the largest datasets, which together represent more than 64% of the data, reflecting their substantial corporate sectors. Smaller economies like Cambodia, Mongolia, and Bermuda contribute minimal observations but are retained to maintain a comprehensive regional scope. The period of this study is from 2000 to 2024.

Carbon emissions data in this study are measured in either intensity, which is emissions divided by total revenue in USD million, or tons of CO2 equivalent (tCO2e) and are classified following the widely recognized Greenhouse Gas (GHG) Protocol into three scopes. Scope 1 emissions represent direct sources owned or controlled by firms. Scope 2 emissions arise from the consumption of purchased electricity or other forms of energy generated externally but used in the firm's operations. Scope 3 emissions encompass all other indirect emissions associated with firm activities.

Table 4.1a. Countries - Asia

Country	Observations	Firms	Percentage
China	58,732	847	25.38%
India	40,573	713	21.37%
Japan	96,119	580	17.38%
Malaysia	21,332	412	12.35%
Thailand	12,717	207	6.20%
Hong Kong	27,225	199	5.96%
Taiwan	23,004	173	5.18%
Indonesia	8,444	95	2.85%
Singapore	11,160	91	2.73%
Pakistan	630	12	0.36%
Macau	672	5	0.15%
Bermuda	196	1	0.03%
Cambodia	64	1	0.03%
Mongolia	28	1	0.03%
Total	300,896	3,337	100%

Table 4.2a. GICS industry classification - Asia

GICS Industry	Firms	Observations	Percentage
Real Estate Management & Development	208	19,325	6.23%
Chemicals	190	15,554	5.69%
Banks	166	19,468	4.97%
Food Products	155	12,993	4.64%
Machinery	131	13,055	3.93%
Construction & Engineering	118	9,249	3.54%
Metals & Mining	118	9,631	3.54%
Semiconductors & Semiconductor Equipment	107	8,043	3.21%
Pharmaceuticals	105	9,457	3.15%
Electronic Equipment, Instruments & Components	97	10,239	2.91%
Capital Markets	85	6,584	2.55%
Oil, Gas & Consumable Fuels	80	8,331	2.40%
Automobile Components	79	6,761	2.37%
Electrical Equipment	78	5,696	2.34%
Hotels, Restaurants & Leisure	71	5,729	2.13%
Textiles, Apparel & Luxury Goods	67	5,474	2.01%
Specialty Retail	57	5,424	1.71%
Independent Power and Renewable Electricity Producers	56	4,198	1.68%
Household Durables	52	4,061	1.56%
Health Care Providers & Services	49	3,644	1.47%
Insurance	46	4,537	1.38%
IT Services	46	4,193	1.38%
Media	46	4,026	1.38%
Construction Materials	45	4,008	1.35%
Transportation Infrastructure	45	4,453	1.35%
Financial Services	44	3,383	1.32%
Software	43	2,696	1.29%
Trading Companies & Distributors	41	3,763	1.23%
Beverages	38	3,818	1.14%
Automobiles	37	5,168	1.11%
Consumer Finance	37	3,059	1.11%
Consumer Staples Distribution & Retail	36	3,241	1.08%
Air Freight & Logistics	35	2,042	1.05%
Commercial Services & Supplies	35	2,671	1.05%
Health Care Equipment & Supplies	35	2,520	1.05%
Technology Hardware, Storage & Peripherals	35	5,129	1.05%
Industrial Conglomerates	32	4,807	0.96%
Diversified Telecommunication Services	31	3,012	0.93%
Ground Transportation	31	4,773	0.93%
Entertainment	30	3,041	0.90%
Paper & Forest Products	30	1,838	0.90%

GICS Industry	Firms	Observations	Percentage
Containers & Packaging	29	1,053	0.87%
Broadline Retail	26	2,566	0.78%
Marine Transportation	26	2,855	0.78%
Personal Care Products	26	2,209	0.78%
Building Products	25	2,372	0.75%
Energy Equipment & Services	24	1,591	0.72%
Gas Utilities	24	3,037	0.72%
Electric Utilities	23	4,123	0.69%
Biotechnology	20	867	0.60%
Aerospace & Defense	19	1,327	0.57%
Passenger Airlines	19	2,390	0.57%
Professional Services	19	1,056	0.57%
Wireless Telecommunication Services	18	2,981	0.54%
Communications Equipment	17	1,023	0.51%
Water Utilities	15	954	0.45%
Industrial REITs	14	904	0.42%
Office REITs	14	1,295	0.42%
Retail REITs	14	1,164	0.42%
Diversified REITs	13	874	0.39%
Diversified Consumer Services	12	539	0.36%
Distributors	10	398	0.30%
Household Products	10	866	0.30%
Life Sciences Tools & Services	10	575	0.30%
Interactive Media & Services	9	904	0.27%
Leisure Products	9	1,542	0.27%
Tobacco	8	1,054	0.24%
Hotel & Resort REITs	7	337	0.21%
Multi-Utilities	3	588	0.09%
Residential REITs	3	72	0.09%
Health Care Technology	2	158	0.06%
Health Care REITs	1	64	0.03%
Specialized REITs	1	64	0.03%
Total	3,337	300,896	100.00%

The descriptive statistics provide a picture of the key variables of the study. In the case of firm returns, the mean is about 0.74 percent, whereas the median is only 0.03 percent indicating that most firms have low returns with only a few having very high returns. For emissions, the median and the mean actual emissions (logged) of CO2 are approximately 11.27 tonnes, which is an indication of a fairly even distribution. The difference between firms is not very extreme.

Table 4.3a. Descriptive Statistics - Asia

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Dependent variables					
Return	0.735	0.025	11.86	-96.92	946.92
ROE	8.652	9.708	271.30	-40,630.46	2,332.03
ROA	4.468	3.939	104.30	-16,371.16	377.82
EBIT margin	0.566	10.900	1145.55	-216,142.40	293.12
EBITDA margin	7.521	16.494	1071.09	-203,754.30	951.09
Gross margin	32.018	29.480	137.83	-15,010.00	181.83
Net margin	-8.949	7.977	1690.06	-217,591.20	4,508.23
Emission variables					
Actual total CO2	11.272	11.264	2.749	-0.735	19.691
Est total CO2	11.763	11.711	2.656	-1.118	23.045
Scope 3	12.125	12.524	3.824	-5.597	21.555
Scope 2	11.007	11.220	2.331	-2.244	21.468
Scope 1	10.277	10.193	3.586	-6.215	20.455
Scope 3 intensity	6.034	5.843	1.470	-0.218	13.677
Scope 2 intensity	3.147	3.217	1.830	-7.355	11.572
Scope 1 intensity	2.315	2.160	3.063	-12.995	11.616
Control variables					
Log size	21.853	21.973	1.616	11.244	28
Log employees	8.861	8.953	1.671	0.693	23
Income before tax margin	-5.916	10.413	1,684	-217,591	4,508
Asset turnover	0.695	0.613	0.597	-0.082	15
Current ratio	2.143	1.545	3.099	-6.124	210
EPS diluted	66.982	2.537	5,556	-846,634	99,177

4.2 Correlations

The correlation analysis reveals that actual and estimated emissions are highly correlated (r=0.9977), indicating reliability in estimation methods. Additionally, there is a strong correlation between Scope 1 emissions and actual total CO2e emissions (r=0.92), suggesting Scope 1 emissions significantly contribute to total emissions. Looking deeper into the relationships between emissions broken down by scope, we see that the logged values of Scope 1, Scope 2, and Scope 3 emissions are positively correlated with each other. This pattern indicates that companies that have high direct emissions (Scope 1) also tend to have higher indirect emissions from electricity use (Scope 2) and other upstream and downstream activities (Scope 3). This interconnectedness is logical because larger or more resource-intensive companies are likely to generate more emissions across all scopes.

Firm size, as measured by market capitalization and total assets, exhibits weak positive correlations with emissions, contradicting the general notion that larger firms tend to have higher emissions. For example, market capitalization has a weak correlation with total CO2e emissions (about 0.26).

Interestingly, some intensity variables show weak negative correlations with company size, such as Scope 2 intensity with assets (-0.14). This could suggest that larger firms may benefit from economies of scale or better emission management practices, leading to lower emissions intensity despite higher total emissions. It means that bigger companies might be relatively more efficient in their electricity-related emissions compared to smaller firms. Overall, this correlation analysis reveals that while larger firms tend to produce more emissions in absolute terms, emission intensity offers additional insight into how efficiently companies manage their emissions relative to their size or output. The nearly perfect alignment between estimated and actual total emissions also validates the use of estimation models in emissions research. These patterns underscore the complexity of corporate emissions and suggest that effective emission reduction strategies should consider both scale and intensity aspect.

4.3 Impact of Carbon Emission on Stock Returns

4.3.1 Scaled Emissions

The presented results examine how different categories of carbon dioxide equivalent emissions—specifically Scope 1, Scope 2, and Scope 3 emissions—relate to firms' stock returns. The analysis is conducted across multiple regression specifications that vary in whether they include emission intensity measures, controls such as firm size, industry classification (GICS), and time fixed effects (month-year). Starting with the models incorporating emission intensities, the coefficients for Scope 3 intensity are generally positive but very small and only statistically significant in some specifications. For example, in one model, Scope 3 intensity has a coefficient of about 0.0087 with a p-value around 0.058, suggesting a weak but borderline statistically significant positive association with returns. This implies that firms with higher Scope 3 intensity—emissions related to value chain activities—may experience slightly higher returns, though this effect is quite modest and not consistently robust. Scope 2 intensity, which relates to indirect emissions from purchased electricity, shows small positive coefficients as well, with significance at the 5% level in some models. This indicates that firms with higher Scope 2 intensity might also see a slight positive effect on returns. However, the magnitude remains small, and the economic significance would need to be evaluated in context. Scope 1 intensity,

Table 4.4a. Correlations - Asia

	Log actual total CO2e	Log estimated total CO2e	Log scope 3 intensity	Log scope 2 intensity	Log scope 1 intensity	Log scope 3	Log scope 2	Log scope 1	Log market capitalization	Log assets	Log employees
Log actual total CO2e	1										
Log estimated total CO2e	0.997	1									
Log scope 3 intensity	0.235	0.237	1								
Log scope 2 intensity	0.391	0.392	-0.022	1							
Log scope 1 intensity	0.708	0.709	0.134	0.428	1						
Log cope 3	0.570	0.574	0.369	0.067	0.297	1					
Log scope 2	0.789	0.793	0.174	0.634	0.346	0.529	1				
Log scope 1	0.920	0.923	0.239	0.268	0.854	0.565	0.629	1			
Log market capitalization	0.258	0.257	0.003	-0.024	-0.068	0.265	0.316	0.166	1		
Log assets	0.296	0.297	0.208	-0.144	-0.103	0.259	0.322	0.199	0.763	1	
Log employees	0.386	0.388	-0.011	0.053	0.009	0.313	0.475	0.294	0.682	0.676	1

Table 4.5a. Carbon emission intensity and stock returns - Asia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
CO2 Scope 3	0.0087			0.001			0.0023			0.032		
	(0.040)			(0.058)			(0.057)			(0.059)		
CO2 Scope 2		0.0403			0.026			0.027			0.039	
		(0.030)			0.054)			(0.033)			(0.037)	
CO2 Scope 1			0.032			–0.0006			0.003			0.014
			(0.033)			(0.039)			(0.038)			(0.045)
Firm size							0.119	0.085	0.082	0.115	0.088	0.085
							(0.072)	(0.060)	(0.059)	(0.074)	(0.064)	(0.064)
Observations	202,083	155,721	152,340	202,083	155,721	152,340	200,983	154,823	151,499	180,681	138,642	136,266
R-squared	12.26	12.96	13.07	12.38	13.11	13.23	12.62	13.22	13.34	12.26	12.88	13.04
Controls	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
GICS-Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

representing direct emissions from owned or controlled sources, displays more mixed results. Its coefficients hover around zero or slightly positive, with some models showing non-significant or very small positive effects on returns. This inconsistency suggests that direct emissions intensity may not be a strong driver of stock returns on its own.

When firm size is introduced as a control variable in later models, its coefficient is positive and generally moderately significant, with values around 0.08 to 0.12. This suggests that larger firms tend to have higher returns, controlling for emissions intensity and other factors. The positive size effect aligns with the notion that larger firms may benefit from economies of scale, stronger market positions, or investor confidence, which could translate into better stock performance. The inclusion of industry fixed effects (GICS) and month-year time fixed effects in the models helps control for sector-specific factors and broader market conditions that could influence returns. These controls improve the model's explanatory power, as seen in the gradual increase in R-squared values from about 12.26% to around 13.34%. This shows that controlling for industry and time adds meaningful context to the analysis, helping isolate the effect of emissions and size on returns.

4.3.2 Unscaled Emissions

Switching to the models without emission intensity, which focus on total emissions, the relationship between emissions and returns shifts noticeably. Here, Scope 3 total emissions coefficients are small and not statistically significant. However, Scope 2 and Scope 1 emissions show negative and statistically significant coefficients in multiple specifications, especially when controls are included. For instance, coefficients around -0.119 to -0.129 for Scope 2 and -0.059 to -0.080 for Scope 1 suggest that higher total emissions are associated with lower stock returns, holding other factors constant. This negative relationship contrasts with the weakly positive or negligible associations found with emission intensities. It suggests that investors might penalize firms with higher absolute emissions, viewing them as riskier or less sustainable, whereas emission intensity—emissions relative to firm size or output—does not attract the same negative reaction. This distinction highlights that investors may focus more on total environmental impact rather than efficiency measures alone.

Firm size remains positively associated with returns in these models as well, with statistically significant coefficients between 0.11 and 0.17. This reinforces the idea that larger companies, despite possibly emitting more in total, can still achieve higher returns, possibly due to better market power or financial strength. In terms of overall model fit, R-squared values are generally higher without intensity measures, sometimes reaching close

to 17%, indicating that total emissions and firm size, along with controls, explain a slightly larger portion of return variation than intensity alone.

4.3.3 Actual and Estimated Emissions

Finally, the comparison between actual and estimated total CO2e emissions shows that estimated emissions have a statistically significant negative association with returns, while actual emissions show weaker or non-significant effects. For example, estimated emissions. have coefficients ranging from about -0.045 to -0.144, often significant at conventional levels. This may reflect that estimated emissions capture risk factors or environmental liabilities better recognized by the market. Firm size in these models remains positively linked to returns, consistent with previous findings. Again, controlling for industry and time improves the models' explanatory power modestly, with R-squared values hovering around 12% to nearly 14%.

Table 4.6a. Actual vs. estimated emissions - Asia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Actual Emissions				Estimated Emissions			
Variable	Return	Return	Return	Return	Return	Return	Return	Return
Total CO2e Emissions	0.012 (0.047)	–0.041 (0.023)	–0.078 (0.057)	–0.089 (0.057)	–0.045* (0.022)	–0.098*** (0.031)	–0.139*** (0.030)	–0.144*** (0.031)
Size			0.110 (0.093)	0.111 (0.098)			0.123* (0.066)	0.126* (0.069)
Observations	64,531	64,531	64,090	58,537	298,097	298,097	295,987	257,495
R-squared	11.97	12.28	12.41	12.23	13.72	13.80	13.99	13.48
Controls	No	No	No	Yes	No	No	No	Yes
GICS-Industry	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.4 Impact of Carbon Emissions on Financial Performance

This section examines the influence of carbon emissions on various dimensions of firm financial performance in Asia, including profitability and operational efficiency metrics. The analysis focuses on both estimated and actual CO2 equivalent emissions, segmented by Scope 1, Scope 2, and Scope 3 categories, to capture the full environmental footprint of

Table 4.7a. Unscaled carbon emission and stock returns - Asia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
CO2e Scope 3	0.023			0.014			–0.005			–0.0165		
	(0.022)			(0.022)			(0.021)			(0.023)		
CO2e Scope 2		–0.036			–0.076			–0.119***			–0.129***	
		(0.030)			(0.04)			(0.040)			(0.041)	
CO2e Scope 1			–0.003			–0.059**			–0.077***			–0.080***
			(0.020)			(0.024)			(0.025)			(0.026)
Firm size							0.141**	0.140**	0.112*	0.169***	0.145**	0.115*
							(0.054)	(0.061)	(0.062)	(0.061)	(0.064)	(0.066)
Observations	83,537	160,169	158,133	83,537	160,169	158,133	83,073	159,246	157,224	73,351	141,886	140,629
R-squared	16.99	13.49	13.64	17.17	13.66	13.83	17.38	13.78	13.94	16.97	13.39	13.57
Controls	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
GICS-Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

firms. The results indicate a consistent and statistically significant negative association between estimated total CO2 emissions and key profitability measures such as Return on Equity (ROE) and Return on Assets (ROA). Specifically, a one-unit increase in estimated total CO2e corresponds to a decrease in ROE by approximately 1.11 percentage points ($p < 0.01$) and a 0.65 percentage point decline in ROA ($p < 0.01$). These findings suggest that firms with higher estimated emissions tend to experience poorer profitability outcomes, potentially reflecting higher costs related to carbon management, regulatory compliance, or reputational risks. Interestingly, the impact on earnings before interest and taxes (EBIT) and earnings before interest, taxes, depreciation, and amortization (EBITDA) margins is not statistically significant, indicating that while emissions appear to depress returns on equity and assets, operational profitability margins may be less sensitive to emission levels, possibly due to offsetting factors such as cost efficiencies or pricing power in some sectors. Gross profit margin (GPM) shows a significant negative relationship with estimated emissions (-2.56, $p < 0.01$), underscoring the broader pressure emissions may exert on core profitability. The net profit margin (NPM), however, does not demonstrate a statistically significant relationship, which may reflect the influence of non-operating factors such as taxes, extraordinary items, or financial structuring. When focusing on actual reported CO2e, a similar but somewhat attenuated pattern emerges. Actual emissions significantly reduce GPM (-0.91, $p < 0.01$) and ROE (-0.45, $p < 0.01$), while also adversely affecting ROA and EBITDA margins at statistically significant levels, albeit with smaller coefficients compared to estimated emissions. This difference highlights the potentially greater predictive power of vendor-estimated emissions, which may better capture the comprehensive carbon footprint, including less transparent indirect emissions.

Decomposing emissions by scope reveals that Scope 3 emissions—representing indirect upstream and downstream emissions—are significantly negatively related to profitability metrics such as ROE (-1.09, $p < 0.01$), ROA (-0.40, $p < 0.01$), EBIT, and EBITDA margins. This reinforces the idea that the broader environmental impact beyond direct emissions bears consequences for firm financial health. However, Scope 3 intensity metrics, which normalize emissions by firm size or activity, largely lack significant effects, with the exception of a negative impact on net profit margin, suggesting that unscaled Scope 3 emissions better capture environmental costs relevant to profitability. Scope 2 emissions, linked to purchased electricity, also show significant negative impacts on most profitability indicators, with coefficients such as ROE (-1.14, $p < 0.01$) and ROA (-0.60, $p < 0.01$), as well as EBIT and EBITDA margins. This supports the idea that indirect emissions from energy consumption adversely affect firm performance. Interestingly,

Table 4.8a. Carbon emissions and financial performance - Asia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	ROE	ROA	EBIT	EBITDA	GPM	NPM	ROE	ROA	EBIT	EBITDA	GPM	NPM
Est. total CO2e	-1.11***	-0.65***	0.88	0.99	-2.56***	-0.38						
	(0.415)	(0.137)	(1.598)	(1.721)	(0.852)	(0.30)						
Observations	259,122	260,107	260,131	260,131	257,880	260,131						
R-squared	0.78	0.76	86.26	83.18	2.34	99.24						
Actual total CO2e							-0.91***	-0.45***	-0.65**	-0.79**	-1.41***	-0.03
							(0.243)	(0.077)	(0.285)	(0.351)	(0.206)	(0.129)
Observations							58,516	58,651	58,663	58,663	58,102	58,663
R-squared							8.85	38.98	55.28	47.67	44.98	88.3
CO2e scope 3	-1.093***	-0.396***	-0.49***	-0.607***	-0.014	-0.431						
	(0.197)	(0.051)	(0.169)	(0.193)	(0.352)	(0.314)						
Observations	73,482	73,639	73,651	73,651	72,692	73,651						
R-squared	33.68	32.76	57.74	57.88	13.19	98.96						
CO2e scope 3 Intensity							0.074	-0.117	-2.009	-2.670	-0.781**	0.437
							(0.676)	(0.129)	(5.366)	(5.817)	(0.312)	(0.523)
Observations							181,412	181,938	181,962	181,962	180,358	181,962
R-squared							2.33	16.3	85.77	82.79	40.15	99.99
CO2e scope 2	-1.136***	-0.596***	-0.550**	-0.585**	-1.341***	0.058						
	(0.240)	(0.070)	(0.268)	(0.289)	(0.209)	(0.380)						
Observations	142,488	142,925	142,937	142,937	141,536	142,937						
R-squared	13.76	23.57	52.99	49.00	40.78	97.58						

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	ROE	ROA	EBIT	EBITDA	GPM	NPM	ROE	ROA	EBIT	EBITDA	GPM	NPM
CO2e scope 2 Intensity							0.687**	0.181**	0.227	0.759**	0.246	1.074
							(0.263)	(0.080)	(0.279)	(0.294)	(0.276)	(0.781)
Observations							139,198	139,627	139,639	139,639	138,284	139,639
R-squared							13.40	22.03	53.17	49.15	39.75	97.59
CO2e scope 1	-0.777***	-0.368***	-0.54***	-0.583***	-1.220***	-0.185						
	(0.232)	(0.057)	(0.199)	(0.202)	(0.147)	(0.191)						
Observations	141,175	141,641	141,653	141,653	140,423	141,653						
R-squared	14.15	23.50	52.96	49.22	40.77	97.38						
CO2e scope 1 Intensity							0.139	0.034	-0.237	0.029	-0.641***	0.306
							(0.277)	(0.063)	(0.232)	(0.227)	(0.181)	(0.308)
Observations							136,750	137,208	137,220	137,220	136,032	137,220
R-squared							13.82	22.54	53.10	49.18	39.46	97.38
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GICS-Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Scope 2 intensity measures have a positive and significant relationship with ROE, ROA, EBIT, and EBITDA in some specifications. This somewhat counterintuitive result could imply that firms with higher energy emission intensity might be engaging in activities or industries where profitability is maintained despite environmental inefficiencies, or it could reflect complexities in how intensity is measured relative to firm characteristics. Scope 1 emissions also negatively correlate with ROE (-0.78, $p < 0.01$) and ROA (-0.37, $p < 0.01$), and importantly, with EBIT and EBITDA margins, supporting the conclusion that direct emissions impose costs on profitability, whether through regulatory burdens, operational inefficiencies, or reputational damage. The intensity measures of Scope 1 emissions, however, show limited significant associations, indicating that absolute emissions rather than scaled emissions are more impactful on firm financial outcomes.

4.5 Governance Mediation Effects on Emission-Return Relationship

Corporate governance is widely recognized as a foundational mechanism influencing how firms respond to environmental risks and opportunities. With sustainability becoming an important aspect of market expectations, governance systems that are specifically structured with the environmental, social and governance (ESG) metrics in mind, are critical in regulating the impact of the carbon emission of firms on their performance on the stock market. The consideration of governance variables as moderators in this analysis is informed by the fact that good governance not only regulates the manner in which firms quantify and manage their emissions, but also has an effect on the manner in which investors recognize and value these environmental risks which eventually affect the stock returns. Strong governance structures are also able to mitigate carbon-related risks through increasing transparency, quality of disclosures, and executive incentives that are aligned with sustainability objectives. Such aspects can help reduce the negative market responses to high emissions because they will indicate good risk management and willingness to take care of the environment.

In order to examine these dynamics, this paper relies on governance moderators extracted using the London Stock Exchange Group (LSEG) ESG dataset, which offers rich, consistent, firm-level governance information. The governance variables reflected covered several aspects of environmental responsibility and strategic purpose. These encompass policy-linked executive compensation tied to ESG performance, indicating whether firms financially incentivize leadership to achieve environmental targets; environmental restoration initiatives, reflecting active efforts to remediate environmental damage; integration of climate change risks and opportunities into financial planning, capturing strategic anticipation of climate-related challenges; and the ESG controversies score, which

measures the extent of firms' involvement in ESG-related disputes or adverse publicity. With the exception of the ESG controversies score—which ranges from 1 (high controversy) to 100 (no controversy)—all other governance variables are coded as binary indicators.

The results expose the conditional nature of how environmental disclosures and sustainability actions influence the valuation of carbon-intensive firms in financial markets. It could also mean that investors do not value these initiatives and they merely consider them as "waste of money." Firms with executive compensation tied to ESG performance show a notable relationship between emissions and stock returns. The total emissions variable (Actual Total) shows a negative and statistically significant coefficient of -0.1391 ($p < 0.01$), suggesting that in such firms, investors penalize emissions more severely. This is in contrast to firms without such a policy, where the baseline effect of emissions is -0.0582 ($p < 0.05$). Notably, this moderation effect does not appear statistically significant on its own, but the direction of the interaction effect is informative: the interaction term between emissions and ESG-linked compensation is generally negative across scopes, though not always significant. In Scope 2 emissions (which often relate to electricity use), the emissions penalty is particularly strong at -0.1079 ($p < 0.01$), indicating that even emissions not directly under the firm's operational control are priced negatively by the market when executives are held accountable via compensation structures. This aligns with the carbon premium hypothesis—investors respond more negatively to emissions when there is a formal incentive for reduction.

Environmental restoration initiatives are associated with a similarly enhanced penalty on emissions. The interaction effects across all scopes are negative and often statistically significant. For example, in the full sample, the interaction coefficient is -0.0601 ($p < 0.1$), while in Scope 2 and Scope 1, the interaction effects are -0.0677 ($p < 0.05$) and -0.0741 ($p < 0.01$) respectively. These suggest that emissions from firms engaged in restoration projects are viewed even more unfavorably by the market, perhaps due to perceived greenwashing or heightened investor expectations of environmental accountability. Interestingly, the moderator effect (the standalone effect of having such initiatives) is positive and significant, particularly for Scope 1 and Scope 2 emissions, suggesting that markets reward environmental initiatives when emissions are low, but penalize them sharply when emissions are high—a dynamic that underscores investor sensitivity to consistency between claims and performance.

The baseline emissions coefficient for firms integrating climate-related risks and opportunities into financial planning is substantially negative (e.g., -0.1126 for actual total, $p < 0.01$). The interaction terms are consistently negative and some are statistically

Table 4.9a. Governance Moderation - Asia

Moderator	Effect Type	Actual total	Estimated total	Scope 3	Scope 2	Scope 1
Policy Executive Compensation ESG Performance	CO_2 Effect	-0.0582**	-0.1391***	-0.0193	-0.1079***	-0.0690***
		(0.0261)	(0.0170)	(0.0139)	(0.0210)	(0.0158)
	Moderator Effect	0.4133	-0.3487	-0.5339	0.5904	-0.0789
		(0.5297)	(0.3940)	(0.3476)	(0.5672)	(0.2777)
	Interaction Effect	-0.0601	0.0125	0.0270	-0.0716	-0.0204
		(0.0409)	(0.0291)	(0.0253)	(0.0457)	(0.0227)
	Observations	57,982	256,864	73,351	141,862	140,605
	R-squared	12.30	13.50	16.98	13.39	13.58
Environment Restoration Initiatives	CO_2 Effect	-0.0587*	-0.1199***	0.0018	-0.0924***	-0.0397**
		(0.0321)	(0.0187)	(0.0190)	(0.0259)	(0.0185)
	Moderator Effect	0.7617*	0.3195	0.3474	0.6398*	0.6575***
		(0.4249)	(0.2463)	(0.2901)	(0.3527)	(0.2257)
	Interaction Effect	-0.0601*	-0.0376**	-0.0298	-0.0677* *	-0.0741***
		(0.0354)	(0.0190)	(0.0230)	(0.0300)	(0.0200)
	Observations	57,982	255,443	73,244	141,491	140,270
	R-squared	12.30	13.49	16.98	13.40	13.60
Climate Change Risks & Opportunities Financial Planning	CO_2 Effect	-0.1126***	-0.1056***	0.0240	-0.1196***	-0.0354*
		(0.0322)	(0.0247)	(0.0245)	(0.0292)	(0.0208)
	Moderator Effect	1.9380	1.5348	1.8804*	1.1312	1.2589*
		(1.2031)	(1.0078)	(1.0406)	(0.9351)	(0.6691)
	Interaction Effect	-0.1270	-0.0971	-0.1236*	-0.0775	-0.0944*
		(0.0875)	(0.0728)	(0.0693)	(0.0744)	(0.0529)
	Observations	41,988	70,784	29,860	58,088	57,117
	R-squared	12.81	12.63	16.50	13.67	14.02
ESG Controversies	CO_2 Effect	-0.1793*	-0.1707***	-0.0530	-0.1021	-0.0811*
		(0.1032)	(0.0541)	(0.0581)	(0.0719)	(0.0474)
	Moderator Effect	-0.0158	-0.0001	-0.0029	0.0072	0.0052
		(0.0142)	(0.0076)	(0.0089)	(0.0096)	(0.0062)
	Interaction Effect	0.0009	0.0004	0.0004	-0.0002	0.0001
		(0.0010)	(0.0005)	(0.0006)	(0.0008)	(0.0005)
	Observations	41,988	256,940	73,351	141,886	140,629
	R-squared	12.81	13.50	16.98	13.39	13.58

significant —particularly for Scope 3 (value chain emissions) and Scope 1 (direct operational emissions), where the interaction coefficients are -0.1236 ($p < 0.1$) and -0.0944 ($p < 0.1$), respectively. These findings suggest that emissions are penalized more harshly when firms claim to internalize climate risks financially. In essence, the market likely interprets such emissions as a failure of strategy execution or lack of credibility.

The ESG controversies score introduces a more nuanced dynamic. A higher score (i.e., fewer controversies) is associated with a stronger negative effect of emissions on stock returns. Though data truncation prevents full reporting here, initial coefficients indicate that firms with cleaner ESG reputations experience a stronger market backlash when emissions are high, perhaps due to reputational risk or perceived hypocrisy. This supports the argument that investors do not evaluate emissions in isolation; rather, they consider them in the context of the firm's ESG profile and stakeholder alignment.

B. Europe

4.1 Descriptive Statistics

This section presents the descriptive statistics of the sample of European firms analyzed in this study, which comprises 1,270 distinct companies and a total of 148,782 firm-month observations. The data coverage spans multiple countries, with the United Kingdom representing the largest share at 44.02% of observations, followed by Germany (21.26%), France (14.49%), and Switzerland (13.94%). Smaller jurisdictions such as Guernsey, Luxembourg, and Ireland contribute more modestly but help provide a broad regional representation.

The distribution of financial and emissions variables reveals substantial heterogeneity among firms, both in size and performance. The average monthly stock return across the sample is 0.69%, with a median of 0.45%, indicating a slight positive tendency in returns but with considerable variability. This is underscored by the notably high standard deviation of 23.12%, which exceeds typical market volatility figures and suggests the presence of extreme return events. Indeed, observed returns range widely from a loss of approximately 93% to an extraordinary gain exceeding 7,300%, highlighting the volatility and risk present in European equity markets.

Turning to carbon emissions, actual total CO2e emissions have a mean logged value of 9.66, with the estimated total CO2e slightly higher at 10.56. Scope 3 emissions, which capture indirect upstream and downstream emissions, have the highest mean at 11.35, followed by Scope 1 and Scope 2 emissions at 9.90 and 9.83, respectively.

Table 4.1b. Descriptive Statistics - Europe

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Dependent variables					
Return	0.68	0.45	23.11	-93	7327.63
ROE	10.24	11.36	107.71	-5857	2409.86
ROA	4.56	4.23	14.23	-697	236.78
EBIT margin	-7.88	11.69	620.84	-41015	2815.24
EBITDA margin	139.4	17.79	15223.73	-33445	1693625
Gross margin	46.77	44.44	41.76	-1531	188.58
Net margin	-9.68	6.73	686.23	-39630	17387.94
Emission variables					
Actual total CO2e	9.66	9.71	2.99	1.09	18.21
Estimated total CO2e	10.56	10.72	3.06	-0.88	19.44
Scope 3	11.35	11.26	3.75	-1.05	21.22
Scope 2	9.82	10.09	2.93	0	16.91
Scope 1	9.90	9.85	3.34	-3.91	19.06
Scope 3 intensity	5.51	5.45	1.63	-0.37	15.41
Scope 2 intensity	1.91	2.05	1.98	-7.77	8.75
Scope 1 intensity	1.92	1.97	2.42	-9.02	11.02
Control variables					
Log size	21.69	21.64	1.82	12.60	28.37
Log employees	8.66	8.74	2.16	0	13.44
Income before tax margin	-7.49	8.98	707.25	-43515	17387.94
Asset turnover	0.765	0.66	0.66	-1.60	6.95
Current ratio	2.52	1.40	11.32	0.0077	630.77
EPS diluted	21.35	0.57	13968.48	-132479	543715

Table 4.2b. Countries - Europe

Country	Firms	Firm-Month Observations	Percentage
United Kingdom	559	68,029	44.02%
Germany	270	28,109	21.26%
France	184	25,254	14.49%
Switzerland	177	20,170	13.94%
Guernsey	26	1,842	2.05%
Luxembourg	13	1,139	1.02%
Ireland	9	1,591	0.71%
Jersey	8	595	0.63%
Netherlands	7	880	0.55%

Country	Firms	Firm-Month Observations	Percentage
Austria	5	403	0.39%
Cyprus	2	103	0.16%
Isle of Man	2	188	0.16%
Liechtenstein	2	128	0.16%
Spain	2	80	0.16%
Belgium	1	76	0.08%
Gibraltar	1	112	0.08%
Italy	1	52	0.08%
Lithuania	1	31	0.08%
Total	1,270	148,782	100%

Table 4.3b. GICS industry classification - Europe

GICS Industry	Firms	Observations	Percentage
Machinery	78	7,664	6.14%
Capital Markets	75	7,962	5.91%
Specialty Retail	44	4,781	3.46%
Real Estate Management & Development	42	4,041	3.31%
Software	41	3,072	3.23%
Hotels, Restaurants & Leisure	40	5,296	3.15%
Media	38	4,520	2.99%
Electrical Equipment	35	3,005	2.76%
Oil, Gas & Consumable Fuels	34	3,821	2.68%
Food Products	33	3,949	2.60%
Professional Services	33	3,951	2.60%
Chemicals	31	4,786	2.44%
IT Services	31	2,512	2.44%
Metals & Mining	31	3,974	2.44%
Commercial Services & Supplies	29	3,417	2.28%
Electronic Equipment, Instruments & Components	29	2,487	2.28%
Household Durables	29	3,088	2.28%
Insurance	29	5,003	2.28%
Banks	25	3,961	1.97%
Health Care Equipment & Supplies	25	2,643	1.97%
Pharmaceuticals	25	3,127	1.97%
Trading Companies & Distributors	24	3,467	1.89%
Construction & Engineering	23	3,300	1.81%
Semiconductors & Semiconductor Equipment	23	2,700	1.81%
Aerospace & Defense	22	3,505	1.73%
Automobile Components	21	2,079	1.65%

GICS Industry	Firms	Observations	Percentage
Biotechnology	21	1,559	1.65%
Building Products	21	1,867	1.65%
Financial Services	19	2,082	1.50%
Textiles, Apparel & Luxury Goods	18	2,880	1.42%
Consumer Staples Distribution & Retail	14	1,960	1.10%
Life Sciences Tools & Services	14	1,220	1.10%
Health Care Providers & Services	13	1,411	1.02%
Construction Materials	12	1,498	0.94%
Consumer Finance	12	1,047	0.94%
Diversified REITs	12	1,548	0.94%
Beverages	11	1,531	0.87%
Diversified Telecommunication Services	11	1,640	0.87%
Entertainment	11	1,128	0.87%
Interactive Media & Services	11	1,107	0.87%
Office REITs	11	1,796	0.87%
Automobiles	10	1,500	0.79%
Independent Power and Renewable Electricity Producers	10	1,005	0.79%
Retail REITs	9	1,239	0.71%
Transportation Infrastructure	9	1,256	0.71%
Ground Transportation	7	1,080	0.55%
Health Care Technology	7	405	0.55%
Industrial Conglomerates	7	1,041	0.55%
Multi-Utilities	7	1,635	0.55%
Air Freight & Logistics	6	587	0.47%
Containers & Packaging	6	383	0.47%
Electric Utilities	6	576	0.47%
Energy Equipment & Services	6	1,146	0.47%
Passenger Airlines	6	1,108	0.47%
Personal Care Products	6	1,033	0.47%
Communications Equipment	5	681	0.39%
Diversified Consumer Services	5	487	0.39%
Health Care REITs	5	354	0.39%
Industrial REITs	5	470	0.39%
Paper & Forest Products	5	389	0.39%
Residential REITs	5	379	0.39%
Technology Hardware, Storage & Peripherals	5	719	0.39%
Wireless Telecommunication Services	5	596	0.39%
Broadline Retail	4	504	0.31%
Leisure Products	4	229	0.31%
Distributors	3	532	0.24%
Household Products	3	666	0.24%
Marine Transportation	3	456	0.24%
Tobacco	3	603	0.24%

GICS Industry	Firms	Observations	Percentage
Water Utilities	3	795	0.24%
Specialized REITs	2	355	0.16%
Gas Utilities	1	148	0.08%
Hotel & Resort REITs	1	40	0.08%
Total	1,270	148,782	100%

4.2 Correlations

Understanding the relationships among carbon emissions, their intensities, and firm-specific characteristics is crucial for interpreting how environmental factors interplay with corporate scale and performance. Table 4.2 presents the correlation matrix for logged actual and estimated total CO2 emissions, emission intensities across the three scopes, and key firm size proxies including market capitalization, total assets, and number of employees for the European sample. A near-perfect correlation between logged actual total CO2e and logged estimated total CO2e is observed ($r = 0.9981$), confirming the close alignment between firm-reported emissions and external estimation models. This strong concordance supports the reliability of estimated emissions as a proxy when actual disclosures are unavailable or incomplete. Emission intensities, measured as emissions normalized by firm size or activity, display more moderate correlations with total emissions.

Correlations with firm size metrics reveal expected relationships. Log market capitalization and log total assets correlate moderately with actual and estimated total CO2e (ranging from 0.54 to 0.58), indicating that larger firms tend to emit more carbon in absolute terms, consistent with their broader operational footprint. Interestingly, emission intensities correlate less strongly with size proxies, especially market capitalization, with correlations generally below 0.25 for Scope 3 intensity and slightly higher for Scope 2 and Scope 1 intensities (approximately 0.22 to 0.24). This suggests that emission intensities are less mechanically linked to firm size, supporting their use as normalized measures to better isolate emissions performance independent of scale.

The moderate positive correlations between emissions and size proxies underline a fundamental challenge in environmental finance research: disentangling the pure effect of emissions from the confounding effect of firm scale. The differing strengths of correlations across scopes and intensity metrics further emphasize the need to carefully select and interpret emission variables in empirical modeling.

Table 4.4b. Correlations - Europe

	Log actual total CO2e	Log est total CO2e	Log scope 3 intensity	Log scope 2 intensity	Log scope 1 intensity	Log scope 3	Log scope 2	Log scope 1	Log market capitalization	Log assets	Log employees
Log actual total CO2e	1										
Log est total CO2e	0.998	1									
Log scope 3 intensity	0.348	0.349	1								
Log scope 2 intensity	0.582	0.584	0.158	1							
Log scope 1 intensity	0.718	0.718	0.265	0.589	1						
Log cope 3	0.705	0.706	0.513	0.283	0.346	1					
Log scope 2	0.893	0.896	0.294	0.743	0.499	0.672	1				
Log scope 1	0.957	0.958	0.356	0.476	0.807	0.674	0.796	1			
Log market capitalization	0.540	0.539	0.232	0.099	0.051	0.583	0.580	0.491	1		
Log assets	0.584	0.586	0.365	0.063	0.056	0.594	0.597	0.532	0.813	1	
Log employees	0.712	0.712	0.191	0.244	0.218	0.631	0.741	0.666	0.634	0.665	1

4.3 Impact of Carbon Emission on Stock Returns

4.3.1 Scaled Emissions

The analysis of carbon emission intensities—defined as emissions normalized by firm size or activity—provides important insights into how relative environmental performance influences stock returns in the European market. Our regression models evaluate the relationship between the logged emission intensities for Scope 1 (direct emissions), Scope 2 (purchased energy), and Scope 3 (other indirect emissions) and firm monthly stock returns, while controlling for firm size, industry effects, and temporal variations.

Beginning with Scope 3 emission intensity, the results indicate a generally weak and statistically insignificant association with stock returns. Coefficients across specifications are small and hover around zero, with p-values failing to achieve conventional significance thresholds. This suggests that investors in Europe may not currently penalize or reward firms based on their relative indirect emissions footprint, possibly due to difficulties in reliably measuring and disclosing Scope 3 emissions or due to a lesser perceived immediacy of these emissions in firm value assessments. In contrast, Scope 2 emission intensity, representing emissions associated with purchased electricity or energy, exhibits a more discernible negative relationship with stock returns. The coefficients, though modest, are consistently negative and statistically significant at the 5% or 1% level in models that incorporate industry controls. Similarly, Scope 1 emission intensity also shows negative but weaker and less consistent associations with stock returns. While the coefficients generally point toward a negative impact (ranging approximately from -0.022 to -0.056), statistical significance is only reached in select models, suggesting a more nuanced or context-dependent investor reaction to direct emissions intensity in Europe. The relatively smaller and less consistent coefficients compared to Scope 2 intensity may be explained by heterogeneous investor perceptions regarding the ease and cost of mitigating direct emissions or differences in sectoral emission profiles.

Firm size, included as a control variable and measured by logged market capitalization, consistently exhibits a positive and statistically significant coefficient across all models. This reinforces the notion that larger firms tend to garner higher stock returns, potentially due to better market positioning, greater financial resources, or perceived resilience to environmental and economic shocks. The explanatory power of the models, as reflected by R-squared values consistently around 27% to 29%, indicates that the included variables—emission intensities, firm size, industry classifications, and time fixed effects—explain a meaningful portion of variation in stock returns

Table 4.5b. Scaled emissions and stock returns - Europe

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
CO2e Scope 3	0.019 (0.042)			0.005 (0.032)			–0.034 (0.036)			–0.024 (0.039)		
CO2e Scope 2		–0.036 (0.021)			–0.052* (0.031)			–0.068** (0.033)			–0.053* (0.030)	
CO2e Scope 1			–0.022 (0.026)			–0.048 (0.031)			–0.056* (0.031)			–0.043 (0.030)
Firm size							0.170** (0.066)	0.152** (0.064)	0.141** (0.063)	0.181** (0.071)	0.162** (0.072)	0.156** (0.071)
Observations	91,126	87,013	86,294	91,002	86,979	86,253	90,388	86,025	85,319	82,370	78,065	77,575
R-squared	27.81	29.33	29.35	27.94	29.43	29.46	28.05	29.61	29.66	27.76	29.04	29.08
Controls	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
GICS-Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.3.2 Unscaled Emissions

This section evaluates the relationship between absolute levels of carbon emissions across Scope 1, 2, and 3 categories and firm stock returns within European markets. The regression results reveal predominantly negative coefficients across all scopes, indicating that higher unscaled emissions are generally associated with lower stock returns. However, the strength and statistical significance of these effects vary by emission scope and model specification. For Scope 3 emissions, the raw coefficients are small and statistically insignificant in simpler models. However, once industry controls and firm size are incorporated (columns 10–12), the coefficients become more negative and achieve significance at the 5% level. This suggests that investors may begin to price in the broader indirect emissions impact when accounting for sectoral differences and firm scale, indicating a latent sensitivity to the extended carbon footprint once confounding factors are controlled for. Regarding Scope 2 emissions, the negative impact on returns is more robust and statistically significant across fully specified models. The coefficients range from approximately -0.121 to -0.129 ($p < 0.01$), implying that firms with higher absolute Scope 2 emissions experience a discernible penalty in their stock returns. Scope 1 emissions also display significant negative associations with stock returns in the fully controlled specifications. The coefficients reach around -0.103 to -0.106 ($p < 0.01$), indicating that investors discount firms with larger direct emissions footprints. This aligns with expectations that direct emissions represent more visible and potentially more manageable environmental risks, attracting greater investor scrutiny.

The inclusion of size and industry fixed effects is critical here, as failure to control for these confounders can mask or distort the true relationship between emissions and returns. Overall, the results indicate that European investors penalize firms with larger total carbon emissions across all scopes, with particularly strong reactions to Scope 1 and Scope 2 emissions. These findings show the importance of distinguishing between absolute and intensity-based emission measures. While intensity metrics help neutralize the confounding influence of firm size, raw emissions remain a meaningful signal for investors, reflecting the total environmental footprint and associated financial risks. For practitioners and policymakers, this implies that disclosure and management of total emissions are crucial for firms aiming to maintain or improve market valuations in Europe.

4.3.3 Actual and Estimated Emissions

This section investigates how total carbon emissions—both actual reported values and vendor-estimated figures—affect stock returns for European firms. Disentangling the

Table 4.6b. Unscaled emissions and stock returns - Europe

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
CO2e Scope 3	–0.003			–0.010			–0.076**			–0.083**		
	(0.034)			(0.020)			(0.031)			(0.032)		
CO2e Scope 2		–0.007			–0.017			–0.121***			–0.129***	
		(0.024)			(0.042)			(0.044)			(0.041)	
CO2e Scope 1			–0.006			–0.019			–0.103**			–0.106***
			(0.020)			(0.027)			(0.040)			(0.039)
Firm size							0.219***	0.244***	0.216***	0.240**	0.264***	0.237***
							(0.079)	(0.083)	(0.078)	(0.093)	(0.088)	(0.086)
Observations	69,843	98,159	98,829	69,772	98,088	98,751	68,898	96,902	97,563	59,678	86,975	87,967
R-squared	31.85	30.74	30.74	31.99	30.85	30.85	32.26	31.08	31.08	30.93	30.21	30.23
Controls	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
GICS-Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

influence of these two data sources is critical, given the variation in disclosure practices and the growing reliance on third-party estimates for comprehensive emissions assessment. Actual CO2 emissions, the coefficients on total emissions are positive but statistically insignificant in the simpler specifications without controls. However, when industry fixed effects and additional controls are incorporated (columns 3 and 4), the coefficient turns negative but remains statistically insignificant at conventional levels. In contrast, estimated CO2 emissions—which aggregate vendor-modelled emissions data—demonstrate a clearer and more significant negative relationship with stock returns.

Initial models without controls show small and statistically insignificant negative coefficients. However, with the inclusion of industry fixed effects and firm controls (columns 7 and 8), the negative association strengthens considerably. These results indicate that investors penalize firms with higher estimated emissions more decisively than those with higher reported emissions, potentially because vendor estimates provide a more standardized, comprehensive, or skeptical view of a firm's environmental footprint. For actual emissions models, size coefficients are robust and large (around 0.37 to 0.41), while for estimated emissions, size effects are smaller yet still significant (approximately 0.17 to 0.20).

Table 4.7b. Actual vs. estimated emissions - Europe

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Actual Emissions				Estimated Emissions			
Variable	Return	Return	Return	Return	Return	Return	Return	Return
Total CO2e	0.087	0.079	-0.081	–0.109	-0.006	-0.027	-0.095**	-0.117***
	(0.053)	(0.03)	(0.074)	(0.072)	(0.021)	(0.029)	(0.039)	(0.04)
Size			0.373***	0.414***			0.174**	0.204**
			(0.127)	(0.138)			(0.075)	(0.082)
Observations	24,920	24,907	24,710	22,630	149,738	149,484	147,682	132,241
R-squared	29.81	30.25	30.49	30.22	8.14	8.18	8.16	7.54
Controls	No	No	No	Yes	No	No	No	Yes
GICS-Industry	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.4 Impact of Carbon Emissions on Financial Performance

This section explores how carbon emissions, measured across various scopes (Scope 1, 2, and 3), influence financial performance in Europe, focusing on metrics such as Return on Equity (ROE), Return on Assets (ROA), EBIT, EBITDA, Gross Profit Margin (GPM), and Net Profit Margin (NPM). The analysis considers both estimated total CO2 emissions and actual reported emissions, as well as emissions by Scope 1 (direct), Scope 2 (purchased energy), and Scope 3 (indirect upstream and downstream). Emissions intensity measures are also considered for a more nuanced understanding of the relationship between emissions and firm performance. The results for estimated total CO2 emissions show a generally negative relationship with financial performance, particularly for ROE and ROA. For instance, the coefficient for estimated CO2 emissions on ROE is -1.99 ($p < 0.05$), suggesting that firms with higher estimated emissions experience a reduction in shareholder returns. Similarly, the estimated emissions have a significantly negative effect on ROA (-1.04, $p < 0.01$), indicating that higher emissions are associated with lower asset returns. This could reflect the growing market perception that high emissions expose firms to environmental, regulatory, or reputational risks that, in turn, undermine their profitability and operational efficiency. Interestingly, EBIT and EBITDA, which measure operational performance, show more muted responses to estimated CO2 emissions. For EBIT, the coefficient is positive (8.24, $p <0.05$) and statistically significant, while for EBITDA, the coefficient is large (110.02) but remains statistically insignificant. This suggests that while emissions affect profitability in terms of net returns (ROE, ROA), their impact on operational efficiency is less straightforward, possibly due to variations in how firms manage their carbon-intensive operations or offset environmental costs. On the other hand, Gross Profit Margin (GPM) and Net Profit Margin (NPM) reveal significant negative effects, with coefficients of -2.12 and -0.36, respectively, but only GPM is statistically significant ($p < 0.01$). These results indicate that firms with higher emissions are penalized in terms of gross profitability and net income, which can be attributed to the higher costs associated with carbon management, compliance, or negative consumer perception.

For actual total CO2 emissions, the relationship with financial performance mirrors the findings for estimated emissions, with negative effects particularly on ROE and ROA. The coefficient for actual emissions on ROE is -1.85 ($p < 0.01$), further supporting the view that firms with larger reported carbon footprints face investor skepticism, which is reflected in reduced returns on equity. The negative coefficient on ROA (-0.69, $p < 0.01$) indicates a similar negative influence on asset efficiency. However, for EBIT (22.80) and EBITDA (17.29), the effects are positive but statistically insignificant, similar to the estimated

emissions models. This suggests that while emissions might be associated with decreased returns on equity and assets, firms might still report strong operational performance, which could be the result of efficiencies or pricing power that offset some of the environmental costs. The Net Profit Margin (NPM) is notably negative (-3.14, $p < 0.05$), suggesting that actual emissions significantly reduce the profitability of firms when considering non-operating income and expenses, likely due to higher carbon-related costs, potential fines, or loss of consumer trust.

Breaking down emissions by Scope 3, Scope 2, and Scope 1 offers additional insights. For Scope 3 emissions—which represent indirect emissions from upstream and downstream activities—there is a significant negative impact on ROA (-0.60, $p < 0.01$), signaling that firms with a larger Scope 3 footprint tend to generate lower returns on assets. This is consistent with the view that investors are concerned with the broader environmental impacts of a firm's supply chain and product lifecycle, which can introduce additional risks not immediately apparent in the firm's direct operations. The coefficient for Scope 3 emissions on GPM is also significantly negative (-1.06, $p < 0.01$), further highlighting the profitability risks associated with high indirect emissions. For Scope 2 emissions—which reflect energy consumption—the coefficients indicate a significant and negative relationship with profitability and returns. For ROE, the coefficient is -2.39 ($p < 0.01$), suggesting that energy-intensive firms face shareholder returns that are significantly lower. Similarly, the Net Profit Margin (NPM) also reflects a negative relationship (-0.23, $p < 0.05$). This finding reinforces the market's sensitivity to energy sourcing and the associated costs of emissions in purchased electricity or energy consumption. Scope 1 emissions—representing direct emissions from firm-controlled sources—demonstrate a similar pattern. The coefficients for ROE (-1.32, $p < 0.01$) and ROA (-0.81, $p < 0.01$) are significantly negative, supporting the notion that direct emissions pose a clear financial cost, likely due to regulatory burdens, compliance costs, and the potential for reputational damage. Interestingly, the coefficient for EBITDA is positive (13.81) but remains statistically insignificant, suggesting that operational performance may not always correlate directly with carbon emissions at the firm level, especially if firms have developed ways to offset their environmental footprint.

When examining emissions intensity (Scope 1, 2, and 3 emissions relative to firm size), the results are mixed. For Scope 3 intensity, there is a positive coefficient for ROE (2.34, $p < 0.05$), indicating that firms with higher relative Scope 3 emissions intensity could experience better shareholder returns. However, the effects on EBIT and EBITDA are not significant, suggesting that intensity measures may have a limited impact on operational

performance. For Scope 2 intensity, the coefficients on GPM and NPM are negative (-0.99 and 1.73, respectively), with the latter being statistically significant ($p < 0.05$). This suggests that while overall Scope 2 emissions are associated with financial penalties, firms that manage their emissions intensity in relation to size may face relatively higher costs in terms of profitability margins. Scope 1 intensity produces more mixed results. For GPM, the coefficient is negative (-1.29, $p < 0.05$), while NPM shows a significant positive effect (1.11, $p < 0.05$). This reflects the complex relationship between direct emissions intensity and profitability—firms with high direct emissions relative to size may struggle with gross margins but could see improved net margins due to other factors such as cost-cutting or tax benefits.

4.5 Governance Mediation Effects on Emission-Return Relationship

Contrary to the notion of a "carbon premium," whereby investors would require higher returns to hold high-emission firms, the findings consistently point to a carbon discount. Specifically, the analysis demonstrates a statistically significant and negative relationship between firm-level carbon emissions and monthly stock returns, measured across total emissions and disaggregated scopes (Scope 1, 2, and 3). These results suggest that, after accounting for firm fundamentals and absorbing time- and industry-level unobservables, firms with higher emissions systematically underperform their lower-emitting peers in terms of stock returns.

For firms engaged in executive compensation ESG policies, the direct effect of emissions on stock returns is uniformly negative and statistically significant across all scopes except for the total actual specification, where the estimate is negative but statistically imprecise. The presence of such policies does not appear to meaningfully alter this carbon discount. The interaction terms between emissions and the policy moderator are small and statistically insignificant, implying that such governance mechanisms, at least in isolation, do not buffer the adverse pricing effects of emissions in European markets.

Table 4.8b. Carbon emissions and financial performance - Europe

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	ROE	ROA	EBIT	EBITDA	GPM	NPM	ROE	ROA	EBIT	EBITDA	GPM	NPM
Estimated Total CO2e	-1.99**	-1.04***	8.24**	110.02	-2.12***	-0.36						
	(0.79)	(0.17)	(3.70)	(98.19)	(0.70)	(0.43)						
Observations	130,434	132,320	132,344	132,296	125,992	132,344						
R-squared	7.2	27.82	86.5	0.72	21.82	99.66						
Actual CO2e							-1.85***	-0.69***	22.80	17.29	0.40	-3.14
							(0.59)	(0.22)	(16.97)	(14.34)	(1.51)	(2.14)
Observations							22,544	22,640	22,640	22,640	21,946	22,640
R-squared							16.05	28.35	82.88	81.52	47.19	99.68
CO2e Scope 3	-1.02*	-0.60***	4.64	11.01	-1.06***	-0.06						
	(0.58)	(0.15)	(3.16)	(7.60)	(0.29)	(0.32)						
Observations	58,991	59,693	59,709	59,673	57,282	59,709						
R-squared	20.95	34.34	83.51	56.65	40.03	99.59						
CO2e Scope 3 Intensity							2.34*	0.33	-9.97	-13.89	0.55	-0.44
							(1.38)	(0.30)	(10.25)	(10.18)	(0.72)	(0.79)
Observations							81,480	82,404	82,428	82,404	78,100	82,428
R-squared							13.00	26.41	89.06	71.38	27.36	99.67
CO2e Scope 2	-2.39***	-0.93***	7.43*	11.01	-1.51***	-0.23						
	(0.66)	(0.17)	(4.48)	(6.72)	(0.51)	(0.56)						
Observations	85,918	87,019	87,035	86,999	84,467	87,035						

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	ROE	ROA	EBIT	EBITDA	GPM	NPM	ROE	ROA	EBIT	EBITDA	GPM	NPM
R-squared	18.11	31.25	86.83	64.00	33.71	99.63						
CO2e Scope 2 Intensity							0.07	-0.13	-8.54	-6.47	-0.99	1.73*
							(0.82)	(0.15)	(7.06)	(6.12)	(0.63)	(0.90)
Observations							77,111	78,104	78,120	78,096	75,895	78,120
R-squared							18.66	30.44	86.97	64.03	33.24	99.64
CO2e Scope 1	-1.32***	-0.81***	9.86	13.81*	-1.12	-0.51						
	(0.49)	(0.15)	(6.10)	(8.13)	(0.69)	(0.65)						
Observations	86,852	88,009	88,025	87,989	85,670	88,025						
R-squared	17.78	31.74	87.02	64.63	33.06	99.65						
CO2e Scope 1 Intensity							1.31	-0.16	-2.19	1.05	-1.29**	1.11*
							(1.28)	(0.22)	(3.18)	(3.19)	(0.58)	(0.57)
Observations							76,606	77,611	77,627	77,603	75,596	77,627
R-squared							18.73	31.3	87.24	64.69	32.97	99.66
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The market continues to associate emissions with value erosion, even when firms ostensibly link compensation structures to ESG considerations. Similarly, in the case of environmental restoration initiatives, the carbon discount persists. Emissions are associated with significantly lower stock returns across all scopes. Although the moderator variable itself shows some variation in direction and magnitude, its interaction with emissions is largely weak and statistically insignificant, except for a marginally significant positive interaction for Scope 3 emissions. However, this does not appear sufficient to offset the baseline negative pricing of emissions. This suggests that while restoration initiatives may represent an effort toward environmental stewardship, they do not substantially reframe investor perceptions of carbon risk in the short term.

A more nuanced pattern emerges in the case of climate-related financial planning, which includes strategic integration of climate change risks and opportunities into core financial decision-making. Notably, firms engaging in such planning still face a baseline carbon discount—emissions continue to exhibit negative and significant associations with stock returns. However, in contrast to the previous moderators, the interaction effects between emissions and this planning variable are positive and statistically significant across all emission scopes and specifications. This indicates that climate-related financial planning may partially mitigate the return penalty associated with high emissions. Investors may interpret such planning as a credible long-term commitment to managing climate risk, thereby moderating their penalization of emissions. Yet, the baseline negative effect of emissions remains dominant, suggesting that these plans, while beneficial, are not sufficient to fully neutralize investor concerns in carbon-intensive firms.

Finally, the ESG controversies score, which ranges from 1 (high controversy) to 100 (no controversy), produces a distinctive profile. Here, the baseline emission coefficients remain negative, particularly in Scope 1 and 2, reinforcing the presence of a carbon discount. The moderator itself exhibits marginal or no significant relationship with returns, and the interaction terms are negligible. This suggests that, regardless of a firm's track record of avoiding ESG controversies, the market continues to penalize emissions independently. Firms with low controversy scores do not appear to benefit from any return premium in the presence of high emissions. This underscores the idea that investors in European markets treat emissions as a standalone negative signal, rather than one that can be easily offset by broader ESG reputation.

Table 4.9b. Governance moderation – Europe

	Effect Type	Actual total	Estimated total	Scope 3	Scope 2	Scope 1
Policy Executive Compensation ESG Performance	CO_2 Effect	-0.096 (0.061)	-0.104*** (0.025)	-0.082*** (0.021)	-0.121*** (0.024)	-0.102*** (0.0221)
	Moderator Effect	-0.098 (0.559)	-0.168 (0.212)	-0.375 (0.251)	-0.191 (0.223)	-0.306 (0.210)
	Interaction Effect	-0.013 (0.061)	-0.011 (0.020)	0.007 (0.020)	-0.005 (0.021)	0.001 (0.018)
	Observations	22,630	132,185	59,678	86,975	87,967
	R-squared	30.23	7.55	30.94	30.22	30.24
Environmental Restoration Initiatives	CO_2 Effect	-0.111** (0.043)	-0.111*** (0.021)	-0.092*** (0.018)	-0.127*** (0.022)	-0.104*** (0.021)
	Moderator Effect	-0.181 (0.533)	0.094 (0.255)	-0.678** (0.302)	-0.088 (0.254)	-0.146 (0.242)
	Interaction Effect	0.007 (0.048)	-0.017 (0.021)	0.042* (0.022)	-0.003 (0.022)	0.001 (0.021)
	Observations	22,630	131,750	59,510	86,687	87,667
	R-squared	30.22	7.53	30.94	30.22	30.24
Climate Change Risks & Opportunities Financial Planning	CO_2 Effect	-0.0775 (0.0532)	-0.0714* (0.0397)	-0.106*** (0.033)	-0.079* (0.041)	-0.037 (0.038)
	Moderator Effect	-1.9113*** (0.7104)	-1.8994*** (0.6366)	-1.602** (0.801)	-1.647*** (0.600)	-1.397** (0.560)
	Interaction Effect	0.1463** (0.0588)	0.1450*** (0.0526)	0.106** (0.054)	0.138** (0.054)	0.105** (0.049)
	Observations	13,224	21,872	16,885	20,010	19,862
	R-squared	32.92	30.71	34.39	32.57	32.69
ESG Controversies	CO_2 Effect	0.0417 (0.1537)	-0.1040* (0.0595)	-0.010 (0.040)	-0.125** (0.052)	-0.138*** (0.045)
	Moderator Effect	0.0217 (0.0232)	0.0072 (0.0087)	0.016*** (0.001)	0.004 (0.006)	-0.001 (0.006)
	Interaction Effect	-0.0014 (0.0016)	-0.00001 (0.0006)	-0.001* (0.001)	0.001 (0.001)	0.001 (0.001)
	Observations	22,614	132,165	59,662	86,959	87,951
	R-squared	30.25	7.55	30.94	30.22	30.25

C. Middle East

4.1 Descriptive Statistics

This section presents an overview of the sample composition and key descriptive statistics for firms operating in the Middle East region. Data are comprised of 357 firms, and 21,163 firm-month observations in four countries, including Turkey, United Arab Emirates (UAE), Saudi Arabia, and Qatar. The largest proportion of the data is represented by Turkey with about 37.25 percent of the observations, after which comes UAE with 25.21 percent, Saudi Arabia with 23.53 percent, and Qatar making up 14.01 percent. This allocation shows the proportionate size and business activity of these nations in the corporate environment of this region. The financial and emissions-related variables are very heterogeneous, which is consistent with the range in the size of the firm, industry mix, and environmental practices in these Middle Eastern markets. Beginning with stock returns, the mean monthly return is 1.30% and the median is nearly zero (0.02%) implying that although most firms generate moderate returns, there are some big positively performing firms. The range of 252.28% to -75.39% indicates the occurrence of instances of extreme market volatility, which may be associated with geopolitical occurrences or sector shocks.

Regarding emissions, actual total CO2 equivalent (CO2e) emissions have a mean logged value of 11.27, closely aligned with estimated emissions at 11.02, indicating reasonable consistency between reported and modeled figures. Emissions by scope show expected differences: Scope 3 emissions average 11.00, reflecting the extensive nature of indirect emissions, while Scope 2 and Scope 1 emissions are slightly lower, averaging 10.62 and 10.57 respectively. Intensity measures, which adjust emissions relative to firm size or activity, reveal a mean Scope 3 intensity of 6.22, significantly higher than Scope 2 and Scope 1 intensities (approximately 3.22 and 3.21). This disparity highlights the importance of accounting for indirect emissions in understanding the full environmental impact.

Table 4.1c. Descriptive Statistics - Middle East

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Dependent variables					
Return	1.30	0.02	13.35	-75.39	252.28
ROE	15.00	12.70	26.20	-349.10	446.48
ROA	6.05	4.00	8.18	-25.50	70.30
EBIT margin	22.20	17.88	33.74	-658.31	178.10

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
EBITDA margin	29.22	26.10	31.28	-560.65	192.04
Gross margin	29.89	27.26	22.22	-163.75	102.45
Net margin	30.34	15.86	122.13	-1,724.35	2,352.41
Emission variables					
Actual total CO2e	11.27	11.17	3.12	3.07	18.84
Estimated total CO2e	11.02	11.12	3.14	0.76	19.18
Scope 3	11.00	11.10	3.99	-1.20	19.20
Scope 2	10.62	10.72	2.65	-2.30	18.19
Scope 1	10.57	10.39	3.67	-1.51	18.79
Scope 3 intensity	6.22	6.11	1.62	0.25	12.09
Scope 2 intensity	3.22	3.09	2.18	-10.04	9.80
Scope 1 intensity	3.21	2.95	3.32	-5.57	10.84
Control variables					
Log size	21.70	21.80	1.90	16.14	30.11
Log employees	7.88	7.86	1.85	1.39	11.69
Income before tax margin	32.29	17.73	123.96	-1,724.35	2,352.41
Asset turnover	0.60	0.33	1.11	0.01	37.68
Current ratio	2.88	1.40	12.81	0.06	276.85
EPS diluted	2.22	0.68	8.37	-10.30	201.84

Table 4.2c. Countries - Middle East

Country	Firms	Observations	Percentage
Turkey	133	9,343	37.25%
United Arab Emirates	90	3,477	25.21%
Saudi Arabia	84	4,939	23.53%
Qatar	50	3,404	14.01%
Total	357	21,163	100%

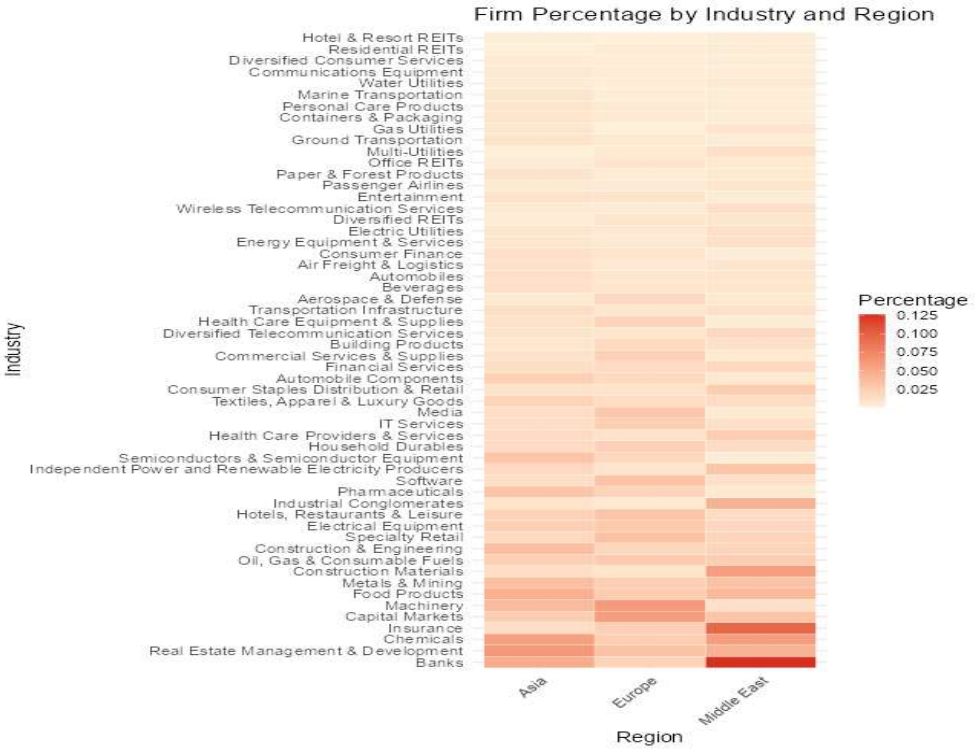

Figure 4.1c. Firm percentage by industry and region.

Source: author's compilation.

Table 4.3c. GICS industry classification - Middle East

GICS Industry	Firms	Observations	Percentage
Banks	45	4,174	12.61%
Insurance	34	1,366	9.52%
Chemicals	21	1,401	5.88%
Construction Materials	21	742	5.88%
Industrial Conglomerates	16	1,076	4.48%
Real Estate Management & Development	16	1,026	4.48%
Food Products	14	765	3.92%
Metals & Mining	12	738	3.36%
Capital Markets	11	508	3.08%
Independent Power and Renewable Electricity Producers	11	417	3.08%
Consumer Staples Distribution & Retail	9	594	2.52%
Health Care Providers & Services	9	352	2.52%
Oil, Gas & Consumable Fuels	9	588	2.52%
Construction & Engineering	7	479	1.96%

GICS Industry	Firms	Observations	Percentage
Specialty Retail	7	352	1.96%
Diversified Telecommunication Services	6	819	1.68%
Electrical Equipment	6	82	1.68%
Financial Services	6	276	1.68%
Hotels, Restaurants & Leisure	5	149	1.40%
Household Durables	5	332	1.40%
Textiles, Apparel & Luxury Goods	5	239	1.40%
Building Products	4	107	1.12%
Electric Utilities	4	311	1.12%
Energy Equipment & Services	4	165	1.12%
IT Services	4	83	1.12%
Machinery	4	208	1.12%
Multi-Utilities	4	170	1.12%
Software	4	89	1.12%
Transportation Infrastructure	4	263	1.12%
Wireless Telecommunication Services	4	577	1.12%
Air Freight & Logistics	3	136	0.84%
Automobiles	3	420	0.84%
Beverages	3	384	0.84%
Diversified REITs	3	120	0.84%
Gas Utilities	3	144	0.84%
Passenger Airlines	3	276	0.84%
Aerospace & Defense	2	104	0.56%
Automobile Components	2	128	0.56%
Commercial Services & Supplies	2	84	0.56%
Media	2	54	0.56%
Office REITs	2	80	0.56%
Paper & Forest Products	2	68	0.56%
Pharmaceuticals	2	64	0.56%
Water Utilities	2	54	0.56%
Communications Equipment	1	52	0.28%
Consumer Finance	1	30	0.28%
Containers & Packaging	1	40	0.28%
Diversified Consumer Services	1	28	0.28%
Entertainment	1	52	0.28%
Ground Transportation	1	22	0.28%
Health Care Equipment & Supplies	1	40	0.28%
Hotel & Resort REITs	1	40	0.28%
Marine Transportation	1	52	0.28%
Personal Care Products	1	64	0.28%
Residential REITs	1	157	0.28%
Semiconductors & Semiconductor Equipment	1	22	0.28%
Total	357	21,163	100%

4.2 Correlations

Understanding the interrelationships between carbon emissions, their intensities, and firm-specific characteristics is essential for unraveling how environmental factors intertwine with corporate scale and performance in the Middle East. Table 5.2 presents the correlation matrix for key variables, including logged actual and estimated total CO2 emissions, emissions intensities across Scope 1, 2, and 3, and standard firm size proxies such as market capitalization, total assets, and number of employees. Starting with the emissions data, actual and estimated total CO2 emissions exhibit a very strong positive correlation ($r = 0.9652$), indicating close alignment between firm-reported figures and vendor-estimated values. This strong correspondence suggests that estimated emissions data can reliably serve as a proxy for actual emissions in this regional context, which is especially important given variations in reporting transparency. Examining emission intensities reveals more nuanced relationships. Scope 1 and Scope 2 intensities show strong correlations with actual total CO2 emissions, at 0.7985 and 0.7221 respectively, suggesting that direct and purchased energy-related emissions scale closely with firms' overall emissions footprint. Scope 3 intensity, representing indirect emissions from upstream and downstream activities, correlates moderately with total emissions ($r \approx 0.29$), reflecting the diffuse and complex nature of indirect emissions relative to direct emissions. Inter-scope relationships between intensities further elucidate emissions dynamics. Scope 1 intensity correlates strongly with Scope 2 intensity ($r = 0.63$), highlighting that firms with high direct emissions often have significant energy procurement emissions as well. The correlation between Scope 3 intensity and other scopes is weaker (ranging between 0.07 and 0.53), underscoring the distinct behavior of indirect emissions and the challenges in their measurement.

Correlations between emissions and firm size proxies suggest meaningful but varied associations. Logged market capitalization has a moderate positive correlation with actual total CO2 emissions ($r = 0.39$) and slightly higher with estimated emissions ($r = 0.44$), indicating that larger firms tend to have greater total carbon footprints. Number of employees correlates more strongly with total emissions ($r = 0.57$ for actual emissions), which may reflect operational scale as an important driver of emissions. Interestingly, asset size shows weaker and sometimes negative correlations with emission intensities, particularly a negative correlation with Scope 2 intensity ($r = -0.05$) and Scope 1 intensity ($r = -0.09$).

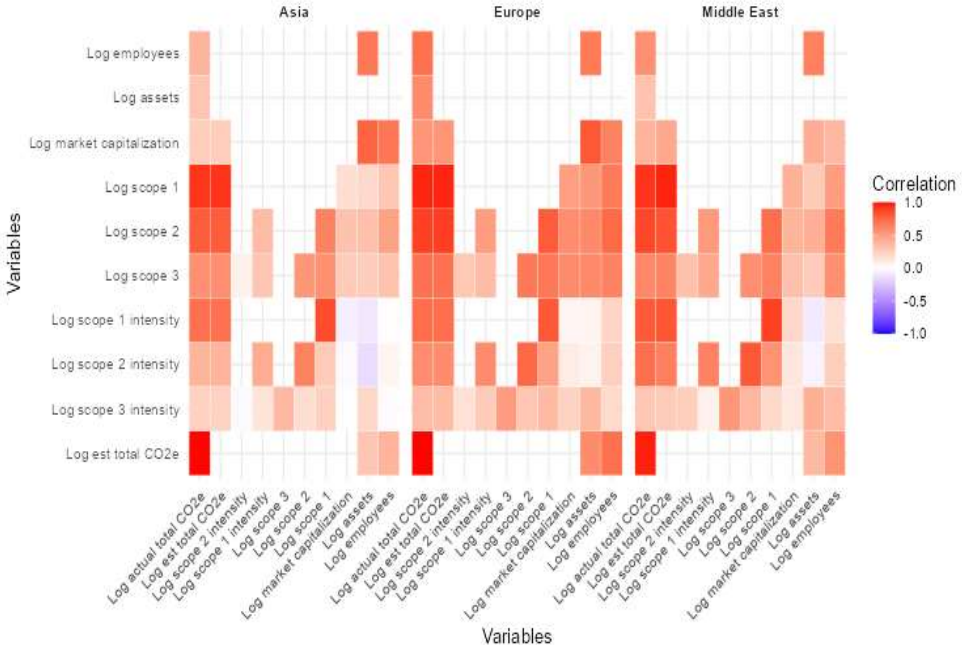

Figure 4.2c. Correlations matrix by region.

Source: author's compilation.

Table 4.4c. Correlations – Middle East

	Log actual total CO2e	Log est total CO2e	Log scope 3 intensity	Log scope 2 intensity	Log scope 1 intensity	Log scope 3	Log scope 2	Log scope 1	Log market capitalization	Log assets	Log employees
Log actual total CO2e	1										
Log est total CO2e	0.9652	1									
Log scope 3 intensity	0.2863	0.2675	1								
Log scope 2 intensity	0.7221	0.6407	0.2515	1							
Log scope 1 intensity	0.7985	0.8166	0.0734	0.6268	1						
Log cope 3	0.6042	0.6244	0.5319	0.3182	0.4393	1					
Log scope 2	0.8698	0.8291	0.3744	0.8122	0.5186	0.5738	1				
Log scope 1	0.9264	0.9613	0.1961	0.5543	0.8914	0.6327	0.723	1			
Log market capitalization	0.39	0.4398	0.1186	0.1246	0.2017	0.3209	0.3903	0.4022	1		
Log assets	0.3123	0.3572	0.4051	-0.0505	-0.0893	0.2641	0.4097	0.2709	0.4198	1	
Log employees	0.5688	0.5494	0.3511	0.253	0.1624	0.5659	0.666	0.5019	0.3661	0.6392	1

This might suggest that larger asset bases do not necessarily translate into proportionally higher emissions intensity, potentially due to efficiency gains or sectoral differences in capital and emissions profiles. The moderate positive correlations between emissions and size measures highlight the need to control carefully for firm scale in empirical analyses. This ensures that the effects attributed to emissions are not confounded by mechanical correlations with firm size, particularly given that firm scale itself is a significant determinant of financial performance.

4.3 Impact of Carbon Emission on Stock Returns

4.3.1 Scaled Emissions

This section evaluates the relationship between the intensities of carbon emissions—measured as emissions normalized by firm size or activity—and monthly stock returns of firms operating in the Middle East. The emissions intensities across Scope 1 (direct emissions), Scope 2 (purchased energy emissions), and Scope 3 (other indirect emissions) provide a normalized lens for assessing environmental performance relative to firm scale, thereby reducing confounding effects related to firm size.

The regression results reveal a complex and somewhat muted pattern of associations between emissions intensities and stock returns. Starting with Scope 3 intensity, which captures the broadest range of indirect emissions, the coefficients are consistently negative, ranging from -0.076 to as much as -0.248 in some models. Although these negative estimates suggest that higher indirect emissions intensity might depress stock returns, the relatively large standard errors indicate these results are not statistically significant in most specifications. This implies that investors in the Middle East may not systematically penalize firms for higher relative indirect emissions, possibly due to limited transparency, measurement challenges, or lower investor focus on Scope 3 emissions in the region.

For Scope 2 intensity, representing emissions from purchased electricity and energy, the coefficients are also negative but smaller in magnitude (around -0.031 to -0.076). Similar to Scope 3, these effects lack consistent statistical significance, suggesting that relative energy emissions exert limited direct influence on market valuation, although the persistent negative signs warrant attention as potential emerging risks.

In contrast, Scope 1 intensity, which reflects direct emissions from operations, shows coefficients close to zero or marginally negative (between 0.046 and -0.071), again with large standard errors and lacking statistical significance. This indicates that relative direct emissions may not currently be a decisive factor in stock return variations among Middle Eastern firms. Firm size emerges as a strong and statistically significant

determinant of returns across all models. The size coefficients range from 0.192 to 0.415 and are significant in most specifications, particularly in models controlling for industry and time fixed effects. This robust positive effect confirms the conventional wisdom that larger firms tend to achieve better market valuations, possibly due to greater financial resources, diversification, or perceived stability in the region's markets. The explanatory power of the models, reflected by R-squared values mostly between 20% and 27%, indicates a reasonable fit given the cross-sectional nature of firm-level return data. These values suggest that factors including emissions intensity, firm size, industry, and time effects jointly explain a meaningful proportion of return variability.

4.3.2 Unscaled Emissions

This section explores how the absolute levels of carbon emissions, without normalizing for firm size or activity, affect stock returns of firms in the Middle East. Focusing on Scope 1 (direct), Scope 2 (purchased energy), and Scope 3 (indirect) emissions, the analysis examines whether investors price firms' overall emissions footprints and how these raw emissions relate to market valuation. The results indicate a generally negative relationship between unscaled emissions and stock returns, especially after controlling for firm size, industry, and temporal factors. Starting with Scope 3 emissions, the coefficients are mostly negative across models, with effect growing stronger and statistically significant in more fully specified regressions. For instance, in models that include industry and month-year fixed effects as well as firm size controls, the coefficient reaches -0.162 ($p < 0.05$) and further declines to -0.264 ($p < 0.05$), suggesting that firms with higher indirect emissions face notable market penalties. This emphasizes investors' growing concern about the broader carbon footprint embedded in firms' supply chains and product use, which may translate into heightened reputational and regulatory risks. For Scope 2 emissions, reflecting emissions from purchased electricity and energy, the pattern is similar but more pronounced. Although initial estimates without controls are negative but not significant, coefficients become larger and statistically significant once controls are included, reaching -0.197 and -0.219 (both $p < 0.05$). This suggests that energy consumption linked emissions weigh heavily on investor valuation, potentially due to perceived risks from energy cost volatility, regulatory tightening, or transition risks in the region. The effect of Scope 1 emissions, representing direct emissions from firm-controlled sources, appears less consistent. Early models show negligible or slightly positive coefficients; however, in fully controlled models, the effect turns negative and becomes significant, with coefficients around -0.107 ($p < 0.10$) and -0.193 ($p < 0.05$). This indicates that direct emissions impose a financial cost that investors increasingly recognize once confounding factors are

Table 4.5c. Scaled emissions and stock returns – Middle East

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
CO2e Scope 3	–0.076			–0.155			–0.217			–0.248		
	(0.075)			(0.025)			(0.162)			(0.166)		
CO2e Scope 2		–0.039			–0.076			–0.052			–0.031	
		(0.087)			(0.073)			(0.078)			(0.078)	
CO2e Scope 1			0.046			–0.049			–0.027			–0.071
			(0.021)			(0.052)			(0.048)			(0.078)
Firm size							0.415***	0.251*	0.329***	0.344***	0.192	0.276**
							(0.108)	(0.132)	(0.120)	(0.107)	(0.121)	(0.108)
Observations	16,623	10,037	10,432	16,623	10,037	10,432	14,828	8,413	8,653	11,056	6,172	6,449
R-squared	20.62	26.23	26.35	21.11	26.82	26.91	19.21	23.05	23.17	20.17	24.82	22.09
Controls	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
GICS-Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4.6c. Unscaled emissions and stock returns – Middle East

	(1)	– (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variable	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return	Return
CO2e Scope 3	–0.013 (0.037)			–0.084 (0.062)			–0.162** (0.076)			–0.264** (0.099)		
CO2e Scope 2		–0.085 (0.094)			–0.081 (0.084)			–0.197** (0.091)			–0.219** (0.107)	
CO2e Scope 1			0.002 (0.043)			–0.050 (0.021)			–0.107* (0.054)			–0.193** (0.084)
Firm size							0.472*** (0.178)	0.328*** (0.114)	0.362*** (0.124)	0.405*** (0.141)	0.285*** (0.095)	0.372*** (0.088)
Observations	6,359	10,209	10,629	6,359	10,209	10,629	4,716	8,515	8,757	3,253	6,241	6,518
R-squared	34.62	26.40	26.69	35.27	26.99	27.26	30.78	23.16	23.29	34.32	25.06	24.87
Controls	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
GICS-Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

accounted for, reflecting concerns about operational environmental risks and possible regulatory sanctions. Firm size consistently exhibits a strong positive relationship with stock returns across all models and specifications. The coefficient values, ranging from approximately 0.285 to 0.472 and statistically significant at the 1% level, confirm the substantial premium investors assign to larger firms. This size effect underscores the necessity of controlling for firm scale when assessing emissions impact to avoid conflating the financial effects of emissions with those of firm size. The models show reasonable explanatory power, with R-squared values ranging from 23% to 35%. These results are notable given the cross-sectional and time-series nature of the data and the complexity of stock return determinants.

4.3.3 Actual and Estimated Emissions

This section examines the differential impact of actual versus estimated total CO2 emissions on stock returns among Middle Eastern firms. Understanding how each emission data type influences market valuations is vital, especially given the varying degrees of disclosure transparency and reliance on third-party estimations in the region.

Starting with actual emissions, the coefficients across models consistently show a negative association with stock returns. While the simplest specifications without controls (columns 1 and 2) show negative but statistically insignificant coefficients (-0.142 and -0.153), the negative effect becomes statistically significant when industry fixed effects and control variables are introduced (columns 3 and 4), reaching values of -0.272 and -0.329 respectively ($p < 0.05$). This suggests that investors penalize firms with higher disclosed emissions once sectoral and temporal confounders are accounted for, reflecting heightened market sensitivity to tangible environmental impacts and associated financial risks such as regulatory costs and reputational damage.

Turning to estimated emissions, the overall picture is more nuanced. In models excluding control variables, the coefficients are near zero and statistically insignificant (0.008 and -0.001), indicating a weak or absent direct relationship between estimated emissions and returns. However, when control variables—including firm size, industry, and time fixed effects—are added (columns 7 and 8), the coefficient on estimated emissions becomes significantly negative (-0.147 and -0.180, $p < 0.05$ and $p < 0.01$ respectively). This result implies that, under more rigorous specifications, investors do respond negatively to higher estimated emissions, suggesting that vendor estimates carry meaningful informational content regarding firms' environmental risks once other confounding factors are accounted for.

Firm size consistently maintains a positive and significant impact on returns across all models, emphasizing the importance of scale in investor valuation. Size coefficients range from approximately 0.351 to 0.475 for actual emissions models, and remain robust around 0.399 to 0.439 in estimated emissions models, reflecting that larger firms generally attract higher returns possibly due to better diversification, resource availability, and market influence.

The R-squared values, ranging from roughly 18% to 21%, indicate moderate explanatory power for the models, which is reasonable given the multifaceted drivers of stock returns and the relatively modest sample sizes. In short, this decomposition clarifies that actual and estimated CO2 emissions play a significant role in stock returns in the Middle East, especially after accounting industry and firm-specific effects. Although the actual emissions contribute to more consistent negative impact, the estimated emissions are also relevant in the description of market responses when the model specifications are stringent. This underlines the increased importance of firm disclosures and third-party estimates in influencing investor perception and that better quality and transparent emission data are necessary to support informed investment decision-making in the region.

Table 4.7c. Actual vs. estimated emissions – Middle East

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Actual Emissions				Estimated Emissions			
Variable	Return	Return	Return	Return	Return	Return	Return	Return
Total CO2e Emissions	–0.142 (0.135)	–0.153 (0.136)	–0.272** (0.128)	–0.329** (0.159)	0.008 (0.043)	–0.001 (0.032)	–0.147** (0.072)	–0.180** (0.085)
Size			0.351** (0.142)	0.475*** (0.101)			0.439*** (0.099)	0.399*** (0.099)
Observations	5,317	5,317	4,837	3,500	20,772	20,772	18,235	13,239
R-squared	19.30	20.55	18.41	21.55	20.78	21.19	18.61	20.25
Controls	No	No	No	Yes	No	No	No	Yes
GICS-Industry	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

4.4 Impact of Carbon Emissions on Financial Performance

This section investigates how carbon emissions, across various scopes and both estimated and actual measures, relate to key financial performance indicators for firms in the Middle

East. The analysis focuses on common profitability and operational metrics, including Return on Equity (ROE), Return on Assets (ROA), EBIT, EBITDA, Gross Profit Margin (GPM), and Net Profit Margin (NPM), while controlling for industry effects, firm size, and time.

Starting with estimated total CO2 emissions, the overall effects on profitability are largely negative but vary in statistical significance and magnitude across metrics. The coefficients for ROE (-0.37) and ROA (-0.09) are negative but not statistically significant, indicating a weak and imprecise relationship between estimated emissions and these returns metrics. EBIT and EBITDA show similarly small and statistically insignificant negative effects (-0.04 and -0.12).

However, when focusing on profitability margins, the negative impact becomes statistically significant: GPM is negatively affected by -1.02 ($p < 0.05$), and NPM is also significantly reduced by -0.32 ($p < 0.05$). This suggests that while operational profits may not be strongly related to estimated emissions, margins reflecting cost structures and net profitability bear a significant negative influence. These results imply that higher estimated emissions correlate with reduced firm profitability, possibly due to increased compliance costs, carbon pricing, or reputational factors. For actual total CO2 emissions, the effects are mixed but generally consistent with a negative trend. The coefficients on ROE (0.01) and ROA (-0.14) are small and statistically insignificant, suggesting limited impact on these measures. However, EBIT (-0.95, $p < 0.10$), EBITDA (-0.89, $p < 0.10$), and GPM (-0.99, $p < 0.10$) all show negative and marginally significant coefficients, indicating that higher actual emissions reduce operational and gross profitability. Net profit margin (-0.20) is negative but not statistically significant. This pattern reinforces the interpretation that emissions primarily erode profitability margins, potentially through higher environmental compliance costs or operational inefficiencies.

When decomposing emissions by scope, a clearer picture emerges. Scope 3 emissions: The coefficients on ROE (0.73) and ROA (-0.14) are not significant, while EBIT (-0.50) and EBITDA (-0.57) indicate negative but insignificant impacts. Notably, GPM shows a statistically significant negative effect (-0.78, $p < 0.05$), pointing to the substantial cost pressures imposed by indirect emissions on profitability. Net margin effects are negative but insignificant (-0.26). Scope 3 intensity displays largely negative but statistically insignificant effects across the board, suggesting that relative Scope 3 emissions are not strongly linked with financial performance in the Middle East.

Scope 2 emissions reveal more consistent negative associations. ROE (-0.97) and ROA (-0.33) are negative though not statistically significant, while GPM shows a

significant negative coefficient (-0.41, $p < 0.05$), indicating reduced profitability tied to energy-related emissions. EBITDA and EBIT effects are negligible or insignificant. Scope 2 intensity has a statistically significant negative effect on ROE (-1.02, $p < 0.05$) but limited impact elsewhere.

Scope 1 emissions also tend to negatively impact financial outcomes, with ROE (-0.88) and ROA (-0.07) negative but insignificant. EBITDA shows a statistically significant negative effect (-0.85, $p < 0.05$), and GPM is negatively affected (-0.31, $p < 0.10$), underscoring the cost burdens associated with direct emissions. Scope 1 intensity coefficients are negative but insignificant overall.

Overall, the findings highlight a nuanced but consistent trend: higher carbon emissions—whether total or scope-specific—are generally associated with weaker profitability and margins in Middle Eastern firms, particularly reflected in gross and net profit margins. Estimated emissions have stronger negative associations with profitability margins than with returns measures like ROE and ROA, suggesting that market participants may price emissions more through expected cost impacts rather than equity returns alone. The significant negative impact on margins (especially GPM and NPM) implies that emissions-related costs, including regulatory compliance, carbon taxes, and reputational damage, may directly erode profitability. Scope 2 and Scope 1 emissions, related to energy use and direct operations, show the clearest negative signals, consistent with their visibility and regulatory scrutiny. These insights emphasize the growing importance for Middle Eastern firms to monitor, report, and manage their emissions proactively to safeguard financial performance amid rising environmental expectations and potential regulatory pressures.

4.5 Governance Mediation Effects on Emission-Return Relationship

The presence of executive compensation policies linked to ESG goals appears to moderately interact with emissions. The direct effect of emissions on stock returns is negative and significant across all emissions scopes, suggesting that investors consistently penalize carbon-intensive firms. The interaction term, however, is statistically significant and negative for actual total emissions (-0.2880, $p < 0.1$), indicating that the introduction of such policies intensifies the carbon discount, rather than mitigating it. In this case, it may suggest a credibility gap—where investors view ESG-linked compensation as either insufficiently rigorous or symbolic, especially when not accompanied by real emission reductions. The moderator effect itself is significantly positive only in the actual total model (4.8555, $p < 0.05$), but this does not offset the stronger negative interaction.

Table 4.8c. Carbon emissions and financial performance – Middle East

Variable	1 ROE	2 ROA	3 EBIT	4 EBITDA	5 GPM	6 NPM	7 ROE	8 ROA	9 EBIT	10 EBITDA	11 GPM	12 NPM
Estimated total CO2e	-0.37 (0.61)	-0.09 (0.22)	-0.04 (0.78)	-0.12 (0.72)	-1.02** (0.51)	-0.32** (0.14)						
Observations	13,478	13,490	13,490	13,490	13,174	13,490						
R-squared	26.18	44.8	39.54	42.29	48.12	99.83						
Actual CO2e							0.01 (0.50)	-0.14 (0.20)	-0.95* (0.49)	-0.89* (0.51)	-0.99* (0.51)	-0.20 (0.22)
Observations							3,527	3,527	3,527	3,527	3,527	3,527
R-squared							53.02	54.32	62.95	66.60	62.10	99.86
CO2e scope 3	0.727 (0.796)	-0.138 (0.222)	-0.501 (0.333)	-0.566 (0.399)	-0.779** (0.308)	-0.257 (0.175)						
Observations	3,283	3,287	3,287	3,287	3,287	3,287						
R-squared	30.48	52.65	69.39	70.70	73.48	99.23						
CO2e scope 3 intensity							-0.938 (1.135)	-0.488 (0.337)	-2.598 (1.748)	-2.912 (1.840)	-1.529 (1.042)	-0.543 (0.363)
Observations							11,225	11,237	11,237	11,237	10,933	11,237
R-squared							23.95	42.44	28.25	36.36	49.83	99.82
CO2e scope 2	-0.967 (0.636)	-0.328 (0.226)	-0.046 (0.475)	0.128 (0.458)	-0.175 (0.513)	-0.414** (0.188)						

Variable	1 ROE	2 ROA	3 EBIT	4 EBITDA	5 GPM	6 NPM	7 ROE	8 ROA	9 EBIT	10 EBITDA	11 GPM	12 NPM
Observations	6,314	6,326	6,326	6,326	6,326	6,326						
R-squared	21.86	43.54	52.83	59.67	58.53	99.73						
CO2e scope 2 intensity							-1.019**	-0.278	0.055	0.338	0.439	-0.320
							(0.513)	(0.199)	(0.561)	(0.540)	(0.577)	(0.199)
Observations							6,242	6,254	6,254	6,254	6,254	6,254
R-squared							21.93	43.73	52.37	59.72	58.64	99.72
CO2e scope 1	-0.875	-0.070	0.086	0.099	-0.854**	-0.305*						
	(0.704)	(0.175)	(0.475)	(0.541)	(0.335)	(0.159)						
Observations	6,597	6,609	6,609	6,609	6,609	6,609						
R-squared	21.48	41.69	48.89	53.83	59.89	99.74						
CO2e Scope 1 intensity							-1.015	-0.013	0.267	0.357	-0.623	-0.269
							(0.762)	(0.210)	(0.596)	(0.657)	(0.426)	(0.180)
Observations							6,525	6,537	6,537	6,537	6,537	6,537
R-squared							21.6	42.05	48.94	54.14	59.09	99.74
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
GICS-Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

For firms engaging in environmental restoration, the emissions coefficient remains negative and significant across all emissions types, such as actual total emissions (−0.2595, $p < 0.05$) and Scope 1 (−0.1891, $p < 0.05$). These results indicate that restoration efforts do not neutralize the market penalty for high emissions. Notably, the interaction terms between emissions and the restoration moderator are statistically insignificant across the board, suggesting no meaningful change in how investors price emissions based on these initiatives. This could reflect investor skepticism regarding the material impact of restoration activities or concerns over greenwashing. The findings imply that environmental restoration alone is not a sufficient mechanism to reverse the stock market's negative pricing of emissions in the Middle Eastern context.

A more complex pattern emerges with climate-related financial planning. While the direct effect of emissions remains significantly negative for Scope 3 emissions (−0.2891, $p < 0.01$), other scopes show weaker or statistically insignificant coefficients. Interestingly, the interaction terms for actual total emissions (0.5322, $p < 0.05$) and Scope 2 (0.4930, $p < 0.05$) are positive and significant, suggesting that climate-related financial planning may partially mitigate the carbon discount. This could indicate that when firms credibly integrate climate risks and opportunities into financial strategy, investors may reduce the penalty associated with emissions—perhaps viewing such planning as a signal of long-term resilience or credible transition management. However, this mitigating effect does not fully eliminate the negative baseline, as Scope 3 emissions remain heavily penalized.

The ESG controversies score reveals a divergent pattern. Unlike previous moderators, the main effect of emissions is not consistently negative; for example, emissions have a positive and significant coefficient in Scope 1 (0.9414, $p < 0.1$) and Scope 2 (1.0911, $p < 0.1$). This is counterintuitive and may suggest that in the Middle East, higher emissions are sometimes correlated with larger, more mature firms that also exhibit strong financial performance, creating confounding signals. However, the interaction terms are negative and statistically significant for Scope 2 (−0.0132, $p < 0.05$), Scope 1 (−0.0114, $p < 0.1$), and estimated total (−0.0083, $p < 0.05$), implying that the return penalty for emissions increases as firms move toward lower ESG controversy. This paradox may reflect that investors hold "clean" firms to higher standards—penalizing them more harshly when they still carry high emissions despite an otherwise strong ESG profile.

Table 4.9c. Governance moderation – Middle East

Moderator	Effect Type	Actual Total	Est. Total	Scope 3	Scope 2	Scope 1
Policy Executive Compensation ESG Performance	CO2 Effect	-0.209**	-0.147**	-0.359***	-0.180**	-0.139**
		(0.092)	(0.063)	(0.121)	(0.086)	(0.068)
	Moderator Effect	4.855**	1.453	-1.299	2.753*	1.893
		(2.136)	(1.219)	(1.382)	(1.619)	(1.257)
	Interaction Effect	-0.288*	-0.077	0.163	-0.206	-0.140
		(0.158)	(0.095)	(0.123)	(0.134)	(0.101)
	Observations	3,404	13,119	3,253	6,241	6,518
	R-squared	21.40	20.22	34.36	25.10	24.89
Environmental Restoration Initiatives	CO2 Effect	-0.259**	-0.168**	-0.215	-0.184*	-0.189**
		(0.119)	(0.066)	(0.161)	(0.101)	(0.079)
	Moderator Effect	1.415	0.033	1.809	0.839	-0.056
		(2.248)	(1.155)	(2.036)	(1.325)	(1.171)
	Interaction Effect	-0.072	0.008	-0.075	-0.080	-0.016
		(0.177)	(0.089)	(0.165)	(0.108)	(0.093)
	Observations	3,404	12,931	3,253	6,208	6,485
	R-squared	21.29	20.24	34.36	25.03	24.84
Climate Change Risks & Opportunities Financial Planning	CO2 Effect	-0.179	-0.085	-0.289***	-0.082	-0.189
		(0.180)	(0.129)	(0.083)	(0.152)	(0.115)
	Moderator Effect	-8.294***	-4.610	2.703	-7.174***	-4.478*
		(2.828)	(3.181)	(4.573)	(2.655)	(2.681)
	Interaction Effect	0.532**	0.288	-0.307	0.493**	0.276
		(0.203)	(0.227)	(0.318)	(0.209)	(0.210)
	Observations	1,591	3,242	1,239	2,068	2,143
	R-squared	20.48	18.29	32.44	23.09	22.83
ESG Controversies Score	CO2 Effect	0.809	0.652	-0.447	1.091*	0.941*
		(2.121)	(0.396)	(0.337)	(0.645)	(0.566)
	Moderator Effect	0.087	0.108**	-0.054	0.148**	0.126**
		(0.2994)	(0.049)	(0.049)	(0.071)	(0.062)
	Interaction Effect	-0.011	-0.008**	0.002	-0.013**	-0.011*
		(0.0213)	(0.004)	(0.003)	(0.007)	(0.006)
	Observations	3,404	13,143	3,253	6,241	6,518
	R-squared	21.30	20.19	34.33	25.08	24.89

CHAPTER V
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In a world increasingly focused on sustainability, one pressing question arises: how do carbon emissions really impact financial performance and stock returns across different regions, and how do governance mechanisms moderate this relationship? This study dives deep into this burgeoning inquiry, exploring the intricate relationship between carbon emissions, stock market performance, and the financial health of firms across Asia, Europe, and the Middle East. The results demonstrate that the impact of carbon emissions on financial outcomes is highly region-specific, with substantial differences in the magnitude of these relationships. A deep inquiry into understanding these variations reveals that governance mechanisms, the type of emissions, and the regulatory environment are crucial factors shaping these relationships.

Intensity measures (i.e., emissions per unit of firm size) generally yielded insignificant results in Asia. This suggests that when emissions are normalized for firm size or operational scale, their impact on stock returns is not substantial. Firms with high emission intensity, while potentially penalized in global markets with stricter sustainability frameworks, do not seem to be significantly punished or rewarded by investors in Asia. The relative lack of significance of intensity measures suggests that, in the Asian context, emissions are not yet seen as a critical factor by investors—possibly due to a less rigorous regulatory environment, less investor awareness regarding sustainability, or the early stages of market-wide sustainability practices. When looking at emissions without intensity, both Scope 1 and Scope 2 emissions showed significant negative relationships with stock returns. This negative relationship suggests that investors are more likely to penalize firms with high direct emissions, possibly due to concerns over regulatory risks, operational inefficiencies, or the increased cost of compliance with potential future regulations. A key finding in the analysis of actual vs. estimated emissions is the discrepancy in how investors react to them. Estimated total CO2 emissions showed a significant negative relationship with stock returns. On the other hand, actual total CO2 emissions showed negative but insignificant results. In Asia, the role of governance mechanisms in moderating the relationship between carbon emissions and financial performance varies across different emissions types. Executive compensation linked to ESG performance showed no significant relationship, suggesting that the impact of emissions on financial performance is not significantly conditional on this governance factor. Environmental restoration initiatives had a stronger and more consistent role in moderating the relationship,

particularly for Scope 1 and Scope 2 emissions, where it significantly improved financial outcomes, suggesting that firms engaging in proactive environmental strategies can offset some of the negative financial impacts of direct and energy-related emissions. The interaction effect for these initiatives was also significant, reinforcing their importance in mitigating emissions-related risks. On the other hand, climate change risks and opportunities financial planning had a positive moderating effect, highlighting the value of having a robust climate strategy in place. The interaction effect was also significant, indicating that companies with strong climate change planning are better positioned to manage the financial risks associated with supply chain emissions. ESG controversies showed no significant moderating or interaction effect, indicating that reputational risks related to ESG issues do not substantially influence the relationship between carbon emissions and financial performance in Asia at this stage.

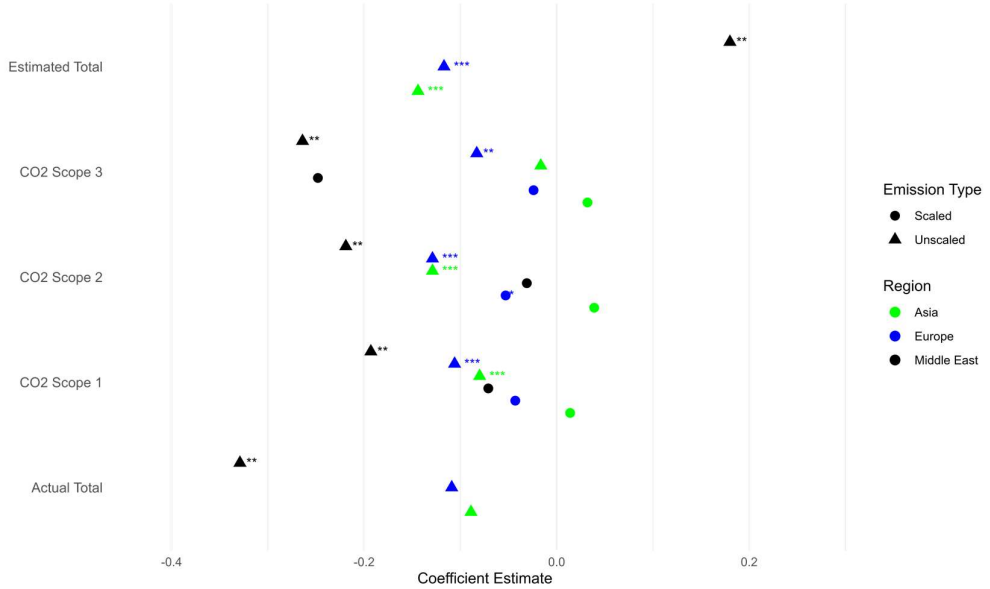

Figure 5.1. Impact of emission types on stock returns by region.

Source: author's compilation

In Europe, the relationship between carbon emissions and stock returns was more pronounced than in Asia or the Middle East. Scope intensity showed a negative significant impact, indicating that firms with higher emissions relative to size or operations face greater market penalties. Similarly, Scope 1 and Scope 2 emissions without intensity were both significantly negative, reflecting investor concerns over direct and energy-related

emissions. However, actual total emissions had an insignificant impact, while estimated emissions showed a significant negative relationship, suggesting that estimated emissions are perceived as a more reliable risk factor by European investors.

In the Middle East, Scope intensity was insignificant, similar to Asia, but Scope 1 and Scope 2 emissions without intensity showed significant negative effects on stock returns, indicating a stronger investor response to direct and energy-related emissions. Both actual and estimated total emissions had a negative significant effect, highlighting the greater investor sensitivity to emissions in this region compared to Asia, where actual emissions had an insignificant effect.

Comparing these regions in Figure 5.1, Asia shows a mixed but generally weaker relationship between carbon emissions and stock returns. While unscaled Scope 1 and Scope 2 emissions are statistically significant and negatively associated with returns, other variables, especially the scaled emissions, are largely insignificant and even slightly positive—indicating weak investor response. Europe, on the other hand, demonstrates more consistent and significant negative effects from unscaled emissions across all scopes, suggesting moderate investor sensitivity to firms' carbon output. Scaled emissions in Europe show weaker effects, with only Scope 2 being marginally significant. In contrast, the Middle East displays the strongest investor reaction, with large and significant negative coefficients for all unscaled scopes and actual totals. Interestingly, the estimated total emissions in the Middle East are positively associated with stock returns, which may reflect differences in how investors perceive disclosed versus estimated data. Overall, Middle Eastern markets appear to penalize carbon emissions most heavily, followed by Europe, while Asia's markets seem less responsive, especially when emissions are scaled.

5.2 Policy Recommendations

The findings of this study highlight the importance of addressing the financial impact of carbon emissions through targeted policies. By promoting region-specific regulatory frameworks, stronger governance practices, standardized emissions reporting, and support for carbon-efficient firms, governments can contribute to building a more sustainable, resilient, and financially sound global economy. Based on the findings of this study, several region-specific policy recommendations can be made to help regulators, investors, and firms manage the financial impacts of carbon emissions and foster sustainable economic growth.

i. Region-Specific Regulatory Enhancement: The policies must be region specific in terms of challenges and opportunities. Some regulatory systems are less strict in Asia, and the focus in this region should be on the progressive improvement of environmental

standards and the stimulation of companies to engage in sustainable activities. Governments can also create tax breaks to companies that minimize carbon emissions or meet sustainability goals, and this will give firms a reason to invest in more environmentally friendly operations. In Europe, where the regulatory framework is already highly developed and where investors have a greater interest in sustainability, it should be aimed at improving the carbon pricing system and increasing the level of transparency in emissions reporting. In the case of the Middle East, a middle ground should be taken as the region is not yet at risk in terms of financial implications of the emission but as the world is gradually getting pressurized, the Middle East region will also be impacted. The policymakers ought to concentrate in developing strong sustainability models that are in line with the international best practices that do not impede economic growth and competitiveness.

ii. Enhancing Governance Mechanisms: The quality of governance is key to reducing the financial risk posed by carbon emissions, particularly in the mature markets such as Europe. The governments are advised to encourage companies to pursue a holistic approach to sustainability governance, especially the ones that associate executive compensation with ESG performance. Governments in Asia and the Middle East, where governance systems are still in their infancy, may drive the adoption of ESG metrics by adopting soft policies, like sustainability reporting standards or providing incentives to companies that perform well with regards to ESG. Also, governments may need to make firms report not only their carbon emissions, but also the financial risks of climate change to empower investors to make informed decisions.

iii. Carbon Footprint Disclosure and Reporting Standardization: There is a great need to standardize carbon footprint disclosure so as to evaluate the financial implications of the emissions in a better way among the regions. This would enable the investors to be able to make better comparisons and make informed decisions. Governments ought to encourage the use of standardized reporting of carbon emissions and climate risks, especially in the harmonization of the types of emissions reporting (Scope 1, Scope 2, Scope 3). This would provide consistent and comparable data that would lead to increased transparency in the business world, and a higher investor confidence.

iv. Promoting Carbon-Efficient Firms Through Incentives: Governments ought to incentivize firms that are at the forefront of carbon efficiency by giving them financial incentives, which can be in the form of investment tax credits or grants in investments in green technology and sustainable operations. This is particularly vital in Asia and the Middle East where such incentives are in their early stages of development. Encouraging

carbon-efficient companies will speed up the shift towards a low-carbon economy giving early movers a competitive advantage. Monetary incentives may encourage companies to implement sustainable policies and reduce their regulatory and operational risks in the long run, which would lead to financial stability.

v. Integrating Sustainability and Financial Performance: This paper points out that carbon emission is correlated with the financial performance, and the connection is dependent on the quality of the governance practices. Policymakers and investors should encourage firms to view sustainability as an investment rather than a cost. Firms that integrate sustainability into their core financial and operational strategies are more likely to thrive in the long term. Encouraging firms to consider carbon efficiency as part of their overall risk management and operational optimization efforts will not only help mitigate the financial risks associated with emissions but also contribute to sustainable profitability.

5.3 Research Limitations

While this study provides robust evidence on the pricing of carbon emissions in financial markets, several limitations should be acknowledged. First, the analysis relies on data for firms' actual total CO2e emissions, which is significantly more limited than estimated emissions data. On average, only about 17% of firms in Europe, 21% in Asia, and 25% in the Middle East report actual total emissions. This data gap introduces potential bias, as firms that voluntarily disclose actual emissions may differ systematically from those that do not—for instance, in size, regulatory exposure, or ESG transparency. Consequently, the results may not be fully generalizable to the broader universe of firms.

Second, Scope 3 emissions data—representing indirect emissions across the value chain—are particularly sparse and challenging to measure accurately. Due to their dependence on third-party disclosures from suppliers, distributors, and customers, Scope 3 estimates are often incomplete or inconsistent across firms and regions. Reporting standards also vary, and estimation methodologies by data providers may introduce measurement error. Therefore, while Scope 3 emissions were included in the analysis where available, the interpretation of their impact on stock returns should be approached with caution.

These data limitations highlight the need for more standardized and comprehensive carbon disclosures, particularly in emerging markets and for indirect emissions. Future research could benefit from advances in mandatory climate reporting frameworks and improved traceability across corporate supply chains.

BIBLIOGRAPHY

Ambec, S., & Lanoie, P. (2008). Does It Pay to Be Green? A Systematic Overview. *Academy of Management Perspectives*, *22*(4), 45–62. JSTOR.

Aswani, J., Raghunandan, A., & Rajgopal, S. (2024). Are Carbon Emissions Associated with Stock Returns? *Review of Finance*, *28*(1), 75–106. https://doi.org/10.1093/rof/rfad013

Bajic, A., Kiesel, R., & Hellmich, M. (2023). Handle with care: Challenges in company-level emissions data for assessing financial risks from climate change. *Journal of Climate Finance*, *5*, 100017. https://doi.org/10.1016/j.jclimf.2023.100017

Bansal, P., & Roth, K. (2000). WHY COMPANIES GO GREEN: A MODEL OF ECOLOGICAL RESPONSIVENESS. *Academy of Management Journal*, *43*(4), 717–736. https://doi.org/10.2307/1556363

Bauer, M. D., Huber, D., Rudebusch, G. D., & Wilms, O. (2022). Where is the carbon premium? Global performance of green and brown stocks. *Journal of Climate Finance*, *1*, 100006. https://doi.org/10.1016/j.jclimf.2023.100006

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of Financial Economics*, *142*(2), 517–549. https://doi.org/10.1016/j.jfineco.2021.05.008

Chakrabarti, G., & Sen, C. (2021). Dynamic market risk of green stocks across regions: Where does the devil lie? *Journal of Cleaner Production*, *303*, 127028. https://doi.org/10.1016/j.jclepro.2021.127028

Chava, S. (2014). Environmental Externalities and Cost of Capital. *Management Science*, *60*(9), 2223–2247. https://doi.org/10.1287/mnsc.2013.1863

Chen, S., Cheng, M., Luo, Y., & Tsang, A. (2024). ESG performance and analyst recommendations: Evidence from sustainability analysts in the Chinese market. *Journal of Accounting Literature*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/JAL-04-2024-0063

Da Silva, P. P., Moreno, B., & Figueiredo, N. C. (2016). Firm-specific impacts of CO2 prices on the stock market value of the Spanish power industry. *Energy Policy*, *94*, 492–501. https://doi.org/10.1016/j.enpol.2016.01.005

Downar, B., Ernstberger, J., Reichelstein, S., Schwenen, S., & Zaklan, A. (2021). The impact of carbon disclosure mandates on emissions and financial operating performance. *Review of Accounting Studies*, *26*(3), 1137–1175. https://doi.org/10.1007/s11142-021-09611-x

Hart, S. L. (1995). A Natural-Resource-Based View of the Firm. *The Academy of Management Review*, *20*(4), 986. https://doi.org/10.2307/258963

Hartzmark, S. M., & Sussman, A. B. (2019). Do Investors Value Sustainability? A Natural Experiment Examining Ranking and Fund Flows. *The Journal of Finance*, *74*(6), 2789–2837. https://doi.org/10.1111/jofi.12841

Heinkel, R., Kraus, A., & Zechner, J. (2001). The Effect of Green Investment on Corporate Behavior. *The Journal of Financial and Quantitative Analysis*, *36*(4), 431. https://doi.org/10.2307/2676219

Helhel, A., Akgun, E., & Helhel, Y. (2024). Did ESG Affect the Financial Performance of North American Fast-Moving Consumer Goods Firms in the Second Period of the Kyoto Protocol? *Sustainability*, *16*(22). https://doi.org/10.3390/su162210009

Ioannou, I., Li, S. X., & Serafeim, G. (2016). The Effect of Target Difficulty on Target Completion: The Case of Reducing Carbon Emissions. *The Accounting Review*, *91*(5), 1467–1492. https://doi.org/10.2308/accr-51307

Jangid, M. L., & Sharma, A. K. (2024). Does carbon performance payoff? An empirical evidence from Asia-Pacific region. *Asian Review of Accounting*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/ARA-08-2023-0204

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. https://doi.org/10.2308/accr-50629

Moneva, J. M., & Ortas, E. (2010). Corporate environmental and financial performance: A multivariate approach. *Industrial Management & Data Systems*, *110*(2), 193–210. https://doi.org/10.1108/02635571011020304

Oestreich, A. M., & Tsiakas, I. (2015). Carbon emissions and stock returns: Evidence from the EU Emissions Trading Scheme. *Journal of Banking & Finance*, *58*, 294–308. https://doi.org/10.1016/j.jbankfin.2015.05.005

Pástor, Ľ., Stambaugh, R. F., & Taylor, L. A. (2021). Sustainable investing in equilibrium. *Journal of Financial Economics*, *142*(2), 550–571. https://doi.org/10.1016/j.jfineco.2020.12.011

Probohudono, A. N., Sangka, K. B., Kurniawati, E. M., & Putra, A. A. (2024). Carbon Emission and Firms' Value: Moderating Role of Financial Sustainability. *International Journal of Sustainable Development and Planning*, *19*(10), 3979–3987. https://doi.org/10.18280/ijsdp.191026

Ramelli, S., Ossola, E., & Rancan, M. (2021). Stock price effects of climate activism: Evidence from the first Global Climate Strike. *Journal of Corporate Finance*, *69*, 102018. https://doi.org/10.1016/j.jcorpfin.2021.102018

Ramirez, A. G., Monsalve, J., González-Ruiz, J. D., Almonacid, P., & Peña, A. (2022). Relationship between the Cost of Capital and Environmental, Social, and Governance Scores: Evidence from Latin America. *Sustainability*, *14*(9). https://doi.org/10.3390/su14095012

Scholtens, B., & Van Der Goot, F. (2014). Carbon prices and firms' financial performance: An industry perspective. *Carbon Management*, *5*(5–6), 491–505. Scopus. https://doi.org/10.1080/20430779.2015.1027862

Sichigea, M., Siminica, M. I., Circiumaru, D., Carstina, S., & Caraba-Meita, N.-L. (2020). A Comparative Approach of the Environmental Performance between Periods with Positive and Negative Accounting Returns of EEA Companies. *Sustainability*, *12*(18). https://doi.org/10.3390/su12187382