



**UNIVERSITÀ
DI TORINO**

Department of Management Valter Cantino

PhD programme in Business and Management XXXVII cycle

**Financial Solutions in response to Climate Change:
How Carbon Credits can improve Financial Performance**

Candidate: Francesco Martielli – 975263

SSD: SECS-P/09

Supervisor: Prof. Antonio Salvi

Coach: Prof. Enrico Battisti

PhD Director: Prof. Stefano Bresciani

Academic year 2023/2024

“In the case of climate, we are not the dinosaurs. We are the meteor. We are not only in danger, we are the danger. But, we are also the solution.”
António Guterres, June 2024

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INTRODUCTION

The global landscape is increasingly characterized by the scarcity of natural resources, with the overshoot day - defined as the date when annual resource consumption exceeds the Earth's capacity to regenerate those resources - occurring progressively earlier each year. Concurrently, the thermal zero point is observed at progressively higher altitudes, and extreme weather events are becoming more frequent, intense, and widespread. Consequently, the urgency and focus on climate change have assumed central importance across all human dimensions and systems - social, political, and economic. This context underscores the critical relevance and role of economics and business in addressing and mitigating the uncertainties and risks associated with climate change. Climate change represents the paramount crisis of our era, advancing at a pace more rapid than previously predicted. No region of the globe is exempt from its catastrophic repercussions. Escalating temperatures exacerbate environmental degradation, provoke natural disasters, and intensify extreme weather conditions. This leads to heightened food and water insecurity, economic instability, conflict, and terrorism. The phenomena of rising sea levels, melting Arctic ice, dying coral reefs, acidifying oceans, and burning forests are stark indicators of this crisis. The current state of affairs is inadequate as the ramifications of climate change approach irreversible thresholds, necessitating immediate and collective action (United Nations, 2024).

The economic disruption caused by climate change has emerged as a significant concern of the 21st century (Zhao et al., 2024). Economic activities are primarily disrupted by extreme weather conditions, such as high temperatures and heavy rainfall, which impact all sectors on a large scale. In the primary sector, extreme heat and frequent heavy rains can disrupt agricultural production, leading to crop failure, increased vulnerability to pests and diseases, and reduced efficiency of agricultural machinery (Skendžić et al., 2021). In the industrial sector, high temperatures affect productivity, causing physical discomfort among employees, cognitive impairments, and a higher probability of errors (Chen et al., 2024). Additionally, extreme temperatures and heavy rains increase the risk of machinery damage due to overheating or excessively humid environments. These factors not only impact the workforce but also hinder the ability to secure financing due to heightened risks (Zhao et al., 2024).

Extreme weather events disrupt product transportation and can lead to geological disasters, causing damage to corporate fixed assets. Even the tertiary sector is not immune to climate change, as it can alter consumer preferences (e.g., in the tourism industry, Dubois et al. (2016)) and increase operating costs, such as those incurred from closures due to extreme weather conditions (Al-Humaiqani & Al-Ghamdi, 2023). These findings support the theory of perceived risk, which posits that the impacts of climate change on businesses have become a critical factor for stakeholders, particularly investors, when considering engagement with companies, their products, or services, or before providing capital (Zhao et al., 2024). Consequently, managers and business owners, increasingly cognizant of this phenomenon, are shifting their focus toward addressing these concerns, which Cornell and Shapiro (2021) refer to as implicit claims.

Climate issues and sustainable development present increasing challenges and opportunities for business strategies. As key market entities, businesses play a pivotal role in energy conservation and emissions reduction within the context of climate change. Their emissions are now a critical focus for sustainable development (Liu et al., 2023). The growing awareness of potential climate-related risks has led an increasing number of financial institutions, investors, and other stakeholders to emphasize the inclusion of climate risk information in corporate communications, thereby detailing response strategies. In this context, government-promoted carbon-neutral policies are gaining traction, aiming to enforce stringent emission requirements. Concurrently, these policies underscore the urgency of establishing a comprehensive climate change risk disclosure system in the capital market, both to mitigate carbon emissions and manage stakeholder pressure (Wang et al., 2024). Carbon neutrality, often referred to as net zero, is a relatively straightforward concept, denoting the balance between the amount of greenhouse gases emitted into the atmosphere and the amount removed. This issue is garnering increased attention from intergovernmental groups, with businesses and the scientific community playing central roles in devising innovative and effective solutions (Mundy, 2024). Governments recognize the necessity of significantly accelerating investments in carbon removal technologies alongside efforts to reduce emissions, particularly given the evidence indicating atmospheric carbon dioxide levels are now 50% higher than pre-industrial levels. According to the IPCC, all pathways limiting global warming to 1.5°C with limited or no overshoot necessitate large-scale carbon dioxide removal (IPCC, 2023). In this evolving landscape, new financial instruments related to climate finance, such as carbon credits, are emerging as crucial components. These credits are linked to carbon removal service providers, including companies engaged in direct air capture that extract carbon dioxide from the atmosphere, as well as projects aimed at avoiding or reducing emissions through the protection and planting of trees.

The carbon credit market associated with emissions reduction has largely emerged and proliferated due to compelling ecological claims aimed at portraying companies as virtuous and climate-conscious. As the importance of eliminating carbon emissions in corporate

strategies has solidified, carbon credits have evolved from mere marketing tools to essential instruments for achieving carbon neutrality, complementing other emission avoidance strategies (Axelsson et al., 2024). In Europe, the sales of carbon credits are experiencing steady growth and are projected to increase by 600-700% by 2028. However, the voluntary purchase of carbon removal credits will fall short of the billions of tons per year required, necessitating governmental mandates for companies to buy carbon removal credits. The latest iteration of the European Union's certification framework indicates a significant shift towards purchasing offsets rather than implementing emissions avoidance and reduction measures. In this context, managers striving to stay abreast of climate-responsible corporate strategy must navigate the potential pitfalls of greenwashing.

In summary, extreme climate changes are among the most pressing global concerns posing an anticipated financial burden of approximately \$1 trillion for businesses due to climate risk (Tol, 2024). To address these risks, corporate social responsibility (CSR) initiatives, such as environmental sustainability efforts and the enhancement of environmental, social, and governance (ESG) ratings, are gaining crucial importance. These initiatives are increasingly being linked to tools and systems that emphasize economic and financial outcomes (Naseer et al., 2024).

The latest academic research is increasingly focused on the intersection of sustainability and business, exploring the reciprocal impacts of these fields in both positive and negative terms. This research aims to provide explanations for the economic, environmental, and social phenomena characterizing our era. The collection of papers presented here seeks to examine and understand the motivations behind entrepreneurs and managers implementing specific corporate sustainability strategies. These strategies often involve the adoption of innovative tools, sometimes unrelated to their core activities, to demonstrate a commitment to the planet's future and ensure the well-being of future generations. Specifically, this study particularly focuses on a relatively new tool in the literature, known as carbon credits/offsets, which has been analyzed as a way to achieve emission reductions and/or carbon neutrality. Hence, this collection seeks to underscore the significance and influence of carbon credits/offsets on financial performance while fulfilling sustainability and emission reduction criteria. The three papers included strive to answer the fundamental question of whether *sustainability practices, specifically in terms of emission reduction, conflict with or serve as a catalyst for enhancing corporate financial performance* (RQ0). The central research question was gradually refined into specific research questions that guided the investigation in each paper, consistently maintaining focus on the overarching inquiry.

The purpose of Chapter One is to conduct a systematic literature review to analyze and rank existing studies that examine the relationship between financial performance and climate change management initiatives, with a particular emphasis on greenhouse gas (GHG) emissions and decarbonization (carbon performance). This chapter aims to contribute to the primary research question (RQ 0) by addressing the following specific research question:

RQ1: What is currently known and unknown about the impact of carbon reduction initiatives on financial performance?

In detail, this study presents a comprehensive literature review to investigate the relationship between carbon performance—encompassing greenhouse gas emissions and decarbonization—and its impact on corporate financial performance. To achieve this, a set of peer-reviewed articles was analyzed, providing a clear and concise overview of the current state of relevant literature. The goal is to identify strategic maneuvers, both policy and financial, being implemented by companies and governments, offering a conceptual framework that presents a descriptive classification of existing knowledge. This framework defines and refines the theoretical foundations for future research, identifies research gaps, and suggests effective pathways for further study. Additionally, it provides an implementation guide that practitioners and policymakers can use as a reference tool.

The urgency of addressing climate change has heightened the significance of carbon offsets/credits in recent years as a strategic measure to mitigate carbon footprints (Gurgel, 2022; Cadez et al., 2019). Many companies are investing in these climate finance tools to reduce their greenhouse gas emissions (Harvey, 2021). The second chapter aims to understand the role of carbon offsets in the relationship between emissions and financial performance through an empirical analysis. These credits are becoming essential due to legal obligations, and this combination influences financial performance. This chapter seeks to address the following research question:

RQ2: Can companies that are unable to reduce their GHG emissions through new technologies use carbon credits as a practical measure to moderate the limited emissions reduction and improve financial performance?

Due to the recent widespread and limited regulation of carbon credits/offsets, the empirical evidence to assess this relationship considers a global, multisector sample of listed companies.

The objective of the third chapter is to provide a deeper comprehension of the relationship between carbon reduction strategies, specifically carbon credits/offsets, and financial performance from a global sample of listed companies using a unique perspective. This chapter investigates the impact of utilizing carbon credits/offsets to achieve carbon neutrality and reduce emissions on financial performance, taking into account the moderating effects of CSR strategy and corporate governance quality. The fundamental research questions guiding this study are as follows:

RQ3: What is the nature of the relationship between carbon credits/offsets tools and financial outcomes?

RQ4: How does the presence of a well-defined CSR strategy influence the association between carbon credits/offsets and financial performance?

RQ5: How do high-quality corporate governance practices influence the relationship between carbon credits/offsets and financial performance?

Through detailed analysis, this chapter seeks to reveal how companies can boost the connection between their efforts to achieve carbon neutrality using carbon credits/offsets and their financial performance. Hence, it explores how variables such as CSR strategy and corporate governance quality may influence this relationship, providing insights into the specific mechanisms and contextual factors influencing these dynamics. Ultimately, this study aims to offer practical guidance for companies striving to achieve sustainable and financial outcomes.

CHAPTER I

A matter of Climate change management and Climate finance: how decarbonization strategies can improve financial performance – A systematic literature review

ABSTRACT

The aim of this paper is to explore and structure the literature on the impact of Climate Change Management and Climate Finance on corporate financial performance, with a specific focus on GHG emissions and decarbonization strategies and highlighting the growing importance of Carbon Performance. A systematic literature review methodology was employed, which identified, analyzed, and correlated specific Carbon Performance strategies to financial performance, thereby emphasizing the crucial role of climate change management. The research draws on 31 carefully selected peer-reviewed articles published between 2015 and 2024. The study provides a comprehensive and coherent descriptive and thematic analysis of the current state of relevant literature. The proposed conceptual framework facilitates the identification of connections between Carbon Performance and external factors, highlighting the varying degrees of research and in-depth analysis across the different areas under consideration. This research contributes valuable and original knowledge by developing a conceptual framework that classifies existing knowledge descriptively, clarifying and explicating the theoretical foundations for scholars to build on, identifying research gaps, and suggesting effective avenues for further impactful research. It also offers practitioners and policymakers a practical guide to the implementation of climate change management strategies.

Keywords: Climate change management, Climate finance, Carbon performance, Decarbonization, GHG emission, financial performance

1. Introduction

The impact of climate change on communities and economies worldwide cannot be overstated. The potential consequences of this crisis on global economies, and subsequently on corporate financial performance, have garnered heightened interest from scholars and policymakers alike. The gravity of this issue is underscored by the increasingly catastrophic and permanent effects it may bring about (Capece, 2017; Cucchiella, 2017). Experts and decision-makers are presently seeking to understand the implications of climate change management policies, specifically with regard to decarbonization, on industries and economies in the foreseeable future. It is crucial to comprehend how these policies will affect financial performance, as they could potentially determine the prosperity or downfall of businesses in the near future.

The reports from the Intergovernmental Panel on Climate Change (IPCC) reinforce that climate change is caused by human activity. Of all the sources of human-induced greenhouse gas emissions, businesses are a notable contributor to the problem, as they generate significant greenhouse gas emissions (Damert et al., 2017). The reports also highlight that urgent action is needed to keep global warming within tolerable limits. This can only be achieved by significantly reducing emissions over the next century. The Kyoto Protocol, an international agreement signed by more than 160 nations in 1997, aimed to reduce greenhouse gas emissions and was an initial step towards achieving this objective (Cucchiella et al., 2017). Also, it has been revealed that transitioning to a low-carbon economy is technically feasible and will not result in excessive economic costs. The reduction in world consumption required would be limited to 0.6 per cent per year. On the other hand, ignoring the obligation to invest in mitigation actions would lead to unsustainable adaptation and reconstruction costs once problems reach unmanageable levels (Capece et al., 2017). European countries, who are at the forefront of promoting the 2015 Paris Climate Agreement, seem to be in a better position to meet sustainability commitments and the 2050 climate neutrality goal, thanks to the implementation of several major policy initiatives. (Haque & Ntim, 2022).

The impact of shifting climate trends and the emergence of new carbon institutions is transforming business practices. It's no surprise that the relationship between these institutions, companies, and their stakeholders has garnered significant attention from academic researchers (He et al., 2022). Their efforts have contributed to a heightened awareness of climate change, resulting in changes to global policies and creating opportunities for business growth. This has fueled a trend of corporate climate commitments in recent years (Hakovirta et al., 2023). Investors and other stakeholders are also recognizing the crucial role businesses play in addressing climate change. As a result, they are now factoring in carbon emissions when making decisions (Ott & Schiemann, 2023). Consequently, companies are responding by placing a greater emphasis on managing and disclosing greenhouse gas emissions, particularly in light of mounting concern over the impact of climate change (Johnson et al., 2023).

Numerous multinational corporations have already embarked on managing climate change, underscoring the considerable investments and innovation required to address this

urgent issue. While an increasing number of companies are committing to achieving zero emissions, these targets often have limited short-term effects and are established far into the future (Bjørn et al., 2021). Successfully tackling climate change entails the adoption of innovative and adaptable business strategies and implementations. Effective solutions must encompass the reduction of greenhouse gas emissions tied to human society's needs, as well as the removal of carbon dioxide from the atmosphere (Hakovirta et al., 2023). Many businesses struggle to adopt strategies aimed at mitigating climate change (through GHG emission reduction and decarbonization) due to the challenge of balancing short-term profit goals with long-term objectives of stabilizing atmospheric CO₂ levels. However, as the issue of climate change continues to gain global attention, companies are recognizing their vital role in addressing it and are beginning to incorporate long-term strategic perspectives into their profit-maximizing efforts (Damert et al., 2017). Hence, maintaining a socially and environmentally responsible business can come with added expenses, which can create a challenging balance between sustainability and profitability. Researchers have conducted several studies to explore how the market and stakeholders react to reducing greenhouse gas (GHG) emissions, with a focus on the connection between a company's financial performance and GHG emissions or their reduction. However, these studies offer varying results that lack consistency. Overall, it appears that there is a nonlinear correlation between carbon performance and financial performance (Wang et al., 2014). Although some studies suggest that reducing GHG emissions can boost financial performance, others suggest that it can have an adverse effect (Kim et al., 2023).

Based on the round-up of reported studies, it appears that the research in this area is currently fragmented. This is due to the fact that the perspective is very new and there is a lack of a cohesive conceptual framework, an international standard for evaluating decarbonization efforts, and overall sustainability strategies implemented by companies. Therefore, to gain a deeper understanding and organize the latest research on a specific subject, it is essential to perform a systematic literature review (SLR) (Battisti et al., 2024; Williams et al., 2020). This method offers an exhaustive and impartial overview of the existing knowledge, utilizing a multidisciplinary process that is transparent, reliable, and thorough (Sitompul et al., 2023; Vrontis & Christofi, 202; Christofi et al., 2017).

Based on these considerations, the objective of this paper is to meticulously analyze and categorize existing literature that delves into the correlation between financial performance and climate change management initiatives, with a focus on greenhouse gas (GHG) emission and decarbonization (carbon performance). The timeframe for this examination spans from 2015 to 2024, marking a pivotal moment in history - the 2015 Paris Agreement. This landmark agreement mandates all nations to pledge their commitment towards achieving net-zero emissions by 2050, in light of the escalating severity of climate change and the emergence of unprecedented and consequential phenomena.

Accurately, this study presents a comprehensive and detailed review of the literature to investigate the relationship between specific carbon performance metrics, including GHG emissions and decarbonization, and their impact on corporate financial performance. Through a meticulous selection process, we analyzed 37 peer-reviewed articles to provide a clear and concise overview of the current state of relevant literature. Our aim is to identify strategic maneuvers, both strategic and political, such as Climate Finance, and highlight their significance. In more detail, our research offers a conceptual framework that presents a descriptive classification of existing knowledge, defines and refines theoretical foundations for future scholars to build upon, identifies research gaps, and provides effective avenues for further impactful research. Additionally, we have created an implementation guide for practitioners and policymakers to use as a tool for guidance.

The results of this study carry significant implications for both research and practical applications. We meticulously analyzed each study's theoretical and methodological contributions and identified crucial theoretical gaps and future research opportunities. The topics covered include finance, sustainability, stakeholder theory, institutional theory, regulatory aspects, competitive advantage, and to a lesser extent, resource-based view (RBV) and agency theory. Hence, using a consistent methodology, we synthesized the main strands related to corporate performance (GHG emission and decarbonization) concerning climate change management. We integrated them into a single theoretical framework that will serve as a foundation for future studies on carbon performance, financial performance, and other climate change management aspects like Climate Finance and its tools: carbon credit and carbon offset. Additionally, the framework's development contributes to our comprehension of the different levels and perspectives of analysis present in existing research.

Our research presents significant findings with relevance to executives and policymakers alike. The implications of our work extend beyond the organizational sphere and touch on broader aspects of business and decarbonization. Specifically, given the limited understanding of the impact of corporate climate change strategies on long-term corporate performance, some managers may be implementing these strategies incorrectly or incentivizing greenwashing behavior. Additionally, the lack of means to verify adherence to well-defined emission rules leaves a wide margin for discretion. Our research can help managers and policymakers gain a better grasp of the less-discussed aspects of climate change management and climate finance in terms of carbon performance (i.e., greenhouse gas emission and decarbonization). It can also help them better comprehend the inherent risks that climate change poses (Mahmoudian et al., 2023; Ott & Schiemann, 2023; Cucchiella et al., 2017; Liesen, 2015) and how they can affect both global economies and business performance. Our research offers a valuable perspective on the potential risks and advantages of climate change management policies in decarbonization for the broader economy.

2. Literature review methodology and research question formulation

This analysis utilizes the systematic literature review (SLR) methodology to delve into how climate change management influences sustainability strategies and, consequently, corporate financial performance (Sitompul et al., 2023). The SLR methodology is a key component in advancing knowledge across a variety of fields, such as climate change management, sustainability, engineering, management, and carbon management (Battisti et al., 2024). By employing a clear and reproducible process, this methodology elevates the quality of review results, leading to a more comprehensive understanding of what is known and unknown about a particular matter (Snyder, 2019).

To ensure reliable and unbiased research results, it is crucial to follow clear and precise steps (Leonidou et al., 2020; Williams et al., 2020). Our systematic literature review (SLR) consists of four essential steps. The first step is to formulate the research question. The second step is to establish the research protocols, including the criteria for inclusion and exclusion, search processes, and extraction form. The third step is to analyze the results using descriptive analysis, and the final step is to perform a thematic analysis. These steps are necessary to produce robust and unbiased knowledge that supports researchers in preventing any factors that may compromise the reliability of their results (Kraus et al., 2024).

To conduct a successful Systematic Literature Review (SLR), it is essential to formulate one or more research questions from the outset (Battisti et al., 2024). This sets it apart from traditional systematic reviews. Following extensive discussions among authors and academics, and taking into account the views of professionals such as managers, policymakers, environmentalists, and industry experts, the following research question was formulated: *To what extent do climate change management strategies and climate finance tools influence corporate financial performance through the lens of decarbonization, and what gaps exist in our current understanding?*

3. Review protocols

3.1. Inclusion criteria

To establish the scope of our research, we selected Web of Science (WOS) from Clarivate and Scopus from Elsevier (Hasan et al., 2024; Jayaram & Singh, 2020), which are two of the most reliable and globally recognized citation databases available today. Following Hasan methodology, we utilized these two databases. We chose WOS for its selectivity and because it has been commonly used by other Systematic Literature Reviews (SLRs) in fields such as management and international business (Battisti et al., 2024). In addition, we chose Scopus for its more extensive coverage, particularly in the areas of green, sustainability, and the environment (Sitompul et al., 2023; Wahyudi et al., 2021; Mishra et al., 2017)

We conducted a systematic literature review to identify articles related to climate change management and climate finance, with a special focus on decarbonization and its impact on corporate financial performance. To do this, we searched for titles, abstracts, and keywords of

articles using a combination of relevant keywords. We used Boolean operators "AND" and "OR" with these keywords to identify suitable search strings. Additionally, we used wildcards to capture all potential combinations of specific words. These keyword combinations were derived from comprehensive research in the field of sustainability, with a specific emphasis on emission reduction and climate change management (He et al., 2022; Velte et al., 2020; Lewandowski, 2017). As a result, we executed six unique searches based on this approach: "Climate change management*" or "Climate finance" and "financial performance"; "Climate change management*" or "Climate finance" and "firm performance"; "carbon performance*" or "carbon management*" and "financial performance"; "carbon performance*" or "carbon management*" and "firm performance"; "ghg emission" or "ghg reduction" and "financial performance"; "ghg emission" or "ghg reduction" and "firm performance"; "decarbonization" and "financial performance"; "decarbonization" and "firm performance".

Furthermore, our investigation adhered to established business research methods, thoroughly examining data spanning 2015 to 2024 across various research fields (Sitompul et al., 2023). The analysis was also specifically honed on the timeframe of 2015 to 2024, with the aim of evaluating the effects of the 2015 Paris Agreement. This global agreement mandates all nations to strive toward achieving net-zero emissions by 2050 while also holding corporations accountable for mitigating the impact of climate change.

The initial sample retrieved using the inclusion criteria consisted of 18,509 publications: 18,417 from Web of Science and 92 from Scopus.

3.2. *Exclusion criteria*

To ensure the accuracy of our research, we had to follow certain criteria. Initially, we conducted a search for scholarly peer-reviewed journals, which are recognized as a reliable source of validated knowledge with the most significant impact on related literature (Battisti et al., 2024; Leonidou et al., 2020). To be more specific, we excluded research works such as books, book chapters, editorials, working papers, conference proceedings, and non-refereed publications (Christofi et al., 2019), which have undergone less rigorous peer-review processes or none at all.

Subsequently, our selection process focused solely on contributions written in English and available in full-text format (Vrontis & Christofi, 2021). We also removed any duplicate articles and those that did not meet our specific subject criteria, which included finance, business finance, economics, and management (Battisti et al., 2024). Lastly, we limited our sample to studies published in peer-reviewed journals ranked 2, 3, 4, and 4* in the ABS Academy Journal Guide (Vrontis et al., 2020).

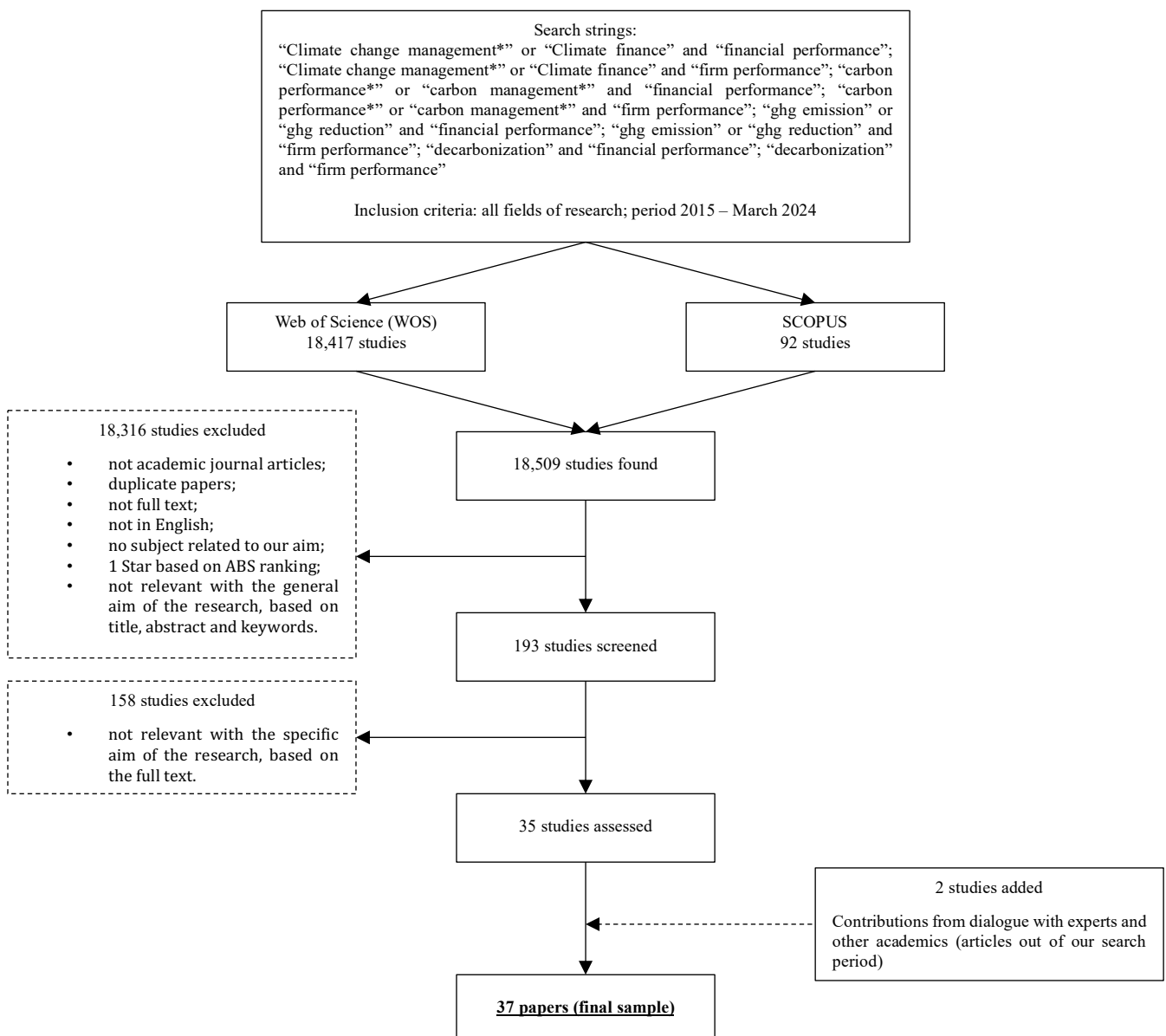
Moreover, we carefully evaluated the titles, abstracts, and keywords of various articles, removing those that did not directly align with our main aim (Sitompul et al., 2023; Christofi et al., 2017). Throughout this process, we remained open-minded and inclusive, taking into consideration both partially and fully relevant articles to our research question. By

implementing these specific exclusion criteria, we were able to acquire a sample of 202 publications. Among these, 169 publications were discovered on Web of Science, and 33 were found on Scopus. Subsequently, we combined the exports from Web of Science and Scopus, eliminated any redundant articles, and ultimately obtained a sample of 193 publications.

3.3. Further search processes

After completing the inclusion and exclusion steps of the systematic literature review (SLR), we performed a comprehensive evaluation of all manuscripts pertaining to decarbonization by thoroughly reviewing their complete texts. During this phase, we identified and acknowledged all the relevant studies that were related to our reviewed topic. Throughout this stage, we eliminated numerous articles as they failed to specifically address decarbonization, or lacked any impact on climate change management, climate finance, and corporate financial performance.

- Figure 1 -
Search strategy



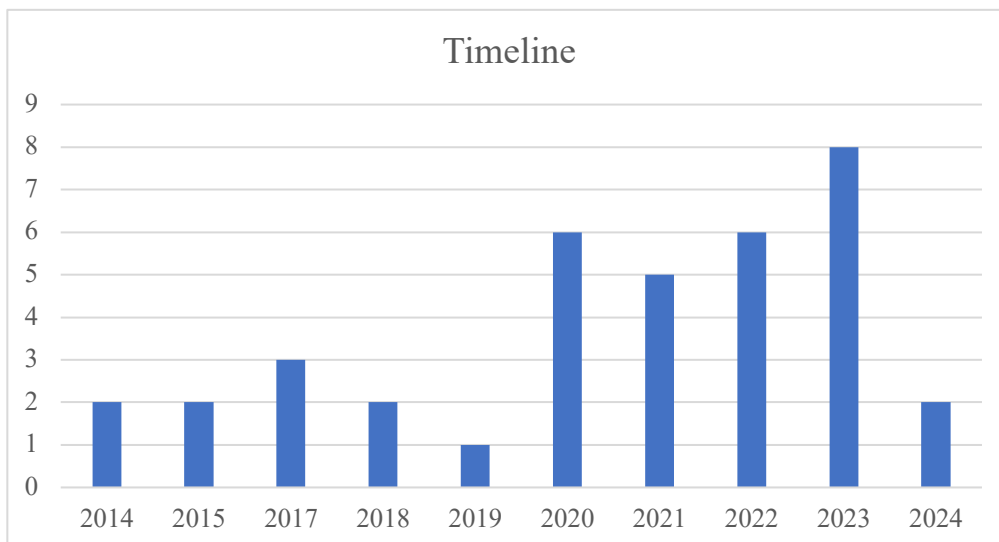
Overall, we excluded 158 papers and narrowed down the number of articles to 35. However, in order to ensure that we did not overlook any important contributions, we took three steps. First, we cross-referenced the references of the 35 selected studies to identify any additional relevant literature (Vrontis & Christofi, 2021). Second, we conducted a thorough search on Google Scholar for any possibly related contribution (Battisti et al., 2024). Third, we consulted with experts to identify any pertinent studies that may have been missed by our methodology (Vrontis & Christofi, 2021). All of the selected studies were peer-reviewed academic works, chosen based on the inclusion and exclusion criteria that we had previously defined.

In the final stage, we incorporated an additional 2 papers into our analysis, sourced from esteemed academics and experts. Despite these two papers falling outside of our designated time frame, their relevance to the topic at hand warranted their inclusion. Our final sample includes 37 manuscripts. Figure 1 shows an illustration of our review methodology process.

4. Descriptive analysis of systematic literature review

4.1. Evolution of publications over time and journal outlets

The publication trend has shown a degree of inconsistency over time, as evidenced by Figure 2. While some years saw only one or two publications, others saw more than three. Nonetheless, recent years have shown a positive shift in this trend, with a noticeable increase in overall attention. For instance, in 2022, six articles were published, and in 2023, the number increased to eight.



- Figure 2 -
Article frequency by year

The signing of the Paris Agreement in 2015, which mandates all nations to commit to net zero emissions by 2050, and the growing attention born out of the increasingly evident magnitude of climate change, which surprises us every day with new, far-reaching phenomena,

are increasingly attracting the attention of academics and policymakers to sustainable issues. This explains the growing number of studies on the subject of decarbonization related to climate change and climate finance in recent years. The increased focus on decarbonization, in our sample of articles, started in 2020 (six studies) and remained constant in the following years. The wave of sustainability is becoming more important every day as we become increasingly aware that what we do today will influence the near future, which is always closer than it seems.

Journal title	ABS ranking	No. Of articles	Weight (%)
<i>Accounting and Finance</i>	2	3	8.11
<i>Accounting Research Journal</i>	2	1	2.70
<i>British Accounting Review</i>	3	2	5.41
<i>Business and Society</i>	3	1	2.70
<i>Business Strategy and the Environment</i>	3	13	35.14
<i>Contemporary Accounting Research</i>	4	1	2.70
<i>Economics Letters</i>	3	1	2.70
<i>Energy Policy</i>	2	1	2.70
<i>Finance Research Letters</i>	2	1	2.70
<i>Financial Analysts Journal</i>	3	1	2.70
<i>International Journal of Accounting</i>	3	1	2.70
<i>International Journal of Contemporary Hospitality Management</i>	3	1	2.70
<i>International Journal of Production Economics</i>	3	1	2.70
<i>Journal of Banking and Finance</i>	3	1	2.70
<i>Journal of Business Finance & Accounting</i>	3	1	2.70
<i>Journal of Cleaner Production</i>	2	4	10.81
<i>Journal of International Accounting Auditing and Taxation</i>	3	1	2.70
<i>Journal of International Accounting Research</i>	2	1	2.70
<i>Management Decision</i>	2	1	2.70

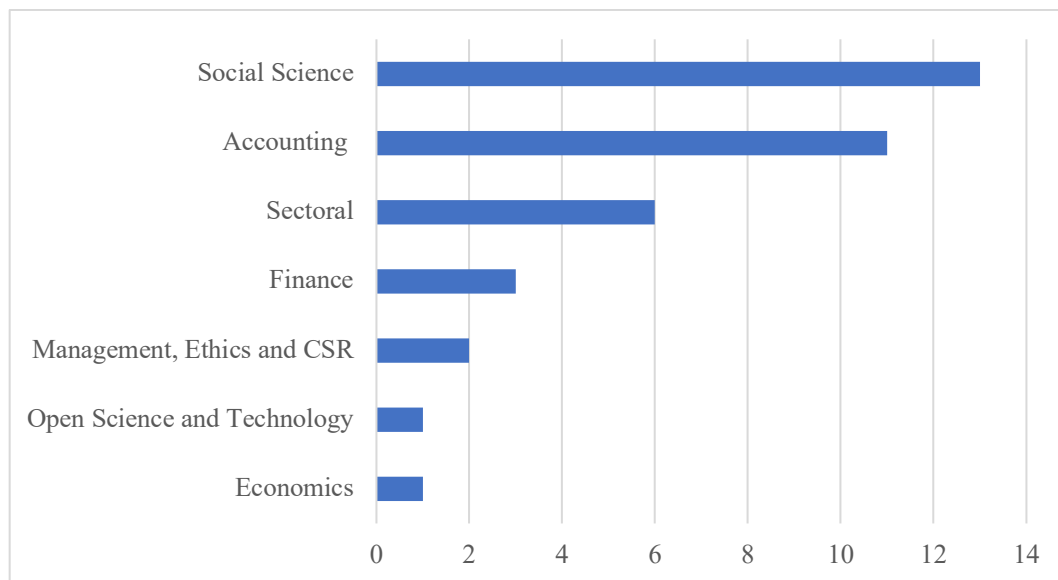
- Table 1 -
Journal title and ranking ABS

In regard to the publications where the studies are made available, there are several factors to consider. Table 1 displays all the journals that have published papers, along with the number of papers published for each journal and their corresponding ABS ranking. It is important to note that our study only considers journals with a ranking of 2 ABS and above. This is because we prioritize the quality of the methodologies utilized and the scrutiny of the articles submitted for publication. The journal with the largest number of publications is Business Strategy and the Environment (35.14%), followed by Journal of Cleaner Production (10.81%). The first Business Strategy and the Environment journal have an ABS ranking of 3, and the second has an ABS ranking of 2. Meanwhile, fifteen journals have 40% of the selected papers, equally

distributed, the more relevant in terms of ranking ABS are: Contemporary Accounting Research (4 ABS), Business and Society (3 ABS), Economics Letters (3ABS), Financial Analysts Journal (3 ABS), International Journal of Accounting (3 ABS), Journal of Banking and Finance (3 ABS), and Journal of Business Finance & Accounting (3 ABS). Overall, our sample contains one journal with 4 ABS, eleven journals with 3 ABS, and seven journals with 2 ABS.

Subsequently, we considered the field of research to which each journal belongs, along with its ranking, to gain insight into the theoretical stance of each article. Figure 3 displays the number of papers and research fields taken into account during the initial ABS-based categorization process. For example, Contemporary Accounting Research was classified under "Accounting," while Management Decision was placed under "Management, Ethics and CSR." It's worth noting that the fields are interconnected, and this categorization is not an inflexible system. There may be studies that address accounting matters but are published in journals belonging to the "Social Science" field, and the opposite may also be true.

More specifically, out of the total number of studies conducted, 13 are in the field of social science while 11 studies are related to accounting in general. As expected, six journals are dedicated to the Sectoral field with a focus on analyzing the most polluting sectors and their implementation of sustainable practices. We also found three journals dedicated to Finance, while one journal each focused on the fields of Economy and Open Science and Technology.



- Figure 3 -
Field of journal outlets

4.2. *Relevance of articles and paper types*

The position of a research paper in a journal reflects its quality. Each paper is unique, and a higher ranking generally indicates better quality, which in turn leads to more citations. To determine the impact of a paper on the scientific community, we have included a table in which

the citations of each paper are listed. However, time is also an important factor, so we have calculated the average citations per year to compare studies published in different years of publication. The paper that has received the most citations in our sample is Wang et al. (2014), with 198. However, it is not the paper with the highest number of citations per year (18), but rather the 45.33 citations per year of He et al. (2022). In absolute terms, the second most cited paper is Broadstock et al. (2018) (161 citations), but in relative terms (23 citations per year), it ranks fourth, preceded by Choi & Luo (2021) with 31.25 citations per year and by Alsaifi et al. (2020) with 30.80. It has been observed that a significant portion of papers with the highest number of citations fall within an editorial range of at least 3ABS. This indicates that these papers are highly valued by the scholarly community.

Moreover, we conducted a thorough analysis of each paper in our sample, examining the methodology employed and categorizing the types of papers and methods used (Table 2). Our sample included 28 quantitative papers, which is in line with the norm for economic and financial studies. Additionally, we identified four qualitative studies, including case studies, as well as three theoretical and/or conceptual studies, one literature review, and one mixed-method study. In the forthcoming paragraphs, we will offer a comprehensive overview of the theoretical topics and relationships explored in each paper.

Empirical papers				
Quantitative (Primary or secondary data)	Qualitative (Interviews and Case study)	Mixed-method	Conceptual and theory building	Review
28	4	1	3	1

- Table 2 -
Paper types

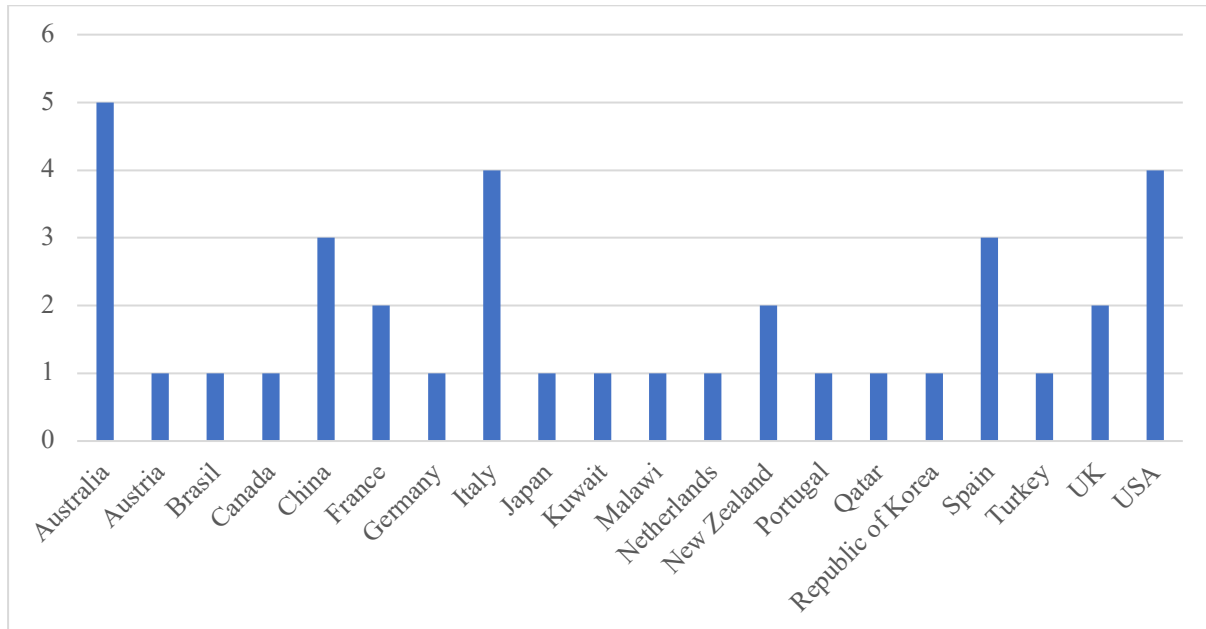
4.3. *Geographic analysis of authors' origin*

Our research has revealed 115 authors hailing from diverse institutions across 20 countries. Analysis of the geographical location of the first author indicates that the majority of contributions stem from Australia, followed by significant inputs from the United States, Italy, and Spain (Figure 4). Although we have a broad representation of countries, a single author or author team from one country accounts for 52% of the research, while two countries contribute to 33% and three or more countries contribute to 15%.

It is quite unexpected that only a fraction of studies exploring the correlation between climate change management, climate finance, and decarbonization on financial performance involve an international team of researchers. Given the existence of global research networks and advanced technologies that promote cross-border collaboration, this observation is rather surprising.

Based on the results, there exists significant potential for worldwide cooperation in research. A more detailed analysis of the geographic origins of author contributions uncovers that the majority of studies arise from Europe (40.54%), trailed by Australia (18.92%), America

(16.22%) and Asia (16.22%). Remarkably, African (2.70%) authorship is not proportionally represented in this research area. This emphasizes the pressing requirement for increased research both from and within the African continent.



- Figure 4 -
First author's geographical location

5. Thematic analysis of the literature

Climate change management is an essential approach that aims to mitigate the current climate crisis. This involves the implementation of strategies to measure and report carbon performance, as well as the utilization of Climate finance tools. The Paris Agreement in 2015 proved to be a defining moment as it launched a global effort to decrease carbon emissions. The objective is ambitious, aiming to limit the global average temperature rise to no more than 2 degrees Celsius. Later, an even more ambitious target of 1.5 C is set, which calls for a reduction of global emissions to zero by 2050, a goal referred to as carbon net neutrality (Capece et al., 2017; Cucchiella et al., 2017). Since then, multiple strategies have gained momentum, promoted by governments and environmentally conscious stakeholders, encapsulating the concepts of climate change management, carbon management, and climate finance. These strategies have a common goal of addressing climate change and achieving carbon neutrality, which is widely acknowledged by various actors in today's economic landscape, including governments, corporations, asset owners, asset managers, and banks. Global decarbonization is considered one of the most important political and business issues of our time (Mahmoudian et al., 2023).

A study by Bolton et al. (2022) reveals that despite the challenges posed by the pandemic, there has been a significant increase in the number of countries committing to carbon neutrality.

In less than a year, the number has almost doubled, with over 130 nations aiming to achieve carbon neutrality by 2050, indicating a growing priority for climate action in recovery plans.

Investors play a crucial role in this shift towards sustainability. By directing their investments towards companies that prioritize environmental goals, they can incentivize sustainable practices, including decarbonization (Haque & Ntim, 2022; Choi & Luo, 2021; Alsaifi et al., 2020; Bui et al., 2020a; Bui et al., 2020b; Broadstock et al., 2018). According to Nikolaeva et al. (2024), before the energy crisis caused by Russia's invasion of Ukraine, investors focused on balancing long-term resilient investments with decarbonization of the economy. However, the crisis and volatility in hydrocarbon markets have added new dimensions to the risk-return assessment used by investors, making it more challenging for asset managers and investment funds in an energy-hungry world.

The apprehension of energy insecurity provoked by conflict, combined with the understanding that we must still depend on fossil fuels for our fundamental energy requirements in the coming years, has led policymakers and managers to reconsider their recent climate pledges (Maia & Garcia, 2023; Ozturk et al., 2022). This is transpiring as the world is grappling with the realities of climate change and a surge in energy consumption. Concerning this Nikolaeva et al. (2024) underlined that the course of energy and climate change will hinge on how investors and managers manage diverse ethical considerations.

Despite this, the recent academic debate has highlighted the pressing need for reducing carbon dioxide emissions (Alsaifi et al., 2020). As scientists warn of the dire consequences, including the rising frequency of extreme events, it remains a challenge for society. In recognition of the fact that environmental strategy can result in cost savings through improved energy efficiency and waste management, among other factors, an increasing number of companies have integrated global warming strategies into their fundamental policies. It is, therefore, well established that global decarbonization is considered one of the most important political and economic-financial issues of our time (Mahmoudian et al., 2023).

Companies are under increasing pressure from stakeholders and regulators to be environmentally sustainable, comply with environmental regulations, and reduce emissions. Therefore, corporate emission reduction initiatives are largely voluntary and are based on the impact of such initiatives on profitability (Homroy, 2023). As pointed out by Elleuch Lahyani (2022), increasing institutional and social pressure is being put on companies to reduce their GHG emissions. Similarly, Fernández-Cuesta et al. (2019) who study how decarbonization strategies affect the cost of European firms' financial debt, that firms are increasingly under pressure from regulators and other stakeholders (such as competitors, suppliers, customers, investors, and creditors) to find appropriate strategic decisions to reduce carbon emissions. Thus, climate change has become an increasingly important business issue, so much so that polluting industries are particularly concerned about future environmental liabilities that result in higher costs (Mahmoudian et al., 2023).

Carbon emissions, similar to other aspects of environmental performance, are not typically recognized in companies' financial statements but can affect future revenues and costs (Ott & Schiemann, 2023). A growing number of companies around the world are undertaking initiatives to measure, monitor, and reduce carbon emissions. Research conducted by Choi & Luo (2021) suggests that companies who prioritize reporting and reducing their carbon emissions may experience notable expenses. Elevated carbon emissions can serve as a warning sign for potential environmental liabilities, which could translate to increased future spending. Businesses with substantial carbon emissions may encounter greater future costs as they are required to invest in less carbon-intensive technologies and production processes, as well as in the creation of products and services with lower carbon footprints (Ott & Schiemann, 2023).

Scholars are currently engaged in a debate surrounding the compatibility of improving environmental performance and achieving financial goals. While some argue that reducing emissions can be a costly endeavor that detracts resources from other productive investments, leading to what is known as the 'green paradox', there are several theoretical arguments supporting pollution prevention strategies. These strategies can lead to the creation of a sustainable competitive advantage by boosting efficiency and productivity, promoting product innovation and differentiation, and enhancing managerial skills and capabilities (Russo et al., 2021).

According to a study by Alsaifi et al. (2020), in today's world, where carbon disclosure and stakeholder demands for carbon-related information are on the rise, managers should view a company's management of carbon emissions and the quality of its reporting as strategic issues. This strategic advantage is closely related to superior financial performance resulting from disruptive innovations that can accelerate carbon neutrality while maintaining corporate growth (Deng et al., 2024) and from implementing innovative solutions necessary to mitigate climate change and achieve corporate commitments (Hakovirta et al., 2023).

In summary, according to the study by França et al. (2023), climate change has the ability to disrupt the competitive environment of many industries. However, implementing strategies to manage carbon risk can lead to competitive advantages for companies, despite the associated time and cost (Zhou et al., 2020).

A large body of literature studies how changes in emissions affect corporate financial performance (Mahmoudian et al., 2023; França et al., 2023; Ott & Schiemann, 2023; Choi & Luo, 2021; Russo et al., 2021; Alsaifi et al., 2020; Bui et al., 2020b; Naranjo Tuesta et al., 2020; Yagi & Managi, 2018; Cucchiella et al., 2017; Damert et al., 2017), as there is evidence that carbon emissions have an impact on the corporate environment, and on the current and future operations of companies. However, the empirical results obtained from previous studies regarding the relationship between carbon emissions and/or decarbonization and corporate performance are not aligned with each other and, therefore can be considered definitive (Kim et al., 2023; Johnson et al., 2020; Fernández-Cuesta et al., 2019; Broadstock et al., 2018; Capece et al., 2017; Wang et al., 2014).

Investors in corporate finance typically evaluate a company's performance by comparing its key performance indicators with those of similar-risk companies. This evaluation process also applies to the relationship between carbon emissions, decarbonization efforts, and financial performance. This is because the concept of risk is intricately linked to these factors. (Ott & Schiemann, 2023). In this regard, according to Cucchiella et al. (2017), companies that fail to tackle climate change face substantial risks. The first risk is physical in nature, as changes in consumer behaviour stemming from climate patterns and their consequences can directly impact corporate profitability. The second risk is regulatory, as emissions reduction regulations at national and international levels are now more stringent than ever before. Companies which do not prioritize climate change can face significant costs due to non-compliance (Mahmoudian et al., 2023; Fernández-Cuesta et al., 2019). Lastly, competitive risk, in fact, as seen above, attention to climate change issues is a key competitive factor (Bui et al., 2020b; Zhou et al., 2020). In contrast, Liesen (2015) points out that the market is still inefficient, as it is unable to price the systematic risk induced by climate change.

According to Alsaifi et al. (2020), Fernández-Cuesta et al. (2019), and Wang et al. (2014), who recall the study by Boiral et al. (2012), The examination of the relationship between greenhouse gas emissions and a company's financial success is typically approached from two angles: win-lose and win-win. In the win-win scenario, a company's efforts to reduce emissions not only benefit the environment but also enhance its competitive edge. Conversely, the win-lose approach contends that emissions reductions would be costly and could diminish a company's competitiveness. Presently, the win-win perspective is predominant in the literature, proposing that cutting carbon emissions can yield economic advantages for the company. This can generate fresh opportunities for profit and a competitive edge through more efficient utilization of natural resources (Alsaifi et al., 2020).

Although there is some evidence to support the relationship between carbon performance management and financial performance, recent studies have not produced clear results. They often remain stuck in the 'green paradox,' where the concern is that investments in environmental technologies that reduce emissions may be detrimental to financial performance. This can increase short-term costs by diverting resources away from more profitable investments (Homroy, 2023). Therefore, despite the increasing focus on companies' environmental impact, the financial benefits of corporate environmental sustainability are not yet well-defined.

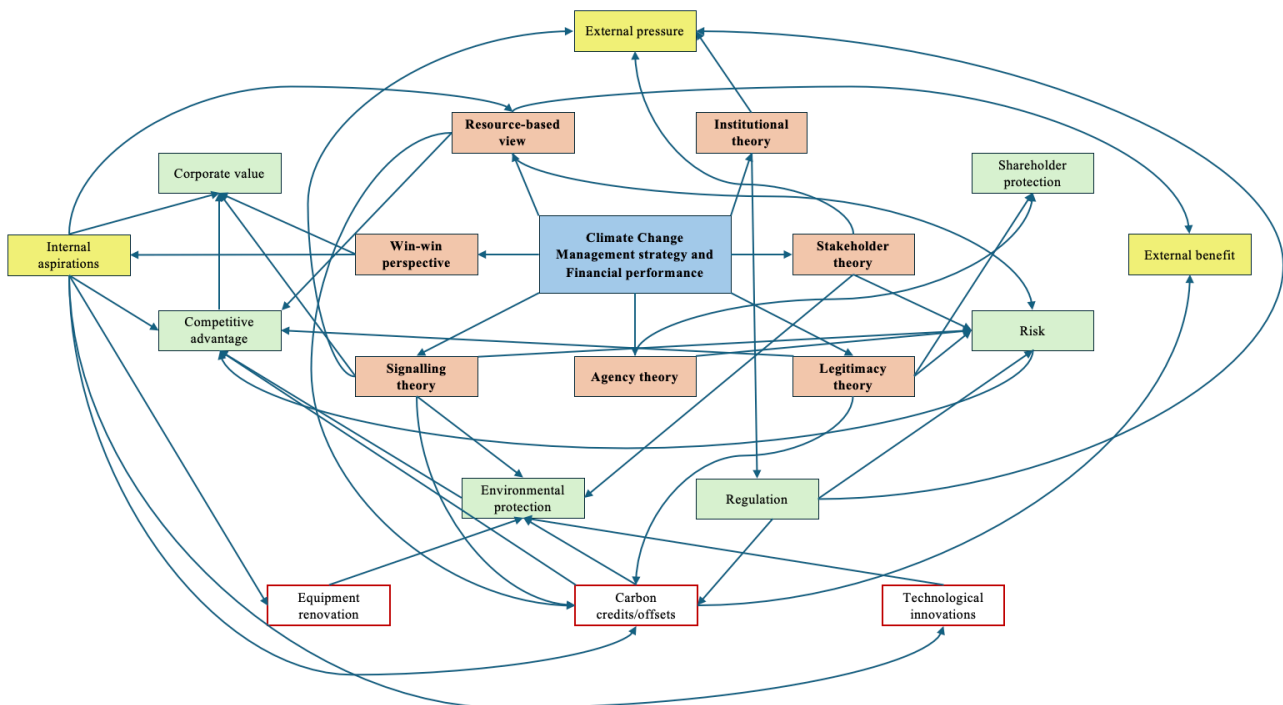
The articles analyzed to highlight research trends concerning the relationship between climate change management, in terms of decarbonization and financial performance, resort to very different theoretical frameworks. Specifically, there are studies that rely exclusively on one theory (Deng et al., 2024; Homroy, 2023; Haque & Ntim, 2022; Alsaifi et al., 2020; Johnson et al., 2020; Zhou et al., 2020; Fernández-Cuesta et al., 2019; Cucchiella et al., 2017; Liesen, 2015) and studies that analyze the relationship through a more complex theoretical

framework involving two or more theories (Kim et al., 2023; Elleuch Lahyani, 2022; Naranjo Tuesta et al., 2020; Damert et al., 2017).

Carbon emissions are linked to the sustainability practices and financial performance of companies. The studies analyzing this relationship have used different theoretical frameworks. First of all, Stakeholder theory has been utilized, which posits that stakeholder pressure on climate change is vital for the development of corporate carbon strategies (Kim et al., 2023; Elleuch Lahyani, 2022; Naranjo Tuesta et al., 2021; Damert et al., 2017; Liesen, 2015). Also, Institutional theory suggests that managerial decisions are driven by coercive forces, such as regulations and conformity to norms (Naranjo Tuesta et al., 2021; Damert et al., 2017). In parallel, Neo-Institutional theory (NIT) suggests that firms' responses to institutional pressures related to climate-related risks are driven by motivations oriented toward symbolic legitimacy and economic efficiency (Haque & Ntim, 2022). The neoclassical perspective suggests that there are two methods to examine these connections (Naranjo Tuesta et al., 2021). The conventional outlook implies that better environmental performance results in poorer economic performance, and vice versa. However, the contemporary perspective posits that nations, industries, and businesses that establish dependable and efficient regulatory frameworks gain a long-term competitive edge. Based on agency theory, environmental performance is deemed a crucial component of optimal management operations, as shareholders wield significant influence over managerial conduct (Elleuch Lahyani, 2022; Naranjo Tuesta et al., 2021; Fernández-Cuesta et al., 2019). From a Resource-based view (RBV) perspective, there are several additional reasons for companies to join voluntary environmental programs, including the opportunity to showcase their environmental actions and thus gain a competitive advantage (Kim et al., 2023; Naranjo Tuesta et al., 2021; Alsaifi et al., 2020; Zhou et al., 2020). Moreover, the Legitimacy theory is used to explain organizational behaviour, the implementation and development of social responsibility policies and the communication of their results (Elleuch Lahyani, 2022; Naranjo Tuesta et al., 2021). In addition, the Signaling theory suggests that revealing more information about carbon metrics in an efficient market sends a favourable signal to market participants (Elleuch Lahyani, 2022). Finally, some studies use theoretical frameworks not often used in sustainability studies, such as the Cobb-Douglas production function (Cucchiella et al., 2017), socio-technical theory (Deng et al., 2024), resource dependence theory (Elleuch Lahyani, 2022), gender socialisation theory (Homroy, 2023), the theory of diminishing marginal utility (Johnson et al., 2020), and the eco-efficiency concept (Kim et al., 2023).

Overall, according to the analyzed studies, mitigating carbon emissions requires a comprehensive approach that considers not only energy and carbon intensity but also financial factors (Morrone et al., 2022). While many organizations concentrate on lowering carbon and energy intensity, financial considerations can have a greater impact on emission reduction. In particular, the decrease in emissions resulting from energy intensity is frequently negated by the increase in emissions from larger firms (Yagi & Managi, 2018).

To sum up, the concept of carbon neutrality implies achieving zero net carbon emissions (Bolton et al., 2022). On the other hand, reducing carbon emissions requires making changes to the energy and industrial structures, as well as adjusting the share of the industrial sector in the GDP (Guo et al., 2023). For businesses, their carbon emissions allowance is a crucial factor that impacts their long-term profitability, especially for those operating in the traditional extensive development stage (Hakovirta et al., 2023). Therefore, as a result of the growing concern over climate change, there has been an increase in the use of offset tools such as carbon credits or carbon offsets, which are supported by climate finance (Trouwloon et al., 2023; Calel et al., 2021). Nevertheless, the "green paradox" theory argues that insufficient policies and regulations may unintentionally encourage companies to boost their energy consumption and carbon emissions in the short run, with the aim of enhancing their overall performance and financial gains (Deng et al., 2024).



- Figure 5 -
Conceptual framework

6. Conclusions, limitations and future researches

The issue of climate change is a significant challenge that requires a united response from individuals, organizations, and governments worldwide. This can be achieved through voluntary or legally mandated initiatives such as Climate change management and Climate finance. It is widely accepted that reducing greenhouse gas emissions, which are the primary cause of human-induced climate change, is necessary, while also learning to adapt to the consequences of such change (Capece et al., 2017; Cucchiella et al., 2017). In today's era of sustainable development, businesses hold a crucial role in reducing and managing greenhouse gas emissions. Some businesses perceive environmental aspects and impacts as a cost, as

shown in the literature ‘pay to be green’ (Wang et al., 2014). However, many studies have demonstrated that focusing on environmental sustainability can generate numerous benefits (Cucchiella et al., 2017). In particular, while carbon mitigation may be expensive, companies that take early action to limit carbon emissions will have a sustained impact on their operational structure, processes, efficiency, reputation, and sustainable outcomes (He et al., 2022). This leads to increased demand, improved productivity, and better financial performance, thereby adding value to the company (Capece et al., 2017; Cucchiella et al., 2017).

According to the analysis conducted in this paper, the relationship between carbon performance (which includes metrics such as greenhouse gas emissions and decarbonization) and financial performance is not straightforward, but it seems to follow a pattern that could yield positive results for companies that adopt climate change management and climate finance strategies. This is especially true for those companies that can benefit from specific policy measures. Although some studies have shown a non-linear relationship between GHG emissions and financial performance (Boradstock et al., 2018; Wang et al., 2014), other studies have provided interesting insights into this relationship from different angles. As shown by Deng et al. (2024), Hakovirta et al. (2023), Alsaifi et al. (2020) and Zhou et al. (2020), carbon disclosure and/or a reduction of carbon emissions, including through the implementation of innovations within the firm, leads to an increase in competitive advantage and consequently improves financial performance. Other studies show that decarbonization strategies impact financial performance in terms of enterprise value, improving it (França et al., 2023; Kim et al., 2023; Bui et al., 2020b; Johnson et al., 2020). This stems from evidence that reducing GHG emissions boosts value creation (França et al., 2023), reduces operating costs (Deng et al., 2024; Ott & Schiemann, 2023), and improves margins (Ott & Schiemann, 2023; Naranjo Tuesta et al., 2021; Yagi & Managi, 2018; Capece et al., 2017). In terms of market value, Choi & Luo (2021) reveal that carbon emissions negatively impact financial performance, as investors perceive polluting firms as riskier (Liesen, 2015). To underscore this, Fernández-Cuesta et al. (2019) empirically prove that better carbon performance is associated with lower costs of debt, as banks perceive virtuous firms as less risky. In addition, there is also empirical evidence that a lower cost of debt incentivizes climate change management practices with a focus on decarbonization (Mahmoudian et al., 2023).

As with other systematic reviews, the evidence reported should be explained within the context of the limitations of such reviews. Firstly, we decided to use two databases (WOS and Scopus), which could have missed some studies, although they are the most recognized (Sitompul et al., 2023). To overcome the limitation of the initial selection of 25 papers, we conducted a comprehensive cross-reference check. In addition, we consulted with experts and academics and performed a thorough search on Google Scholar to identify more relevant articles. These efforts allowed us to partially resolve the issue. Thus, research has confirmed that the 37 publications that were examined offer a comprehensive glimpse into the present literature on the multidisciplinary subject. As such, it may not be feasible or essential to

encompass all published studies (Battisti et al., 2024). Furthermore, this systematic review does not encompass non-refereed publications like books, book chapters, editorials, conference proceedings, working papers, and papers that are written wholly or partially in other languages, which could also be pertinent (Leonidou et al., 2020). Also, our primary objective was to delve into the existing literature and merge it cohesively, instead of proposing research concepts that link the different aspects (Christofi et al., 2017). An obvious progression would be to establish these links. Furthermore, given the interdisciplinary nature of the subject, we had to maintain a broader scope of interests, occasionally opting for breadth rather than depth when analyzing outcomes (Vrontis et al., 2021). Going forward, this framework can serve as a source of inspiration for empirical investigations.

For example, researchers could investigate how the introduction of decarbonization facilities, such as climate finance, impacts the financial performance of a company, as well as the potential consequences of not having these facilities in place. Furthermore, exploring strategies aimed at assisting industries that struggle with decarbonization, such as logistics and transportation, is essential. Carbon credits and carbon offsets are examples of such strategies that companies are increasingly adopting to achieve zero-emissions targets without altering their production processes. Investigating the impact of these strategies on companies' financial performance and their contribution to reducing carbon emissions is paramount. Doing so would help determine if these strategies are legitimate efforts to reduce carbon emissions or simply greenwashing practices. Lastly, contextualizing the proposed framework within widely used sustainability theories would provide insight into how these theories impact financial performance. This will shed light on the new decarbonization tools that specific policy measures promote and make available.

CHAPTER II

Climate Change Management and Companies' Financial Performance: exploring the moderator role of Carbon Credits

ABSTRACT

The purpose of this paper is to examine how carbon emissions affect companies' financial performance, exploring the moderating role of carbon credits. Drawing on institutional theory, this study analyzed 118 worldwide companies that used carbon offsets from the period 2018-2022. Results reveal that carbon emissions have a detrimental effect on financial performance; however, this negative impact can be mitigated by adopting climate finance tools, such as carbon credits, which can moderate this relationship. This research offers valuable contributions to both theoretical and practical domains, also supporting regulators in monitoring carbon emissions.

Keywords: Climate finance tools, Climate change management, Institutional Theory, Carbon credits, financial performance

1. Introduction

The issue of climate change is of utmost importance and has a significant impact on every aspect of society and businesses worldwide. This was emphasized in the Global Risks Report 2024, compiled by the World Economic Forum. According to 1,500 experts, 5 out of the 10 most serious risks in the next 10 years will be environmental, with climate change leading the way. The frequent occurrence of extreme natural events is a clear indication of the need to address this matter urgently and with the utmost attention and care. In July 2023, the UN Secretary-General, António Guterres, drew attention to the measures implemented to mitigate the effects of global warming, declaring the "era of global boiling," to emphasize the importance of finding effective solutions to address climate change (Niranjan, 2023). Among these measures are carbon offsets/credits, which were introduced under the Kyoto Protocol as the final document of the 1997 Conference of the Parties (COP 3). They were subsequently implemented through the 2015 Paris Agreement, which also established the Sustainable Development Goals (SDGs). These goals include a 45% cut in global emissions and the use of climate finance instruments.

The rising urgency to address climate change has increased the importance placed on carbon offsets/credits over the past couple of years (Gurgel, 2022). Many companies are investing in these climate finance tools to mitigate their greenhouse gas emissions (Harvey, 2021). It is worth noting that every offset/credit is a representation of a ton of emissions that have been either avoided or removed from the atmosphere.

Investments in carbon offsetting have recently come under scrutiny due to concerns of over-crediting and selling of offsets that promise more emissions reductions than they can deliver, as highlighted by Fan et al. (2021). Despite these challenges, the carbon offset market has demonstrated resilience and has even made progress during the ongoing coronavirus pandemic, thanks in part to a boost in corporate demand and high-profile initiatives (Gross, 2020).

Although carbon credits and carbon offsets are often used interchangeably, it is important to note that they refer to distinct stuffs, each with its own specific purpose. A carbon offset involves removing greenhouse gases from the atmosphere in sectors and/or geographic areas different from those in which the company operates, while a carbon credit represents a reduction in the amount of greenhouse gases released into the atmosphere (Calel et al., 2021). In conclusion, both terms are often used to balance emissions that are difficult to remove and have gained traction as an essential element of corporate sustainability initiatives. However, their impact on financial outcomes remains an area of ongoing debate (Wang, 2023; Wang et al., 2022; Busch et al., 2022). Because the tool has only recently been deployed, no differentiation is made between credits and offsets in accounting. Therefore, for the purposes of this study, we will refer to a single variable known as carbon credits/offsets.

Recent literature in the field of emissions has examined the effect of carbon emissions and emissions reductions on financial performance (Sitompul et al., 2023; Busch et al., 2022;

Ganda, 2022; Siddique et al. 2021). Nevertheless, a definitive conclusion has not yet been reached. Divergence in findings can be attributed to specific sectors and analytical approaches, as well as to country-specific focuses influenced by regulatory and normative factors related to emissions. Additionally, there has been no comprehensive study on this relationship focusing on the automotive sector during the peak of the COVID-19 pandemic, a time when many companies stopped their operations due to lockdowns. The aim of this paper is to explore the relationship between carbon emissions and a company's financial performance, and to analyze the impact of climate finance instruments, carbon offsets/credits, on this relationship (Peterson, 2022), with a specific focus on the years of pandemic and post pandemic. The purpose of this study is to examine the relationship between carbon emissions and financial performance, with a particular emphasis on the role of carbon credits. Moreover, empirical evidence is provided to enhance understanding of the effects of climate change practices on financial performance, highlighting the role of climate finance tools. Considering firms that may not be able to reduce their greenhouse gas emissions through the incorporation of new technologies, would carbon credits serve as a practical measure in curbing emissions?

Recent research has examined the correlation between carbon emissions, financial performance, and carbon credits from various theoretical perspectives concerning sustainability (Sitompul et al., 2023). First, carbon offsets/credits can be seen as important resources or capabilities that a company can use to improve its competitive advantage, according to the Resource-Based View (Kaplan et al., 2023; Shrestha et al., 2023). Furthermore, carbon offsets/credits can help companies gain or maintain legitimacy in the eyes of stakeholders and meet their responsibilities, as stated by Legitimacy Theory (Suchman, 1995; Dowling & Pfeffer, 1975) and Stakeholder Theory (Cornell & Shapiro, 2021; Jones et al., 2017). The current research is framed from the perspective of institutional theory, a concept widely debated in sustainability studies, especially in the context of climate change. It seeks to explain why organizations within a given industry often exhibit similar behaviors and characteristics (DiMaggio & Powell, 1991). It underscores the influence of institutional pressures in shaping the adoption of voluntary sustainable practices (Daddi et al., 2018). Therefore, from a theoretical perspective, we have focused on institutional theory as a theoretical framework to understand if carbon offsets/credits programs are able to develop a reduction in carbon emissions by complying with government policies, market forces, and social norms, that is becoming more and more mandatory due to the pressing nature of the matter (Moufty et al., 2024; Matten & Moon, 2020; Campbell, 2007; DiMaggio & Powell, 1991).

In the current scenario, where environmental concerns are on the rise, many organizations are adopting carbon offset/credit as a strategic measure to mitigate their carbon footprint (Cadez et al., 2019). It is important to understand the role of carbon offsets, which are becoming increasingly necessary due to stakeholder pressure and emerging regulatory obligations. The combination of these obligations and responsibilities has an impact on financial results, making

it an interesting topic to take into account. More specifically, we assume that carbon emissions have a negative impact on financial outcomes, but carbon offsets/credits can moderate their negative effects.

We conducted an analysis using a global sample of companies that utilized carbon offsets/credits over a period of 5 financial years (2018-2022). In order to determine the impact of carbon emissions on financial performance, we conducted a longitudinal analysis using the generalized least squares random-effect model (Guestella et al., 2022; Tuesta et al. 2020; Alsaifi et al. 2020).

The study's findings confirm that carbon emissions have a detrimental effect on financial performance. However, this negative impact can be mitigated by adopting climate finance tools such as carbon offsets/credits, which can moderate this relationship. This highlights that companies can still have positive outcomes despite reducing carbon emissions. Based on the obtained findings, there are several significant contributions that can be highlighted.

The integration of insights from recent studies and our empirical evidence has led us to conclude that investments in the reduction of carbon emissions can significantly enhance financial performance (Meng et al., 2023). In addition, this research delves into the impact of carbon offsets/credits on this relationship, which can further drive positive outcomes for financials. This study aims to contribute towards our understanding of this subject matter.

Our findings also provide valuable insights from a management perspective. Our research emphasizes the significance of sustainable entrepreneurship over investment in climate finance tools (carbon offsets/credits), due to mandatory law, which also leads to an improvement in financial performance. Also, the study's findings can serve as a valuable tool for companies to make informed decisions regarding sustainability practices and carbon credit utilization. By doing so, companies can promote long-term financial success while also contributing to the cause of sustainability. Finally, policymakers can use the research insights to implement effective policies that encourage businesses to adopt sustainable practices.

2. Literature review and hypotheses development

2.1. Carbon emission and institutional theory

The link between climate management and financial performance is frequently established through mandatory requirements, in addition to social, commercial, and ethical considerations. This is the main reason behind our emphasis in this study on the theoretical framework of Institutional Theory. In underdeveloped countries, some politicians assert that reducing pollution could impede GDP growth and industrial development (Başar and Tosun, 2021). They posit that a company's higher pollution output could indicate its superior performance, potentially resulting in higher production volume, revenue, and lower costs. However, with the growing emphasis on sustainable business practices, it has become crucial for companies to ensure their sustainability, for climate change concerns and due to the increasingly strict regulations that go beyond just the behavior of a single company (Tuesta et al., 2021). It is

necessary to analyze the entire supply chain to comply with international regulations (Ganda, 2018). For instance, the focus has shifted from direct carbon emissions, faced by a single company, to indirect carbon emissions that come from the companies in the supply chain. Previous research suggests that companies exhibiting less sustainable behavior, also arising from inaccurate supplier selection, tend to carry higher levels of risk exposure (Cohen, 2023). This higher level of risk often translates into increased costs, including higher debt expenses, greater tax obligations, and amplified raw material expenditures (Gleißner et al., 2022). The increase in costs can be attributed to the national and/or international regulations that focus on promoting the use of renewable sources of energy and sustainable supply chains for raw materials (Qian et al., 2020; Bitat, 2018). This highlights the growing importance of Environmental, Social, and Governance factors (ESG) in financing and investing decisions, as well as the benefits that accrue to national entities, such as taxation.

Prior studies have explored the connection between climate change management, especially in terms of carbon emissions, and company financial performance or value using various samples and methodologies. However, the results have been various, and there is still no agreement on the exact nature of this relationship. Extensive research has been conducted to establish the relationship between carbon emissions and financial performance. This link matches established regulatory best practices and new technologies, even if voluntarily adopted (Børing, 2019). Efforts towards emissions reduction through compliance with international regulations not only foster innovation but also have an indirect impact in enhancing productivity (Guastella et al., 2022). Several strands of evidence emerge from the previous works, based on many different theoretical frameworks that are highly interconnected.

Previous studies have analyzed different theoretical perspectives, either as a single theory or as multiple theories. The prevalent theories are stakeholder theory, institutional theory, resource-based view theory and legitimation theory. In addition to the primary theory, a number of alternate theories have also been observed and studied. Busch et al. (2022) conducted a study to assess the robustness of a previous study's findings on the relationship between carbon emissions (GHG emissions) and financial performance, specifically return on assets. However, their study produced different results compared to the one they had hypothesized. In particular, Delmas et al. (2015) study employed an innovative method that distinctly analyzes short-term and long-term performance, which has been taken up by further subsequent studies. The results showed a positive correlation in the short-term and a negative correlation in the long-term. Moreover, it is important to highlight that the difference in time orientation for research on carbon emissions was first observed by Slawinski and Bansal (2009). Organizations that are focused on short-term goals tend to be disconnected from the past and future. They are more likely to perceive emerging issues, such as climate change, as trade-offs rather than opportunities for growth. Conversely, companies that take a long-term perspective are more inclined to justify investing more in greenhouse gas reduction efforts with the understanding that this will result in long-term benefits for the organization.

Furthermore, Ganda (2022) and Siddique et al. (2021) both focus on the stakeholder theory framework. In light of increasing pressures from stakeholders and institutions, businesses are expected to adopt and conform to carbon management strategies. A key differentiation factor for companies and an opportunity to achieve long-term financial benefits is to demonstrate and communicate their commitment to addressing climate change issues. This theory underscores the significance of implementing effective carbon management strategies to ensure long-term sustainability and success in a constantly changing business environment. The results of their studies show positive outcomes are over a long time, while negative outcomes are in the short term.

Another important theory is resource-based view or more specifically natural resource-based view, which suggests that firms can gain a competitive edge by utilizing their resources and unique attributes. This approach emphasizes the importance of leveraging all available resources, investments, and differentiating factors. (Tuesta et al., 2021; Alsaifi et al., 2019; Borghei et al., 2018). Other studies are based on legitimacy theory, which that companies consider implementing carbon management strategies as a means to acquire or maintain legitimacy in the eyes of stakeholders. This will ensure compliance with laws and regulations, thus establishing a reputable image for the company (Siddique et al., 2021). This study highlights a positive relationship between a company's carbon disclosure and carbon performance ratings and its financial performance (Ganda, 2018; He et al., 2016), and a negative relationship between a company's direct and indirect emissions indicators and its financial performance (Tuesta et al., 2021).

Our theoretical framework is based on institutional theory, which suggests that coercive forces, such as regulations and regulatory compliance, drive managerial decisions (Tuesta et al., 2021; Ganda 2018; Luo & Tang, 2016). The relationship between a company's carbon management and financial performance can be better understood through the lens of institutional theory. This view helps in comprehending how the physical and social environment can affect the development of a company's dynamic capabilities (Sitompul et al., 2023). The argument is that the connection between environmental strategy and competitive advantage depends on how environmental improvement is perceived, as it differs based on the focus - whether it is pollution prevention, product management or sustainable development.

According to previous studies, corporate sustainable practices are influenced by institutional forces (Moufty et al., 2024; Matten & Moon, 2020; Ansari et al., 2013; Campbell, 2007; DiMaggio & Powell, 1991). In accordance with Institutional theory, companies are examined from the perspective of three different types of pressure (Daddi et al., 2020; DiMaggio & Powell, 1991): coercive, normative and mimetic. Nowadays, institutional theory concentrates on sustainability and scrutinizes how institutions exert pressure on firms and how firms respond to such pressure (Scott, 1995). In essence, it is widely accepted that institutions create pressure on firms to adopt specific practices that can enhance their legitimacy (Moufty et al., 2024; Scott, 1995). In addition, institutional theory has demonstrated its effectiveness in

elucidating the worldwide dissemination of business practices, including sustainability, and their assimilation by organizations (Brammer et al., 2012; Matten & Moon, 2020; Campbell, 2007). The Institutional theory posits that three categories of institutional forces can exert an influence on a corporation's sustainability practices (Moufty et al., 2024). The first type is called coercive and occurs when those in power and authority force the organization to implement certain practices. Secondly, mimetic forces result from imitating the best practices, procedures and structures of successful organizations. Finally, normative forces are linked to the pressure of professionalizing organizational members, their values, and norms.

The theory posits that firms are active actors who are capable of proactively responding to the pressures exerted on them by their surroundings (Scott, 1995). Institutional theory is commonly employed in literature to describe how organizations can establish their legitimacy within their internal, external, and competitive environments. This theory explains the influence of various institutions that can shape the sustainable practices implemented by businesses (Moufty et al., 2024). It can be argued that recognizing sustainability practices as key resources that meet the demands of various stakeholders and providing legitimacy to them encapsulates in the Institutional theory, the theories previously set forth. Summing up, institutional theory argues the institutional context in which businesses operate influences their sustainability practices (Campbell, 2007). However, previous studies have pointed out that due to differences in institutional contexts across countries, the sustainable practices developed by firms tend to vary across nations (Moufty et al., 2024; Campbell, 2007).

In summary, stakeholder and institutional theories shed light on the substantial influence of stakeholders and institutions on companies, compelling them to adopt and adhere to carbon management strategies. By demonstrating and communicating their unwavering commitment to addressing climate change issues, companies can set themselves apart from their competitors and potentially gain sustainable financial benefits in the long term. (Sitompul et al., 2023; Busch et al. 2022). Based on these considerations, we lead to the following hypothesis:

Hp1: Carbon emissions have a negative impact on a company's financial outcomes.

The current hypotheses have been divided into 3 hypotheses as follows:

Hp1a: Carbon emissions have a negative impact on a company's earnings before interests, taxes, depreciation and amortization.

Hp1b: Carbon emissions have a negative impact on a company's enterprise value.

Hp1c: Carbon emissions have a negative impact on a company's Tobin's q.

2.2. *Climate finance and Carbon offsets/credits*

According to The Intergovernmental Panel on Climate Change (IPCC) report of 2023, increased availability and access to financing will facilitate the acceleration of climate action. To address the growing climate risks and support investments in emissions reduction, it is

imperative to significantly increase both adaptation and mitigation finance. The sources of finance can be diverse, including public or private, local, national, or international, bilateral or multilateral, and alternative sources (IPCC, 2023). One such source is carbon offsets/credits. Climate finance, more specifically carbon finance, is currently the core issue in this context. Due to the absence of a globally recognized definition of climate finance, it can be broadly defined as all funds provided and mobilized by the governments of developed countries (through public or voluntary initiatives) for mitigation actions related to climate change (Michaelowa et al., 2022).

Carbon offsets/credits, as a climate finance tool, have become a popular instrument in global efforts to mitigate climate change (Calel et al., 2021). They work by offering regulated polluters the opportunity to reduce their own emissions by subsidising equivalent emission reductions through other initiatives (Michaelowa et al., 2022). These tools are part of the world's largest carbon offset program in the world, called the Clean Development Mechanism (CDM), established as part of the Kyoto Protocol in 1997. As part of the program, companies that are responsible for polluting can meet their obligation to reduce emissions by financing emission reduction projects that are equivalent in nature, even if they are not directly connected with the company's core business (Calel et al., 2021).

Carbon credits and carbon offsets are often used interchangeably, but they are different products with distinct purposes. A carbon offset refers to the removal of greenhouse gases from the atmosphere, to compensate for emissions that have already occurred; while a carbon credit represents a way of buying the right to release carbon (Hume, 2023; Calel et al., 2021). These credits and offsets are commonly used to balance emissions that are difficult to remove, and they have become an essential element of corporate sustainability initiatives, directly connected with climate management strategies. More specifically, a carbon credit denotes a reduction of 1 metric ton in greenhouse gas emissions to offset emissions made elsewhere (Gurgel, 2022). This credit can be bought, sold, or traded until it is retired, signifying that it can no longer be traded. Also, it is important to note that carbon credits are a result of mandatory regulations, while carbon offsets are voluntary measures taken to reduce carbon emissions. For the purpose of the research, a generic variable is used for carbon offsets/credits without making a distinction between them. Based on these considerations we lead to the following hypothesis:

H_{p2}: Climate finance tools are a moderator of the relationship between carbon emissions and company financial outcomes.

3. Methodology

3.1. Sample, data collecting and research design

As stated by Sitompul (2023), carbon emission has a large negative influence on financial performance, however implementing carbon management techniques could improve performance. Starting from this point of view, we built our analysis on a worldwide sample of firms (Siddique et al., 2021). The sample includes companies with carbon offsets/credits for

the last 5 fiscal years, involved in all industries (energy, utilities, industrials, materials, information technology, communication services, health care, real estate, consumer discretionary and consumer staples) except the financials (Luo, 2019). Table 1 shows the distribution of the companies in the sample, classified through industry sector, following the Global Industry Classification Standard (GICS), and the continent where the headquarters is located. The industrial sector comprises the highest number of firms, with 18.26% of the sample, followed by the consumer discretionary sector (13.04%), the energy sector (11.30%) and the information technology sector (11.30%). The materials sector has the lowest number of companies in the sample (4.35%). Europe has the highest number of companies, accounting for 38.26% of the sample, followed by North America (United States of America and Canada) with 31.30% of companies in the sample.

Continent	GICS Sector										Total of companies	% of Total
	Energy	Utilities	Industrials	Materials	Information Technology	Communication Services	Health Care	Real Estate	Consumer Discretionary	Consumer Staples		
Europe	7	4	8	2	3	6	4	2	7	1	44	38.26%
North America	4	4	5	2	7	3	3	1	3	4	36	31.30%
South America	1	3	2	-	-	-	-	-	-	1	7	6.09%
Asia	1	-	6	1	2	1	-	2	4	4	21	18.26%
Australia	-	1	-	-	1	-	1	2	1	-	6	5.22%
Africa	-	-	-	-	-	-	-	1	-	-	1	0.87%
Total of companies	13	12	21	5	13	10	8	8	15	10	115	100%
% of Total	11.30%	10.43%	18.26%	4.35%	11.30%	8.70%	6.96%	6.96%	13.04%	8.70%	100%	

- Table 1 -
Distribution of sample companies by sector and country

To create panel data, the data were collected between 2018 and 2022. Time series and cross-section data are gathered for multiple years and multiple individuals in the panel data analysis. Hsiao (2007) outlined several advantages of panel data studies over cross-sectional or time series studies: (i) more sample variability and degrees of freedom for a more precise inference of model parameters; (ii) enhanced control of unobserved heterogeneity, the primary cause of bias in omitted variables; (iii) more effective estimation which allow the application of models with fixed and random effects; (iv) improved dynamic relationship modelling using time-varying variables and (v) improved ability to deduce the cause of the variation in the variables. Panel data analysis can be conducted through four different techniques: (i) fixed effect models; (ii) random effect models; (iii) pooled analysis and (iv) dynamic panel models. The goal of the analysis and the issues surrounding the assumptions of the regression model's error term (ϵ_{it}) are the core for defining which model is best (Alsaifi et al., 2020). Our choice for the model and related tests are explained in the results paragraph.

Previous studies on carbon emissions and financial performance based their analysis only on a single country (Delmas et al., 2015; Alsaifi et al., 2020; Ganda, 2022; Meng et al., 2023) focusing on both non-developing countries and developing countries. However, carbon offsets/credits are still a young and growing climate finance tool. Therefore, for our analysis, we focused on a worldwide sample. Our data collection is based on Thomson Reuters database, according to previous studies (Qian, 2020; Tuesta et al., 2021; Palea and Santhia, 2022). The

worldwide sample ensures the homogeneity of the sample. Companies with a market capitalization of less than 10 billion US dollars were excluded (Kaplan and Ramanna, 2021). We focused this research on large-cap, generally well-established and with a solid track record of performance, which makes them less risky (Eun et al., 2008). After applying the filters, we have a sample of 115 public companies.

Variables		Definition	References
Dependent variable	EBITDA	Earnings before interests, taxes, deprezation and amorttization	Guastella et al., 2022
Dependent variable	TQ	The ratio of the market value of a firm's assets (as measured by the market value of its outstanding stock and debt) divided by the replacement cost of the firm's assets (book value).	Ganda, 2022
Dependent variable	EV	Enterprise value	Borghei et al. 2018
Independent Variable	CO2Em	Report the company emission in tons	Busch et al., 2022
Moderator Variable	CC	Carbon Offsets/Credits of the company tons	Mark et al., 2023; Heal, 2022; Betz et al., 2022;
Control Variable	MktCap	Market capitalization	Qian et al., 2020
Control Variable	Size	The natural logarithm of total assets	Siddique et al., 2021
Control Variable	Lev	Ratio between financial debt and total equity	Tuesta et al., 2021
Control Variable	Empl	Number of employee	Busch et al., 2022
Control Variable	inflation	Inflation level of the country where headquarter is located	Agyapong et al., 2024
Control Variable	Industry	Dummy variable: 1 manufacturing, 0 services	Nishitani et al., 2017
Control Variable	Europe	1 if firm headquarter is located in Europe, 0 otherwise	Tuesta et al., 2020; FernándezCuesta et al., 2019
Control Variable	Australia	1 if firm headquarter is located in Australia, 0 otherwise	Tuesta et al., 2020; FernándezCuesta et al., 2019
Control Variable	NorthAmerica	1 if firm headquarter is located in North America, 0 otherwise	Tuesta et al., 2020; FernándezCuesta et al., 2019
Control Variable	SouthAmerica	1 if firm headquarter is located in South America, 0 otherwise	Tuesta et al., 2020; FernándezCuesta et al., 2019
Control Variable	Africa	1 if firm headquarter is located in Africa, 0 otherwise	Tuesta et al., 2020; FernándezCuesta et al., 2019
Control Variable	Asia	1 if firm headquarter is located in Asia, 0 otherwise	Tuesta et al., 2020; FernándezCuesta et al., 2019

- Table 2 -
Variables' description

3.2. *Variables description*

In order to test our hypotheses, we followed the methodologies of previous research in carbon management studies and used widely accepted variables from the literature (Sitompul et al., 2023). Prior research adopts different strategies for evaluating the effects of carbon

management issues on companies' performance in general (Busch et al., 2022; Ganda, 2022; Siddique et al. 2021), for instance evaluating the effects of carbon emission disclosure on firms' financial performance. For our analysis, following previous studies, we used carbon emission, carbon offsets/credits and financial performance variables developed by Thomson Reuters. All of our variables are summarized in Table 2.

3.2.1 *Dependent variables*

Existing studies frequently use accounting and market-based measures interchangeably to assess the impact of carbon emissions on financial performance (Tuesta et al., 2020; Delmas et al. 2015). Although both approaches could seem similar, they are not completely interchangeable. Accounting measures such as Return on Assets (ROA) and Return on Equity (ROE) are frequently used to evaluate short-term impacts (Busch et al., 2022; Tahat and Mardini, 2021), such as higher operating costs and higher cost of capital (Choi and Luo, 2021). Alternatively, market-based measures, such as Tobin's q, reflect investors' long-term perceptions of a firm's management practices and its performance forecasts (Ganda, 2022; Tuesta et al. 2021). We use EBITDA, Tobin's q and Enterprise value (Guastella et al., 2022; Borghei et al. 2021). The first variable is from the accounting side to approximate short-term perspectives and the second two variables are from the market-based side to evaluate long-term perspectives. However, we use both for different objectives: offer additional insight to evaluate financial performance, and as a tool for assessing the robustness of the results.

EBITDA is used as profitability measures, in order to evaluate the effect of carbon emissions on companies' operating performance. As suggested by literature review carbon emissions could potentially erode performance by deteriorating the contractual conditions and/or increasing their costs (Guastella et al., 2022). Tobin's q is a ratio that compares a company's market value to the cost of replacing its assets. It takes into account intangible attributes that are not captured by accounting-based measures, making it a more accurate reflection of a firm's market value (Ganda, 2022; Delmas et al., 2015). Using enterprise value as a variable of financial performance reflects a firm's value and is related to market-based measures (Borghei et al. 2018). We adopt it to evaluate if carbon emissions could harm firm value.

3.2.2 *Independent variable*

As independent variables, we used CO₂ emission in tonnes (CO₂Em) from Thomson Reuters (Busch et al., 2022; Tuesta et al. 2021; Tahat and Mardini, 2021; Jayasundara et al., 2019). The measure represents the direct emissions of a company's sources, classified according to the greenhouse gas (GHG) protocol for emission types. The emissions include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorinated compounds (PFCs), sulfur hexafluoride (SF₆), and nitrogen trifluoride (NF₃), which are owned or controlled by the company. Many previous studies use this variable as a measure of GHG

emission reduction to evaluate the effect of reduction in emissions on companies' financial performance (Ganda, 2022; Tuesta et al., 2020). Our research aims to evaluate the impact of carbon emissions on financial performance and assess the effectiveness of climate finance tools such as carbon offsets/credits (our moderator variable) in reducing the impact.

3.2.3 *Moderator variable*

Carbon offsets/credits (CC), established by Kyoto Protocol, are instruments used for offset emissions largely widespread during the last years as a tool for mitigating greenhouse gas emissions (Mark et al., 2023; Heal, 2022; Betz et al. 2022). It is our moderator variable. Carbon offsets/credits represent the equivalent of the CO₂ offsets, credits and allowances in tonnes purchased and/or produced by the company during the fiscal year. Some companies in certain sectors are regulated to a specific limit of emissions. If they exceed this limit, they can purchase carbon credits to balance it out. Alternatively, if they emit less than their limit, they can sell their remaining allowance. It's important to note that only purchased and produced carbon credits are taken into account (Heal, 2022).

3.2.4 *Control variables*

By incorporating a range of pertinent control variables, we were able to account for the influence of various firm characteristics and financial variables, thereby avoiding the issue of omitted variables (Smelser and Baltes, 2001). This approach aligns with previous studies and enhances the reliability of our analysis. It is widely recognized that companies with greater market capitalization have more resources to invest in carbon reduction strategies. These strategies have the potential to impact on carbon emissions and consequently on financial performance. Also, market capitalization reflects investor expectations of a company's future performance. Effective carbon reduction strategies can increase market capitalization (Qian et al., 2020). Additionally, larger companies are better equipped to manage the risks associated with carbon emissions, such as regulatory, reputational, and physical risks related to climate change (Palea and Drogo, 2020). First, we control for market capitalization (MktCap) to better isolate the relationship between carbon emissions and financial performance, ensuring reliable and robust findings. We also examined the impact of firm size, which we measured as the natural logarithm of total assets. Larger companies generally have more resources to invest in both carbon emission reduction and carbon offsets or credits (Siddique et al., 2021). By using a logarithmic scale, we were able to mitigate the high standard deviation caused by the difference between smaller and larger companies. Furthermore, we took into account the leverage ratio (Lev), which is the proportion of external financing sources compared to the company's equity (Tuesta et al., 2021). This ratio is known to impact a company's focus on its shareholders and creditors, which ultimately affects the success of its carbon emissions reduction efforts. We also consider the inflation rate (inflation) of the country where the company's headquarters are located to account for the difference in the size of the economy of

each country. This is important because the inflation level could impact the relationship between our independent and dependent variables (Li et al., 2021). Larger economies may have different characteristics than smaller ones, such as a more diverse range of industries, more robust financial markets, and more complex regulatory environments (Choi and Luo, 2021). Moreover, the inflation level can influence companies' operating costs and spending priorities (Agyapong et al., 2024). By controlling for inflation, we can isolate the effect of these characteristics and obtain more accurate results. Moreover, as part of our analysis, we looked at the industry sector of the company (Industry). To do this, we followed the methods used in previous studies (Nishitani et al., 2017) and created a dummy variable with a value of 1 for manufacturing companies and 0 for service companies. Finally, in order to take into account, the local context, we have incorporated dummy variables that help identify the geographic locations of company headquarters (Siddique et al., 2021; Tuesta et al., 2020; Fernández-Cuesta et al., 2019). Specifically, we have considered the six continents: Europe, North America, South America, Australia, Asia, and Africa.

4. Results

4.1. Descriptive analysis

The data summary of the sampled companies is shown in Table 3 below. The dependent variable with the highest mean value is earnings before interest taxes, depreciation, and amortisation (EBITDA) at $9.32e+09$, followed by EV at about $1.47e+11$ and Tobin's Q at 2183449. The variables were not normalised to avoid any influence on the regression results (Siddique et al., 2021). The range for carbon emissions (CO2Em) is 0 to $1.48e+0.8$, and for carbon offsets/credits (CC) is 0 to $2.09e+0.7$. Thus, It is essential to highlight the objective of implementing initiatives to reduce carbon emissions. Notably, the maximum value of CC, which represents the total carbon footprint, is higher than CO2Em, which only reflects direct emissions. This finding demonstrates that there is a collective effort to reduce carbon footprint beyond the direct emissions of individual companies. However, the mean of the two variables is different. CC has higher CO2 than CO2Em, which suggests significant interest in the firms' carbon-reduction initiatives. It is worth noting that the mean carbon emissions stand at 5150295. On average, companies undertake 766029.7 activities aimed at reducing these emissions, which, in turn, is reflected in their mean carbon offsets/credits.

4.2. Correlations

The present article employs a set of variables that exhibit a one-to-one relationship with each other. This relationship is represented in Table 4, the correlation matrix, which is included below. It is clear that there is a negative direct association between carbon emissions (CO2Em) and the dependent factors (EBITDA, TQ, and EV) in all cases.

Variable	Obs	Mean	Std. dev.	Min	Max
CC	575	766209.7	2520208	0	2.09e+07
CO2Em	570	5150295	1.59e+07	0	1.48e+08
EBITDA	575	9.32e+09	2.22e+10	-7824311	1.93e+11
TQ	570	2183449	4013615	0.007	4217954
EV	575	1.47e+11	5.57e+11	7.56e+08	5.19e+12
MktCap	570	8.33e+10	3.00e+11	1.18e+07	2.47e+12
Size	575	23.788	1.499	18.755	27.459
Lev	575	.813	0.334	0.004	1.982
Emplo	575	50747.6	79126.85	30	543000
inflation	575	1.92	19.41	-60.4	66.8
Industry	575	0.313	0.773	0	1
Europe	575	0.383	0.486	0	1
Australia	575	0.052	0.223	0	1
NorthAmerica	575	0.313	0.464	0	1
SouthAmerica	575	0.061	0.239	0	1
Africa	575	0.009	0.093	0	1
Asia	575	0.183	0.387	0	1

- Table 3 -
Descriptive statistics

According to our research, we have found that there exists a statistically significant and positive correlation (coefficient = 0.339, p-value = 0.000) between carbon offsets/credits (CC) and carbon direct emissions (CO2Em). Our analysis suggests that companies with higher carbon emissions tend to have more carbon offsets/credits, which can be attributed to regulatory requirements or private initiatives. Financial performances (EBITDA, TQ and EV) decrease as carbon emissions (CO2Em) increase (correlation coefficient = -0.2010, p-value = 0.000 for EBITDA). These findings suggest that ignoring to reduce emissions could have a detrimental impact on financial performance. Furthermore, the finding aligns with existing literature, which suggests that many firms choose to reduce their carbon emissions voluntarily as a means to enhance their financial performance (Busch et al., 2022; Tuesta et al., 2021; Tahat and Mardini, 2021; Jayasundara et al., 2019; Nishitani et al., 2017; Rokhmawati et al., 2017). Moreover, the correlation coefficient between carbon offsets/credits and financial performances is positive and significant (for instance with EBITDA, the correlation coefficient = 0.064, p-value = 0.000), so investing in climate finance tools to reduce carbon emissions has been observed to have a positive impact on a company's overall performance. Companies with headquarters in Europe, North America, Asia, Australia and Africa are negatively correlated with carbon emissions (correlation coefficient between carbon emissions and Europe = -0.037, p-value = 0.000), compared with companies with headquarters in South America which is positively correlated (correlation coefficient between carbon emissions and South America = 0.258, p-value = 0.000). This difference could be due to variations in regulatory frameworks or less stringent regulations in different geographic areas. However, the correlation between these variables is not really significant.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) CC	1.000																
(2) CO2Em	0.339*	1.000															
(3) EBITDA	0.064	-0.210*	1.000														
(4) TQ	0.063	-0.059	0.065	1.000													
(5) EV	0.019	-0.021	0.454*	0.052	1.000												
(6) MktCap	0.017	-0.013	0.906*	0.145*	0.502*	1.000											
(7) Size	0.113*	-0.376*	0.940*	0.002	0.382*	0.778*	1.000										
(8) Lev	0.037	-0.099*	-0.125*	0.096*	0.006	-0.123*	-0.118*	1.000									
(9) Emplo	-0.025	0.362*	0.325*	-0.009	0.107*	0.232*	0.411	0.153*	1.000								
(10) inflation	0.021	-0.132*	0.077	0.022	-0.119*	0.029	0.031	0.011	0.042	1.000							
(11) Industry	0.074	0.007	-0.127*	-0.161*	0.009	-0.047	-0.137*	-0.027	-0.185*	-0.209*	1.000						
(12) Europe	0.128*	-0.037	-0.099*	0.084*	-0.141*	-0.139*	-0.084*	0.138*	-0.116*	-0.139*	-0.128*	1.000					
(13) Australia	-0.070	-0.076	-0.094*	0.007	-0.059	-0.063	-0.096*	-0.031	-0.146*	-0.511*	0.143*	-0.185*	1.000				
(14) NorthAmerica	-0.106*	-0.026	0.266*	0.029	0.097*	0.309*	0.229*	-0.038	0.191*	0.117*	0.032	-0.531*	-0.158*	1.000			
(15) SouthAmerica	-0.023	0.258*	-0.015	-0.078	0.307*	-0.059	-0.003	-0.051	0.063	-0.537*	0.155*	-0.201*	-0.059	-0.172*	1.000		
(16) Africa	-0.028	-0.030	-0.038	-0.020	-0.000	-0.026	-0.049	0.042	-0.060	-0.199*	0.125*	-0.074	-0.022	-0.063	-0.024	1.000	
(17) Asia	0.028	-0.033	-0.121*	-0.091*	-0.094*	-0.114*	-0.099*	-0.088*	-0.024	0.705*	-0.086*	-0.372*	-0.111*	-0.319*	-0.121*	-0.044	1.000

- Table 4 -
Correlations matrix

4.3. Regression analysis

To test our research hypotheses, we ran the generalized least squares random-effect model. Despite the propensity for fixed effect models to be employed more frequently in social studies, it has been observed that there has been a marked increase in the utilization of random effects models (Guestella et al., 2022; Tuesta et al. 2020; Alsaifi et al. 2020).

In contrast to the fixed effect model, the random effect framework posits that the individual-specific effect is a random parameter that is not tied to the independent variables. Yet, when the individual-specific effect is indeed uncorrelated, the random effect framework is the superior choice over the fixed effect framework. (Ganda, 2022).

Moreover, as highlighted by Bell and Jones (2015), if the assumptions of random effect models are correct, then the random effect is the preferred choice due to its increased flexibility and generalizability. The application of the Hausman test is limited to homoscedasticity and is unable to account for fixed effects. So, we performed a Hausman test (Hausman, 1978) to determine the best model for our data. Based on the Hausman test, it is determined that the optimal model for our study is the random effects model. By employing this methodology, we can utilize a random effects model to accommodate unobserved variability between firms that could influence our independent and dependent variables.

This approach helps to direct the focus of the investigation. Furthermore, this model assumes that these unobserved differences are random and do not correlate with the independent variables. Our hypotheses were examined through the application of the regression models outlined below.

$$EBITDA_t = \beta_0 + \beta_1 CO2Em_t + \sum_i \beta Control + u_i + e_{it}$$

(Model 1)

$$TQ_t = \beta_0 + \beta_1 CO2Em_t + \sum_i \beta Control + u_i + e_{it}$$

(Model 2)

$$EV_t = \beta_0 + \beta_1 CO2Em_t + \sum_i \beta Control + u_i + e_{it}$$

(Model 3)

The results of regression analyses are organized in Table 5. In all four of the previous hypotheses, we suggested that carbon emissions (CO2Em) have a negative impact on financial outcomes Model 1 presents the random effects estimates using EBITDA as the dependent variable to test Hypothesis 1a. As hypothesized, carbon emissions have a negative and significant effect on EBITDA ($p < 0.01$). Specifically, a 1% increase in emissions leads to a 0.7543 (b1) decrease in EBITDA. Furthermore, Hypothesis 1b in Model 3 found that carbon emissions also have a significant negative effect on EV. A 1% increase in carbon emissions

decreases EV by 11.0033 (b3) ($p < 0.01$). Finally, in Model 4, we confirm Hypothesis 1d, which states that carbon emissions have a negative impact on the company's Tobin's q (TQ).

	Model 1 (EBITDA)	Model 2 (EV)	Model 3 (TQ)
CO2Em	-75.426*** (0.005)	-1100.332** (0.000)	-0.022* (0.075)
CO2Em '19	-10.201** (0.041)	-449.501* (0.060)	-0.002*** (0.006)
CO2Em '20	-21.190** (0.012)	-338.827** (0.035)	-0.082** (0.054)
CO2Em '21	-8.411* (0.087)	-289.089** (0.027)	-0.009*** (0.003)
CO2Em '22	-10.922* (0.072)	-385.196** (0.046)	0.005** (0.037)
inflation	-0.318* (0.061)	0.172** (0.031)	-0.216** (0.063)
MktCap	0.031*** (0.000)	0.942*** (0.000)	1.892*** (0.000)
Size	0.144*** (0.000)	-0.089*** (0.002)	-5.692*** (0.000)
Lev	-1.219 (0.250)	-0.816 (0.206)	1.805*** (0.000)
Emplo	-7986.866 (0.142)	-144738.1** (0.011)	7.227 (0.143)
Sector	-0.029 (0.118)	0.069 (0.686)	-0.020 (0.116)
Europe	1.053 (0.145)	0.585 (0.472)	-1.102** (0.020)
NorthAmerica	1.472* (0.072)	1.036 (0.112)	-0.485 (0.203)
SouthAmerica	1.087** (0.010)	2.757 (0.110)	-3.384*** (0.001)
Australia	-0.144 (0.526)	0.512 (0.775)	-3.484*** (0.001)
Asia	1.301 (0.275)	-0.074 (0.548)	-0.982 (0.141)
Africa	-0.594 (0.153)	4.185** (0.023)	-3.155*** (0.003)
_cons	19.325*** (0.000)	21.080** (0.043)	1.809* (0.094)
Observation	564	564	564
R_squared	0.705	0.371	0.567
Adjusted R	0.697	0.371	0.556
Wald chi2	92.37 0.000	35.24 0.000	50.74 0.000

Values in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

- Table 5 -

Random Effects Regression Analysis of Carbon Emissions on EBITDA, EV and Tobin's q

The coefficient is significant ($p < 0.1$). Exactly, a 1% increase in carbon emissions leads to a decrease in TQ by 0.00022 (b4). Furthermore, when examining the data for specific years, the regression analysis revealed that the COVID-19 pandemic had a significant impact on the accounting variable EBITDA. It showed a reduction in the negative impact of emissions on financial performance during the middle years of the pandemic (2021 and 2022). However, in

terms of market indicators EV and TQ, this effect was not observed. Instead, the impact remained relatively consistent across the survey years, despite the pandemic's significant effects. Based on the results, Hypotheses 1 and 2 are strongly supported. The regression models indicate significant negative effects ($b_1 = -0.7542$; $b_2 = -0.6208$; $b_3 = -11.0033$) with p-values less than 0.01 for all three models. As a result, we can confirm all our hypotheses.

In terms of the control variables, we obtained positive and significant outcomes for market capitalization ($b_1 = 0.00031$, $p < 0.01$; $b_2 = 0.00942$, $p < 0.01$; $b_3 = 0.01892$, $p < 0.01$). Additionally, we observed both positive and negative results for size ($b_1 = 0.00144$, $p < 0.01$; $b_2 = -0.00089$, $p < 0.01$; $b_3 = -0.05692$, $p < 0.01$). These two control variables are directly correlated with our dependent variable. There are no significant results for our dependent variables based on the geographical localization of headquarters. In conclusion, there is no consistent significant impact on the other control variables.

Furthermore, in Models 4 to 6, we examined whether carbon offsets/credits (CC) moderators affect the relationship between carbon emissions and financial performance, as proposed by Hypothesis 2. First of all, Table 6 shows that Carbon offsets/credits (CC) have a positive impact on financial performance ($b_1=0.3199$; $p<0.05$; $b_2 =1.2794$; $p<0.01$), except for the firm's Tobin's q ($b_3=-0.0172$; $p<0.1$). It is interesting to note that when carbon credits/offsets (CC) are added to the model, the impact of carbon emissions (CO₂Em) is still significant, but the effect is weaker ($b_1 = -1.0206$; $p<0.1$; $b_2 = -13.1012$; $p<0.01$).

The interaction term between carbon emissions (CO₂Em) and carbon offsets/credits (CC) is positively and significantly related to financial outcomes ($b_1 = 0.0884$; $p<0.1$; $b_2 = 0.0009$; $p<0.01$), still except for firm's Tobin's q ($b_3=-0.04501$; $p<0.1$). Additionally, the interaction term shows that the joint effect of carbon offsets/credits and carbon emissions is positive and significant. This implies that carbon offsets/credits help in reducing the negative impact of carbon emissions on the company's performance. Also, this improvement is sufficient to increase the performance of the company. The analysis was expanded to include the impact of the COVID-19 pandemic. The regression analysis revealed a more pronounced effect in the years leading up to the pandemic (2018, 2019, and 2020), indicating a decline during the pandemic years (2021 and 2022) in terms of EBITDA and EV. In relation to Tobin's, there was a reduction in the moderating effect of carbon credits/offsets in the pre-pandemic years, while an increased significance was observed in the post-pandemic years. Therefore, considering the positive and significant association between the interaction term of CO₂Em and CC with financial performance, we can accept Hypothesis 2.

In terms of the accuracy of the models, the main econometric models (including hypotheses 1 and its variations) show an R-squared range of 0.705 to 0.371 and an adjusted R-squared range of 0.697 to 0.371. Additionally, the Wald chi test is statistically significant with a value between 92.37 to 35.24. Finally, in random effects regression analysis with carbon offsets/credits as a moderator (hypothesis 2), which are referred to as models 5 to 8, the R-squared range is between 0.665 to 0.261, and the adjusted R-squared range is between 0.632 to

0.259. The Wald chi test is significant with a value between 6288.84 to 35.43. Overall, the model provides a satisfactory level of detail.

	Model 4 (EBITDA)	Model 5 (EV)	Model 6 (TQ)
CO2Em	-102.059* (0.094)	-1310.919** (0.042)	-1.875* (0.073)
CO2EmXCC	8.836** (0.020)	0.088*** (0.000)	-4.501** (0.050)
CO2EmXCC '19	1.232** (0.032)	0.032*** (0.009)	0.017* (0.099)
CO2EmXCC '20	2.258** (0.019)	0.079** (0.011)	0.013 (0.110)
CO2EmXCC '21	1.273* (0.051)	0.009** (0.033)	0.141*** (0.001)
CO2EmXCC '22	1.11* (0.057)	0.012** (0.027)	0.297** (0.012)
inflation	-7.217** (0.017)	3.208* (0.074)	0.738* (0.090)
MktCap	0.031*** (0.000)	0.921*** (0.002)	6.721*** (0.000)
Size	0.143*** (0.000)	-0.098 (0.142)	-1.311*** (0.000)
Lev	6.208 (0.106)	4.539* (0.051)	1.772*** (0.000)
Emplo	-6452.675 (0.345)	-124753.7 (0.473)	-2.876 (0.254)
Sector	-2.720 (0.110)	-6.782 (0.446)	-0.309** (0.030)
Europe	-3.757 (0.661)	4.031 (0.817)	1.562 (0.171)
NorthAmerica	4.017 (0.973)	2.611 (0.711)	1.176 (0.326)
SouthAmerica	1.159 (0.560)	8.421 (0.225)	1.416 (0.465)
Africa	-1.126 (0.472)	1.521*** (0.000)	1.116 (0.792)
Australia	-3.161 (0.111)	-2.139 (0.935)	2.019 (0.324)
Asia	-4.587 (0.960)	-7.051 (0.260)	-1.407 (0.100)
_cons	2.969* (0.054)	5.218 (0.261)	1.567 (0.246)
Observation	564	564	564
R_squared	0.665	0.369	0.261
Adjusted R	0.632	0.369	0.259
Wald chi2	1471.31	791.92	35.43
	0.000	0.000	0.000

Values in parentheses: *p < 0.1, **p < 0.05, ***p < 0.01.

- Table 6 -
Random Effects Regression Analysis with Carbon Offsets/Credits as Moderator

5. Conclusion

Organizations face a considerable risk today due to climate change (Cohen, 2023). It is widely recognized that the unmitigated emissions of greenhouse gases could accelerate the rise in temperature, leading to a heightened frequency and severity of extreme weather events that could adversely impact businesses and communities (Palea & Santhia, 2022; Choi & Luo, 2021). In order to ensure the sustainability of businesses, it is crucial to assess their overall profitability, taking into account factors such as CO₂ consumption, which are linked to sustainability practices and financial performance (Wang, 2023; Tuesta et al., 2021; Borghei et al, 2018). A company's management strategies for addressing climate change are particularly important, as greenhouse gas (GHG) emission levels are a key indicator of its carbon performance (Busch et al., 2022). By analyzing both direct and indirect GHG emissions, it is possible to gauge environmental performance (Guastella et al., 2022). Additionally, it is worth noting that different scopes of emissions are subject to regulations that can directly or indirectly impact the types of stakeholders involved, as well as a company's financial performance (Tuesta et al., 2021).

In this landscape, the use of climate finance tools to mitigate the negative effect of companies on the environment while simultaneously improving financial performance is becoming increasingly popular (Michaelowa et al, 2022). However, there is a paucity of research on climate finance tools serving business and related sustainability practices. In particular, the literature focuses on the effects on carbon emissions levels in different systems, mainly economic, environmental and political (Betz et al., 2022; Alsaifi et al., 2020). The number of studies available with regard to a specific climate finance instrument, such as carbon credits/offsets, is significantly lower (Calel et al., 2021; Fan et al., 2021). Many studies have investigated the relationship between financial and environmental performance, with a focus on carbon emissions (Li et al., 2021; Alsaifi et al., 2020; Jayasundara et al., 2019). There are two main approaches to this topic. The first approach analyzes how reducing CO₂ emissions affects a company's economic performance and its impact on environmental performance (Başar & Tosun, 2021; He et al., 2016). It also examines the influence of a company's environmental certifications. The second approach looks at regulated environments such as the Emissions Trading System (ETS) and studies the voluntary participation of companies in such programs (Yan et al., 2020; Borghei et al., 2018).

Our current research delves into the relationship between climate finance tools and corporate financial performance. We aim to investigate and analyze the potential connection between the two and provide insights into the topic. We seek to examine how climate finance tools, particularly carbon offsets/credits, can influence this relationship. Our hypothesis draws from the Institutional theory (Tuesta et al., 2021; Ganda 2018; Luo & Tang, 2016), stating that the investment programs of enterprises are intrinsically linked to the mandatory requirements in the sustainability field. Moreover, our proposed theoretical framework is designed to evaluate the efficacy of carbon offset/credit programs in mitigating carbon emissions within

the framework of government policies, market dynamics, and societal norms (Trouwloon et al., 2023). The literature has limited evidence on the connection between climate finance tools and the financial benefits of investing in them to improve companies' environmental performance and GHG emission reduction. Our research aimed to bridge the gap in knowledge that existed on this topic. In order to validate our hypotheses, we conducted an empirical analysis of data from nearly 100 companies worldwide, spanning the years 2018 through 2022, which implemented carbon credits and offsets.

This study presents an analysis of carbon credits/offsets in a transnational context and contributes to the existing literature on sustainability practices and climate finance. The research findings provide valuable insights into the use of carbon credits/offsets as a climate finance tool. Our research findings are in line with previous studies, which indicate that carbon emissions have a statistically significant negative impact on financial performance (Busch et al., 2022; Alsaifi et al., 2020; Borghei et al., 2018). Our study examined four key performance indicators, namely EBITDA, EV, and TQ, and found that companies with more sustainable practices and lower carbon emissions tend to experience fewer economic losses. As part of our research, we have introduced an innovative component: carbon credits/offsets as a moderating variable in the analyzed relationship. The data we have gathered suggests that the implementation of climate finance instruments, such as carbon credits/offsets, not only mitigates the negative impact of carbon emissions but also has the potential to reverse it, leading to a positive and statistically significant influence. The analysis conducted reveals that even during the COVID-19 pandemic, when there was a decrease in emissions, the effects observed are similar but with changing levels of impact.

The present study aims to provide a comprehensive outlook on how climate finance instruments, such as sustainability practices, can enhance corporate financial performance while simultaneously addressing environmental concerns. The outcome of our research has revealed significant practical implications for managers, investors, and policymakers. In today's business landscape, managers tasked with addressing environmental risks can leverage a range of tools to implement sustainable practices without imposing a financial strain on their company. As a result, sustainability is increasingly recognized as a valuable practice that can enhance both environmental outcomes and overall financial performance. Also, investors enjoy enhanced capabilities to assess investments founded on sustainable practices. They have at their disposal a wide range of tools to evaluate diverse investments and steer clear of companies that engage in greenwashing - the practice of falsely claiming sustainability for the sole purpose of gaining recognition without implementing sustainable practices. Finally, there is a growing call for policymakers to incentivize companies to adopt sustainable practices. One approach is to establish laws that support environmentally conscious businesses and ensure compliance. These companies can significantly influence the entire system, and a more comprehensive set of guidelines and effective monitoring can further encourage their proactive efforts.

Government-led initiatives can play a critical role in driving these companies to take the necessary actions.

In conclusion, our study has an important theoretical implication emphasizing the importance of institutional theory and the institutional framework in a sustainability context. We recognized the importance of climate finance tools, highlighting their financial and environmental impact. In order to achieve institutional climate goals, it is crucial to increase financing for both adaptation and mitigation. This is because finance, international collaboration, and technology are critical factors in accelerating climate action (IPCC, 2023). The findings of our study reveal that the efficacy of climate action is contingent upon a confluence of factors, namely political commitment, well-aligned multi-level governance and institutional frameworks, laws, policies, and strategies. It requires clearly defined objectives, adequate funding, and financing tools. These findings are in line with the theoretical precepts of institutional theory, which underscores the significance of institutional frameworks and regulatory structures in shaping collective action. In sum, our study highlights the need for a robust and coordinated approach to climate action that is anchored in sound institutional arrangements, strategic policies, and adequate financing mechanisms.

The current study, similar to other sustainability studies, has a few limitations that should be acknowledged. First, we chose to focus our study on large companies because they have the financial capacity to handle the costs associated with implementing climate finance tools, such as carbon credits/offsets. However, future research could expand to include or concentrate on a sample of smaller companies as climate finance tools become more widespread. In addition, this study is one of the first to examine the use of carbon credits/offsets. Due to the limited use of this tool, the study does not focus on a single geographic area or sector but rather uses a worldwide sample. Therefore, the results could be influenced by the political and legislative dynamics unique to each country.

Finally, with the increasing recognition of the impacts of climate change, there has been a notable uptick in the adoption of decarbonization commitments and the utilization of climate finance tools (Badri et al., 2023). As highlighted by the study, companies are taking swift and decisive action to mitigate greenhouse gas emissions and offset any residual carbon footprints. However, while we have made significant progress so far, it is important to acknowledge that there are still some critical questions that need to be addressed. The primary question is whether companies fund carbon credits/offsets through their marketing or sustainability budgets (Hodgson, 2022). This main question raises a pertinent concern that has gained traction in academic and professional fields, namely the concept of greenwashing. As novel sustainability practices, such as those pertaining to climate finance tools, continue to gain prominence, there is a potential risk of reduced transparency in sustainability initiatives, culminating in an upsurge of greenwashing in its different forms.

CHAPTER III

Carbon Credits and Financial Performance: exploring the moderating role of CSR Strategy and Corporate Governance practices

ABSTRACT

Climate change represents a significant challenge to humanity, necessitating urgent action across all sectors of society. Globally, companies are increasingly vocal about their current climate efforts and future mitigation commitments. This paper delves into the role of Carbon Credits in the context of climate change management, particularly focusing on their impact on financial performance. Drawing on the resource-based view theory and legitimacy theory frameworks, the study examines a sample of worldwide listed companies that adopted Carbon Credits as an emissions reduction strategy. The objective is to investigate the relationship between Carbon Credits and financial performance and to explore the potential influence of CSR strategy and the quality of Corporate Governance as moderating variables. The findings indicate that the reduction of carbon emissions through Carbon Credits has a positive effect on financial performance, with moderator variables influencing this relationship. This research underscores the potential for carbon reduction initiatives, without disruptive changes, to enhance financial performance, offering valuable contributions to both theoretical and practical fields.

Keywords: Climate Finance, Carbon Credits, Carbon Offsets, CSR strategy, Corporate Governance, Financial performance

1. Introduction

Climate change presents an increasing risk to the planet and necessitates urgent and coordinated action by all sectors and stakeholders in society. Unchecked greenhouse gas emissions from human activities are driving unprecedented changes in Earth's climate, with deep implications for ecosystems, economies, and human well-being (Adu et al., 2023; Tansan et al., 2023; Alsaifi et al., 2020). Addressing the multifaceted challenge of climate change requires a concerted effort by governments, businesses, civil society, and individuals. With its influence, resources, and expertise, the financial community also has a crucial role in guiding the transition to a low-carbon, climate-resilient economy. Particularly, Climate finance and carbon finance are two key areas of the financial sector that are particularly relevant to addressing climate change. They provide mechanisms for mobilizing capital, managing risk, and making investment decisions to support climate mitigation and adaptation efforts (Li, 2024; Bolton et al., 2022; Gong et al., 2022).

Recent research underscores that numerous organizations globally have incorporated climate change strategies into their decision-making frameworks in reaction to regulatory requirements and other stakeholders (Issa & Hanaysha, 2023). Nevertheless, the increasing influence exerted by diverse stakeholder groups is not the exclusive catalyst prompting firms to adopt environmentally sustainable practices. Indeed, empirical research indicates that embracing environmentally friendly practices can yield economic advantages, including heightened energy efficiency, lowered operational expenses, enhanced waste management, favourable public relations outcomes, and expanded avenues for investment opportunities (Hakovirta et al., 2023; Homroy, 2023; Kim et al., 2023; Lewandowski, 2017). This underscores how environmental responsibility can contribute to sustained financial prosperity. As a result, companies worldwide are increasingly integrating sustainable measures into their operations to capitalize on these advantages (Issa, 2024).

In the current challenging environment, there is an increasing focus on financial tools aimed at addressing climate change and helping companies adhere to climate regulations. One such tool is carbon credits/offsets, which are designed to assist companies in reducing their emissions and achieving carbon neutrality (Michaelowa et al., 2022). Through this tool, companies that produce pollution can fulfill their emission reduction requirements by funding projects that reduce emissions, even if these projects are not directly related to the company's primary business (Bleuel & Müller, 2024).

The evolving perspectives and actions of stakeholders underscore the growing significance of sustainability in business operations. Over the past decade, there has been a substantial increase in corporate awareness and commitment to environmental and social issues (Deng et al., 2024; Delmas et al., 2015). This shift is supported by empirical evidence demonstrating that implementing climate change management strategies can lead to both emission reduction and improved corporate returns (Hailemariam & Erdiaw-Kwasie, 2023). Sustainability strategies represent distinct resources and capabilities that enable companies to

gain a competitive advantage and establish legitimacy by meeting stakeholder expectations and social norms. This perspective is based on the resource-based view theory, which emphasizes the unique role of sustainability strategies and practices as valuable assets for companies, as articulated by Barney (1991). Additionally, it aligns with legitimacy theory, which emphasizes the need for companies to observe stakeholder expectations and social norms in order to sustain their operations (Dowling & Pfeffer, 1975).

By adopting sustainability strategies to mitigate greenhouse gas emissions, companies can not only help achieve environmental goals but also enhance their business performance (Ganda, 2022; Naranjo Tuesta et al., 2020). Sustainability strategies are often challenging to replicate and can provide a unique competitive advantage to companies. This study is motivated by the potential benefits that companies can derive from embracing sustainability strategies and practices. While several studies have explored this relationship, they have not produced unequivocal evidence (Wang et al., 2014). The importance of this relationship and its results can differ based on the specific metrics utilized to assess both carbon emissions and financial performance.

Moreover, considerable efforts have been dedicated to exploring the connection between sustainability practices and financial performance, emphasizing the impact of key moderating factors (Issa, 2024; Grewatsch & Kleindienst, 2017) such as the quality of corporate governance and the CSR strategy. Empirical evidence shows that a company with a well-developed sustainability strategy will prioritize sustainability-related practices, leading to a positive impact on the implementation of sustainability activities and, consequently, on company performance (Elleuch Lahyani, 2022).

The primary goal of this study is to enhance our comprehension of the connection between carbon reduction initiatives and financial outcomes. By thoroughly analyzing existing research and identifying potential moderating factors, this study seeks to gain new insights into this relationship from an original and innovative perspective. Specifically, it delves into the impact of climate finance and carbon finance instruments, such as carbon credits/offsets, used to achieve carbon neutrality and reduce emissions. The study also considers the potential influence of CSR strategy and the quality of corporate governance as moderating variables. Through this analysis, it seeks to uncover insights into how companies can strengthen the link between their carbon reduction efforts through carbon credits/offsets and financial performance. The study aims to explore the connection between carbon credits/offsets, which are commonly used to achieve carbon neutrality, and financial performance. The research also seeks to explore how variables such as CSR strategy and the quality of corporate governance can affect this association. The goal is to fill gaps in understanding the specific mechanisms and contextual elements influencing this connection, offering practical insights for organizations aiming to achieve both sustainability and financial success.

In order to explore this relationship, we employed the theoretical frameworks of the resource-based view and legitimacy theory. Our analysis involved a global sample of

companies that utilized carbon offsets/credits over a 5-year period (2019-2023). We conducted a longitudinal analysis using the Pooled Ordinary Least Squares (Issa, 2024) model to evaluate the impact of carbon credits/offsets on financial performance. Additionally, we conducted a robust check to validate the obtained results.

The research findings strongly support our theoretical hypothesis. In particular, it highlights that embracing carbon credits/offsets to achieve carbon neutrality has a positive and significant effect on financial performance. Furthermore, we have also observed that the strength of this relationship depends on the effectiveness of CSR strategies and the quality of corporate governance. The results highlight the significance of adopting prompt and clear CSR strategies and robust corporate governance practices in achieving financial benefits through emission reduction efforts. Aligning the implementation of sustainable practices with high-quality governance that addresses stakeholders' concerns, along with adhering to regulatory sustainability requirements, allows companies to attain substantial benefits. These benefits, including financial gains from reduced carbon emissions, can be realized without necessarily undergoing structural changes.

2. Literature review and hypotheses development

An increasing number of global companies are integrating measures to mitigate and address climate change into their decision-making processes in response to regulators and other stakeholders (Issa & Hanaysha, 2023; Kim et al., 2023). Nevertheless, the mounting influence from diverse stakeholder groups is not the only driving force behind companies' adoption of environmentally conscious practices. Research findings suggest that embracing sustainable practices can result in financial gains through enhanced energy efficiency, lowered operational expenses, better waste management, positive public image, and increased investment prospects (Issa, 2024).

It is evident that the excessive carbon emissions represent a significant environmental threat to businesses, increasingly affecting business risk (Alsaifi et al., 2020). Consequently, many companies have begun to take proactive measures to comply with government regulations and embrace best practices in order to preserve their competitive edge and avoid exclusion from the market. Implementing and developing emission trading schemes, carbon taxes or tariffs, and disclosure regulations (Issa, 2024) are among the most crucial methods for managing and reducing GHG emissions. Furthermore, financial instruments such as carbon credits and offsets have gained traction in recent years. However, there remains a lack of detailed regulation on strategies and objectives for corporate responses to climate change. In a global level, the emphasis is on achieving carbon neutrality and curbing temperature increases (Bolton et al., 2022).

Moreover, companies are under growing pressure from stakeholders and regulators to prioritize environmental sustainability, adhere to environmental regulations, and decrease emissions. Corporate efforts to reduce emissions are largely voluntary and are influenced by

their potential impact on profitability (Homroy, 2023). Previous research has explored the connection between climate change management, specifically in relation to carbon emissions, and financial performance or value. However, the findings have been diverse, and there is still no agreement on the precise nature of this correlation (Kim et al., 2023; Fernández-Cuesta et al., 2019; Wang et al., 2014). As per the research by Alsaifi et al. (2020), Fernández-Cuesta et al. (2019), and Wang et al. (2014), the analysis of the correlation between greenhouse gas emissions and a company's financial performance is commonly viewed from two perspectives: win-lose and win-win. In the win-win scenario, a company's efforts to reduce emissions not only benefit the environment but also bolster its competitive advantage. On the other hand, the win-lose approach argues that emission reductions could be expensive and detrimental to a company's competitiveness. Currently, the prevailing view in the literature is the win-win perspective, suggesting that reducing carbon emissions can result in economic benefits for the company. This can lead to new opportunities for profitability and a competitive edge through more efficient use of natural resources (Alsaifi et al., 2020).

Recently, carbon offsets and credits have gained popularity as essential tools in global efforts to address climate change (Trouwloon et al., 2023; Calel et al., 2021). These mechanisms aim to support companies that are unable to reduce their emissions and to expedite emissions reduction for companies actively pursuing carbon neutrality (Martielli & Salvi, 2023; Michaelowa et al., 2022). They are integral components of the Clean Development Mechanism (CDM), established under the Kyoto Protocol in 1997. Through this program, polluting companies can fulfill their emission reduction obligations by financing equivalent emission reduction projects, even if these projects are not directly related to the company's core business (Bleuel & Müller, 2024; Calel et al., 2021). A carbon offset involves the removal of greenhouse gases from the atmosphere to compensate for emissions that have already occurred, whereas a carbon credit allows the purchase of the right to release carbon (Hume, 2023). Specifically, a carbon credit signifies a reduction of 1 metric ton of GHG emissions to offset emissions produced elsewhere (Gurgel, 2022).

Prior research has explored various theoretical perspectives, either as a single theory (Deng et al., 2024; Homroy, 2023; Alsaifi et al., 2020) or as multiple theories (Kim et al., 2023; Elleuch Lahyani, 2022). The main theories considered are stakeholder theory, institutional theory, resource-based view theory, and legitimation theory. For our study, which seeks to assess the impact of climate finance and climate management tools designed to achieve zero emissions or carbon neutrality on financial performance, with a specific focus on the moderating influence of corporate governance and CSR strategies, in line with the studies of & Lange (2022) and Gaia & Jones (2019) we believe that a single theory cannot fully explain the impact of sustainable practices, such as the use of carbon credits/offsets. Therefore, we find it advantageous to employ a broader theoretical framework that integrates different theoretical perspectives to enrich our comprehension of climate change management and climate finance tools. Drawing from prior research in the field of carbon management, we have chosen to utilize

the theoretical framework of resource-based view theory (Issa, 2024; Kim et al., 2023; Alsaifi et al., 2020; Zhou et al., 2020) and legitimacy theory (Elleuch Lahyani, 2022; Naranjo Tuesta et al., 2020).

The resource-based view theory has gained significant traction in sustainability studies, and previous research endeavours focused on highlighting the correlation between carbon reduction efforts and financial outcomes (Issa & Hanaysha, 2023; Alsaifi et al., 2020). This theory introduced by Wernerfelt (1984) and developed by Barney (1991), underscores the pivotal role of resources and strategic capabilities in attaining sustainable competitive advantage. It perceives a firm as a set of resources and capabilities that, under effective corporate governance, ends in strategic decisions and actions. According to Barney (1991), a firm's resources and capabilities are rare, costly to imitate, distinct, irreplaceable, and can serve as a foundation for competitive advantage, thereby optimizing overall firm performance. Furthermore, the resource-based view theory offers valuable insights into the relationship between emission reduction initiatives and financial performance, which is pertinent to our examination of various mechanisms targeted at achieving carbon neutrality (such as carbon credits/offsets). Research reveals that companies skilled in managing and reducing their carbon footprint can develop unique resources and capabilities, which can give them a competitive edge (Issa, 2024). As noted by Zhang et al. (2021), these resources and capabilities encompass investments in advanced technologies, energy-efficient processes, sustainable supply chains, eco-friendly innovations, and the adoption of climate finance mechanisms. Furthermore, Dahlmann et al. (2019) suggest that companies can enhance operational efficiency, lower costs, and differentiate themselves in the marketplace by strategically leveraging these resources. Thus, the reduction of carbon emissions can lead to a variety of tangible and intangible benefits that positively impact financial performance.

As per the resource-based view, prior research indicates that effectively managing carbon emissions can have a positive impact on a company's financial performance (Issa, 2024; Alsaifi et al., 2020). The theory posits that a company's unique resources and capabilities, such as proficient carbon emissions management, can confer a competitive advantage and bolster business performance. Numerous studies indicate that firms implementing carbon reduction strategies observe enhancements in both accounting and market performance (Issa, 2024; Kim et al., 2023; Bolton et al., 2022). Moreover, other studies have found a negative relationship between GHG emissions and market value (Orazalin et al., 2024), indicating that higher emissions can adversely affect a firm's market value. Nevertheless, the strength of this relationship may differ across countries, sectors, and time periods, underscoring the importance of considering contextual factors (Issa, 2024). This evidence underscores the detrimental impact on a firm's market value when climate change is not addressed through well-considered strategies, thus linking the resource-based view theory and the legitimacy theory framework. Indeed, the legitimacy theory posits that there exists a social contract between a company and the society in which it operates. Therefore, companies must observe stakeholder expectations

and social norms in order to maintain their operations (Elleuch Lahyani, 2022). Consequently, an organization's ability to uphold its social legitimacy is just as crucial as its business prowess. According to Dowling and Pfeffer (1975), pioneers of legitimacy theory, legitimacy serves as a resource that contributes to an organization's longevity. This notion is interconnected with the resource-based view theory and the concept of competitive advantage. Organizations' responsiveness to stakeholders' concerns can enhance their perception of legitimacy within the community in which they function (Deng et al., 2024). It is imperative that firms' environmental initiatives align with societal values, norms, and regulations, thus underscoring the increasing significance of timely and transparent disclosure (Elleuch Lahyani, 2022).

In essence, organizations that employ strategies like carbon credits and offsets to advance carbon neutrality in accordance with societal values, norms, and regulations (legitimacy theory) can improve their rapport with stakeholders, gain a competitive advantage, optimize resource utilization (resource-based view theory), and ultimately realize a mutually advantageous outcome in terms of both climate change mitigation and financial performance. Consequently, it is reasonable to explore the correlation between the utilization of carbon credits/offsets and financial performance. Thus, we posit the following assumption:

Hp1: The implementation of carbon credits/offsets to achieve carbon neutrality is positively associated with financial performance.

The link between employing carbon credits/offsets to achieve carbon neutrality and a company's financial performance may be impacted by moderating factors. It is plausible that the utilization of carbon credits/offsets and the subsequent decrease in carbon emissions can lead to an enhancement in financial performance through a company's CSR strategy. Firms that are willing to address carbon emissions and meet stakeholder expectations are more likely to integrate a CSR strategy, which can empower them to enhance the mechanisms used to handle carbon emissions and financial performance (Issa, 2024). Companies that prioritize CSR strategy are more inclined to implement effective approaches to curtail carbon emissions, ultimately resulting in reduced carbon intensity (Zhang et al. 2022). Furthermore, a company that embraces a CSR strategy possesses a heightened awareness of the potential risks it could encounter if it fails to address and subsequently mitigate its emissions (Ott & Schiemann, 2023). Consequently, the association between carbon credits/offsets and financial performance could be magnified for companies that adopt a well-defined and transparent CSR strategy. Hence, we propose the following hypothesis:

Hp2: CSR strategy plays a positive moderating role in the relationship between carbon credits/offsets and financial performance.

Furthermore, empirical research suggests that the relationship between emissions reduction and financial performance can be influenced by the quality of corporate governance (Zhang et al., 2021). Companies that follow best practices in corporate governance are believed to enhance the connection between carbon emissions and financial performance (Issa, 2024). The effectiveness of a company's carbon emissions management heavily depends on its corporate governance system (Elsayih et al., 2023). Additionally, studies have demonstrated that a strong governance structure can result in reduced carbon emissions and improved carbon performance practices (Toukabri & Youssef, 2023). Moreover, board composition has been found to have a positive impact on environmental performance in terms of strategy, implementation, and disclosure (Elmagrhi et al., 2019). Gender-diverse boards have also been associated with more effective carbon reduction efforts (Elleuch Lahyani et al., 2022). Therefore, it is reasonable to speculate that corporate governance practices play a role in moderating the positive impact of carbon reduction on financial performance:

H_{p3}: The quality of corporate governance practices enhances the relationship between carbon credits/offsets and financial performance.

3. Methodology

3.1. Sample, data collecting and descriptive analysis

According to multiple studies in the literature, the relationship between reducing greenhouse gas emissions and financial performance is complex (Kim et al., 2023; Fernández-Cuesta et al., 2019; Wang et al., 2014). Some evidence suggests that financial performance could increase as a result of higher production, without taking emissions into account, which could lead to more profitable investments (Homroy, 2023). Conversely, other studies indicate that modern consumers tend to favor environmentally responsible companies, displaying loyalty and trust. This trend may push less environmentally friendly companies to align with their competitors in order to remain competitive and profitable (Deng et al., 2024; Hakovirta et al., 2023). In general, it appears that companies implementing climate change management strategies, such as decarbonization and utilizing tools like carbon credits/offsets, may experience positive outcomes.

According to prior research, our sample comprises internationally listed companies that have implemented carbon offsets/credits in the last 5 fiscal years. These companies operate in a range of industries including energy, utilities, industrials, materials, information technology, communication services, healthcare, real estate, consumer discretionary, and consumer staples, with the exception of financials (Issa, 2024). Following the establishment of the initial selection criteria for companies, our final sample encompasses 72 listed companies from six continents.

Table 1 displays the distribution of the companies within the sample, categorized by industry sector based on the Global Industry Classification Standard (GICS), along with the continent where their headquarters are situated. The industrial sector comprises the highest

number of firms, with 25% of the sample (18 companies), followed by the information technology sector (12.50%), the consumer discretionary and the energy sectors (both at 11.11%). The materials sector has the lowest number of companies in the sample (1.39%). Europe has the highest number of companies, accounting for 43.06% of the sample, followed by North America (United States of America and Canada) with 26.39% of companies in the sample.

Continent	GICS Sector											Total of companies	% of Total
	Energy	Utilities	Industrials	Materials	Information Technology	Communication Services	Health Care	Real Estate	Consumer Discretionary	Consumer Staples			
Europe	5	3	8	1	2	3	2	-	6	1	31	43.06%	
North America	2	1	3	-	4	3	1	-	1	4	19	26.39%	
South America	-	2	2	-	-	-	-	-	-	-	4	5.56%	
Asia	1	-	3	-	2	-	-	2	1	2	11	15.28%	
Australia	-	1	2	-	1	-	-	2	-	-	6	8.33%	
Africa	-	-	-	-	-	-	-	1	-	-	1	1.39%	
Total of companies	8	7	18	1	9	6	3	5	8	7	72	100%	
% of Total	11.11%	9.72%	25.00%	1.39%	12.50%	8.33%	4.17%	6.94%	11.11%	9.72%	100%		

- Table 1 -
Distribution of sample companies by sector and country

Furthermore, we analyzed the breakdown of companies by sector and target year for emission reduction (Table 2), as well as by target year of emission reduction and continent (Table 3). Notably, almost half of the companies in the sample (47.22%) are targeting emission reduction by 2030. The largest portion of these companies are in the industrials sector (8 companies), with the energy sector following closely behind (6 companies). In the sample, 37.50% of companies have chosen 2025 as their target year for reducing emissions. The majority of these companies are in the industrials sector (6 companies), followed by the consumer staples sector (4 companies). Only 1.39% of companies have set 2040 as their target year, all of which are in the information technology sector. Furthermore, companies aiming for reductions by 2025 and 2030 are mainly located in Europe (13 companies for 2025 and 16 companies for 2030), with North American companies following closely behind (6 companies for 2025 and 8 companies for 2030). The sole company aiming for emission reduction by the year 2050 is based in Africa. It's crucial to consider that the target year for emission reduction is tied to the specific regulations and guidelines of the country where the company operates.

Year of the emission reduction target	GICS Sector											Total of companies	% of Total
	Energy	Utilities	Industrials	Materials	Information Technology	Communication Services	Health Care	Real Estate	Consumer Discretionary	Consumer Staples			
2025	2	2	6	-	2	3	2	3	3	4	27	37.50%	
2030	6	4	8	1	4	3	-	1	4	3	34	47.22%	
2035	-	-	2	-	2	-	-	-	-	-	4	5.56%	
2040	-	-	-	-	1	-	-	-	-	-	1	1.39%	
2050	-	1	2	-	-	-	1	1	1	-	6	8.33%	
Total of companies	8	7	18	1	9	6	3	5	8	7	72	100%	
% of Total	11.11%	9.72%	25.00%	1.39%	12.50%	8.33%	4.17%	6.94%	11.11%	9.72%	100%		

- Table 2 -
Distribution of companies by sector and year of the emission reduction target

Continent	Year of the emission reduction target					Total of companies	% of Total
	2025	2030	2035	2040	2050		
Europe	13	16	-	1	1	31	43.06%
North America	6	8	4	-	1	19	26.39%
South America	1	2	-	-	1	4	5.56%
Asia	4	5	-	-	2	11	15.28%
Australia	3	3	-	-	-	6	8.33%
Africa	-	-	-	-	1	1	1.39%
Total of companies	27	34	4	1	6	72	100%
% of Total	37.50%	47.22%	5.56%	1.39%	8.33%	100%	

- Table 3 -

Distribution of companies by year of the emission reduction target and headquarter location

Each company's unique characteristics are shaped by its mission, vision, and the requirements of various stakeholders. In addition, our analysis provides a breakdown of the target percentage of emission reductions based on the sector (Table 4), company location (Table 5), and target year of emission reduction (Table 6). It is apparent that the largest number of companies in the sample (28) are aiming to reduce their emissions by 26% to 50%, with 9 of them belonging to the industrial sector (Table 4). Furthermore, 13 of these companies are located in Europe and 9 in North America (Table 5). The majority (14 companies) have set 2030 as their target year for reduction (Table 6).

% emission reduction target	GIICS Sector										Total of companies	% of Total	
	Energy	Utilities	Industrials	Materials	Information Technology	Communication Services	Health Care	Real Estate	Consumer Discretionary	Consumer Staples			
0% - 10%	2	-	1	-	1	-	1	-	-	-	1	6	8.33%
11% - 25%	4	-	4	1	1	1	-	1	-	-	1	13	18.06%
26% - 50%	1	4	9	-	3	2	1	1	5	2	2	28	38.89%
51% - 75%	-	-	2	-	-	-	-	-	1	1	1	5	6.94%
76% - 100%	1	3	2	-	4	3	1	2	2	2	2	20	27.78%
Total of companies	8	7	18	1	9	6	3	5	8	7	7	72	100%
% of Total	11.11%	9.72%	25.00%	1.39%	12.50%	8.33%	4.17%	6.94%	11.11%	9.72%	100%		

- Table 4 -

Distribution of companies by sector and % of the emission reduction target

Continent	% emission reduction target					Total of companies	% of Total
	0% - 10%	11% - 25%	26% - 50%	51% - 75%	76% - 100%		
Europe	1	7	13	1	9	31	43.06%
North America	3	3	6	2	5	19	26.39%
South America	-	-	2	1	1	4	5.56%
Asia	2	3	4	-	2	11	15.28%
Australia	-	-	2	1	3	6	8.33%
Africa	-	-	1	-	-	1	1.39%
Total of companies	6	13	28	5	20	72	100%
% of Total	8.33%	18.06%	38.89%	6.94%	27.78%	100%	

- Table 5 -

Distribution of companies by % of the emission reduction target and headquarter location

Year of the emission reduction target	% emission reduction target					Total of companies	% of Total
	0% - 10%	11% - 25%	26% - 50%	51% - 75%	76% - 100%		
2025	4	7	5	-	11	27	37.50%
2030	2	6	14	5	7	34	47.22%
2035	-	-	4	-	-	4	5.56%
2040	-	-	-	-	1	1	1.39%
2050	-	-	5	-	1	6	8.33%
Total of companies	6	13	28	5	20	72	100%
% of Total	8.33%	18.06%	38.89%	6.94%	27.78%	100%	

- Table 6 -

Distribution of companies by % of the em. reduction target and year of the em. reduction target

In our analysis, we utilized a dataset that combines features of both cross-sectional data and time series data, known as panel data. This panel data was collected between 2019 and 2023 and includes time series and cross-sectional data for multiple years and multiple individuals. Hsiao & Pesaran (2008) highlighted several advantages of panel data studies over cross-sectional or time series studies, including increased sample variability and degrees of freedom, better control of unobserved heterogeneity, more effective estimation enabling the application of models with fixed and random effects, improved modeling of dynamic relationships using time-varying variables, and enhanced ability to infer the cause of variation in the variables. Panel data analysis can be performed using four distinct techniques: (i) fixed effect models; (ii) random effect models; (iii) pooled analysis; and (iv) dynamic panel models. The selection of a model is contingent upon the objectives of the analysis and the assumptions pertaining to the error term in the regression model.

Previous studies on carbon emissions and financial performance used to base their analysis only on a single country (Kim et al., 2023; Elleuch Lahyani et al., 2022; Ganda, 2022; Wang et al., 2014). Carbon offsets/credits are a relatively new and evolving climate finance mechanism. As a result, our research focused on a global sample, consistent with previous studies on the relationship between carbon reduction and financial performance (Bui et al., 2020). Our data was gathered from the Thomson Reuters database, in line with established research practices (Mahmoudian et al., 2023; Homroy, 2023; Naranjo Tuesta et al., 2021). The global sample was carefully curated to ensure homogeneity. This research was targeted towards large-cap companies with solid track records of performance, thereby reducing risk. Following the application of our filters, we identified a sample comprising 72 public companies.

3.2. *Variables description*

In order to validate our hypotheses, we conducted our study in accordance with the methodologies outlined in previous research on carbon emission reduction. We incorporated established variables from the literature, as cited by Issa (2024). Previous studies have utilized diverse approaches to assess the impact of decarbonization, particularly in relation to carbon credits/offsets, on the financial performance of companies (França et al., 2023; Kim et al., 2023; Bui et al., 2020; Johnson et al., 2020). In our analysis, we utilized carbon offsets/credits, financial performance, and moderators (Corporate governance and CSR strategy) variables

provided by Thomson Reuters, following established research practices. A summary of all variables can be found in Table 7.

Variables	Symbol	Definition	References
<i>Dependent variables</i>			
Return on Asset	ROA	It evaluates how effectively assets are used to generate profits. It is computed by dividing net income before extraordinary items by total assets	Issa, 2024 Yu et al., 2022
Return on Equity	ROE	It evaluates a firm's capacity to convert equity investments into profits. It is computed by dividing net income before extraordinary items by total equity	Issa, 2024 Lewandowski, 2017
Earnings before interest, taxes, depreciation, and amortization	EBITDA	Earnings before interest, taxes, depreciation, and amortization (EBITDA) is a measure of core corporate profitability	Bolton et al., 2022
Tobin's Q	TQ	The ratio of a company's market value (determined by its outstanding stock and debt) to the replacement cost of its assets (book value)	Alshorman et al., 2024 Issa, 2024
<i>Independent variable</i>			
Carbon Credits/Offsets	CC	It measures carbon credits/offsets the tons held by companies	Martielli & Salvi, 2023
<i>Moderating variables</i>			
Corporate Governance	GOV	The measurement assesses a company's dedication and success in adhering to corporate governance principles, resulting in a percentage score between 0 and 100	Adeneye et al., 2024 Elamer & Boulhaga, 2024 Issa, 2024
CSR Strategy	CSR	It indicates how well a company integrates economic, social, and environmental factors into its decision-making, with a maximum score of 100 reflecting full adoption of a comprehensive CSR strategy	Issa, 2024 Issa & Hanaysha, 2023
<i>Control variables</i>			
Firm size	SIZE	The size is determined by the natural logarithm of total assets	Appiah-Kubi et al., 2024
Leverage	LEV	The ratio between financial debt and total equity of a company	Schreck, 2011
Organizational slack	SLACK	It is calculated as current assets minus current liabilities	Issa, 2024 Tang et al., 2012
Systematic risk	BETA	It is used to capture the risk impact on a company	Schreck, 2011
Liquidity	LIQ	The ratio between current assets and current liabilities of a company	Issa, 2024 Blanco et al., 2013
Industry dummy	INDUSTRY	A dummy variable represents ten industries	Appiah-Kubi et al., 2024
Number of Employee	EMPL	It represents the number of employees in the years	AlZayani et al., 2024

- Table 7 -
Variables' description

3.2.1 *Dependent variables*

Numerous prior studies have analyzed the connection between carbon emissions and financial performance, as well as the effects of emission reduction on financial performance. These studies have employed various accounting and market measures to evaluate this correlation (Naranjo Tuesta et al., 2020; Delmas et al., 2015). It is crucial to delve into the rationale for selecting a specific measure over another, particularly in light of the specific sector and national context in which a company functions. As summarized by Grewatsch & Kleindienst (2017),

the accounting-based variables often used are Return on Assets, Return on equity, Return on sales, Growth in sale, Earnings per share, Cash flow and Net revenues; while the market-based variables used by previous studies are TQ, Cumulative abnormal return, Stock equity return and Sharpe ratio. Accounting measures are often used to analyze short-term impacts (Busch et al., 2022), such as increased costs from implementing practices to reduce emissions (Mahmoudian et al., 2023) and/or contractions in turnover due to consumer choices that do not reward the company for its inattention to sustainability (Ott & Schiemann, 2023; Naranjo Tuesta et al., 2021). On the other hand, market-based measures reflect investors' long-term perceptions of a company's management practices and its performance forecasts (Ganda, 2022).

In our research, we employ ROA, ROE, EBITDA, and Tobin's q (Alshorman et al., 2024; Issa, 2024; Bolton et al., 2022; Yu et al., 2022; Lewandowski, 2017). The initial three variables are accounting measures utilized to assess short-term outlooks, while the fourth is a market measure used to appraise long-term outlooks. Nevertheless, we leverage all of these metrics for various purposes: to acquire further insights into financial performance and as a means to evaluate the robustness of performance. Return on assets (ROA) and Return on equity (ROE) are important metrics used to evaluate the efficiency of a company's assets and equity in generating income. ROA is calculated by dividing net income by total assets, while ROE is determined by dividing net income by total equity. Additionally, Earnings before interest, taxes, depreciation, and amortization (EBITDA) provides insight into operational margin and helps assess the impact of costs on revenue. Finally, Tobin's Q is a measure of a firm's long-term performance, calculated as the ratio of the firm's market value to its total assets (Chung & Pruitt, 1994).

3.2.2 *Independent variable*

The independent variable in our study is carbon credits/offsets (CC), which are utilized to address greenhouse gas (GHG) emissions by supporting projects that either reduce or absorb equivalent emissions elsewhere (Heal, 2022; Betz et al., 2022). Each credit signifies one ton of GHG that has been avoided, reduced, or absorbed. These credits were originally introduced by the Kyoto Protocol and are now overseen by a variety of mechanisms and institutions. For instance, the Clean Development Mechanism (CDM), integrated into the 2015 Paris Agreement.

The main function of this tool is to allow companies that are unable to make substantial and immediate reductions in their emissions to offset them through credits, while still meeting their legal requirements. This is particularly relevant for industries such as shipping and airlines. However, there has been a growing trend in recent years of companies from various sectors utilizing these credits to help them achieve their emission targets. With the diverse global corporate landscape, there are also companies that are innovative and mission-driven, prioritizing the absorption of greenhouse gases rather than emitting them. These companies

have the opportunity to sell their carbon credits to less environmentally conscious companies in the market (Martielli & Salvi, 2023).

3.2.3 *Moderator variable*

In order to gain a better understanding of how carbon credits/offsets impact financial performance, in focusing on the strength and the direction of the relationship, we examined two moderator variables: CSR strategy (CSR) and the quality of Corporate governance (GOV). The CSR strategy score evaluates the extent to which a company integrates environmental, social, and governance (ESG) considerations into its regular decision-making processes (Issa & Hanaysha, 2023). For our research, we employed the CSR strategy score sourced from the Refinitiv Eikon database, a widely recognized metric commonly used in studies of corporate governance (Issa, 2024). This score is represented as a percentile ranging from 0 (indicating minimal integration) to 100 (indicating strong integration). In assessing corporate governance quality (GOV), we utilized the corporate governance score available in the Refinitiv Eikon database, as described by Adeneye et al. (2024) and Elamer & Boulhaga (2024). This score measures a company's commitment to and effectiveness in adhering to best-practice corporate governance standards, standardized as a percentage from 0 to 100. The use of the Refinitiv Eikon database provides benefits such as considering factors like the company's country of incorporation and industry classifications. The CSR strategy and corporate governance quality scores offer valuable insights into a company's performance relative to benchmarks aligned with similar institutional, regulatory, and business contexts (Issa, 2024).

3.2.4 *Control variables*

In our analysis, we incorporated a range of pertinent control variables to account for the influence of various firm characteristics and financial variables. This enabled us to mitigate the issue of overlooking crucial factors (Smelser & Baltes, 2001). Our methodology aligns with prior research and contributes to the robustness of our analysis. Consequently, we integrated multiple control variables into the statistical analyses following a comprehensive review of past literature on carbon emission and financial performance.

First, we take into account the size of firms, as larger firms are expected to have more resources available to reduce their environmental impact (Palea & Drogo, 2020). We measure firm size (SIZE) as the natural logarithm of the firm's total assets (Appiah-Kubi et al., 2024). Second, we acknowledge the significant impact of leverage on environmental and financial performance (Issa, 2024). We calculate leverage (LEV) as total debt divided by total assets (Schreck, 2011). Third, we include organizational slack (SLACK) as a control variable, denoting the pool of resources available within a company that can be reallocated to support various business objectives, including initiatives focused on carbon reduction goals (Issa, 2024; Tang et al., 2012). Fourth, we use systematic risk (RISK) as a control variable, capturing the impact of beta on risk (Wang et al., 2014; Schreck, 2011). Fifth, we control for the firm's

liquidity (LIQU) as strong liquidity can positively impact financial performance (Lewandowski, 2017; Blanco et al., 2013). The liquidity ratio is determined by dividing current assets by current liabilities. Additionally, we include as sixth industry dummies (INDUSTRY) to control for industry-specific effects (Appiah-Kubi et al., 2024). Finally, we include the number of employees (EMPL) as a control variable (AlZayani et al., 2024).

4. Empirical analysis and results

4.1. Descriptive statistics

The summary of the data for the sampled companies is presented in Table 8. The dependent variable with the highest mean value is earnings before interest, taxes, depreciation, and amortization (EBITDA) at \$104,000,000, followed by Tobin's q (TQ) at 12.08, Return on Equity (ROE) at approximately 8.16, and Return on Assets (ROA) at 0.34. The variables were not normalized to avoid influencing the regression results (Issa, 2024; Siddique et al., 2021). The spectrum for carbon credits/offsets (CC) ranges from 27 to 27,000,000 tons, while for CSR strategy (CSR) it is between 2.38 and 99.55, and for the quality of corporate governance (GOV) it falls within 3.82 to 98.01. These figures underscore the growing emphasis on sustainable practices driven by a robust CSR strategy and strong corporate governance. Despite the initial investment required for sustainable strategies, such as those involving carbon credits/offsets, there is potential for substantial financial gains.

Variable	Obs	Mean	Std. dev.	Min	Max
CC	360	1,276,543	3,583.580	27	27,000,000
GOV	360	63.26	20.59	3.82	98.01
CSR	360	71.83	22.81	2.38	99.55
ROA	360	0.07	0.06	-0.21	0.34
ROE	360	0.22	0.56	-1.04	8.160
TQ	360	2.24	1.98	0.01	12.08
EBITDA	360	7,350,000	16,400,000	-5,850,000	104,000,000
SIZE	360	23.57	1.52	19.2	26.82
LEV	360	2.02	10.55	-45.71	151.27
SLACK	360	4,110,000	17,200,000	-16,100,000	124,000,000
BETA	360	1.04	0.42	0.7	2.77
LIQ	360	1.34	0.72	0.23	4.4
INDUSTRY	360	5.33	2.68	1	10
EMPL	360	59,086.30	87,659.37	59	543,000

- Table 8 -
Descriptive statistics

4.2. Correlations

The article utilizes a group of variables that exhibit a one-to-one correspondence with each other. This correlation is illustrated in Table 9, the correlation matrix, provided below. It is clear that there is a positive and direct relationship between carbon credits/offsets (CC) and the dependent variables (ROA, ROE, EBITDA, and TQ) in all instances.

Our research has revealed a significant positive correlation between carbon offsets/credits (CC) and the quality of corporate governance (GOV) with a coefficient of 0.0627 and a p-value of 0.000. We have also found a positive correlation between carbon offsets/credits (CC) and CSR strategy, with a coefficient of 0.019 and a p-value of 0.000. Our analysis suggests that companies with stronger CSR strategies and higher quality of corporate governance tend to have more carbon offsets/credits, whether due to regulatory requirements or voluntary initiatives. Furthermore, as carbon credits/offsets (CC) increase, financial performance indicators such as ROA, ROE, EBITDA, and TQ also show improvement, with correlation coefficients of 0.198, 0.099, 0.040, and 0.173, and p-values of 0.000 for each, respectively. The findings suggest that incorporating sustainable practices, such as reducing carbon emissions through methods like carbon credits/offsets, can result in improved company financial performance. While there may initially be higher costs and lower margins due to emission reduction efforts, companies can ultimately see increased revenue and greater stability. This is supported by existing research (Mahmoudian et al., 2023; Ott & Schiemann, 2023). Additionally, the correlation coefficient between carbon credits/offsets and beta, a measure of risk, is negative (correlation coefficient = -0.023, p-value = 0.000), indicating that the use of carbon credits/offsets can decrease the perceived risk associated with stakeholders engaging with the company.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1 CC	1													
2 GOV	0.063	1												
3 CSR	0.019	0.391	1											
4 ROA	0.198	0.052	0.155	1										
5 ROE	0.099	0.070	0.088	0.248	1									
6 TQ	0.173	0.024	0.123	0.652	0.215	1								
7 EBITDA	0.040	0.245	0.243	0.302	0.029	0.167	1							
8 SIZE	0.140	0.071	0.349	0.030	-0.067	-0.086	0.641	1						
9 LEV	0.019	-0.002	-0.025	-0.116	-0.061	-0.058	-0.047	-0.058	1					
10 SLACK	-0.047	0.146	0.127	0.300	0.034	0.255	0.784	0.391	-0.038	1				
11 BETA	0.023	0.080	-0.136	-0.239	0.047	-0.195	-0.039	-0.002	0.016	0.002	1			
12 LIQ	-0.126	-0.128	-0.025	0.369	0.010	0.252	0.136	0.006	-0.098	0.350	-0.217	1		
13 INDUSTRY	0.129	0.013	-0.124	-0.189	-0.002	-0.175	-0.225	-0.225	0.042	-0.103	0.121	-0.082	1	
14 EMPL	-0.062	0.115	0.243	0.157	0.227	0.104	0.365	0.501	0.037	0.184	-0.023	-0.084	-0.210	1

- Table 9 -
Correlations matrix

4.3. Results

In order to test our research hypotheses, we utilized the Pooled Ordinary Least Squares model (Pooled OLS) based on previous studies in the field of emission reduction (Issa, 2024). While fixed effect models are more commonly employed in social studies and there is a growing use of random effects models (Beck & Katz, 1995), we chose to use a simple OLS on panel data due to the innovative nature of our investigation, and its widespread application in previous research on carbon emission and emission reduction (Škare et al., 2024; Hailemariam & Erdiaw-Kwasie, 2023). The Pooled OLS model is a straightforward and basic approach for

analyzing panel data. It views all data as belonging to a single group, without taking into account variations between observation units or time periods. However, it overlooks the potential differences between observation units and the presence of fixed or random effects (Osobajo et al., 2020). Our hypotheses were examined using the regression models detailed below.

$$ROA_t = \beta_0 + \beta_1 CC_t + \sum_i \beta \text{Control} + u_i + e_{it}$$

(Model 1)

$$ROE_t = \beta_0 + \beta_1 CC_t + \sum_i \beta \text{Control} + u_i + e_{it}$$

(Model 2)

$$EBITDA_t = \beta_0 + \beta_1 CC_t + \sum_i \beta \text{Control} + u_i + e_{it}$$

(Model 3)

$$TQ_t = \beta_0 + \beta_1 CC_t + \sum_i \beta \text{Control} + u_i + e_{it}$$

(Model 4)

The results of the regression analyses are detailed in Table 10. In line with our initial hypotheses, carbon credits/offsets (CC) were found to have a positive impact on financial outcomes. Model 1, using ROA as the dependent variable to test Hypothesis 1a, demonstrated a significant and positive effect of carbon credits/offsets (CC) on ROA ($p < 0.001$), with a 1% increase in emissions resulting in a 0.069 (b1) increase in ROA. Additionally, Model 2 confirmed a positive association between carbon credits/offsets (CC) and the firm's ROE ($p < 0.01$), with a 1% increase in carbon credits/offsets leading to a 0.099 (b2) increase in the firm's ROE. Model 3 further supported these findings, showing a significant positive effect of carbon credits/offsets (CC) on EBITDA, with a 5% increase resulting in a 674.622 (b3) increase ($p < 0.05$). Also, Hypothesis 1d was confirmed in Model 4, as the data revealed an increase in Tobin's q (TQ) by 0.037 (b4) for a 5% increase in carbon credits/offsets (CC) ($p < 0.05$). Based on the findings, it is clear that Hypotheses 1 have strong support. The regression models show significant positive effects (b1 = 0.069; b2 = 0.099; b3 = 674.622; b4 = 0.037) with p-values below 0.05 for all models. This confirms our first hypotheses. In the case of hypothesis 1d, which has the lowest coefficient in the analysis, it is possible that the market is not perfectly aligned, leading to a delayed assessment of the effects attributed to the use of carbon credits/offsets.

In terms of the control variables, we obtained positive and significant outcomes for the number of employees (EMPL) (b1 = 0.096, $p < 0.05$; b2 = 0.006, $p < 0.1$; b3 = 129.337, $p < 0.05$; b4 = 0.006, $p < 0.05$) and negative and significant outcomes for the risk perception

(BETA) ($b_1 = -0.025$, $p < 0.1$; $b_2 = -0.049$, $p < 0.1$; $b_3 = -195,223$, $p < 0.1$; $b_4 = -0.693$, $p < 0.01$). Additionally, we observed both positive and negative results for size (SIZE), leverage (LEV), slack (SLACK), liquidity (LIQ) and industry (INDUSTRY).

	Model 1 (ROA)	Model 2 (ROE)	Model 3 (EBITDA)	Model 4 (TQ)
CC	0.069*** (0.005)	0.099*** (0.007)	674.622** (0.019)	0.037** (0.040)
SIZE	-0.007*** (0.003)	-0.284 (0.137)	595,201** (0.017)	-0.411** (0.031)
LEV	-0.001** (0.047)	-0.004* (0.064)	4,896.743 (0.170)	-0.009 (0.203)
SLACK	0.008*** (0.000)	-0.022** (0.022)	0.480** (0.051)	0.033** (0.041)
BETA	-0.025* (0.089)	-0.049* (0.075)	-195,223* (0.055)	-0.693*** (0.003)
LIQ	0.021 (0.131)	-0.007 (0.129)	-331,061** (0.010)	0.307** (0.037)
INDUSTRY	-0.003** (0.025)	0.005* (0.058)	-44.401 (0.121)	-0.103*** (0.005)
EMPL	0.096** (0.013)	0.006* (0.073)	129.337** (0.038)	0.006** (0.011)
Constant	0.240 (0.123)	2.253** (0.012)	-136,358** (0.022)	17.607** (0.047)
Observations	360	360	360	360
R-squared	0.45	0.48	0.41	0.38
p value in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$				

- Table 10 -

Pooled OLS Analysis of Carbon Credits/Offsets on ROA, ROA, EBITDA and Tobin's q

The data presented in Table 10 confirms our hypothesis that utilizing tools like carbon credits/offsets to control emissions can have a positive impact on financial outcomes. The results suggest that companies actively engaged in carbon management practices tend to see better financial performance, indicating that implementing emission reduction initiatives can lead to sustainable competitive advantages in the market. This supports the acceptance of the H_{p1} hypothesis, which is in line with the Resource-Based View approach. According to this perspective, a company's distinctive resources and capabilities, such as its capacity to effectively manage carbon emissions, can enhance its competitive advantage and overall performance. These findings align with prior studies that have established a connection between capable carbon management and financial outcomes (Kim et al., 2023; Alsaifi et al., 2020; Elleuch Lahyani, 2022; Adu et al., 2023; Naranjo Tuesta et al., 2020; Zhou et al., 2020). Notably previous studies consistently demonstrated that companies with robust carbon management practices tend to achieve better financial performance.

Moreover, the findings are consistent with the legitimacy theory, which is reinforced by financial indicators like EBITDA and Tobin's q. Incorporating sustainable initiatives, such as utilizing carbon credits/offsets, enables companies to uphold or enhance their legitimacy. This, in turn, enables them to garner backing from stakeholders, notably customers and investors, and protect their standing (Elleuch Lahyani, 2022; Naranjo Tuesta et al., 2020).

In Models 5 to 8 show whether quality of corporate governance (GOV) moderators affect the relationship between carbon offsets/credits (CC) and financial performance (FP) as proposed by Hypothesis 2. First of all, Table 11 shows that overall quality of corporate governance (GOV) have a positive impact on financial performance (b1= 0.052; p<0.05; b2= 0.123; p<0.05; b3= 17.129; p<0.05; b4= 0.033; p<0.05). It is interesting to note that when quality of corporate governance (GOV) is added to the model, the impact of carbon credits/offsets (CC) is still significant, but the effect is weaker, excepted for EBITDA (b1 = 0.003; p>0.1; b2 = 0.001; p<0.1; b3 = 612.652; p<0.1; b4 = 0.035; p<0.1).

	Model 5 (ROA)	Model 6 (ROE)	Model 7 (EBITDA)	Model 8 (TQ)
CC	0.003* (0.087)	0.001* (0.098)	612.652* (0.061)	0.035* (0.088)
GOV	0.052** (0.046)	0.123** (0.049)	17.129** (0.025)	0.033** (0.039)
SIZE	-0.003 (0.101)	-0.155** (0.022)	372,103** (0.021)	-1.201** (0.010)
LEV	-0.001 (0.162)	-0.004* (0.071)	8,174.349* (0.087)	-0.001 (0.237)
SLACK	0.008* (0.084)	-0.008 (0.106)	0.053** (0.033)	0.015 (0.243)
BETA	-0.020* (0.051)	-0.008* (0.059)	-0.017** (0.012)	-0.474*** (0.002)
LIQ	-0.003 (0.197)	-0.019* (0.095)	-228,511 (0.201)	-0.034* (0.073)
INDUSTRY	0.054* (0.079)	0.221 (0.129)	23,102* (0.091)	-0.010 (0.226)
EMPL	0.002 (0.108)	-0.003 (0.221)	133.606 (0.143)	-0.051* (0.091)
Constant	0.164* (0.088)	4.015* (0.059)	1.331 (0.114)	30.538** (0.015)
Observations	360	360	360	360
R-squared	0.46	0.39	0.41	0.37
p value in parentheses *** p<0.01, ** p<0.05, * p<0.1				

Table 11
Pooled OLS Analysis with CSR Strategy as Moderator

Moreover, Models 9 to 12 show whether CSR strategy (CSR) moderators affect the relationship between carbon offsets/credits (CC) and financial performance (FP) as proposed by Hypothesis 3. First of all, Table 12 shows that overall CSR strategy (CSR) have a positive impact on financial performance (b1= 0.122; p<0.05; b2= 0.141; p<0.001; b3= 3.989; p<0.05; b4= 0.091; p<0.05). Also, as for quality of corporate governance (GOV) moderators when CSR strategy (CSR) is added to the model, the impact of carbon credits/offsets (CC) is still significant, but the effect is weaker, , excepted for EBITDA (b1 = 0.021; p>0.1; b2 = 0.039; p<0.1; b3 = 275.849; p<0.1; b4 = 0.054; p<0.1).

	Model 9 (ROA)	Model 10 (ROE)	Model 11 (EBITDA)	Model 12 (TQ)
CC	0.021* (0.091)	0.039* (0.059)	275.849* (0.058)	0.054* (0.072)
CSR	0.122** (0.049)	0.141*** (0.008)	3.989** (0.041)	0.091** (0.023)
SIZE	-0.004 (0.132)	-0.162 (0.206)	350,631** (0.032)	-1.205** (0.010)
LEV	-0.001* (0.055)	-0.004** (0.016)	4,890.789 (0.223)	-0.001 (0.126)
SLACK	0.081 (0.212)	-0.007 (0.133)	0.051* (0.090)	0.001 (0.248)
BETA	-0.023* (0.099)	-0.009 (0.129)	-0.002* (0.072)	-0.474*** (0.002)
LIQ	-0.004 (0.221)	-0.018* (0.084)	-226,317 (0.210)	-0.033* (0.097)
INDUSTRY	0.441 (0.181)	0.918 (0.173)	2.031* (0.091)	1.815 (0.185)
EMPL	0.098* (0.061)	-0.004* (0.083)	129.785** (0.049)	0.004 (0.197)
Constant	0.176 (0.163)	4.179* (0.063)	798,112** (0.035)	30.639*** (0.005)
Observations	360	360	360	360
R-squared	0.39	0.41	0.33	0.47
p value in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

- Table 12 -
Pooled OLS Analysis with quality of Corporate Governance as Moderator

In terms of the accuracy, the primary econometric models (hypotheses 1 and its variations) indicate an R-squared range of 0.38 to 0.48, with a statistically significant F-test. In the Pooled OLS analysis with moderators (hypothesis 2 and hypothesis 2), known as models 5 to 12, the R-squared range falls between 0.33 to 0.47, and the F-test continues to show significance for these models. In general, the model offers a satisfactory level of detail.

Based on our results, it is clear that a company's CSR strategy and the strength of its corporate governance play a critical role in moderating the relationship between carbon credits/offsets and financial performance. This reinforces our belief that integrating CSR into a company's daily decision-making and establishing a robust corporate governance structure can help companies improve carbon management through carbon credits and enhance financial performance. The econometrical findings are consistent with the observed moderating impacts of CSR strategy and corporate governance quality, thereby corroborating hypotheses Hp2 and Hp3. A complete CSR strategy underscores a company's commitment to ethical business practices, encompassing sustainable resource management, environmental conservation, and social accountability. By integrating CSR principles into their strategic framework, companies demonstrate proactive engagement with environmental challenges, including reducing emissions (Issa & Hanaysha, 2023). Additionally, corporate governance quality influences the mechanisms and frameworks that ensure effective oversight, accountability, and transparency within an organization. Robust corporate governance promotes responsible decision-making and enhances risk management throughout the organization (Issa, 2024). Regarding carbon emission reduction, companies with strong corporate governance practices are more likely to prioritize sustainability goals and incorporate emission reduction initiatives into their strategic agendas (Issa, 2024; Elsayih et al., 2023).

4.4. *Robustness checks*

Previous studies have indicated that the relationship between carbon emissions and financial performance is endogenous (Issa, 2024; Wang et al., 2022). This means that the use of carbon credits/offsets to reduce carbon emissions may create a reverse causality/simultaneity issue, leading to the question: Do carbon credits/offsets (CC) predict financial performance (FP), or does financial performance (FP) predict carbon credits/offsets (CC)?

Furthermore, our econometric model acknowledges the potential for bias from omitted variables stemming from unobserved temporal disparities, which could impact the relationship between carbon credits/offsets (CC) and financial performance (FP). To address this issue, we employed a fixed effects model specifically to assess the endogeneity between carbon credits/offsets and financial performance variables. The outcomes obtained (not detailed) align with our baseline models, suggesting that our initial findings remain unaffected by endogeneity. Further analyses utilizing diverse estimation techniques produce consistent results, reinforcing the conclusion that endogeneity does not distort our findings. In conclusion, our research consistently shows a significant positive impact of carbon credits/offsets (CC) on financial performance (FP), with the incidence of a CSR strategy (CSR) and high-quality corporate governance (GOV) operating as moderators in this relationship.

5. Conclusion

Climate change management is going through a phase of increasing importance and centrality within companies but, at the same time, transition stage. In detail, the pursuit and achievement of sustainability certifications are no longer exclusively linked to drastic changes or process or product innovations within the companies but can come from market-negotiable products and instruments, such as carbon credits/offsets (Michaelowa et al., 2022). These financial instruments, known for their liquidity, were developed to assist companies facing challenges in rapidly reducing their emissions. They provide a pathway for achieving or striving towards carbon neutrality, in particular at the start of their use for heavily polluting industries like airlines, shipping, and traditional energy, whose transition to zero emissions is very expensive and requires a lot of time and resources (Trouwloon et al., 2023). However, their adoption is nowadays increasingly prevalent across various. This growing popularity and use, supported by the recognition of reduced emissions and the attainment of carbon neutrality, is also drawing the interest of scholars and practitioners, increasingly involved in using carbon credits or analyzing their market and benefits on various levels (economic, environmental and social). Lastly, the widespread use of this tool necessitates policymakers' efforts to regulate its use, which is not yet completely established.

To date, empirical research in carbon management has predominantly focused on the impact of carbon emission reduction on corporate financial performance, as well as the implications of overlooking sustainability issues on competitive advantage and overall corporate performance. Previous research suggests a non-linear relationship between greenhouse gas (GHG) emissions and financial performance, as demonstrated in studies such as Wang et al. (2014). Additionally, Deng et al. (2024) and Hakovirta et al. (2023) have highlighted that disclosing carbon emissions and implementing innovations to reduce them can enhance competitive advantage and, in turn, improve financial performance. Other studies have demonstrated that decarbonization strategies can positively influence financial performance. For instance, Kim et al. (2023) and Bui et al. (2020) have indicated that such strategies can enhance enterprise value. This is supported by evidence suggesting that reducing greenhouse gas emissions can lead to value creation, decreased operating costs (Deng et al., 2024; Ott & Schiemann, 2023), and improved profit margins (Naranjo Tuesta et al., 2021). Conversely, carbon emissions can negatively impact market value, as investors tend to perceive polluting firms as riskier (Fernández-Cuesta et al., 2019).

By employing a dataset of listed companies that have used carbon credits continually over the past 5 fiscal years (2019-2023) to reduce their carbon emissions and tend toward or achieve carbon neutrality, our study reveals a positive relationship between a company's use of carbon credits/offsets and its financial performance. Furthermore, our results on the moderating investigation of this relationship suggest that the implementation of a CSR strategy in conjunction with the quality of corporate governance might be vehicles for enhancing the effect of carbon credits/offsets, as tools for achieving carbon neutrality, on financial performance. It

is important to note that our main results remain consistent across distinct dimensions of financial performance (Return on asset, Return on equity, EBITDA and Tobin' q) used as dependent variables in the empirical analysis of the relationship between carbon credits/offsets and financial performance, which are also valid for the econometric control methodology used to ensure the reliability of our results, and this lends robustness to our results.

5.1. *Theoretical implications*

Our research contributes to the extant literature by emphasizing a positive correlation between reducing carbon emissions through the use of carbon credits/offsets and financial performance. Additionally, it underscores the moderating influence of CSR strategies and corporate governance quality on this relationship. These findings provide valuable insights for researchers, practitioners, and policymakers seeking to promote sustainable practices and underscore the connection between sustainability initiatives and financial outcomes. This study represents a significant addition to the existing literature. Unlike previous studies, it delves into the relationship between carbon reduction initiatives and financial performance while considering moderating variables. It acknowledges the complex nature of the link between sustainability practices and financial performance. The paper offers theoretical insights into reducing carbon emissions by examining specific tools used for this purpose and their impacts on firms' financial performance. Furthermore, it explores the moderating effects of CSR strategy and the quality of corporate governance on the influence of carbon credits/offsets on financial performance. Through the lens of a resource-based view theory, carbon credits/offsets are seen as a scarce resource that can offer a competitive edge to companies using them, potentially leading to enhanced financial performance. Furthermore, from a legitimacy theory perspective, the utilization of carbon credits/offsets can help companies establish credibility with stakeholders, fostering customer loyalty and reducing risk perception, ultimately contributing to improved financial performance through cost savings. This study examines the unique resource of carbon credits/offsets as a method for achieving carbon neutrality, emphasizing a company's capacity to manage emissions. By delving into the relationship between carbon credits/offsets and financial performance, the study expands the framework of the resource-based view theory and legitimacy theory by examining how financial tools, such as carbon credits/offsets derived from unique resources, create value for companies by impacting their financial performance. Also, this study empirically examines how CSR strategy and corporate governance quality moderate the relation between carbon credits/offsets and financial performance. Our results regarding promising moderating factors contribute to the existing empirical literature, emphasizing that CSR strategies and strong quality corporate governance can act as mechanisms through which carbon performance impacts corporate financial outcomes. Moreover, this research extends current empirical investigations into the relationship between reducing carbon emissions and financial performance by encompassing a limited emphasis on direct relationships.

5.2. *Managerial and policymaker implications*

Furthermore, the investigation presents significant implications for managers, investors, and policymakers. Firstly, reducing carbon emissions can be advantageous for businesses by contributing to improved financial performance. Managers need to acknowledge the importance of adopting effective sustainable strategies and implementing robust corporate governance practices, as these measures can enhance the positive effects of employing carbon credits/offsets on financial performance. The research suggests that while regulatory pressures and stakeholder expectations are influential, they are not the exclusive drivers compelling companies to adopt sustainable practices. In fact, by implementing sustainable practices such as emission reductions, companies can achieve substantial financial benefits, including energy improvements, cost reductions, and better investment opportunities. Moreover, the study offers valuable insights for investors. Corporate initiatives aimed at addressing climate change and positively impacting financial performance introduce new variables to consider when evaluating an investment. Consequently, investors should take into account the sustainability strategies companies implement, as these can significantly influence their profitability and value creation. Finally, the research findings underscore the important role of regulators in promoting and motivating initiatives to reduce carbon emissions, including the use of new tools such as carbon credits/offsets. Regulatory frameworks can move companies to take actions aimed at cutting carbon emissions, which can also lead to enhanced financial outcomes. Finally, regulators can apply these findings to develop and implement policies that promote sustainable practices. This involves providing guidance, incentives, and assistance to companies as they strive to transition towards achieving zero emissions or carbon neutrality.

5.3. *Limitations and future research*

Our study has certain limitations that point to opportunities for future research. Firstly, our sample is confined to publicly traded companies that have consistently utilized carbon credits over the past five years to achieve carbon neutrality and reduce emissions. The recent surge in the use of carbon credits has resulted in a relatively small sample size. For instance, as of May 2024, there are 432 publicly traded companies worldwide using carbon credits, compared to 72 in 2019 (according to the Eikon Refinitiv database). This limitation affects the universality of our results, indicating the necessity for future research as the use of carbon credits/offsets becomes more widespread. This approach will offer a more comprehensive understanding of the relationship between carbon credits/offsets and financial performance. Additionally, our study emphasizes the indirect impact of moderating variables, such as CSR strategy and the quality of corporate governance, on this relationship. This focus may have overlooked other potential variables that could intervene and moderate this relationship. Therefore, future research could delve into additional variables and mechanisms that indirectly influence the connection between emission reduction tools and financial outcomes, offering further insight into this intricate relationship.

In conclusion, integrating climate finance strategies with sustainable and green finance is vital for reducing carbon emissions, building resilient climate infrastructure, and advancing environmental sustainability, thus making a significant contribution to achieving the Sustainable Development Goals (SDGs) for 2030 (Tang & Zhang, 2020). Additionally, the evolution of green financial innovation is pivotal in addressing climate risks and sustainability challenges, further emphasizing its relevance. Lastly, the emergence of new green financial instruments and innovative green financing methods underscores the necessity for continued research to gain new insights into the complexities of the expanding climate finance landscape (Cumming et al., 2019; Vismara, 2019; Dimic et al., 2023).

CONCLUSION

The issue of climate change presents a significant challenge that demands a unified response from individuals, organizations, and governments worldwide. It is widely agreed by scientists and policymakers that in order to cap the global temperature increase at 1.5°C, emissions need to be slashed across all sectors by nearly 50% by 2030. Therefore, in this era of sustainable development, businesses have a critical role to play in reducing and managing greenhouse gas emissions to combat climate change effectively. Some entrepreneurs and managers have usually viewed sustainability practices and impacts primarily as a cost (Boradstock et al., 2018; Wang et al., 2014). However, recent literature has effectively shown that embracing sustainability can lead to numerous benefits, including cost savings, improved brand reputation, and increased customer loyalty (Deng et al., 2024; Hakovirta et al., 2023; Alsaifi et al., 2020; Zhou et al., 2020; Cucchiella et al., 2017). This signifies a shift in perspective, showing that sustainable practices can yield long-term advantages for businesses in both improving and justifying financial outcomes. As highlighted in the latest IPCC report (2023), finance, international cooperation, and technology are pivotal factors for accelerating climate action. Both adaptation and mitigation funding are imperative in achieving climate goals. However, addressing institutional, regulatory, and market access barriers is necessary to overcome implementation limitations. It is crucial to reduce these barriers to meet the needs and opportunities, economic vulnerability, and indebtedness, especially in developing countries. This requirement also involves bolstering international cooperation. Lastly, enhancing technological innovation systems is essential for expediting the widespread adoption of sustainable technologies and practices.

In recent years, there has been a significant increase in the use of carbon credits by organizations. This is driven by a collective urgency to take real action to address climate change and to meet the demands of stakeholders, particularly government agencies. While the use of carbon credits remains voluntary, it has become indirectly obligatory to comply with legal regulations. This practice dates back to the introduction of the Kyoto Protocol, which operationalizes the United Nations Framework Convention on Climate Change (UNFCCC). As highlighted in previous chapters, utilizing carbon credits enables companies to achieve

emission reduction and/or carbon neutrality more expediently, without having to wait for the development of new innovations. Before utilizing carbon credits, companies must take decisive actions within their value chains to set and achieve short-term goals for reducing climate change. This involves implementing concrete strategies at the operational level. The issue often arises as to whether using carbon credits/offsets may merely justify, rather than eliminate, emissions by offsetting them. Consequently, if companies opt to use credits, they should ensure their high quality and conduct due diligence on the projects from which they procure credits to avoid the possibility of engaging in greenwashing practices. Additionally, transparent accounting and separate reporting of the credits used are crucial, including all necessary details to ensure robust and transparent accounting. Therefore, the ethical and moral principles that companies should consider before using carbon credits can be condensed into questions: (i) when to use credits; (ii) what type of credits to use; and (iii) how to account for credits.

Through the studies encompassed in this papers collection, the use of carbon credits has been highlighted as an effective tool for mitigating climate change while simultaneously proving beneficial for improving corporate financial performance. The findings contribute in multiple ways to the expansion of the literature on sustainability, climate change management, carbon performance, climate finance, and financial outcomes, serving as a valuable guide for managers, policymakers, practitioners, and investors, as well as academics who intend to further investigate this topic by building on the limitations of current studies in future research.

The literature review conducted in the first chapter, aimed at analyzing the relationship between carbon performance (encompassing parameters such as greenhouse gas emissions and decarbonization) and financial performance, does not yield unequivocal evidence. However, it suggests a pattern indicating that companies adopting climate-friendly measures may achieve positive financial outcomes through climate-conscious corporate management. This analysis confirmed that the reviewed publications provide a comprehensive overview of the current literature on this highly relevant and urgent research area. The literature review allowed for a focus on strategies that support companies engaged in decarbonization. Carbon credits and carbon offsets have proven to be valuable tools that companies are increasingly adopting to achieve zero-emission goals without immediate alterations to their production processes. Additionally, investigating the impact of these strategies on companies' financial performance and their contribution to reducing carbon emissions is crucial in determining whether these strategies represent genuine efforts to mitigate emissions or merely greenwashing practices. This research lays the foundation for the studies conducted in the second and third chapters.

The second chapter, building on the literature review, analyzes the relationship between carbon emissions and financial performance, evaluating the moderating impact of carbon credits/offsets. It provides a comprehensive perspective on how climate finance instruments and the implementation of sustainable strategies - specifically focusing on carbon credits/offsets - can enhance corporate financial performance while simultaneously addressing environmental concerns. The research delves into the moderating role of carbon credits in the

relationship between emissions and corporate financial performance, drawing on the theoretical framework of institutional theory. It emphasizes that corporate investment programs are tied to mandatory sustainability requirements. The existing literature offers limited evidence on the connection between carbon credits/offsets and financial benefits. Therefore, this empirical analysis aims to fill this gap, highlighting the utility of studying and implementing sustainability strategies through financial instruments for managers, entrepreneurs, and policymakers, who collectively tend to represent the demands and pressures common to many stakeholders.

The primary purpose of this paper collection finds its fullest expression and summary in the third chapter, given that the literature has limited evidence on the connection between climate finance tools and the financial benefits of investing in them to improve companies' environmental performance and GHG emission reduction. This study examines the relationship between carbon credits/offsets and financial performance, focusing on the moderating role of CSR practices and the quality of corporate governance. Indeed, this study is grounded in the theoretical framework of the resource-based view, integrated with legitimacy theory. Through the lens of resource-based view theory, carbon credits/offsets are seen as a scarce resource that can offer a competitive edge to companies utilizing them, potentially leading to enhanced financial performance. Furthermore, from a legitimacy theory perspective, the utilization of carbon credits/offsets can help companies establish credibility with stakeholders, fostering customer loyalty and reducing risk perception, ultimately contributing to improved financial performance through cost savings. The outcome of our research reveals significant practical implications for managers, investors, and policymakers. In today's business landscape, managers tasked with addressing environmental risks can leverage a range of tools to implement sustainable practices without imposing a financial strain on their companies. As a result, sustainability is increasingly recognized as a valuable practice that can enhance both environmental outcomes and overall financial performance. Additionally, investors benefit from enhanced capabilities to assess investments based on sustainable practices. They have at their disposal a wide range of tools to evaluate diverse investments and avoid companies that engage in greenwashing - the practice of falsely claiming sustainability for recognition without implementing genuine sustainable practices. Finally, there is a growing call for policymakers to incentivize companies to adopt sustainable practices. One approach is to establish laws that support environmentally conscious businesses and ensure compliance. These companies can significantly influence the entire system, and a more comprehensive set of guidelines and effective monitoring can further encourage their proactive efforts. Government-led initiatives can play a critical role in driving these companies to take the necessary actions.

In conclusion, it is crucial to integrate climate finance strategies, such as leveraging investment flows towards low-carbon and climate-resilient development, with sustainable and green finance initiatives. This integration is vital for effectively reducing carbon emissions, fostering the development of resilient climate infrastructure, and advancing environmental

sustainability. These efforts make a significant contribution to achieving the Sustainable Development Goals (SDGs) for 2030. Moreover, the evolution of Climate finance tools plays a pivotal role in addressing climate risks and sustainability challenges. This involves the development of new financial products and services that incentivize and channel investment towards environmentally sustainable projects and technologies. The ongoing advancement of Climate Finance innovation underscores its critical relevance in the transition to a low-carbon, sustainable economy.

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