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The Impact of Profitability on Scope 1, 2 and 3 GHG Emissions in Europe

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Abstract

This thesis examines the effect of corporate profitability on the levels of greenhouse gas (GHG) emissions, specifically analyzing Scope 1, 2, and 3 emissions for European companies listed on the STOXX Europe 600 index from 2017 to 2023. Given increasing regulatory pressures, inconclusive evidence on whether profitability drives sustainability, and potential bidirectional causality, researching this relationship is highly relevant. Using a systematic literature review (SLR) and fixed-effects regressions, this thesis investigates this relationship. Results show profitability, measured by return on assets (ROA), negatively correlates with Scope 3 emissions, suggesting higher profits may promote sustainability. However, no significant correlation exists for Scope 1 and 2 emissions, except for a positive link with Scope 2 emissions in low-emission sectors. High-emission industries show stronger model explanatory power, indicating a closer profitability-emissions link. Findings are robust against outliers but vary with changing profitability metrics. This research contributes to the profitability-sustainability debate, offering insights for policymakers, scholars, and managers, while emphasizing the need to consider industry and Scope-specific dynamics to combat climate change.

Keywords: GHG emissions; profitability; sustainability reporting

1. Introduction

In the last decades, the accelerating pace of climate change has brought the issue of greenhouse gas (GHG) emissions to the forefront of global discussions (Manabe, 2019; Solomon et al., 2009; van Vuuren & Riahi, 2008). The impact of corporate activities on the environment, mainly through GHG emissions, has become a critical area of concern. Companies worldwide are still making substantial profits based on business practices detrimental to the environment (Trucost, 2013). The United Nations' (UN) Sustainable Development Goals (SDGs) and the Paris Climate Agreement of 2015 underscore the need for a global effort to reduce GHG emissions and combat climate change (United Nations, 2015a). These international frameworks have set the stage for more stringent regulations and reporting requirements, particularly in the European Union (EU), which is recognised as a leader in sustainability reporting (Barbu et al., 2022). The EU has taken significant steps to integrate sustainability into corporate reporting, primarily through the Non-Financial Reporting Directive (NFRD) and its successor, the Corporate Sustainability Reporting Directive (CSRD) (European Union, 2022). These directives mandate large companies to disclose their environmental social, and governance (ESG) performance, with a specific emphasis on GHG emissions categorised under Scope 1, Scope 2 and Scope 3 as per the GHG Protocol (WRI & WBCSD, 2004). Scope 1 encompasses direct emissions from sources owned or controlled by the company. Scope 2 refers to indirect emissions resulting from the production of electricity, steam, heating and cooling that the company purchases. Scope 3 covers all other indirect emissions associated with the company's value chain. (WRI & WBCSD, 2004)

Amidst the increasing public and regulatory attention on GHG emissions, both scholars and business professionals have questioned whether "it pays to be green" (see, e.g., Busch and Hoffmann, 2011; Cote, 2021; Hoang et al., 2020; Lewandowski, 2017). This inquiry suggests that companies achieving lower GHG emissions may experience enhanced profitability or increased firm value. This perspective aligns with Porter's Hypothesis, which posits a "win-win" scenario

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where stricter regulations foster innovation, improve competitive advantage and ultimately enhance financial performance (Porter, 1980; Porter & van der Linde, 1995; Waddock & Graves, 1997). However, existing literature presents mixed findings on this relationship (Galama & Scholtens, 2021; Iwata & Okada, 2011; J. Wang et al., 2021). Some studies even suggest that "it pays not to be green", implying that higher GHG emissions may be associated with greater profitability (Rokhmawati et al., 2015; L. Wang et al., 2014). These conflicting results highlight the complexity of this research area, with some scholars proposing the existence of reverse causality or bidirectionality between financial performance and GHG emissions, which could significantly influence the observed outcomes (Endrikat et al., 2014; Testa & D'Amato, 2017; Waddock & Graves, 1997). Nonetheless, limited research addresses this potential reverse relationship, encapsulated in the question: "Does profitability drive sustainability?" (Hassan & Romilly, 2018; Meng et al., 2023; Shahgholian, 2019). This potential relationship, grounded in the Slack Resource Theory and aspects of Stakeholder and Legitimacy Theory, suggests that more profitable companies may naturally invest more in GHG reduction efforts to achieve legitimacy and manage stakeholder relations (see, e.g., Cyert and March, 1963; Dowling and Pfeffer, 1975; Freeman, 1984; Waddock and Graves, 1997). The impact of profitability on GHG emissions represents a critical yet underexplored area of study, which could contribute to a deeper understanding of the profitability-sustainability nexus.

This thesis addresses this research gap by comprehensively analysing Scope 1, 2 and 3 GHG emissions reported by European companies from 2017 to 2023 and empirically examining profitability's impact on these emissions. Given Europe's robust reporting framework, high data quality and availability are anticipated. Consequently, the study will focus on companies listed on the STOXX Europe 600 index, including some of the region's largest firms. The central research questions of this thesis are twofold:

(1) *What are the Scope 1, 2 and 3 GHG emissions levels for European companies from 2017 to 2023?*

(2) *How does firm profitability impact total and individual Scope 1, 2 and 3 GHG emissions?*

By answering these questions, this thesis aims to contribute to the current literature on corporate sustainability reporting, CO2-Footprints, and the relation between financial performance and GHG emissions to provide valuable insights for policymakers, corporate managers, and other stakeholders. This work will be structured as follows: The second chapter provides a detailed overview of the fundamentals of sustainability reporting, including the regulatory landscape and the specific requirements of the GHG Protocol. The third chapter presents a systematic literature review (SLR), highlighting the academic relevance of the research questions and identifying gaps in the existing literature. The fourth chapter explains the theoretical framework, drawing on Slack Resources, Legitimacy and Stakeholder Theory, to explain the potential impact of profitability on GHG emissions. The fifth chapter develops and discusses the hypotheses for this regression. The sixth chapter outlines the methodology used to collect and analyse data, followed by a presentation of the results in the seventh chapter. The concluding chapter discusses the implications of the findings, their limitations and provides concluding remarks.

This research is particularly timely as companies prepare to comply with the new CSRD requirements, which will make the disclosure of all three Scopes of GHG emissions mandatory for approximately 50,000 companies starting in 2024 (European Parliament, 2022; European Union, 2022). The findings of this thesis will not only shed light on the current state of GHG emissions reporting in Europe but also guide future research and policies. Furthermore, by exploring the relationship between profitability and GHG emissions, this study aims to inform the ongoing debate on whether and how economic performance is aligned with environmental sustainability. Before proceeding with the literature review and the analysis of GHG emissions, it is essential to understand the basics of sustainability reporting, specifically the GHG Protocol, which will be discussed in the following chapters.

2. Fundamentals of Sustainability Reporting

Broad publications of GHG emissions by companies occurred relatively recently and has been largely influenced by recent advancements in non-financial reporting practices. A basic understanding of the non-financial or sustainability reporting landscape is necessary to analyse the countervailing trends in GHG emissions and understand the factors influencing them. Therefore, this thesis first briefly introduces sustainability reporting and the sustainability reporting landscape.

2.1. Introduction to Sustainability Reporting

The introduction to sustainability reporting begins with a basic definition of the term and then briefly discusses its importance, benefits, and challenges.

2.1.1. Definition

At first, the meaning of sustainability reporting might seem easy to grasp; it focuses primarily on Environmental, Social, and Governance (ESG) topics and is also described as non-financial information (NFI). However, according to Erkens et al. (2015), who analysed 787 articles published in 53 journals from 1973 to 2013, non-financial information seems to need a more precise definition. They attribute this to the ambiguity of the concept of NFI and try to define the topic on their own.

Before we move on to the definition of NFI, it is helpful to first define financial reporting to distinguish between the two topics and highlight the differences. Traditional financial reporting has become highly standardised and is based on generally accepted accounting principles (Ampofo & Sellani, 2005). In Europe, for example, these are published by international associations such as the International Accounting Standards Board (IASB) and form the basis of today's financial reporting (Van Greuning et al., 2011). This type of reporting aims to inform investors about a company's financial performance. The IFRS Framework states that the objective is to "*provide financial information about the reporting entity that is useful to existing and potential investors, lenders and other creditors in making decisions about providing resources to the entity*" (IFRS Foundation, 2018, Conceptual Framework, §1.2). Per definition, the disclosure of financial information provides the correct information for investors, lenders, and other creditors, but in the last decades, calls from investors and other stakeholders for non-financial reporting on crucial ESG issues have increased (KPMG, 2022).

According to Erkens et al. (2015, p. 25), NFI can be defined as a disclosure "*on dimensions of performance other than the traditional assessment of financial performance*", including, but not limited to, topics related to ESG. Tarquinio and Posadas (2020) conducted a literature review on the term "non-financial information" and found that there is still no consensus on the exact definition of this term. In addition to the NFI, the term "sustainability reporting" is employed almost synonymously, and increased use of it can be observed (Baumüller & Grbenic, 2021; Eccles et al., 2020). The change from the Non-Financial Reporting Directive to the Corporate Sustainability Reporting Directive is an example of the shift to the term "sustainability reporting", which, as the name suggests, consciously emphasises the importance of a more integrated way of thinking about global issues and a tool to fight climate change (Baumüller & Sopp, 2022). The term "sustainability reporting" has now established itself and, to some extent, replaces and expands the term "non-financial information" (Baumüller & Grbenic, 2021). For this thesis, these definitions are sufficient since we limit ourselves to the information on GHG emissions included in the sustainability or annual reports and do not engage with the documents in their entirety. Having established an understanding of the definition of sustainability reporting, the next step is to delve into its relevance and importance for the business landscape.

2.1.2. Importance and Relevance

The topic of sustainability reporting has become omnipresent for companies, and an increase in research concerning sustainability reporting can be observed (Erkens et al., 2015). New regulations primarily drive the trend, as around 11,700 public-interest entities have been obliged to report by the EU NFRD starting in 2017, and about 50,000 will be, under the new CSRD (European Broadcasting Union, 2023). This reporting regulation is needed because past efforts to fight climate change have not been enough, and governments have committed themselves, albeit not legally binding, to achieving the SDGs (United Nations, 2015b). Conversely, this means they must encourage the achievement of the climate goals and monitor progress through national or international regulation. The reporting of non-financial information has made significant progress over the last years and comes with great benefits for various stakeholders (Bualllay, 2019; James, 2015), but still has significant challenges to overcome, particularly concerning its alignment with the attainment of the UN SDGs (Tsalis et al., 2020). Both benefits and challenges will be discussed in the following two chapters.

2.1.3. Benefits and Advantages

Various research on the benefits of sustainability reporting was published, and the positive effects can be observed for companies and the common good (Bellantuono et al., 2016; Ioannou & Serafeim, 2017; Tomar, 2022). Research conducted by Tomar (2022) analysed the effects of the U.S. GHG Reporting Program on the GHG amounts emitted by facilities and found that the disclosure alone led to a 7,9% reduction of their respective GHG emissions. Benchmarking and reporting GHG emissions alone seem to encourage reduction and is, therefore, a welcome positive effect of sustainability reporting (Tomar, 2022). Another benefit is the increased transparency and disclosures firms make on sustainability issues (Ioannou & Serafeim, 2017). The stakeholders are, on the one hand, pushing firms to increase disclosures and, on the other hand, benefit from it because mandatory but also voluntary reporting on environmental, social, and governance matters provides the stakeholders with insights into companies that would not be common before this trend (Bellantuono et al., 2016; Fernandez-Feijoo et al., 2014; Herremans et al., 2016; Manetti & Toccafondi, 2012). In 2015, the Chief Executive Officer of the Global Reporting Initiative (GRI), a global standard-setter for sustainability reporting, proposed another view of sustainability reporting during an interview (Kiron & Kruschwitz, 2015). According to him, the reports can highlight material and relevant sustainability issues for the companies (Kiron & Kruschwitz, 2015) and, therefore, be used as a strategic tool for decision-making and risk management, which was already researched by C. A. Adams and Frost (2008). Furthermore, sustainability reporting and, therefore, the combination of higher transparency, better risk assessment and decision-making seems to have a positive impact on firm valuations (Kuzey & Uyar, 2017; Loh et al., 2017).

Nevertheless, most research observing the benefits of sustainability reporting was conducted before it became mandatory for most major European companies. The current regulatory developments, namely the NFRD and upcoming CSRD, could lead to a situation where it is no longer reporting per se, which brings advantages for the companies but rather relative performance towards sustainability goals. After having reviewed the potential benefits, we will look at the current challenges sustainability reporting faces.

2.1.4. Challenges and Obstacles

Although the beginnings of sustainability reporting go back several decades, many challenges can still be observed. Despite a significant number of companies using the GRI standards for their reporting, a considerable challenge is the lack of comparability between their current reports and past ones, as well as with the reports of other companies and industries (Zsóka & Vajkai, 2018). Another study by Cardoni et al. (2019) analysed the comparability of 41 GRI reports of listed oil and gas companies and noted the low comparability between the reports. Poor comparability is still a problem that will hopefully improve with more regulation and requirements on crucial aspects like the key performance indicators and the format of sustainability reports.

Reporting standards such as GRI seem to have increased the quality of sustainability reports, as Diouf and Boiral (2017) analysed through stakeholder interviews. However, the quality of the sustainability reports still lacks behind financial reporting and is highly influenced by the specific application and interpretation, e.g., the GRI principles (Boiral et al., 2019; Diouf & Boiral, 2017). Next to quality issues, the materiality is challenging to assess due to the subjective nature of specific information (Wu et al., 2018). A solution would be assurance statements, as we see them for financial statements and annual reports (Wallage, 2000). However, a study by O'Dwyer and Owen (2005) and a newer one by Boiral and Heras-Saizarbitoria (2020) question the usefulness of this practice and show the lack of reliability of assurance statements. A significant issue Boiral and Heras-Saizarbitoria (2020) criticises in the assurance procedures is the seeming disconnection "*from real sustainability issues and reporting requirements*" (Boiral & Heras-Saizarbitoria, 2020, p. 12). Time will tell how and whether mandatory audits on sustainability reporting will prevail. As for now, the new EU CSRD will require limited assurance of sustainability information (European Union, 2022). The low quality, low comparability and lack of transparency of sustainability reports contradict their actual goal, namely, providing transparent information on the sustainability performance of companies. In a study of 21 GRI reports rated A and A+, Boiral (2013) found that 90% of the relevant sustainability events were not correctly presented in the reports. Furthermore, greenwashing is still a problem, making it difficult for sustainability reports to build credibility in the fight against climate change (de Freitas Netto et al., 2020). This undermines the transparency and credibility of the reports (Boiral, 2013; de Freitas Netto et al., 2020) and raises the question of whether they are conducive to achieving climate goals.

In summary, despite standards such as the GRI and efforts by companies, sustainability reports remain difficult to compare and can lack transparency. Regulators and independent initiatives have been trying to establish standards for several years and have already greatly improved reporting, but a multitude of diverse standards and frameworks have emerged, leading to complexity and challenges in comprehension and implementation.

2.2. The Sustainability Reporting Landscape

Building on the introduction to sustainability reporting, the following chapter will explore the landscape of regulations, standards, and frameworks around sustainability reporting, with a focus on the global goals and principles and the regulations in Europe.

2.2.1. Introduction to Sustainability Regulations and Frameworks

Sustainability reports have been an integral part of corporate reporting for several years. In contrast to financial reporting, the regulatory environment was and still is much more fragmented (Young, 2023). This section analyses the landscape around sustainability reports, and the latest developments in the field are discussed. Inspired by the publication of Helbing (2022) on the reporting landscape, this work opted for a pyramid-shaped structure, displayed in Figure 1, which represents the various sub-areas of sustainability reporting effectively. The SDGs of the UN and the Paris Climate Agreement are the overarching goals for sustainability reporting, and the governmental regulations to achieve them will be examined in the following. The focus is on the European standards NFRD and CSRD, which have already been published and cover the companies in our study. Not to be forgotten are the China ESG Disclosure Standards, the upcoming SEC Climate Disclosures from the USA, and other country-specific regulations, which we will not examine further in the context of this work. The cornerstones of sustainability reports are the various frameworks and standards that have been established in recent years. These include the newly founded International Sustainability Standards Board (ISSB), which aims to consolidate multiple standards and frameworks under the IFRS Foundation to establish itself as a global standard (IFRS Foundation, 2024). In addition, the GRI, the GHG Protocol, the Task Force on Climate-related Financial Disclosures (TCFD), the Science Based Targets Initiative (SBTi), and the Carbon Disclosure Project (CDP), have also established themselves in the sustainability reporting landscape.

The two sub-areas, Global Goals & Principles and Governmental Regulations, will be covered in more detail below. The GHG Protocol and the three different Scopes are discussed in a separate chapter due to their importance for our analysis of corporate GHG emissions.

2.2.2. Global Goals and Principles

The 17 SDGs adopted by the UN in September 2015 mark a milestone for global goals and have also influenced sustainability reports (United Nations, 2015b). For the first time in history, the UN shifted to "*one sustainable development agenda*", setting the goals on a global scale (Biermann et al., 2017, p. 26). The new approach adopted by the UN is "governance by goals", which is not legally binding (Kim, 2016) but based on shared objectives from the UN Member states (Biermann et al., 2017). An additional unique characteristic of the SDGs is the focus on all relevant actors, including companies and social organisations, rather than only focusing on the states (United Nations, 2015b). The 17 SDGs combine 169 defined targets with specific deadlines, but some remain qualitative, leaving room for interpretation (United

Figure 1: Sustainability Reporting Landscape Pyramid, based on Helbing (2022)

Nations, 2015b). In recent years, standards setters, institutions, and companies have sought to include SDGs in their corporate reporting, an essential step towards achieving the goals (Elalfy et al., 2021; Subramaniam et al., 2023). For example, GRI links the GRI standards to SDGs, thus allowing companies to firmly establish the SDGs in their reporting (GRI, 2022). However, the qualitative nature of some SDGs, together with the challenges of sustainability reporting discussed in Chapter 2.1.4, lead to shortcomings such as intangibility, low standardisation, omission of negative impacts, and lack of comparability (Diaz-Sarachaga, 2021). Despite their voluntary character and some shortcomings in the disclosures, the SDGs have found their way into sustainability reports. They can be seen as the global goals and principles that businesses, governments and other parts of society aim to achieve.

Another global goal alongside the SDGs is the limitation of the global average temperature increase to well below 2°C, as agreed on by the UN in the Paris Agreement, the first in time legally binding global climate change agreement (United Nations, 2015a). This agreement explicitly limits the rise in temperature and the global emission levels, which is linked to the GHG emissions in sustainability reports. The main mitigation objectives are to limit the global average temperature increase to well below 2°C above pre-industrial level and strive to the more ambitious 1,5°C target. These targets require global emissions to peak as soon as possible and subsequently reduced quickly. In addition, it was agreed in the Paris Agreement to track the progress of the commitments and to rely on a transparent system for this purpose. (United Nations, 2015a) Subsequently, the limitation of GHG emissions and transparent measurement of targets requires countries and companies to clearly disclose and reduce GHG emissions.

The two UN conventions require, although only the Paris Agreement is legally binding, governments to incorporate the goals into their legislation (United Nations, 2015a, 2015b). To meet these requirements, countries and country unions such as the EU have published laws and requirements for sustainability reporting, which we will discuss in the following chapter.

2.2.3. NFRD and CSRD in Europe

Regulations shape today's financial reporting and have contributed significantly to the standardisation and comparability of financial reports (Van Greuning et al., 2011). Similarly, new regulations on non-financial reporting have developed in recent years and already characterise a significant proportion of sustainability reports. Based on global principles, this text will now focus on the European scope only.

In the European Union, the first relevant regulation on non-financial reporting was published on 5 December 2014, under the name NFRD (European Union, 2014). Directive 2014/95/EU on disclosure of non-financial and diversity information requires large public-interest entities with more than 500 employees, which amounts to approximately 11'700 companies in the European Union, to disclose relevant non-financial information to investors and other stakeholder (European Broadcasting Union, 2023). To quote the official summary of the law:

> "*Such companies are required to give a review of their business model, policies, outcomes, principal risks and key performance indicators, including on: environmental matters; social and employee aspects; respect for human rights; anti-corruption and bribery issues.*" (European Union, 2019, p. 1)

The NFRD required companies to comply with the directive for the first time in the 2017 financial year reports published in 2018, raising the sustainability reporting requirements in Europe. Although the disclosure of GHG emissions by Scopes only becomes mandatory with the CSRD, a large share of European companies already reporting their Scope 1, 2 and 3 GHG emissions is expected. Therefore, the GHG emission numbers of FY 2017 mark the ideal starting period for our analysis period from 2017 to 2023. Nevertheless, the NFRD gave the reporting companies substantial freedom in the choice of how to report and did not require a specific standard or framework, which led to difficulties in comparability, relevance, and reliability of the different non-financial disclosures (Hahnkamper-Vandenbulcke, 2021).

As part of the European Green Deal, it was decided on 11 December 2019 to review the NFRD and solve the associated problems and shortcomings (Hahnkamper-Vandenbulcke, 2021). The main issues and needs identified during the public consultation were the lack of comparability, reliability and relevance, overlaps with other regulations, the lack of a mandatory reporting standard, stricter audit requirements, a digitalisation of non-financial reporting, the disclosure of the materiality assessment procedures used by companies and last but not least the extension of mandatory non-financial reporting to other listed and incorporated companies active in the EU (Hahnkamper-Vandenbulcke, 2021). The EU's solution to these problems was to come into force on January, 5, 2023 under the CSRD (European Union, 2022). The CSRD applies to companies with two out of the three following characteristics: >500 employees and/or, > € 40mio turnover and/or, > € 20mio total assets and for all listed companies (European Union, 2022), which enlarges the number of companies required to report under CSRD to approximately 50,000 (European Parliament, 2022; European Union, 2022). In addition to the supplementary companies covered by the new directive, the reporting requirements of the NFRD remain in effect, next to the additional requirements introduced by the CSRD (European Union, 2022). Companies must report in accordance with the CSRD from the 2024 financial year onwards, following the new European Sustainability Reporting Standards (ESRS) developed by the European Financial Reporting Advisory Group (EFRAG). Since compliance with new standards involves significant direct and indirect costs, and organisational effort, as EFRAG's cost analysis points out (EFRAG, 2023a), there will be simplified reporting for small and medium-sized enterprises. With the ESRS, the European Union is responding to the demand of Stakeholders for a uniform standard for sustainability reports, which should lead to greater comparability (European Commission, 2023).

An essential principle introduced with the CSRD is the double materiality, which states that companies must first document the impact of sustainability issues on their company's financial and corporate situation and, secondly, the impact the company has on sustainability issues. In contrast to the regulations of the NFRD, this requires companies to report on topics that impact the environment but not their economic situation, thus preventing one-sided reporting (envoria, 2022). Furthermore, the CSRD requires companies to report additional information on intangibles, including forward-looking targets, and link them to the relevant targets of the Paris Agreement and UN SDGs.

Another objective of the new directive is a standardised reporting design. Most of the relevant information from CSRD-compliant reporting will have to be digitised and machine-readable in the European Single Electronic Format (ESEF/XHTML), which should facilitate comparability and information search within the sustainability reports (ESMA, n.d.). Finally, the new CSRD introduces a mandatory limited external assurance of the published sustainability information (European Commission, n.d.).

It is still too early to observe the effects of the CSRD on sustainability reporting, but the NFRD has already led to interesting developments. A study by Cuomo et al. (2022) analysed the effects of the NFRD on corporate social responsibility and found an increase in performance and transparency. Another study linked the NFRD to better environmental and social performance on ESG scores but could not find a significant effect on the governance dimension (Aluchna et al., 2023).

In summary, significant developments in the regulatory environment of the European Union are observed. The new CSRD addresses many of the problems of the NFRD, which will hopefully lead to the desired effects, such as increased transparency, comparability, GHG reduction and usefulness of sustainability reporting. A single standard standing out when it comes to the definition and calculation of GHG emissions is the GHG Protocol. Therefore, getting an overview of this standard and understanding the individual Scope 1, 2 and 3 GHG emission Scopes is worthwhile. Accordingly, the GHG Protocol will be discussed in the next chapter.

2.3. The GHG Protocol: Scope 1, 2 and 3 GHG Emissions

The GHG emissions of European companies are a key focus of this study, and the GHG Protocol has established itself as a standard for their definition and calculations. Therefore, this chapter will provide a brief introduction to the GHG Protocol and the individual Scope 1, 2 and 3 emissions.

2.3.1. Introduction and Relevance of the GHG Protocol

The GHG Protocol Initiative was launched in 1998 by a partnership of NGOs, governments, businesses and institutions. The first edition of the GHG Protocol Corporate Standards was published in 2001, with a revised edition in 2004, and was well received by the stakeholders (Green, 2010). The protocol provides a standard and recommendations for companies, as well as other organisations, to quantify their GHG emissions, and includes accounting and reporting guidelines for the seven GHG defined by the Kyoto Protocol: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), and Nitrogen trifluoride (NF3). (WRI & WBCSD, 2004) After its introduction, the GHG Protocol has gained acceptance as a standard in recent years and is explicitly recommended or required by the GRI, CDP, SBTi, and ESRS, among others, to calculate GHG emissions (CDP, 2023; EFRAG, 2023b; Green, 2010; GRI, 2024; SBTi, 2024).

An introduction to the GHG protocol is essential for this work, as the GHG Protocol has become the standard in reporting and accordingly, most of the calculation of GHG emissions by companies are calculated with the GHG Protocol Corporate Standard (Green, 2010). The GHG Protocol provides a comprehensive framework consisting of five steps to identify and quantify GHG emissions. These emissions are categorised into three distinct Scopes—Scope 1, Scope 2, and Scope 3—each of which has unique implications and methodologies for calculation. Consequently, a short insight into the three different Scopes, explained by the example of Thyssenkrupp AG, will be given. The first step is to identify the sources of GHG emissions, which typically occur from stationary combustion, mobile combustion, process emissions, and fugitive emissions. After the identification comes the selection of a calculation approach; the most accurate way would be to measure the emissions directly at the point of origin, which can hardly be guaranteed in reality and would often cause too high costs. Therefore, emission factors for specific processes or fuel quantities are often used, allowing a cost-effective and relatively accurate measurement. However, companies are always encouraged to use the most accurate and appropriate method. Next comes the collection of data across the three Scopes and the application of calculation tools, like the GHG Protocol Initiative publishes on their website. The calculation tools can be divided into two categories: the cross-sector tools for GHG emissions that apply to multiple sectors equally, like stationary combustion and mobile combustion, and the sector-specific tools for specific sectors like cement, steel, aluminium, or offices. Finally, the collected information must be aggregated at the corporate level. This can be done with the centralised and decentralised approaches; a centralised approach requests activity or fuel use data from the reporting units, and the emissions are calculated by the central based on this information; a decentralised approach requires reporting units to calculate GHG emission themselves, which leads to additional work for the strategic business units but creates more understanding for the emissions. (WRI & WBCSD, 2004, p. 41–46) Next follows a short description of Scope 1 to 3 and examples of the respective emissions.

2.3.2. The Three Emission Scopes

Scope 1 GHG emissions refer to direct emissions of GHG from sources owned or controlled by an organisation. These emissions result from activities or processes that occur within an organisation's operational boundaries. Common sources of Scope 1 emissions include on-site combustion of fossil fuels, such as those used in heating, industrial processes, and transportation, as well as emissions from chemical reactions or other on-site activities. (WRI & WBCSD, 2004) According to the definition, Scope 1 emissions will be high for companies burning fossil fuels during their production. ThyssenKrupp AG (TK) seems to be a good example as they recorded comparably high emissions for Scope 1 and provided further information on their methodology in their CDP Response Report – Climate Change 2023 (Thyssenkrupp, 2024). The company records all its emissions according to the Corporate GHG Protocol and chose October 1, 2017, to September 30, 2018, as a base year for all three emission Scopes. Scope 1 emissions for the base year were 24.2 Mio. t. of CO_2equivalents (CO2e) and 21.4 Mio. t. of CO_2e for the year 2023, which is relatively high due to their direct emissions from coal and coke usage in their steel business (Thyssenkrupp, 2024). According to TK, the steel division is responsible for 95% of their GHG emissions, and blast furnaces and electric arc furnaces cause the most significant volume.

Scope 2 GHG emissions encompass indirect emissions associated with consuming purchased or outsourced energy, such as electricity, steam, or heat. These emissions occur outside an organisation's operational boundaries but result from the generation of energy the organisation uses. Common sources of Scope 2 emissions include electricity purchased from the grid, district heating or cooling systems. (WRI & WBCSD, 2004) TK's Scope 2 GHG emissions are calculated using a location- and market-based approach. The location-based approach defines a specific CO2e per kWh number for everyone using the same power grid. The market-based approach allows the company to calculate its emissions based on specific energy purchase agreements, with an energy mix varying from the grid average (brightest, n.d.). The location-based Scope 2 emissions of TK for 2023 are 0.8 Mio. t. of CO_2e and 1.1 Mio. t. of CO_2e for the market-based approach, indicating that TK sources energy from specific supply contracts with higher than grid average CO_2e emissions per kWh (Thyssenkrupp, 2024).

Scope 3 GHG emissions encompass all other indirect emissions that occur due to an organisation's activities but are beyond its direct control and operational boundaries. Typical sources of Scope 3 emissions involve emissions associated with the entire supply chain of a product or service, including the life cycle, purchased goods and services, transportation and distribution, employee commuting, and the disposal or end-of-life treatment of products and services. These emissions can be much larger than a company's Scope 1 and 2 emissions and often account for the most significant portion of an organisation's total carbon footprint. (WRI & WBCSD, 2004) Continuing with the TK example, it becomes clear that measuring Scope 3 emissions is a major challenge for companies. The Scope 3 calculation from TK is based on the Corporate Value Chain Accounting and Reporting Standard of the GHG Protocol and is distributed across 17 emission categories (WBCSD, 2011). The most important in the case of TK appears to be *Purchased goods and services* with 27.2 Mio. t. of CO_2e, *Fuel-and-energy-related activities (not included in Scope 1 or 2)* with 4 Mio. t. of CO_2e and *Upstream transportation and distribution* with 5.3 Mio. t. of CO_2e. Other categories that are of minor relevance to TK and cause no or only minor emissions are *the use of sold products, employee commuting, business travel, capital goods, investments, or franchises* (Thyssenkrupp, 2024). In total, the Scope 3 GHG emissions of TK are assumed to be about 37 Mio. t. of CO_2e, making Scope 3 emissions the most significant part of total emissions (Thyssenkrupp, 2024). As shown in the TK example, Scope 3 emissions are challenging to assess as they come from many sources that a company cannot always directly influence. The accuracy and completeness have been criticised in current literature (Downie & Stubbs, 2013; Ducoulombier, 2021), and according to the research of Hertwich and Wood (2018), the Scope 3 emissions percentage of total emissions is highly variating across industries.

After this brief introduction to sustainability reporting, the reporting landscape and, in particular, the GHG Protocol, the core question of this thesis will be addressed. In the forthcoming chapter, a systematic literature review will be conducted to provide an overview of the existing research, thus establishing the relevance and validity of the research questions.

3. Systematic Literature Review and Academic Relevance

It is essential to contextualise the topic within current and past research to assess the relevance of this thesis. This is achieved with a systematic literature review examining the impact of financial performance on GHG emissions. The first section offers an overview of the systematic literature review methodology utilised, while the second section discusses the SLR findings and academic relevance of this thesis.

3.1. Systemic Literature Review

This chapter begins with a brief introduction to SLRs, followed by an explanation of the five-step methodological approach used to perform this SLR by Khan et al. (2003)

3.1.1. SLR Methodology

A systemic literature review is a "*clearly formulated question, identifies relevant studies, appraises their quality and summarises the evidence using explicit methodology*" (Khan et al., 2003, p. 118). The SLR's advantages are the transparency and reproducibility of research findings (Snyder, 2019), and it can help to systematically identify current studies, research approaches, trends and findings about the topic of this work: the impact of profitability on GHG emission levels. A five-step approach by Khan et al. (2003) is used to conduct the SLR, as it provides a clear structure to this research.

Step 1: Framing Questions for a Review

The research questions remain the same as presented in the introduction and are divided into two parts:

(1) *What are the Scope 1, 2 and 3 GHG emissions levels for European companies from 2017-2023?*

(2) *How does firm profitability impact total and individual Scope 1, 2 and 3 GHG emissions?*

The goal of the SLR is to systematically identify current research on these or similar topics, find research gaps, and assess the academic relevance of the research questions.

Step 2: Identifying Relevant Work

Relevant work is identified with a proper research strategy, including carefully selecting databases, defining key search terms, and systematically documenting the entire research process. Web of Science and Scopus were selected for the databases due to their wide range of academic articles and size. The search terms derived from the research questions above were organised into different blocks, summarising related terms in English to achieve optimal accuracy. Only English keywords were utilised in the search process, as prior analysis indicated that the most pertinent literature is predominantly available in this language. Albeit this thesis focuses on the European scope, the SLR will look for worldwide studies, to understand the global state of research. Table 1 provides an overview of the search terminology across the three identified blocks, effectively representing the research questions.

Consequently, each database of interest, Web of Science and Scopus, is subject to a query search, and all matching results exported to Endnote for a title and abstract screening in the next step. The exact search query can be found in Appendix 1.

Step 3: Assessing the Quality of Studies

This step involves critically evaluating the quality and relevance of the studies identified in the previous research step, using predetermined criteria for including or excluding studies. The inclusion criteria are outlined as follows:

Availability and Access: The papers must be accessible and available through the University of St. Gallen libraries.

Language: Papers must be written in English.

Date of Publication: The studies should be published between 1997 and 2024, aligning with the Kyoto Protocol's resolution, which marked a significant milestone in the global effort to combat GHG emissions (United Nations, 1998).

Relevance: The papers must be relevant to the research questions and align with analysing the relation between financial performance and GHG emissions, as determined by reviewing the titles and abstracts.

Publication Status: Only papers that are published and peer-reviewed in renowned journals will be considered.

The exclusion criteria automatically apply to papers not meeting the above inclusion criteria. This approach ensures

Table 1: SLR Search Term Matrix

	Block 1	Block 2	Block 3
Primary Search Terms	Financial Performance	GHG Emission	Firm
Related Terms	Profitability, Economic Performance, Financial Returns	Greenhouse Gas Emission, Carbon Emission, Carbon Footprint, Carbon Dioxide Equivalent (CO2e), CO2 Emissions, Carbon Dioxide Emission, Carbon Output, Scope 1, Scope 2, Scope 3	Companies, Company, Corporation, Corporate, Organisation, Organization

that only the most pertinent and credible studies are considered in the research. All studies identified in step 3 are classified with a four stars scoring system described below, allowing to classify the studies by direction of analysis (Profitability <–> GHG Emissions)

> * = **Excluded**, if one of the inclusion criteria is not met.
>
> ** = **Excluded**, gives a good overview of the relation of GHG emissions and financial performance but does not address the research question thoroughly enough.
>
> *** = **Included**, addresses the research question indirectly, analysing the link of corporate GHG emissions on the financial performance or more broadly, the relation between both variables.
>
> **** = **Included**, addresses the research questions directly, analysing the impact of corporate financial performance on corporate GHG emissions.

Step 4: Summarising the Evidence & Step 5: Interpreting the Findings

Upon reviewing the relevant academic literature, a comprehensive summary will be presented. This summary will highlight the topics previously explored by scholars, accompanied by a PRISMA Flow Diagram, based on Page et al. (2021), to illustrate the selection process from identified studies to those included in this literature review. Additionally, the studies gathered through the SLR will be leveraged to address the research questions and pinpoint existing gaps in the current research, thereby justifying the necessity of this study.

3.2. Findings and Academic Relevance

In the following chapter, the results of the literature review are presented. First, a brief introduction is provided, followed by an analysis of the number of studies found and their geographical and industry focus. Additionally, the used variables and the direction of analysis between the variables of financial performance and GHG emissions is discussed. After examining the theoretical frameworks employed, the findings of the studies are analysed and the chapter concludes with a summary.

3.2.1. Introduction

The systematic literature review approach ultimately identified 1,320 records, of which 69 were included in the final review sample. Figure 2, a PRISMA-Diagram, represents the SLR screening process and the number of records excluded during each step. The 69 studies included in the final sample were all reviewed in-depth. The following elements were collected, if applicable, in an Excel table: Geographical focus, industry focus, indices, research questions, hypotheses, study design, methodology, dependent variables, independent variables, moderating variables, control variables, Scopes of GHG emissions included, relation direction of GHG emissions to financial performance, findings, published year, time period of sample, sample size (in firms) and the theories used in the theoretical background.

3.2.2. Sample Overview

The systematic literature review identified 69 relevant papers from various industries, regions, and years. This chapter will first provide an overview of the sample of 69 studies before analysing their geographical and industry focus. As shown in Figure 3, the first relevant study was published in 2010, although the research was aimed at studies starting in 1997. The exact reason for this is unknown but probably attributable to the lack of relevant data before 2010 or the limited scope of the search of this SLR in terms of Databases or search terms. Nevertheless, a positive trend in the number of publications per year can be observed, and there is an increasing amount of research on the relationship between GHG emissions and financial performance.

The climate crisis is a global problem for all industries, and research in this field is expected across various regions and sectors. Figure 4 shows that most studies analysed samples of global companies without a specific regional focus. The studies with a country or regional focus are well diversified across high- and low-income regions, indicating that the topic is relevant to a global audience. For the industry focus of the studies, also shown in Figure 4, we identified the four categories: Multi-Sector, Manufacturing, CO2 Intensive, and Others. Most studies did not focus on a specific industry; ten focused on manufacturing, and five focused on what we classified as CO2-intensive sectors, which can include energy, oil and gas, and similar. As CO2-intensive sectors are, per definition, responsible for the majority of GHG emissions, a focus on these high-polluting sectors makes sense (Ritchie et al., 2020).

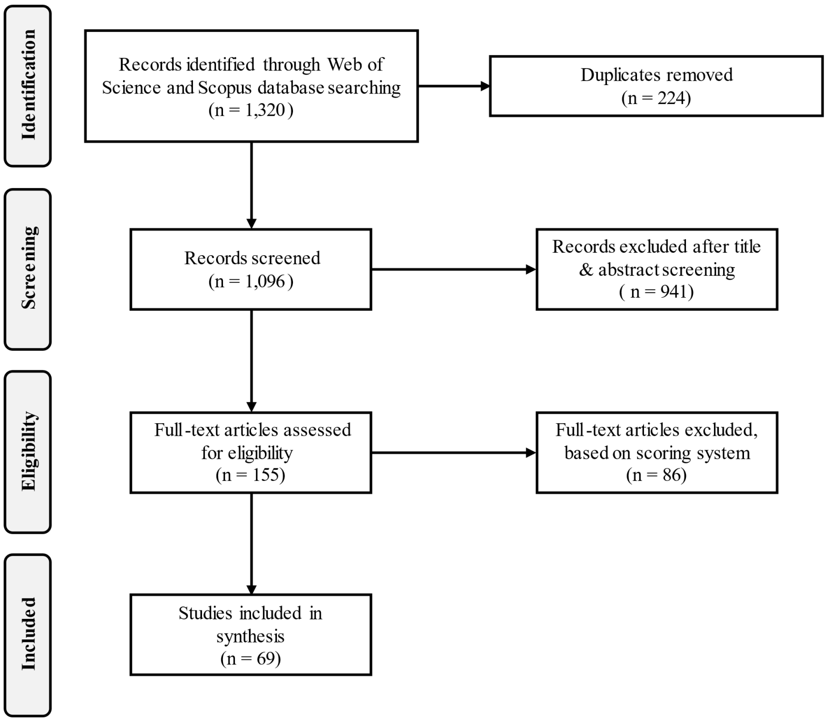

Figure 2: PRISMA-Diagram of SLR, based on Page et al. (2021)

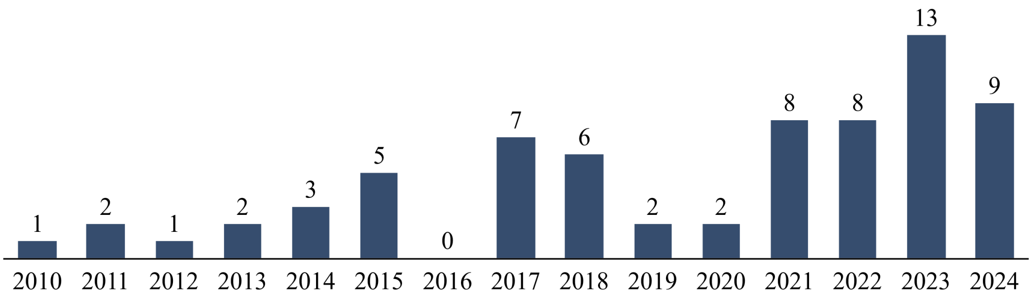

Figure 3: Distribution of Identified Studies between 2010-2023

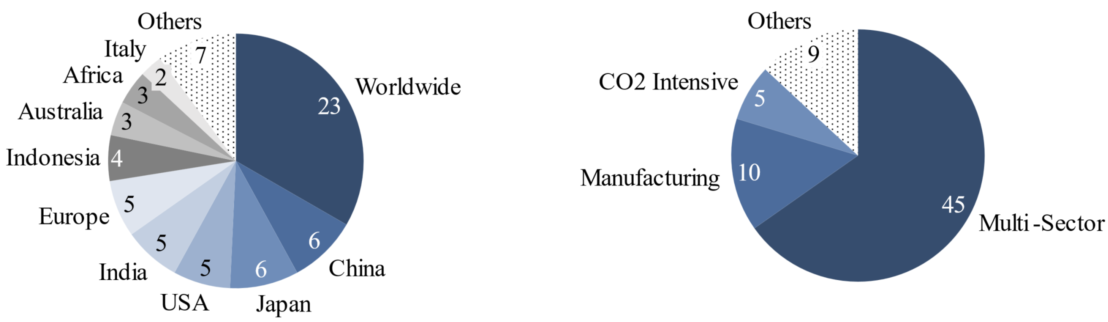

Figure 4: Number of Studies by Geographical and Industry Focus

In the systematic literature review sample comprising 69 studies, 62 are quantitative, while seven are qualitative. Focusing exclusively on the quantitative studies, the average sample size includes 523 firms, and the average data collection period spans 9.2 years. This calculation excludes the 11 studies with a data sample covering only one year. Concluding the broad overview of the study sample, the next chapter will focus on the most relevant types of variables used to analyse the relationship between the GHG emissions of companies and their financial performance.

3.2.3. Variables and Directions of Analysis

This thesis investigates the impact of profitability on GHG emissions across all Scopes. The primary objective of this SLR was to identify relevant studies examining this relationship and the broader correlation between GHG emissions and financial performance. Notably, 64 or over 90% of the studies reviewed focused on the unilateral impact of GHG emissions on financial performance rather than examining how factors such as profitability influence emission levels, therefore, classified as ***, as mentioned in the methodology. Similarly to our findings, Meng et al. (2023) noted the lack of literature on the impact of financial performance on carbon performance. Regardless of the direction of variable analysis, we will initially provide an overview of the metrics used to measure GHG emissions and financial performance. Additionally, we will briefly discuss the most commonly employed control variables in these studies to ensure that our analysis is grounded in scientifically recognised methodologies.

For most studies, GHG emissions represented the independent variable, and a variation of terms was used for similar or different metrics of GHG emissions, which can create some confusion at first glance. The commonly used terms to describe this variable are GHG emissions, which is used in this thesis, and environmental or carbon performance. Carbon performance is a widely used term, but the exact meaning or calculation can vary extensively, as it can represent total emissions (Busch et al., 2022) or emission intensity (Ganda, 2022; Meng et al., 2023). The metrics can be classified into two categories, mainly GHG emissions in absolute amounts (Ababneh, 2019; Ganda & Milondzo, 2018) or GHG emissions in relative amounts in relation to firm size metrics like sales or assets (Benkraiem et al., 2023; Di Pillo et al., 2017; Fujii et al., 2013). The absolute amount of GHG is an essential metric because the Kyoto Protocol and the Paris Agreement aim to reduce GHG emissions to fight climate change (United Nations, 2015a). Studies like Busch et al. (2022), Ganda (2022), and Homroy (2023) have been using the absolute amount of total GHG emissions or the change in GHG emissions between years as a variable to assess carbon performance. However, the relative amount introduces a notion of productivity in the metric, which is equally essential to achieving climate goals. Two different metrics commonly used to assess the relative carbon performance of a company are carbon intensity, defined as the total amount of GHG emissions divided by net sales or net assets, and carbon productivity, defined as net sales divided by Total GHG emissions (Benkraiem et al., 2023; Di Pillo et al., 2017; Ghose et al., 2023; P. Kumar & Firoz, 2018). Furthermore, some studies used the natural logarithm of the amounts above to counter the non-normal distribution of GHG emissions across firms (Busch & Hoffmann, 2011; Delmas et al., 2015; Desai et al., 2021; Houqe et al., 2022; Mahapatra et al., 2021; Raval et al., 2021; L. Wang et al., 2014). Unfortunately, as illustrated in Figure 5, 41 studies, representing approximately 59%, fail to specify what they mean by total GHG emissions, omitting any reference to the Scopes of GHG emissions considered in their analysis.

This lack of differentiation represents a significant research gap. Consequently, this study aims to address this and focus on all three Scopes of GHG emissions, recognising their distinct real-world implications. Each Scope is critically essential and necessitates different interventions from management and policymakers.

Financial performance or profitability is commonly approximated by two categories of metrics in the analysed studies: market-based and accounting-based metrics (Busch & Lewandowski, 2018). The most represented market-based metric is Tobin's Q (Busch & Lewandowski, 2018; L. Wang et al., 2014), a ratio comparing the market value of a firm to the replacement cost of its assets. This metric reflects a forward-looking perspective on profitability (Tobin, 1969). Tobin's Q incorporates future earnings expectations, making it a crucial indicator for assessing a firm's potential financial performance. However, for the scope of this research, we want to focus on actual and not expected earnings, which makes accounting-based profitability metrics better suited. The most represented accounting-based metric is Return on Assets (ROA) representing the operating performance of a firm (H. B. Chen & Manu, 2022; Gallego-Alvarez et al., 2015), followed by Return on Equity (ROE) representing the financial performance of a firm, Return on Sales (ROS), Return on investment (ROI) and similar (Galama & Scholtens, 2021; Velte, 2023; Q. Wang, 2023). However, financial performance is commonly used for all kinds of financial metrics and does not only refer to ROE.

In order to isolate the effects of the independent variable on the dependent variable, reduce biases, and improve the validity, the implementation of control variables is crucial for viable results in a regression model (Bernerth & Aguinis, 2016; Shibata, 1981). An excessive number of control variables can increase the complexity of the model (Gordon, 1968). Therefore, a focus on the most important ones observed in the SLR sample is taken. The first noteworthy control variable is related to firm size, usually approximated by the natural logarithm of total assets or sales (Busch et al., 2022; Delmas et al., 2015; Hassan & Romilly, 2018). The second is revenue growth from year to year (Raval et al., 2021; Rokhmawati & Gunardi, 2017). The third one is leverage, calculated in different ways but generally representing the amount of debt compared to total equity, assets, or profit measures (Raval et al., 2021; Rokhmawati & Gunardi, 2017). The fourth widely used control variable is capital intensity, calculated as capital expenditures divided by sales (Rokhmawati et al., 2017; Tarmizi & Brahmana, 2023). Last but not least, the fifth variable often represents the industry of a firm (Hassan & Romilly, 2018; Mahapatra et al., 2021; Shahgholian, 2019). As one of the few studies to incorporate variables from other domains, Velte (2023) analysed metrics related to corporate governance and their impact on GHG emissions. His findings suggest that board diversity may be an indicator of lower GHG emissions, making board diversity a potentially valuable control variable for our analysis.

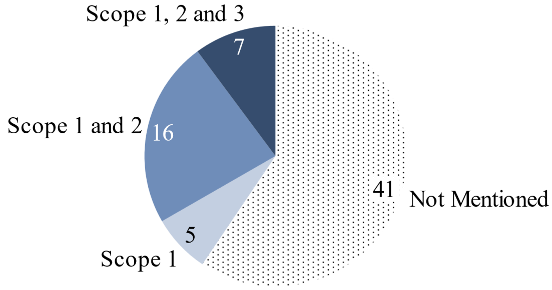

Figure 5: Number of Studies Distinguishing between the Scope 1, 2 and 3 GHG Emission Levels

3.2.4. Common Theoretical Frameworks in the Studies

This chapter will focus on the most common theories used to explain the relationship between GHG emissions and a company's financial performance. Two theories leading to potentially contractionary outcomes are the Neo-Classical Theory or Traditionalist View, and Porter's Hypothesis (Porter, 1980) or, similarly, the Revisionist View (Porter & van der Linde, 1995). Porter (1980) laid the foundation of this theory by stating that stringent environmental regulation can lead to better innovation. Further, he elaborated on the relationship between environment and competitiveness in Porter and van der Linde (1995). This theory argues for a win-win situation where reducing GHG emissions by regulation requires innovation, improving efficiency, and financial performance. The Traditionalist or Neo-Classical Theory argues for a win-lose relationship, as stringent environmental regulation leads to additional costs for firms, having a negative impact on profitability and competitiveness (Palmer et al., 1995). To build upon the win-win perspective, the Resource-Based View (RBV) (Barney, 1991; Wernerfelt, 1984) and Natural Resource-Based View (NRBV) (Hart, 1995) are also commonly used in many studies of our sample. Both theories argue that a company can achieve a competitive advantage by effectively using its internal resources, and the NRBV by Hart (1995) adds environmental sustainability to the framework. In this thesis context, this theory emphasises that focusing on better environmental sustainability and reducing GHG emissions creates a competitive advantage for a firm, potentially leading to higher financial performance.

Shifting from the economic-based to social-based theories, another critical theory to explain this relation is the Stakeholder Theory introduced by Freeman (1984), arguing for a shift from shareholders profit maximisation to the needs of a broader scope of stakeholders. In the context of the analysed relationship, this theory argues, particularly for firms with strong financial performance, that there is an increased societal expectation to engage all stakeholders. This encompasses, notably, reducing the environmental footprint and implementing environmentally beneficial initiatives associated with fewer GHG emissions. This argument is also supported by the Legitimacy Theory from Dowling and Pfeffer (1975), which discusses the relationship between organisations, stakeholders, and society. The theory posits that organisations strive to achieve and maintain legitimacy by aligning with societal norms, values, and expectations, an effect that is further strengthened by better financial performance (Akhter et al., 2023; Kuruppu et al., 2019). Given that climate change is unequivocally recognised as a global challenge, Legitimacy Theory suggests that firms are likely to voluntarily adhere to norms to reduce their GHG emissions to address this pressing issue.

Lastly, the Slack Resource Theory provides a robust theoretical foundation for understanding the anticipated impact of financial performance on a company's GHG emissions, which has been mentioned several times in the studies of this SLR. This theory, introduced by Cyert and March (1963), posits that firms with excess resources are better positioned to enhance performance across various dimensions, including environmental responsibility and GHG emission levels. Empirical research has established a positive association between slack resources and corporate social performance, suggesting that financial performance can facilitate improved environmental outcomes through the availability of slack resources (Waddock & Graves, 1997). This linkage underscores the integral role of resource availability in enabling firms to meet social and environmental objectives, thereby aligning financial success with sustainability goals. Having established the theoretical framework, the subsequent chapter will be devoted to a detailed examination of the study findings, underpinning the formulation of the research hypotheses for this thesis.

3.2.5. Findings of the Studies

The 69 studies were classified into 5 categories, indicating the main findings. To facilitate the comparability of study results, the categories were delineated as follows:

Negative: There is a negative correlation between GHG emissions and financial performance, indicating that higher emissions are associated with poorer financial performance.

Positive: There is a positive correlation between GHG emissions and financial performance, indicating that higher emissions are associated with better financial performance.

Mixed: A relationship between GHG emissions and financial performance is observed, but the direction of this relationship is unclear.

Non-linear: A non-linear relationship exists between GHG emissions and financial performance.

Not Significant: No relationship is found between GHG emissions and a company's financial performance.

This categorisation, shown in Figure 6, ensures a systematic and consistent approach to analysing and comparing the findings of various studies.

Out of 69 studies, 38 or 55% indicate a negative relationship between the amount of GHG emissions and the financial performance of companies. Desai et al. (2021) examined the impact of GHG emissions on financial performance utilising emissions data from the Carbon Disclosure Project, covering the period from 2013 to 2019 in India. Using Scope 1 GHG emissions to approximate the carbon footprint and both market- and accounting-based metrics for financial performance, the study indicates a significant negative relationship of GHG emissions on both measures. Another study by Gallego-Alvarez et al. (2015) analysed emission data from 89 companies between 2006 and 2009 and found a positive impact of GHG emission reduction on financial (defined by ROE) but not operational performance (defined by ROA).

Five studies associated higher GHG emissions positively with financial performance, favouring the neo-classical win-lose view mentioned in Chapter 3.2.4. Busch et al. (2022) analysed 4873 companies between 2005-2014 and used ROA as short-term and Tobin's Q as long-term metrics for financial performance as the dependent variable and total (direct and indirect) GHG emissions as the independent variable. The study found strong evidence of a positive relationship between GHG emissions and short-term financial performance (ROA) and long-term financial performance (Tobin's Q), indicating that higher emissions are associated with better financial performance. Similarly, L. Wang et al. (2014) examined 69 Australian companies and found a positive correlation between GHG emissions and financial performance across all industry sectors, stating that Australia's dominant mining industry could explain this finding. It is also important to emphasise that four studies reporting positive findings utilised data samples from single years. This methodological approach may compromise the comparability and validity of the results.

Several studies did not make clear, one-sided conclusions and found mixed results for the abovementioned relationship. A study from Bouaddi et al. (2023) found a difference in the effect depending on the size of a company, where the carbon emissions negatively affected small-size firms. However, the effect became positive with the increased size of the company. Another factor that seems to influence this relationship is a firm's industry. While a reduction in GHG emissions does lead to higher financial returns for firms in a sample of privately owned Australian firms, it does not appear to pay off for firms in environmentally sensitive sectors (Qian & Xing, 2018). Furthermore, two studies found a difference in the effect, depending on the metric used for financial performance. Delmas et al. (2015) found a detrimental impact of environmental performance on the present-time oriented ROA but a beneficial impact on the long-term oriented Tobin's Q, indicating a difference between short- and long-term effects of GHG emissions on financial performance. In contrast, van Emous et al. (2021) found lower GHG emissions to improve ROA, ROE, and ROS but no significant effect on Tobin's Q and a firm's current ratio. In conclusion, these mixed results indicate a further need to analyse the relationship between GHG and financial performance, considering the metrics used to approximate the variables, their time horizon, and the respective industries of the firms.

The last interesting finding not mentioned in previous studies is the potential non-linear relationship between GHG emissions and financial performance. Several studies have observed non-linear relationships both of U-shaped and inverted U-shaped form (Fujii et al., 2013; Misani & Pogutz, 2015; Ogunrinde et al., 2022; Tatsuo, 2010). Misani and Pogutz (2015) approximated financial performance by Tobin's Q and found that firms achieve the highest financial performance with neither too high nor too low carbon performance, indicating an inverted U-shaped relation. Similarly, a study involving Japanese manufacturing firms demonstrates an inverted U-shaped relationship between environmental and economic performance, signifying economic benefits from GHG reduction only up to a certain trade-off point. Adding to the mixed results and the influence of the firm industry discussed above, differences between non-linear relationships can also be observed depending on the industry emissions levels (Ogunrinde et al., 2022). For firms in the low-carbon sectors, an inverted U-shaped relationship between financial performance and carbon intensity seems to exist, whereas, for firms in high-carbon sectors, a U-shaped relationship seems to be the case (Ogunrinde et al., 2022). These studies highlight the complexity of the discussed relationships and the strong impact of influencing factors like a firm industry. However, the limited number of studies shows the necessity for further research on non-linear relationships.

Although the results sometimes appear contradictory, and many studies have mixed findings, a consensus seems to emerge, that GHG emissions negatively correlate with financial performance. However, the analysis predominantly focuses on the impact of GHG emissions on financial performance, with insufficient attention given to examining the potential reverse impact, reverse causality, or bidirectional relationship — how financial performance affects GHG emissions, or if profitability drives sustainability.

3.2.6. Impact of Financial Performance on GHG Emissions

As previously noted, there is a lack of research examining the impact of financial performance on GHG emissions. Six studies have addressed this relationship within the sample. Therefore, they are classified as ****, and their findings are outlined subsequently. Hassan and Romilly (2018) analysed

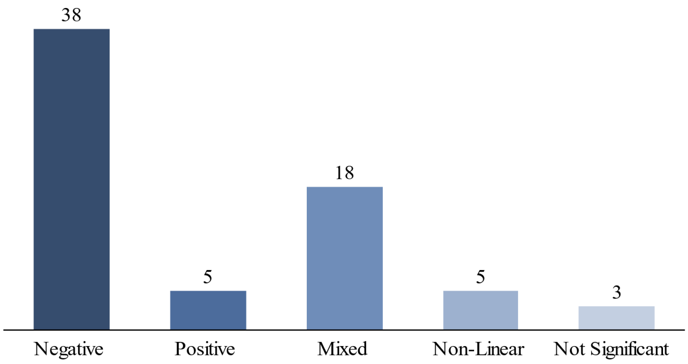

Figure 6: Relationship Types of Identified Studies

the relationship between corporate economic performance, environmental disclosure, and GHG emissions in different directions. Although a highly significant negative impact of GHG emissions on financial performance was found, the impact on the reverse relationship of financial performance on GHG emissions does not seem significant. Another study by Meng et al. (2023) with 352 Chinese companies, found that higher financial performance is linked to lower GHG emissions, which is contradictory to the previous study from Hassan and Romilly (2018). The impact of financial performance on the GHG emissions of companies was also analysed in combination with the R&D expenditures by Vaitiekuniene et al. (2024), which found a significant negative correlation between ROA and a relative measure of GHG emission. R&D expenditures were also negatively associated with GHG emissions (Vaitiekuniene et al., 2024), which is consistent with the Resource-based View Theory, according to which a company with more financial flexibility invests more in R&D, which can also lead to a reduction in GHG emissions (Hart, 1995). These findings indicate a potential effect of financial performance on GHG emissions. However, given the limited number of studies examining this specific relation, it is impossible to draw definitive conclusions. Albeit not analysed by many studies, studies analysing the impact of GHG emission on financial performance also mention this relationship and possible reverse or two-way causality of these variables as a limitation that could influence the results (Busch & Hoffmann, 2011; Endrikat et al., 2014; Gallego-Álvarez et al., 2014; Testa & D'Amato, 2017). Waddock and Graves (1997) have already drawn a bidirectional and reverse connection between corporate social and financial performance, but further research must be conducted. Consequently, additional research is necessary to provide a more comprehensive understanding of this potentially reverse relationship, namely the effect of profitability on sustainability, and this thesis aims to address this research gap.

3.2.7. Research Gap, Relevance and Conclusion

The systematic literature review identified 69 promising studies on the relationship between financial performance and GHG emissions, published between 1997 and 2024. In recent years, a growing body of research has examined the relationship between GHG emissions and financial performance. The metrics predominantly used to approximate financial performance include the accounting-based Return on Assets (ROA) and the market-based Tobin's Q, which sometimes yield similar but contradictory results. Studies employ absolute and relative measures to assess carbon performance, which are defined primarily by the level of GHG emissions, which also seem to influence the outcomes. The primary findings suggest a negative correlation, indicating that firms with higher GHG emissions tend to exhibit poorer financial performance. Furthermore, this relationship appears to vary based on industry, time horizon, and firm size. However, a potential two-way or reverse causation is mentioned, and a lack of literature on the opposite directional relation is identified. A potential reason for this one-sided research could be the interest of companies to understand the factors increasing profitability and simultaneously improving their environmental footprints, making the win-win argument of Porter's Hypothesis more intuitive to analyse.

Building on the identified research gaps and the calls for further research on the relationship direction, namely the lack of research on how profitability impacts GHG emissions, this study aims to explore whether higher profitability is linked to lower GHG emissions. A potential relation based on the Slack Resources, Legitimacy and Stakeholder Theory, which will be further discussed in the next chapter. Understanding the factors influencing GHG reduction, particularly low GHG emission levels, is crucial for enhancing the implementation of effective carbon reduction strategies and regulations and achieving the reduction goals of the Paris Agreement. Furthermore, the lack of differentiation between the three emission Scopes is a significant shortcoming of current studies, as all three Scopes and the underlying business reason for their emissions differ substantially from each other (WRI & WBCSD, 2004). Lastly, a higher data quality and quantity is expected for the most recent years, due to the upcoming CSRD (European Union, 2022). Consequently, this thesis will analyse the separate relation of profitability between all three GHG Scopes and provide an overview of corporate GHG emission levels from 2017 to 2023.

This research is particularly significant due to new European Union regulations, such as the Corporate Sustainability Reporting Directive (CSRD), which mandate GHG emission disclosure for many firms under the criteria shown in Chapter 2.2.3. By offering current information on corporate GHG emissions in Europe and examining the relationship between firm profitability and emission levels, this study provides valuable insights for regulators, company management, and other stakeholders. Nonetheless, the potential limitations of this systematic literature review, such as publication or reporting biases and the search strategy, might lead to incomplete or misleading conclusions. For instance, publication bias could result in overrepresenting studies with significant findings, while underreporting of non-significant results might skew the overall understanding of the relationship between GHG emissions and financial performance. Additionally, the scope and search strategy employed in this review may have inadvertently excluded relevant studies, thereby limiting the comprehensiveness and generalisability of the findings. Such limitations necessitate caution in interpreting the results and highlight the importance of further research to validate and expand upon these initial insights.

These findings will be extended with quantitative research explored in the second part of this thesis. Based on this review and a further discussion on the theoretical background, the exact research hypotheses will be developed in the next chapters.

4. Theoretical Background

Individual theories do not seem to do justice to the complex topic of factors influencing companies' environmental performance outlined in the literature. Therefore, this chapter introduces the Slack Resources Theory, together with the Legitimacy and Stakeholder Theory, as theoretical frameworks to explain this thesis' research topic.

4.1. Slack Resources Theory

The first theoretical concept this research will be based on is the Slack Resources Theory, introduced by Cyert and March (1963). This theory posits that companies with slack resources have a greater capacity to adapt to change and invest in opportunities (Bourgeois, 1981). Slack resources are related to firm performance and, more specifically, profitability, fitting the argument of this thesis (Daniel et al., 2004; George, 2005). This theory makes a solid foundation for the research questions this thesis aims to answer, namely, the impact of profitability on companies' GHG emissions. Within the context of this study, the assumption is that firms with slack resources, therefore higher profitability, are likely to invest more in sustainable initiatives, which should result in lower GHG emissions. Previous research by Oestreich and Tsiakas (2023) has concluded that more profitable companies tend to emit fewer GHG emissions than less profitable companies. On the other hand, financial constraints are linked to enhanced carbon emissions (Rehman et al., 2024). However, it is crucial to differentiate between direct and indirect emissions, as the extent to which companies can influence these with their resources varies significantly.

4.2. Legitimacy and Stakeholder Theory

The Legitimacy Theory originates from Dowling and Pfeffer (1975) and posits that "*organizations seek to establish congruence between the social values associated with or implied by their activities and the norms of acceptable behavior in the larger social system of which they are a part*" (Dowling & Pfeffer, 1975, p. 122), and has been linked to explain CSR behaviour of companies in the past and also recent literature (Bachmann & Ingenhoff, 2016; J. C. Chen et al., 2008; Deegan, 2002; Palazzo & Scherer, 2006; Patten, 2020). Firms demonstrating higher profitability often achieve superior CSR scores (Coelho et al., 2023). According to the Legitimacy Theory, this phenomenon can be attributed to the ability and inclination of profitable companies to align with prevailing social values and norms. This is also in line with the Stakeholder Theory introduced by Freeman (1984). This framework highlights the evolution of corporate focus from purely economic concerns to a broader consideration of various stakeholder needs, including environmental and ethical concerns. Furthermore, with higher profitability comes greater responsibility, which can be explained by more significant stakeholder pressure and firms more willing to adhere to this pressure (Jakhar et al., 2019). Also, the visibility and resources of profitable firms make them more likely to be targeted by stakeholder demands (Gold et al., 2022). Therefore, this thesis argues, that under the frameworks of Legitimacy and Stakeholder Theory, firms with higher profitability face increased pressure from stakeholders to comply with social norms, resulting in lower GHG emission levels. However, it is essential to note that CSR can also improve financial performance reversely, and the relation between GHG emission and financial performance might go both ways, as discussed in the findings of the SLR.

Building on the Slack Resources, Legitimacy and Stakeholder Theory, a company's profitability is expected to negatively correlate with GHG emissions, meaning that more profitable companies are expected to emit less GHG emissions. This hypothesis will be formulated and expanded in the next chapter.

5. Hypothesis Development

This chapter elaborates on the analysis and regression hypotheses of this thesis, based on the findings of the literature review and the theoretical background.

Before the empirical analysis of the relationship between profitability and GHG emissions, there is a need to understand the distribution and trends of GHG emissions in Europe, including the differences between each Scope. Therefore, the first research question is as follows: "*What are the Scope 1, 2 and 3 GHG emissions levels for European companies from 2017-2023?*". This overview will be the foundation for the work on the second research question and help understand the dynamics of and between Scope 1, 2 and 3 GHG emissions. To accomplish this, the initial section will concentrate on the emission disclosures, statistics, and distribution, highlighting their different implications. Particularly noteworthy will be the examination of Scope 3 emissions, as their calculation remains challenging (Fouret et al., 2024). GHG trends over time and distribution among sample companies will further complete the analysis. Lastly, a comparative analysis across sectors and countries will be performed, as differences across sectors and geographical locations are expected (Ghose et al., 2023). These insights will help to identify the trends in sectors, companies and countries.

The SLR analysed studies focusing on the relationship between financial performance and GHG emissions and found that studies mostly focus on the relationship direction of whether it "pays to be green" but revealed a lack of studies examining the impact of profitability on GHG emissions. The lack of studies on this reverse relationship, together with mentions of potential reverse and two-way causation, was discussed in several papers (Busch & Hoffmann, 2011; Testa & D'Amato, 2017; Waddock & Graves, 1997), motivating the following analysis. This thesis argues that financial performance impacts GHG levels, adding to the research needs of scholars in this field. Based on the Slack Resources, Legitimacy, and Stakeholder theories, we hypothesise that profitability significantly negatively impacts GHG emissions, especially focusing on this directional relationship. Furthermore, most studies in the SLR do not distinguish between the three Scopes of GHG emissions. This lack of differentiation is problematic because the sources and implications of GHG emissions vary extensively across Scopes 1, 2 and 3, requiring different approaches and policies for effective reduction (WRI & WBCSD, 2004). This lack of distinction in current literature limits stakeholder interpretation and relevance. Motivated by this gap, we aim to differentiate and analyse the impact of profitability on individual Scopes of GHG emissions. Hence, the second research question is formulated: "*How does firm profitability impact total and Scope 1, 2 and 3 GHG emissions performance?*". To answer this question, we divided it into four sub-hypotheses to distinguish the effects on total, Scope 1, Scope 2, and Scope 3 GHG emissions. The first hypothesis we make is the following.

Hypothesis 1: Firm profitability is negatively associated with Total GHG emission levels.

According to Slack Resources Theory, firms with higher profitability would have more financial resources to invest in GHG emissions reduction, therefore suggesting lower Total GHG emissions (Cyert & March, 1963). Hassan and Romilly (2018) did not find an impact of economic performance on emissions, but other studies suggest a negative or bidirectional relation (Meng et al., 2023; Testa & D'Amato, 2017; Waddock & Graves, 1997). This relation will be tested with GHG emissions numbers from LSEG Eikon and a proxy for financial performance. The metric choice was ROA, the most used accounting-based metric in the analysed studies. Further methodological choices will be outlined in the next chapter.

A significant research gap identified is the lack of differentiation between the three GHG emissions Scopes. Therefore, hypotheses 2, 3, and 4 focus on the effect of firm profitability on specific Scopes. The second hypothesis focuses on Scope 1 emissions and is formulated as follows.

Hypothesis H2: Firm profitability is negatively associated with Scope 1 GHG emission levels.

Scope 1 GHG emissions refer to direct emissions from owned or controlled assets (WRI & WBCSD, 2004). As highlighted in our theoretical background using the Slack Resources Theory by Cyert and March (1963), higher profitability can allow firms to invest more in reducing these direct emissions. Additionally, firms face pressure from stakeholders to maintain legitimacy by reducing their GHG emissions (Dowling & Pfeffer, 1975; Freeman, 1984). In contrast to *Total GHG* emissions, Scope 1 emissions are, per definition, more related to the specific firm assets (WRI & WBCSD, 2004) and specific industries (Ghasemi et al., 2023), which might lead to different results for this regression. Scope 1 GHG emissions are emitted mainly by companies with energy-intensive processes, like in the energy, material, or manufacturing industry, and the reduction and potential decarbonisation strategies include the shift to low-carbon fuels, Carbon Capture and Storage (CCS), Process Optimisation, and Innovation (Cavaliere, 2019). All these solutions are considered resource-intensive (Cavaliere, 2019) and might require higher profitability. Out of five studies identified during the SLR approximating carbon performance through Scope 1 GHG emissions, three have a negative, one a mixed, and one has no significant correlation to financial performance, indicating mixed findings. However, innovation advantages reducing GHG emissions and improving operational efficiency, as suggested by Porter's win-win Hypothesis (Porter & van der Linde, 1995), could also lead to higher profitability, creating a potential two-way relationship and biasing results. Like H1, a negative correlation between firm profitability and Scope 1 GHG emissions is expected, but some caveats may influence this relation.

The third hypothesis focuses on Scope 2 GHG emissions and is the following.

Hypothesis H3: Firm profitability is negatively associated with Scope 2 GHG emission levels.

Scope 2 GHG emissions refer to indirect emissions from the consumption of purchased energy (WRI & WBCSD, 2004). Reducing Scope 2 emissions often requires switching to renewable energy sources, which has become cheaper than fossil fuel electricity in the last few years (IRENA, 2022). Reducing Scope 2 GHG emissions by buying renewable energy can be both cost-saving and a demonstration of environmental responsibility, making this decision relatively straightforward for companies. Furthermore, reducing Scope 2 emissions is seemingly easier for a company to achieve than for Scope 1 emissions, which might lower the impact of profitability on this relationship (Bricheux et al., 2024). Another influencing factor of Scope 2 emission levels is the market- or location-based calculation methodology mentioned in Chapter 2.3.2, which highly influences the emission numbers (brightest, n.d.; WRI & WBCSD, 2004). This highlights the problem of energy purchase agreements, which might reduce the Scope 2 GHG emission with the market-based approach. However, a local production facility could be operated exclusively with local CO2-intensive energy. The location approach calculates Scope 2 emissions based on the local energy mix and provides a better picture of the emissions, but it is more resource-intensive to be influenced by companies (Roston et al., 2024). To conclude, a negative correlation between firm profitability and Scope 2 GHG emissions is anticipated, as firms with greater financial resources can readily reduce these emissions. However, the impact of profitability is expected to be less significant for Scope 2 emissions than other emission Scopes, as it is influenced by factors such as the company's sector, energy needs, and the local energy mix.

The fourth hypothesis focuses on Scope 3 GHG emissions and is the following:

> *Hypothesis H4: Firm profitability is negatively associated with Scope 3 GHG emission levels.*

Scope 3 GHG emissions are all other indirect emissions in a company's value chain (WBCSD, 2011). While firms have no direct influence on Scope 3 emissions, they can pressure and innovate along the entire supply chain to reduce their footprint (Patchell, 2018), which is expected to be more likely with more resources, thus higher firm profitability (Koh et al., 2023). However, business choices like outsourcing heavily affect these emissions, making the calculation potentially complex and small-scale (Mytton, 2020; Radonjič & Tompa, 2018). Furthermore, due to the complexity and comparability challenges associated with calculating and determining Scope 3 emissions (Fouret et al., 2024), a high number variance is expected, which could negatively influence the regression performance. Scope 3 emissions are also highly dependent on the industry and the company's products (Günther et al., 2015). Currently, to the best of the author's knowledge, no studies have examined the correlation between Scope 3 emissions and financial performance, making this a novel perspective. The impact of profitability on Scope 3 emissions is expected to be negative if the data situation allows for a significant regression model.

Accordingly, the null hypothesis for *H1*, *H2*, *H3* and *H4* is formulated as follows, and would indicate that profitability is not or positively associated with the respective GHG emission category:

> *Hypothesis H0: Firm profitability is not negatively associated with Total GHG, Scope 1, Scope 2 or Scope 3 emission levels.*

Having established the hypotheses to be tested in response to the second research question, the subsequent chapter will delineate the methodological framework adopted for this study.

6. Methodology

This chapter outlines the methodological approach for analysing GHG emissions from European companies, which are used to address both research questions. It begins with an overview of the sample companies and the data collection, followed by a discussion of the selection of dependent, independent, and control variables. The chapter then details the model specifications used for regression analysis, focusing specifically on answering the second research question: *How does firm profitability impact total and individual Scope 1, 2 and 3 GHG emissions?*

6.1. Sample and Data Collection

In order to provide an overview of Scope 1, 2 and 3 GHG emissions of European companies and analyse the impact of profitability on these GHG emissions, we opted for the companies in the STOXX Europe 600 index as our sample. The STOXX Europe 600 represents the 600 largest companies in 17 European and is well diversified by industries (STOXX, 2024). Furthermore, Europe is still seen as a pioneer in sustainability reporting and environmental responsibility (Barbu et al., 2022), which makes us expect solid and comparable data. The data will be collected from the LSEG Eikon database for the financial years 2017 to 2023, as 2017 marks the first year the NFRD regulation became mandatory in European Union member states and is a significant milestone for non-financial reporting (European Union, 2014). The GHG emission variation during the COVID-19 pandemic years may pose a challenge (A. Kumar et al., 2022). However, the time horizon of 7 years will help to get consistent results and is not far away from the average time horizon of 9.2 years identified in the SLR. All relevant data points for this research were initially accessed through the LSEG Eikon platform to minimise the use of multiple sources and rely on systematically sourced information. However, GHG emissions data for most firms for the year 2023 was not available in the LSEG Eikon database. Consequently, if available, the 2023 GHG emissions data was manually collected from annual or sustainability reports for all firms with missing values. The GHG emission figures were reviewed and updated during data collection to account for any retroactive changes in previous years. This step was necessary to ensure accuracy, as changes in companies' calculation methods sometimes resulted in significant deviations. The full dataset is available in Appendix 1.

6.2. Dependent Variables

Although there is extensive literature on the impact of GHG emissions on financial performance, vice versa, it is not the case. Accordingly, the dependent variables will be the GHG emissions across all Scopes of sample companies, collected for the financial years 2017 to 2023. In line with the four hypotheses, four dependent variables representing the GHG emissions are used. Scholars have used absolute and relative measures for GHG, as highlighted in the SLR. This research will be based on absolute emissions levels, as used by Mahapatra et al. (2021) or Porles-Ochoa and Guevara (2023), because, ultimately, only a reduction of absolute GHG emissions can reduce climate change. The four dependent variables for each hypothesis are, therefore, Total GHG emissions, representing the sum of Scope 1, 2 and 3 emissions (*Total GHG*) for Hypothesis 1, Scope 1 GHG emissions (*Scope 1*) for Hypothesis 2, Scope 2 GHG emissions (*Scope 2*) for Hypothesis 3 and Scope 3 GHG emissions (Scope 3) for Hypothesis 4.

6.3. Independent Variables

As an analysis of the impact of profitability on the dependent variables is the aim of this study, Profitability is the independent variable for the regressions. However, there is no clear consensus on how to approximate profitability in literature, but Return on Assets (*ROA*) is seen as a common metric for an accounting-based, short-term measure of financial performance (Benkraiem et al., 2023; Busch et al., 2022; Delmas et al., 2015; Feng et al., 2024), and Tobin's Q as a common metric for a market-based measure of long-term financial performance (Busch et al., 2022; Hassan & Romilly, 2018; Houqe et al., 2022; K. H. Lee et al., 2015). Considering profitability as the independent variable, an accounting-based measure of profitability is more appropriate than a future expectation-based market metric like Tobin's Q, which is based on expectations rather than actual profits. Therefore, profitability will be approximated by *ROA*, calculated as net income by total assets. Furthermore, to check the robustness of our regression, we will also test our hypotheses with *ROE*, calculated as net income by shareholders' equity and lastly, *ROS* as net income divided by sales.

6.4. Control Variables

Studies investigating the relationship between financial performance and carbon performance, as identified in the SLR, have used a common set of control variables (see Chapter 3.2.3) and the ones used for this regression analysis are outlined subsequently. This study implements four control variables to account for other effects next to probability, influencing GHG emissions. First, firm size (*SIZE*) has been linked to better socially responsible behaviour (Waddock & Graves, 1997), and we use the natural logarithm of the firm's revenues to define this metric (Alvarez, 2012; França et al., 2023). Second, as discussed by Velte (2023), board diversity (*BOARDDIV*) can drive GHG emissions performance. It will, therefore, be included as a control variable, calculated as a percentage number of women to total board members. Third, capital expenditures is found to be an indicator of GHG emissions (Xia & Cai, 2023), and the relative measure of capital intensity (*CAPINT*), calculated as CAPEX divided by total sales, is used in numerous studies (Busch et al., 2022; Desai et al., 2021; Meng et al., 2023). Additionally, sales growth (GROWTH) is the last control variable that accounts for the potential increased GHG emissions associated with output growth. Sales growth is calculated as percentual annual changes in sales, in line with similar studies (Desai et al., 2021; Gallego-Alvarez et al., 2015; Ghose et al., 2023; Lewandowski, 2017). Furthermore, the industry type of a company is undeniably a significant determinant of the amount of GHG emissions (Ritchie et al., 2020), which is why a classification in *Low* and *High-Emission-Sectors* is performed. The 11 sectors from the GICS sector classification are used and divided into both categories. Consumer discretionary, energy, industrials, materials, and utilities as *High-Emission-Sectors*, according to MSCI (2023) and the sector analysis performed later in Chapter 7.1.2. Financials, information technology, consumer staples, real estate, communication services and health care, as *Low-Emission-Sectors*. The method with which these sectors will be accounted for is discussed in the model specification chapter, as an invariant dummy variable is not suited for the planned fixed-effect regressions model (Wooldridge, 2012, p. 484-492).

6.5. Model Specifications

To test the hypotheses regarding the impact of firm profitability on GHG emissions, we will employ multiple linear regression models using an Ordinary Least Squares (OLS) approach (Greene, 2019). As Shahgholian (2019) notes in a literature review study, endogeneity between dependent and independent variables is a significant risk in the analysed relationship, 48 out of 80 studies of their literature review check for endogeneity. Because panel data from 2017 to 2023 is used, a fixed effects model is chosen to control for firm heterogeneity and endogeneity of variables that could bias the results, such as industry-specific effects or inherent company policies towards sustainability that do not change over time (Greene, 2019). Furthermore, the Hausman test will be performed to test the fixed-effects against random-effects and deduce the proper fit of the model (Hausman, 1978).

This approach allows to test for between-company variations over the study period and is used by several studies with similar panel data (Iwata & Okada, 2011; Lewandowski, 2017; J. Wang et al., 2021), providing a more accurate estimation of the relationship between profitability and GHG emissions. Literature and publications agree that industry is a significant determinant of GHG emissions. However, a fixed-effect model cannot process such an entity invariant variable separately in the model, only in combination with all the other potential fixed-effects. Since varying effects between *Low-* and *High-Emission-Sectors* are expected, the dataset will be split into two parts: entities from *Low-Emission-Sectors* and entities from *High-Emission-Sectors*, similar to the approach of Ghose et al. (2023). This separation accounts for the expected differences between these sectors, as noted in the literature (Ghasemi et al., 2023). Each regression model will be performed separately on the high-emission and low-emission datasets and compared against each other's.

The fixed-effects regression models for each dependent variable are specified as follows:

$$\text{H1: Total GHG}_{it} = \beta_1 ROA_{it} + \beta_2 SIZE_{it} + \beta_3 BOARDDIV_{it} + \beta_4 CAPINT_{it} + \beta_5 GROWTH_{it} + \mu_i + \varepsilon_{it}$$

$$\text{H2: Scope } 1_{it} = \beta_1 ROA_{it} + \beta_2 SIZE_{it} + \beta_3 BOARDDIV_{it} + \beta_4 CAPINT_{it} + \beta_5 GROWTH_{it} + \mu_i + \varepsilon_{it}$$

$$\text{H3: Scope } 2_{it} = \beta_1 ROA_{it} + \beta_2 SIZE_{it} + \beta_3 BOARDDIV_{it} + \beta_4 CAPINT_{it} + \beta_5 GROWTH_{it} + \mu_i + \varepsilon_{it}$$

$$\text{H4: Scope } 3_{it} = \beta_1 ROA_{it} + \beta_2 SIZEE_{it} + \beta_3 BOARDDIV_{it} + \beta_4 CAPINT_{it} + \beta_5 GROWTH_{it} + \mu_i + \varepsilon_{it}$$

Where:

- β_1, β_2, β_3, β_4 and β_5 are the coefficients for the independent and control variables.
- μ_i represents the unobserved company-specific fixed effects.
- ε_{it} is the error term.

The regression results will be interpreted based on the coefficients' sign, magnitude, and statistical significance. The primary focus will be on the coefficient of ROA to understand its impact on GHG emissions across all Scopes. A negative coefficient would support the hypothesis that higher profitability is associated with lower GHG emissions. Control variables will also be interpreted to understand their influence on GHG emissions. The next chapter will now start with the analysis of the collected dataset.

7. Analysis and Results

This chapter is divided into two sections representing the two research questions relevant to this work and will focus on the quantitative and empirical analysis of the collected panel data. The first chapter will analyse the Scope 1, 2 and 3 GHG emissions of European companies, and the second chapter will focus on the impact of profitability on these GHG emission Scopes.

7.1. Quantitative Analysis: Scope 1, 2 and 3 GHG Emissions in Europe

Before delving into an in-depth analysis of Scope 1, 2 and 3 emissions, providing a brief introductory overview of the GHG emissions disclosures across the sample companies is essential. The following chapters will focus on the distinction between the individual Scope 1, 2 and 3 GHG emissions figures within the dataset. Before a detailed analysis of these figures, an overview of the data's quality and quantity will be provided. This overview will be the foundation for a more detailed examination of the emission numbers.

7.1.1. Overview of the GHG Emission Disclosures

As previously highlighted, the high quality and availability of data were anticipated due to stringent European regulations, Europe's dominant role in sustainability reporting, and corresponding research in Europe (Singhania & Chadha, 2023). An initial indicator of this data quality is the number of data points available for each company and each year, illustrated in Figure 7.

A clear trend of increasing data availability over the years is observable, as many companies disclose their GHG emissions across all Scopes. These results complement the findings of Barbu et al. (2022), which analysed the evolution of non-financial reporting and the impact of the NFRD on disclosures of European companies and found a positive influence over time. The slight decrease in data points for 2023 can likely be attributed to the manual collection of data from annual and sustainability reports rather than to an actual decline in data point numbers. With a maximum of 600 data points per Scope, constrained by the number of companies in the STOXX Europe 600 index, 98% reported their *Scope 1* and *Scope 2* GHG emissions in 2022, and 89% reported their *Scope 3* emissions. Notably, Scope 3 emissions were significantly less frequently published than *Scope 1* and *Scope 2* in the initial years, but this disparity has markedly narrowed recently. The same goes for the other Scopes, where a high disclosure increase has occurred. A positive trend was expected since all companies of our sample will be required to disclose their GHG emissions across the three Scopes when the CSRD comes into action for the FY2024 disclosures (European Union, 2022). Having addressed the availability of the data, we shall now examine the reported figures in depth.

7.1.2. Analysis of the Scope 1, 2 and 3 GHG Emissions

This chapter commences with a descriptive statistical analysis of the dataset to provide an overarching view of the data. Subsequently, a trend analysis is conducted to compare the dynamics of *Scope 1*, *Scope 2* and *Scope 3* emissions over time. Finally, a comparative analysis by sector and country is performed before the chapters end with a brief conclusion.

Descriptive Statistics

Before delving deeper into the data, it is essential to examine some basic statistics to better understand the dataset. Table 2 provides an overview of the most important numbers, which allows for the first insights.

Based on the mean emission numbers for each Scope over 2017–2023, it is possible to calculate the average share of total emissions of all Scopes. Figure 8 visualises the average total reported GHG emissions shares and shows the size differences between the three Scopes.

Scope 3 emissions have by far the most significant share of all three scopes, making up 88.5% of average *Total GHG* emissions, which is in line with expectations and findings in the literature (Matthews et al., 2008). *Scope 1* GHG Emissions, also called direct emissions are directly emitted by the companies and account for about 9,5%, and *Scope 2* represents

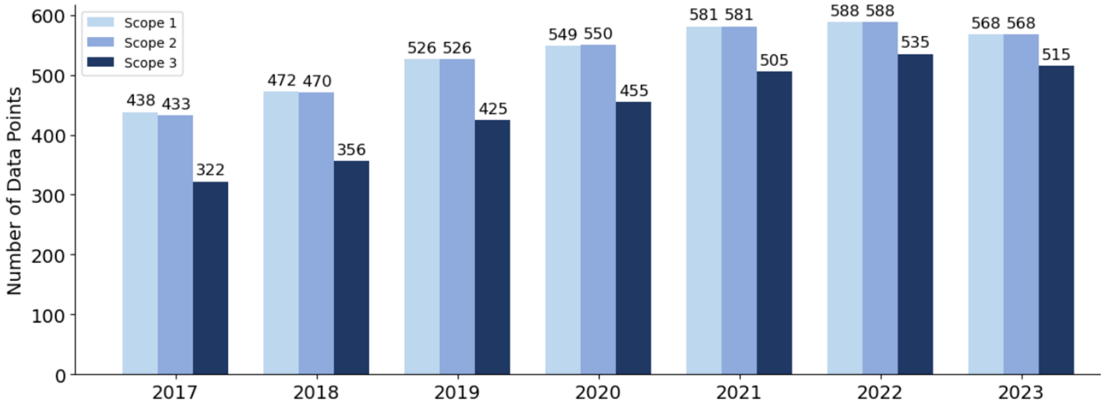

Figure 7: Number of Scope 1, 2 and 3 Data Points per Year

Table 2: Summary of Statistics for Scope 1, 2 and 3 GHG Emissions (in tons CO_2e)

Emission Types	N	Mean	SD	Min	25%	Median	75%	Max
Scope 1	3,722	2,611,755	12,406,433	0	4,859	33,833	269,580	179,700,000
Scope 2	3,720	431,302	1,425,410	0	8,513	46,078	225,205	22,057,000
Scope 3	3,113	24,466,782	126,861,683	0	31,500	539,638	6,300,000	2,823,000,000

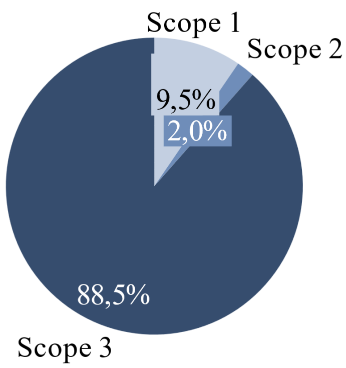

Figure 8: Average Share of the Three Scopes of Total Reported GHG Emissions

the purchased energy by companies, which represents the smallest portion of *Total GHG* emission in the sample, with about 2,0%. Furthermore, the wide range of values across all Scopes is notable, for example, with *Scope 1* emissions where values between the 25th and 75th percentiles differ by a factor of 55. This variability is expected, given the significant differences in the sizes of the companies within the STOXX Europe 600 index. However, this extensive range presents challenges for regression analysis performed in later chapters, as it can lead to heteroscedasticity (Gallego-Alvarez et al., 2015). To address this issue, we will apply natural logarithms to the emission values in our regressions, as discussed in Chapter 6.2. This transformation will help normalise the data and mitigate the impact of extreme values (Wooldridge, 2012). To ensure the comparability and quality of GHG emission data, the variance within entities is a crucial metric, as it helps to understand the deviation of these numbers from the mean. In this context, a high variance would suggest significant variability in GHG emissions across a specific Scope within an entity and over time, potentially undermining the reliability of the data or indicating significant changes in the calculation methodology. As mentioned in Chapter 5, we expect some challenges in the data quality of *Scope 3* emissions, as the calculation is complex and allows for a higher margin of discretion than *Scope 1* and *Scope 2* emissions. Figure 9 represents the standard deviation (SD) as a percentage of the mean within the GHG emission numbers of each entity in the data set from 2017 to 2023, and a clear difference between the Scopes can be seen.

The lowest standard deviation is observed for *Scope 1* emissions, with an average of 29.63% deviation from the mean, followed by *Scope 2* emissions at 37.41%. In contrast, *Scope 3* emissions exhibit a significantly higher standard deviation of 56.15%, indicating considerable variance among the *Scope 3* values reported within companies over time. During the manual collection of the latest 2023 values, this high deviation became apparent and is likely due to the lack of clear guidance, incomplete composition, and measurement diver-

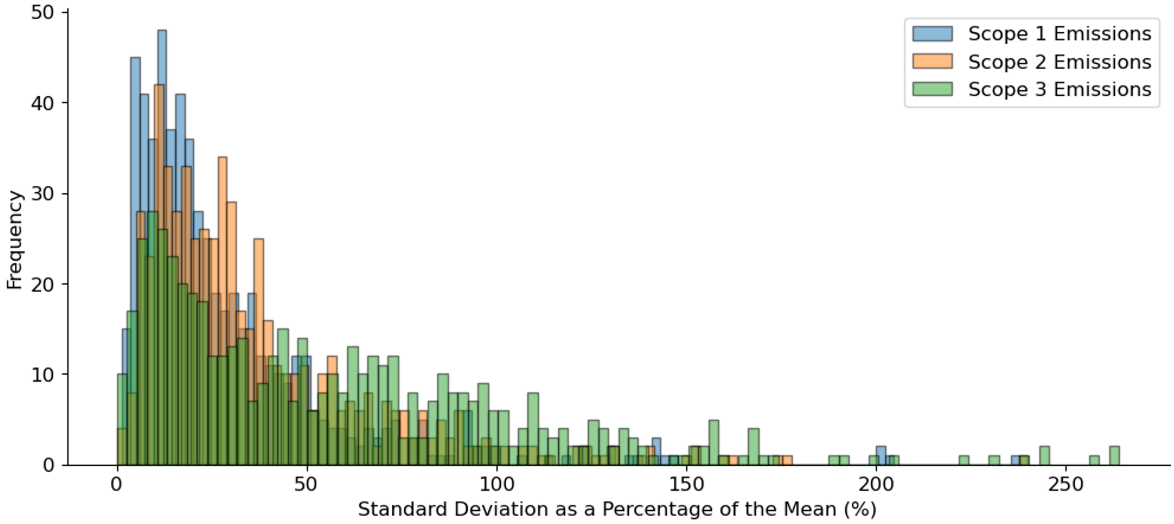

Figure 9: Comparison of the SD of Emissions as Percentage of the Mean by Entity

gence, three main problems cited by Nguyen et al. (2023), which studied the data quality of *Scope 3* emissions. The graph shows that the standard deviation distribution of *Scope 3* emission is less left skewed than for *Scope 1* and *Scope 2*, indicating more extreme values and underscoring the need for further standardisation of *Scope 3* emission reporting to enhance comparability in the future. Despite the high fluctuations in *Scope 3* emissions, the number of companies publishing all three scopes is promising at around 89% in 2022, which should allow us to conduct solid analyses afterward. In the next section, we will look at striking trends in the dataset.

Emission Trends by Scopes

In this analysis, shown in Figure 10, the trends in *Scope 1*, *Scope 2*, and *Scope 3* GHG emissions from European companies from 2017 to 2023 are examined. These findings allow us to gain insights into the carbon performance of these companies and will ideally identify a trend of negative GHG emissions growth. However, before delving into these trends, it is crucial to highlight certain peculiarities of the unbalanced panel data to avoid false interpretations. Specifically, the number of companies reporting their GHG emissions has increased over the years, making it impractical to analyse the trend in total emissions over the entire timeframe, as it would distort the results. Consequently, variables independent of the total number of reporting companies each year ensure a more meaningful analysis. To avoid the problem of outliers, the median growth rates of all three Scopes over the years are plotted in Figure 10, which offers interesting insights.

The initial observation is the pronounced decline in growth rates in 2020, marked by negative growth rates of -8.89% for *Scope 1*, -10.45% for *Scope 2*, and -10.28% for *Scope 3* GHG emissions. This decline was followed by a subsequent recovery beginning in 2021. In 2022 and 2023, the trends normalised, showing slightly negative growth rates for *Scope 1* and *Scope 2* GHG emissions, while *Scope 3* emissions exhibited a growth rate of approximately 1%. The exact growth rates can be found in Table 10 of Appendix 2. The sharp decline in GHG emission levels in 2020 is in line with expectations of the effects of the COVID-19 Pandemic. A. Kumar et al. (2022) analysed the impact of COVID-19 on GHG emissions and found similar results. These results were attributed, among other factors, to a decline in energy consumption, mobility, trade, and economic output (A. Kumar et al., 2022). In conclusion, the analysis reveals that *Scope 1* and *Scope 2* emissions have negative median growth rates between 2017 and 2023, registering at -2.02% and -5.44%, respectively. In contrast, *Scope 3* emissions exhibited a median annual growth rate of 1.37%, which can probably be attributed to the increasingly comprehensive methodologies employed in the calculation basis and the other challenges of *Scope 3* GHG emissions mentioned in Chapter 2.3.2 and 5.

Absolute Emission Levels by Companies

As mentioned, the absolute sum of GHG emissions per year is not a viable metric for unbalanced panel data. However, some absolute emission data comparison would provide valuable insights into the biggest GHG emitters of the STOXX Europe 600 index. To account for unbalanced numbers of entries per company, we opted for the average sum of *Scope 1* and *Scope 2* GHG emissions and the average revenues over the timeframe, plotted in Figure 11, helping to visualise significant outliers. *Scope 1* and *2* emissions are, per definition, the ones directly attributable to a firm. Therefore, the combination is an often-used metric to compare GHG emission levels across companies. These emissions are visualised against the average revenues of each company to provide a firm size metric as orientation.

Figure 11 illustrates the distribution of *Scope 1* and *Scope 2* GHG emissions among European companies. The data in-

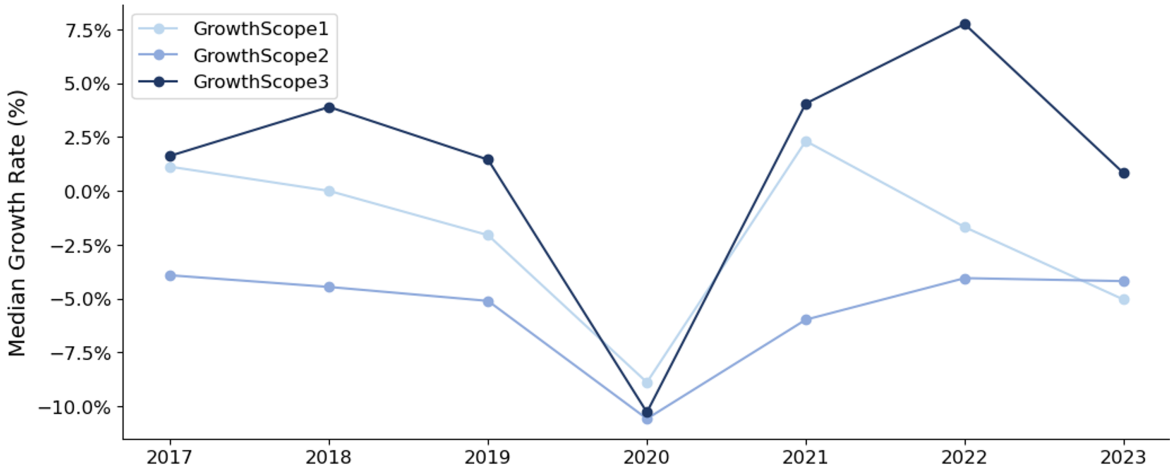

Figure 10: Median Growth Rates per Year, per Scope

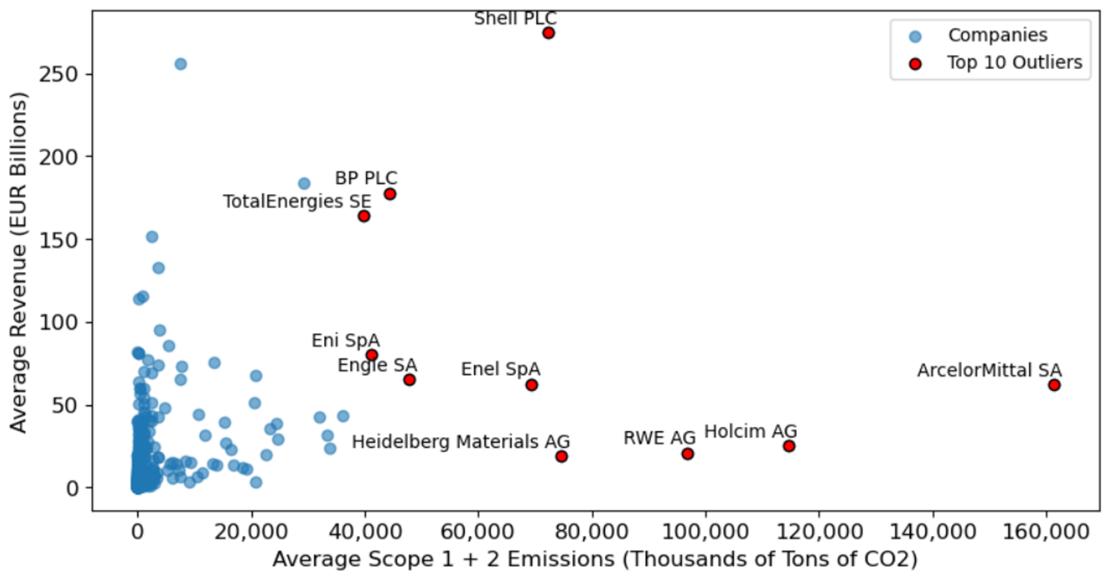

Figure 11: Average Scope 1 + 2 Emissions vs Revenues (2017-2023)

dicates that most companies generate low to medium GHG emissions. However, a significant portion of the emissions is concentrated among a small number of outliers. Specifically, the top ten companies with the highest emissions have been identified and labelled in the figure. Among these, seven companies belong to the energy sector, while the remaining three are in the materials sector, with two specialising in cement production and one in steel manufacturing. A report published by the CDP supports these findings, showing that 100 companies from the fossil fuel sector have been responsible for over 70% of industrial GHG emissions since 1988 (Griffin, 2017). Interestingly, when *Total GHG* instead of *Scope 1 + 2* emissions is plotted, the top 10 outliers change substantially. Figure 15 shows this plot and can be found in Appendix 2. After adding *Scope 3* GHG emissions, the energy sector is still dominant, but the materials sector not anymore. Firms with high fossil fuel consumption in their product life cycles predominate the list, including Airbus SE, Volkswagen AG, Siemens Energy, Siemens AG and Rolls-Royce Holdings PLC.

This distribution suggests that industry type and associated business models play a crucial role in determining a company's emission levels. It is also the reason for the decision to analyse the impact of profitability on GHG emissions on low- and high-emission companies separately. To further explore the relationship between industry sectors and emissions, the following chapter will examine the distribution of GHG emissions across various European sectors in greater detail.

Sector Analysis

Having observed that companies within the energy and materials sectors exhibit significantly higher GHG emissions than those being in other sectors, GHG emissions across different sectors in the sample are examined, because they are seemingly major determinants of absolute GHG emissions. Instead of using average figures as in the previous chapter, this industry analysis will rely on the most recent data from 2023. To facilitate meaningful comparisons without excessive granularity, we have adopted the Global Industry Classification Standard (GICS), categorising companies into 11 sectors. This classification is widely utilised by financial professionals, investors, and researchers due to its consistency and comprehensiveness (Bhojraj et al., 2003). The GICS 11-sector framework balances avoiding excessive fragmentation and capturing essential distinctions among different sectors. Figure 12 shows the Scope 1, 2 and 3 GHG emissions distribution across all 11 sectors for 2023.

For *Scope 1* emissions, displayed in Figure 12, the sectors materials, utilities, energy, and industrials are responsible for approximately 94.65% of the total *Scope 1* emissions, leaving the remaining seven industries to account for only 5.35%. This suggests that these four sectors significantly contribute to direct emissions through their business models, a fact also observed by other emissions reports (Polizu et al., 2023). In contrast, for *Scope 2* emissions, the materials sector is the most significant contributor, responsible for about 45.61% of the total *Scope 2* emissions. This indicates that companies in this sector purchase substantial amounts of energy for their business activities. The remaining emissions are more evenly distributed across the other sectors compared to *Scope 1* emissions. Utilities rank second with 13.76%, while all other industries contribute less than 10% of *Scope 2* emissions. *Scope 3* emissions, also referred to as value-chain emissions, have only gained attention in recent years, when the GHG Protocol published the Corporate Value Chain (Scope 3) standard in 2011 (WBCSD, 2011). However, their significance in the context of global GHG reduction is substantial (Matthews et al., 2008). As demonstrated in Chapter 7.1.2, *Scope 3* GHG emissions constitute approximately 90% of the *Total GHG* emissions for companies within the STOXX 600 Europe index. Consequently, their reduction is crucial to attain the goals of the Paris Agreement (United Nations, 2015a) and the responsibility lies with the companies and their respective business models. The sectors causing the highest amounts of *Scope 3* GHG emissions are industrials (32.79%), energy (27.72%), materials (13.68%), and consumer discretionary (13.22%). The consumer discretionary sector includes major automotive firms like Mercedes-Benz, Volvo, BMW, Stellantis, and Volkswagen, which report high *Scope 3* emissions due to the emissions in their value-chain and product life cycles (Wells & Nieuwenhuis, 2012). Similar to the distribution observed for *Scope 1* emissions, a few sectors are responsible for most GHG emissions.

In addition to examining the distribution of total emissions by sector, analysing GHG emission growth rates per sector serves as a valuable complement, as it shows the current trends. Figure 13 presents an overview of the median growth rates for all three Scopes across the 11 GICS sectors, with the number of data points per industry depicted in the *Scope 1* histogram. Between 133 and 805 data points represent each sector over the period from 2017 to 2023. This substantial dataset ensures the robustness of the median against outliers and provides meaningful insights into the trends of GHG reduction performance across different sectors.

The figures reveal that growth rates for *Scope 1* and *Scope 2* emissions are negative across all sectors, albeit with varying magnitudes. Notably, the financial sector exhibits the highest reduction rates for both types of emissions. For *Scope 1* emissions, the high-emission sectors, as shown in Figure 13, display relatively modest rates of decline between 0% and -1,5%, with the utilities sector as an outlier in the group, achieving the third best reduction rate at approximately 5%. Conversely, *Scope 2* emissions show significantly higher reduction rates across all sectors. This suggests that companies may find it easier to mitigate *Scope 2* emissions than *Scope 1* emissions, particularly in energy-intensive sectors such as materials, energy, and industrials. Improving *Scope 1* emissions often requires enhancing the energy efficiency of industrial processes, while *Scope 2* reductions can be more easily achieved through green energy purchase agreements, as highlighted by McKinsey in their report on the consumer goods industry (Bricheux et al., 2024), or a lower energy grid GHG footprint. Regarding *Scope 3* emissions, the growth rates for most sectors are positive, aligning with the trends discussed in Chapter 7.1.2. Unexpectedly, the information technology sector demonstrates the highest growth rates by a considerable margin. This anomaly may indicate that some companies have revised their assessment methodologies, leading to a higher attribution of *Scope 3* in this sector. The shift to cloud services by many IT companies could also be the reason for this trend, as such emissions are categorised as *Scope 3* under the GHG Protocol (WBCSD, 2011). This phenomenon has been previously examined in the literature (Mytton, 2020), and the results depicted in Figure 13 match these findings.

In conclusion, as observed in the previous chapter regarding company-specific emissions levels, the sector analysis shows that a limited number of sectors and companies are responsible for most GHG emissions. From both regulatory and research perspectives, focusing on these high-emission sectors is advisable, as they each require tailored solutions based on their specific business models and types of emissions. This development could also be observed in the SLR performed in the earlier chapters, where about one-quarter of the studies focused solely on companies in CO2-intensive sectors. Furthermore, regulations and policies have been increasingly targeted at these high-emission industries, with successful emission reductions (Pan et al., 2024; Yin et al., 2024), which also speaks in favour of our findings and the willingness to reduce global GHG emissions. In summary, the negative growth rates observed are encouraging in the context of combating climate change. However, this study does not assess whether these trends align with the climate targets outlined in the Paris Agreement. Additionally, the significant increase in *Scope 3* emissions within the IT sector highlights the potential for companies to shift their *Scope 1* or *Scope 2*

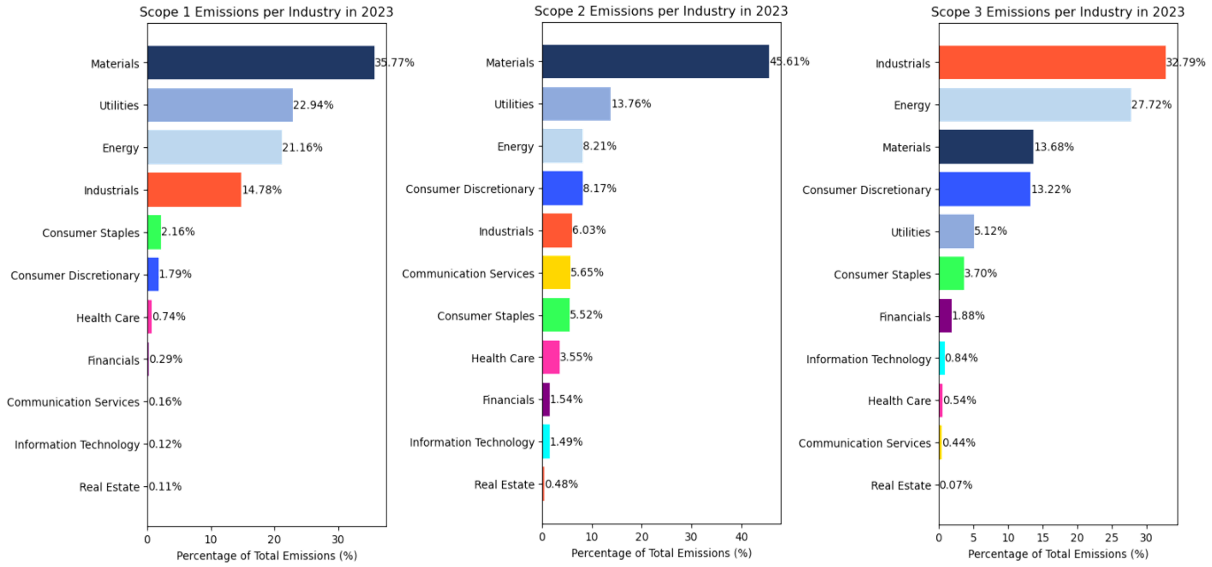

Figure 12: Distribution of Scope 1, 2 and 3 GHG Emissions across the GICS Sectors

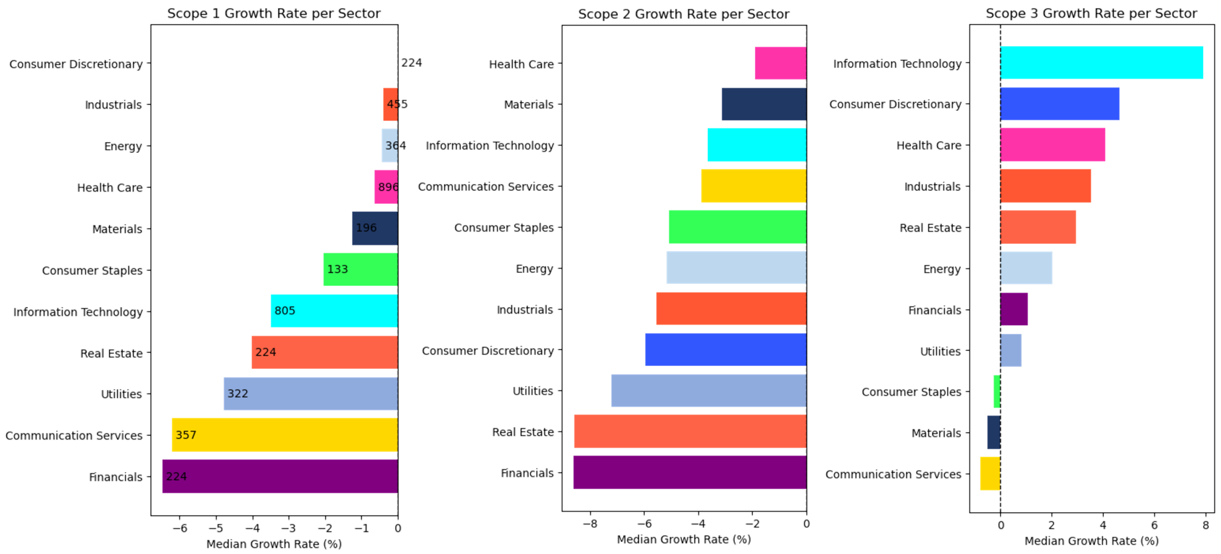

Figure 13: Median Growth Rates per Sector, per Scope

emissions through business practices. This underscores the importance of accurately accounting for *Scope 3* emissions to obtain a comprehensive picture of a company's environmental impact. Addressing these issues requires the collaboration of policymakers, regulators, and other stakeholders, who must respond swiftly to emerging trends across various sectors, making this sector analysis with the latest numbers from 2023 a valuable source of information.

In the concluding section of this analysis, we will investigate countries' Scope 1, 2 and 3 GHG emissions.

Country Analysis

In this chapter, we will analyse the growth rates of companies within the STOXX Europe 600 index by country. Consistent with the methodology employed in the previous chapter, the median growth rate has been used as the benchmark. The country-specific analysis in Figure 14 parallels the industry-specific breakdown across all three Scopes of emissions.

Notably, *Scope 1* emission reduction rates are generally lower than those for *Scope 2* emissions, with exceptions observed in countries such as Poland, Italy, and Belgium. Acknowledging that the STOXX Europe index encompasses only a limited selection of companies per country is essential. Thus, the provided chart offers insights specific to these companies rather than the national economy. In the case of *Scope 3* emissions, it is noteworthy that Germany exhibits a negative median growth rate despite having a significant number of companies represented. This suggests that German companies, or the industries prevalent in Germany,

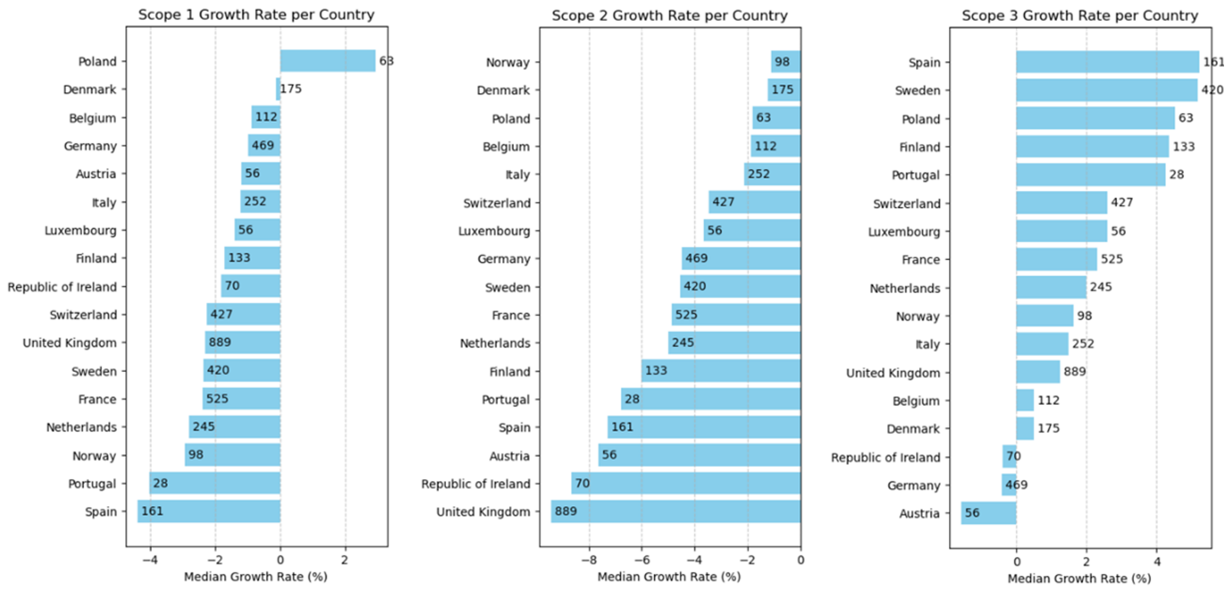

Figure 14: Median Growth Rates per Country, per Scope

may prioritise the reduction of Scope 3 emissions more than their counterparts in other countries included in the sample. While Ireland and Austria also show negative median growth rates, the limited number of data points for these countries makes the median growth rate less reliable.

Before proceeding to the second analytical section of this study, which will examine the impact of profitability on Scope 1, 2 and 3 GHG emissions, a summary of the key findings from the previous chapters is provided.

7.1.3. Key Findings and Discussion of Scope 1, 2 and 3 GHG Emissions in Europe

In this chapter, we quantitatively analysed the Scope 1, 2 and 3 GHG emissions of European companies within the STOXX Europe 600 index. Our investigation into the data quality and availability from 2017 to 2023 revealed that European companies demonstrate a high level of compliance with GHG emissions disclosures, a result of stringent European regulations (Barbu et al., 2022; European Union, 2014, 2022). The consistency in the number of companies reporting *Scope 1* and *Scope 2* emissions was notable, and there was a significant increase in the reporting of *Scope 3* emissions over the years. The descriptive statistical analysis underscored that *Scope 3* emissions constitute the largest share of *Total GHG* emissions, which aligns with expectations, given their broader definition and other publications on their respective share (Matthews et al., 2008). However, the data variability is substantial between and within companies, especially for *Scope 3* GHG emissions, as the standard deviation analysis revealed. This considerable variance in *Scope 3* values reported by companies underscores the need for further standardisation in *Scope 3* emission reporting to enhance comparability, as discussed by Nguyen et al. (2023).

The trend analysis illustrated a pronounced decline in growth rates in 2020, which can be attributed to the effects of the COVID-19 pandemic, as publications from other scholars also indicate (A. Kumar et al., 2022). This decline was followed by a recovery beginning in 2021. Overall, *Scope 1* and *Scope 2* emissions have negative median growth rates of -2.02% and -5.44%, respectively, from 2017 to 2023. Conversely, *Scope 3* emissions exhibited a median annual growth rate of 1.37%, which can be partially attributed to the challenges of *Scope 3* emission calculations (Nguyen et al., 2023). Examining absolute emission levels by companies revealed that a small number of outliers contribute significantly to the total emissions. Specifically, the energy and materials sectors were identified as the primary contributors. This finding was further substantiated by the sector analysis, which revealed that the sectors of materials, utilities, energy, and industrials are responsible for approximately 94.65% of total *Scope 1* emissions. Similarly, *Scope 2* emissions were predominantly from the materials sector, which accounted for about 45.61% of the total. A few sectors also dominated the distribution of *Scope 3* emissions, and the median growth rate for *Scope 3* emissions in the IT sectors was unexpectedly the highest by a high margin with about 8%. A potential reason could be the fast shift to cloud application in the whole sector, a trend that has already been the subject of other scientific work (Mytton, 2020). This analysis underscores the significant impact of business practices on the distribution of emissions across different Scopes. It highlights the critical importance of mitigating *Scope 3* emissions to meet the climate objectives outlined in the Paris Agreement. Therefore, it is not just important, but urgent for policymakers and other stakeholders to continuously monitor prevailing trends. This will enable them to respond effectively with appropriate measures when necessary, ensuring we stay on track to meet our climate goals.

Before concluding the chapter, it is essential to address the limitations of the data. The figures for the emission distribution across sectors are from a single year, making them potentially sensitive to outliers. *Scope 3* emissions can vary significantly within and between companies in the same industry. Furthermore, the median growth rate was selected due to extreme outliers, which can significantly distort the mean average and complicate its interpretation. Consequently, the evolution of *Total GHG* emissions by Scope may differ substantially from the patterns suggested by median growth rates. Given the unbalanced nature of the panel data set and the high variance observed between and within entities, the median growth rate remains the most suitable metric for this analysis. Additionally, the sample comprises companies represented in the STOXX Europe 600, which includes the 600 largest companies in Europe. This could result in an undervaluation of fragmented sectors with many small companies and an overvaluation of industries dominated by a few large firms.

In conclusion, this chapter provided a detailed examination of the Scope 1, 2 and 3 GHG emissions of European companies between 2017 and 2023, answering the first research question: *What are the Scope 1, 2 and 3 GHG emissions levels for European companies from 2017-2023*, highlighting significant trends and variances across sectors, countries, time and companies. The findings underscore the importance of continued efforts to standardise emission reporting and the need for targeted regulatory measures to address *High-Emission-Sectors*. To investigate one of the factors that might determine the GHG emissions levels, this thesis will analyse the impact of profitability on GHG emissions starting in the next chapter. This analysis aims to provide valuable insights for companies, managers, policymakers, and other stakeholders interested in understanding how a specific factor, such as profitability, influences GHG emissions.

7.2. Empirical Analysis: Impact of Profitability on GHG Emissions

This chapter presents the core analysis of this study, focusing on the relationship between profitability and *Total*, *Scope 1*, *Scope 2* and *Scope 3* GHG emissions of European companies, thereby addressing the second research question of this thesis. To begin with, the collected data undergoes descriptive analysis, including a summary of statistical measures and an examination of correlations among all variables. The subsequent section details the fixed-effects regression analysis and its results, with individual assessments of the four subhypotheses. The chapter concludes with the robustness tests conducted and the limitations inherent in the regressions, followed by a summary of the findings.

7.2.1. Descriptive Statistics

The section on descriptive statistics is divided into two segments. The first segment, a summary of statistics, involves the analysis of essential statistical characteristics of the data. The second segment addresses the analysis of correlations between the variables, wherein preliminary insights are derived.

Summary of the Statistics

To start the empirical analysis, the summary of statistics of both datasets is provided in Table 3, displaying basic metrics for the variables in the *Low-Emission-Sectors* and *High-Emission-Sectors*.

As stated earlier, the data originates almost entirely from the LSEG Eikon platform, and missing relevant data was added manually wherever possible. This included, in particular, the emission values for 2023, which were not yet available via Eikon for the most important companies. Although manual additions are prone to error, they enable the subsequent analysis to be conducted using the latest data. Further data transformations were conducted using Python, including removing rows with missing values and preparing variables for logarithmic transformation. As mentioned in the previous chapters, the natural logarithm of all emission variables is used to improve the fit for a regression, similar to many other studies using GHG emissions in regressions (Houqe et al., 2022; Mahapatra et al., 2021; Raval et al., 2021). A small constant with a value of 1e-2 was added to address zero values. This is why the minimum value of certain emission variables is below zero when the natural logarithm of zero plus the small constant is calculated. The complete Python code can be found in Appendix 1. All numbers presented are after the removal of missing values and thus represent the complete dataset used for the subsequent regression analyses. As shown in Table 3, the final dataset has 2,524 observations, representing 538 individual firms, or about 90% of the initial sample. The *Low-Emission-Sectors* dataset has 1,245 observations (N), corresponding to 267 individual firms, whereas the *High-Emission-Sectors* dataset has 1,279 observations, corresponding to 271 individual firms.

The difference between high-emission and low-emission firms also becomes apparent in the data when comparing mean, median, and max values, which are higher for all emission Scopes in *High-Emission-Sectors*. Comparing the *ROA* numbers, the mean and median numbers do not differ significantly, but the SD of 14.6 percentage points in *Low-Emission-Sectors* is much higher than 6.3 percentage points in *High-Emission-Sectors*. This indicates a higher range of values for *Low-Emission-Sectors* and a more constant number for *High-Emission-Sectors*. Variables for GHG emissions will not be analysed in depth again, as the natural logarithm makes the interpretation challenging, and Chapter 7.1.2 already discussed this matter. Along with this summary of statistics, the correlations between all variables help to understand the dataset and will be analysed using a Pearson correlation matrix in the following chapter.

Correlation Matrix

Pearson (1895) introduced the concept of linear correlation between two variables, which allows us to understand the relationship between two variables in both directions. A widely used tool in modern statistics is the Pearson Correlation Matrix, displayed in Table 4. This matrix shows the

Table 3: Summary of Statistics for the Regression Variables

Low-Emission-Sectors	**N**	**Mean**	**SD**	**Median**	**Min**	**Max**
Total GHG	1,245	12.355	2.834	12.307	4.804	18.808
Scope 1	1,245	9.090	3.090	9.157	-4.605	15.126
Scope 2	1,245	9.890	2.668	10.087	-4.605	15.387
Scope 3	1,245	11.643	3.299	11.710	-4.605	18.807
ROA	1,245	0.066	0.146	0.044	-0.263	2.511
SIZE	1,245	22.171	1.567	22.143	17.809	25.691
BOARDDIV	1,245	0.208	0.149	0.200	0.000	1.000
CAPINT	1,245	0.075	0.138	0.034	-0.059	2.058
GROWTH	1,245	0.068	0.244	0.014	-1.689	5.041
High-Emission-Sectors	**N**	**Mean**	**SD**	**Median**	**Min**	**Max**
Total GHG	1,279	15.212	2.587	15.279	7.271	21.789
Scope 1	1,279	12.231	2.958	11.865	-4.605	19.007
Scope 2	1,279	11.511	2.454	11.493	-4.605	16.909
Scope 3	1,279	14.618	3.024	14.927	2.231	21.761
ROA	1,279	0.070	0.063	0.060	-0.205	0.585
SIZE	1,279	22.816	1.259	22.709	19.260	26.599
BOARDDIV	1,279	0.173	0.138	0.167	0.000	0.714
CAPINT	1,279	0.075	0.142	0.041	0.000	2.208
GROWTH	1,279	0.115	0.364	0.064	-0.869	7.999

correlation between all variables of the data set and thus provides initial insights into their relationships.

Unsurprisingly, there is a high correlation at the 1% significance level between all four variables for GHG emissions. As discussed in Chapter 7.1.2, *Scope 3* emissions constitute the largest share of *Total GHG* emissions. Therefore, high correlations of 0.96 and 0.95 between *Total GHG* and *Scope 3* in both datasets are expected. Additionally, *ROA* appears to be negatively correlated with GHG variables in both datasets, although there are significant differences between high-emission and low-emission firms. The effect is approximately twice as large for *Scope 1* and *Scope 3* emissions in *High-Emission-Sectors* but does not differ significantly for *Scope 2* emissions. This correlation between financial performance, measured by *ROA*, and the Scopes of GHG emissions are consistently negative at the 1% significance level, indicating a strong relationship. Similarly, the *SIZE* of a company, measured by the natural logarithm of annual revenues, is strongly positively correlated with the amount of GHG emitted across all Scopes, consistent with prior research (Hassan & Romilly, 2018; Wells & Nieuwenhuis, 2012). Moreover, the high significance of the correlation between all variables for *Scope 1* and *Scope 2* in *Low-Emissions-Sectors*, is in contrast with the more nuanced picture for *Total GHG* and *Scope 3*.

In summary, no multicollinearity is detectable between the independent variables. Firm *SIZE* seems to be highly correlated with GHG emission levels across all Scopes, and *ROA* shows a moderate negative correlation. Most control variables have a significant correlation with *Scope 1* and *Scope 2* emissions. However, apart from firm *SIZE*, they do not significantly correlate with *Total GHG* and *Scope 3* emissions. The correlation matrix indicates differences between the *Low-* and *High-Emission-Sectors*, which supports the distinction between these two groups. Subsequently, to unilaterally examine the impact of profitability on Scope 1, 2 and 3 GHG emissions, the results of the linear regressions will be analysed and evaluated in the following chapters.

7.2.2. Multiple Linear Regressions Analysis

This chapter addresses the four sub-hypotheses of the second research question: *How does firm profitability impact total and individual Scope 1, 2 and 3 GHG emissions performance?* An overview of the regression results from both *Low-* and *High-Emission-Sectors* is provided, and the implications of the results will shortly be discussed. For each hypothesis, fixed-effect panel OLS regressions are performed, and the null hypothesis (*H0*) is rejected for p-values < 0.05, indicating a significance at the 5% level. Before the individual regression results, the basic assumptions for a fixed-effect Panel OLS regression should be met and tested. The following assumptions, as outlined by Wooldridge (2012) in his book Introductory Econometrics: A Modern Approach (5^{th} Edition), are tested with specified tests or graphical analysis on all regression models performed in the subsequent chapters. Linear relationship between the dependent and independent variables, normality of residuals, no multicollinearity, exogeneity of independent variables, homoscedasticity of residuals, no autocorrelation, and specifically for fixed-effect models, the assumption that entity-fixed effects are constant over time.

Table 4: Pearson Correlation Matrix

Low-Emission-Sectors	Total GHG	Scope 1	Scope 2	Scope 3	ROA	SIZE	BOARDDIV	CAPINT
Total GHG								
Scope 1	0.749 ***							
Scope 2	0.742 ***	0.810 ***						
Scope 3	0.956 ***	0.637 ***	0.615 ***					
ROA	-0.103 ***	-0.080 ***	-0.135 ***	-0.074 **				
SIZE	0.640 ***	0.632 ***	0.612 ***	0.588 ***	-0.162 ***			
BOARDDIV	-0.008	-0.099 ***	-0.067 ***	0.009	0.182 ***	0.023		
CAPINT	0.036	0.076 **	0.129 **	-0.019	-0.077 ***	-0.126 ***	-0.033	
GROWTH	-0.044	-0.117 ***	-0.096 ***	-0.016	0.113 ***	-0.080 ***	0.019	-0.029
High-Emission-Sectors	Total GHG	Scope 1	Scope 2	Scope 3	ROA	SIZE	BOARDDIV	CAPINT
Total GHG								
Scope 1	0.729 ***							
Scope 2	0.600 ***	0.642 ***						
Scope 3	0.947 ***	0.585 ***	0.508 ***					
ROA	-0.251 ***	-0.298 ***	-0.179 ***	-0.185 ***				
SIZE	0.688 ***	0.623 ***	0.574 ***	0.610 ***	-0.198 ***			
BOARDDIV	0.056 **	-0.019	-0.052 *	0.076 ***	0.080 ***	-0.016		
CAPINT	0.029	0.108 ***	0.086 ***	-0.013	-0.128 ***	-0.158 ***	0.123 ***	
GROWTH	0.042	0.030	-0.061 **	0.050 *	0.082 ***	0.068 **	0.012	-0.022 ***

Linearity is assumed between the dependent and independent variables, and graphical analysis of the scatter plots between these variables tests the assumption. Most similar studies, identified in the previously performed SLR, assume the relationship between financial performance and GHG emissions as linear, with a few exceptions using non-linear regression models and finding U-shaped and Inverted U-shaped relations. The plots in Appendix 3 indicate a strong linear relationship between GHG emission and firm *SIZE*, a weaker linear relation with *ROA,* and a more nuanced picture of the other variables.

High or perfect multicollinearity between independent variables can cause several problems in regression models (Wooldridge, 2012, pp.94–99). Multicollinearity can highly influence the estimation of the regression coefficient and is to be avoided (Wooldridge, 2012, pp. 94–99). No or low multicollinearity is a basic assumption of the fixed-effect regression model and can easily be tested with the Variance Inflation Factor (VIF) (Wooldridge, 2012, p. 98). The VIF tests the variance increase when variables are correlated and is usually interpreted in the following increments (Wooldridge, 2012, p. 98). VIF = 1, indicating no multicollinearity; 1 < VIF < 5, indicating moderate correlation not requiring specific measures; VIF> 5, indicating significant and potentially problematic correlation; and VIF >10, considered as a threshold for serious multicollinearity (Wooldridge, 2012, p. 98). Since all VIF values for the independent variables of the performed regressions are between 1.018 and 1.085, multicollinearity is not seen as a problem and is neglected in further analysis. The VIF values for each variable can be found in Appendix 3.

The following basic assumptions of linear regression models is the homoscedasticity of residuals, which refers to the constant variation of error terms across the whole range of the independent variables (Wooldridge, 2012, pp. 93–94) and non-autocorrelation of residuals, which means no correlation of residuals across time (Wooldridge, 2012, p. 353). To test for homoscedasticity, or the presence of the opposite, namely heteroscedasticity, the Breusch-pagan test by Breusch and Pagan (1980) can be used. Autocorrelation or serial correlation in panel data is tested with the commonly referred Wooldridge test (Wooldridge, 2010, pp. 176–178). After performing both tests, shown in Appendix 3, the results indicate that heteroscedasticity is present in most regressions, and there is evidence of serial correlation between the residuals. Violating the homoscedasticity assumption still allows for valid results but requires further adjustments in the model (Wooldridge, 2012, pp. 268–296). A commonly used way to account for heteroscedasticity and autocorrelation is using robust standard errors, which have no influence on the coefficients but the respective f-statistic and p-values (Wooldridge, 2012, pp. 268–296). Clustered standard errors are explicitly suited for panel data and will be used on all regressions to test the hypotheses (Petersen, 2009).

Another assumption is that the normality of residuals is expected when performing an OLS regression (Wooldridge, 2012, pp. 118–121). This assumption can be tested with the Shapiro-Wilk test (Shapiro & Wilk, 1965) and by a graphical analysis of the regression models' histograms and Q-Q plots of residuals. The Shapiro-Wilk test tests the hypothesis that a sample comes from a normally distributed population and was developed by Shapiro and Wilk (1965). The results of this test indicate a non-normal distribution of residuals for the regressions performed, which motivates the further graphical analysis of residuals. The plots can be found in Appendix 3 and show a normal distribution for the major parts of the data, but outliers seem to influence the regression in the tails. These outliers are to be expected with GHG emissions data (Griffin, 2017), and are consistent with the findings from the previous analysis of company Scope 1, 2 and 3 GHG emissions in Chapter 7.1.2, which indicates that the majority of GHG emissions come from a small number of companies, namely outliers, making these outliers an essential part of these regressions and hypotheses. Consequently, the assumption for normal distribution of residuals is not entirely met, but scholars indicate that it is not strictly needed for consistent results in fixed-effect regressions and emphasise the use of robust standard errors to address non-normality issues (Greene, 2019, pp. 987–988; Wooldridge, 2012, p. 490).

The two last assumptions discussed are especially relevant for the work with GHG emissions data and the specific fixed-effect regression models. Many studies mention endogeneity, referring to the missing significant influencing variables in the regression model, as a potential issue for the relationship between financial and sustainability performance (Busch et al., 2022; Delmas et al., 2015; Gallego-Alvarez et al., 2015; Shahgholian, 2019). The opposite, exogeneity is a major assumption of every regression, but can rarely be guaranteed in real-life situations, particularly for time series data (Wooldridge, 2012, p. 355). As mentioned earlier, endogeneity is tested with the Hausman test, which compares fixed-effect regression to random-effect regression (Hausman, 1978). The presence of endogeneity would make the fixed-effect regression model more significant than the random-effect, as all time-invariant fixed entity effects are accounted for by definition (Wooldridge, 2012, p. 496). The Hausman tests, shown in Appendix 3, indicate that there might be endogeneity issues in the regression models, and the use of a fixed-effect regression should help to diminish these issues. The last assumption is inherent to fixed-effect regressions, which assumes that fixed-entity effects are time-invariant (Wooldridge, 2012, pp. 484–492). This can hardly be tested but is assumed, since in the context of this work, company sector and business model seem to be significant factors influencing GHG emission levels and are both time-invariant in most cases (IPCC, 2023; WRI & WBCSD, 2004).

The following chapters show, analyse, and discuss the results of the fixed-effect regression models used to answer the four sub-hypotheses of the second research question.

Results for Hypothesis H1

The regression results for *Hypothesis H1* are displayed in Table 5. The regression analysed the link of Profitability, measured by *ROA*, with *Total GHG*, measured by the sum of Scope 1, 2 and 3 GHG emissions. To analyse the results correctly, it is essential to highlight that all dependent variables and *SIZE* were transformed as natural logarithms, and the other variables are in percentages, which requires caution for the interpretation of the coefficients. Furthermore, some studies calculate *Total GHG* emissions as the sum of *Scope 1* and *Scope 2* (Czerny & Letmathe, 2024; Ghose et al., 2023). Whereas this study sees *Scope 3* emissions as necessary for assessing a company's most realistic carbon footprint. An approach mentioned in the literature, due to the risk of potential carbon leakage, the shift of *Scope 1* or *Scope 2* emissions to *Scope 3* by business practices (Wei et al., 2020), or the misleading or distorting picture from only including *Scope 1* and *Scope 2* emissions (Radonjič & Tompa, 2018). However, this also means that the *Total GHG* emissions are significantly influenced by *Scope 3* emissions, as these account for the largest share, as previously analysed in Chapter 7.1.2. Next to the p-value, the significance of a variable is indicated by *, ** and ***, respectively standing for a 10%, 5% and 1% significance level.

The model demonstrates statistical significance in the *Low-Emission-Sectors*, as indicated by an F-statistic p-value of 0.000. However, only a few variables exhibit significant impacts on GHG emissions. Specifically, firm *SIZE* and *BOARDDIV* are statistically significant predictors, with p-values of 0.000 and 0.001, respectively. Firm *SIZE*, with a coefficient of 0.744, suggests that larger firms tend to have higher *Total GHG* emissions, likely due to a larger scope of operational activities and energy use, as suggested by J. Lee and Yu (2019). *BOARDDIV* shows the most substantial positive impact on emissions, with a coefficient of 1.890, indicating that increased *BOARDDIV* correlates with higher emissions. This suggests that diverse boards may face challenges in aligning sustainability goals with business objectives or are in companies where emissions are more complicated to manage. Although this relation seems unintuitive because board diversity is often associated with better CSR performance (Hossain et al., 2023), other studies mention challenges of more diverse boards, which could impact this relationship (R. B. Adams et al., 2015). *ROA* exhibits a negative coefficient of -0.528, suggesting that profitability potentially reduces emissions; however, this relationship is not statistically significant, with a p-value of 0.339, indicating that profitability does not substantially influence *Total GHG* emissions in *Low-Emission-Sectors*. Although this study did not explicitly analyse *Low-Emission-Sectors*, these findings corresponded to the research of Hassan and Romilly (2018), finding no significant impact of economic performance on GHG emissions. Other factors, such as capital intensity and growth, do not significantly affect emissions within these sectors.

In contrast, the regression model in the *High-Emission-Sectors* is robust, as indicated by a higher overall R^2 value of 0.562 compared to 0.339 in *Low-Emission-Sectors*. This suggests that the model explains a more significant portion of the variability in emissions in *High-Emission-Sectors*. Notably, four out of the five independent variables significantly affect GHG emissions at the 5% level. *ROA* has the most significant negative impact on emissions, with a coefficient of -4.046

Table 5: Regression Results for Hypothesis H1

Dependent variable				
Total GHG	**Low-Emission-Sectors**		**High-Emission-Sectors**	
Independent Variables	Coefficient	P-Value	Coefficient	P-Value
Intercept	-4.515	0.317	-19.203 ***	0.001
ROA	-0.528	0.339	-4.046 **	0.019
SIZE	0.744 ***	0.000	1.516 ***	0.000
BOARDDIV	1.890 ***	0.001	0.046	0.943
CAPINT	0.295	0.577	1.751 ***	0.008
GROWTH	-0.097	0.434	-0.200 **	0.028
No. Observations:	1,245		1,279	
No. Entities:	267		271	
F-statistic (robust):	5.916		9.917	
P-Value:	0.000		0.000	
R^2 (Between):	0.339		0.562	

and a p-value of 0.019. This result indicates that more profitable companies tend to have lower *Total GHG* emissions, possibly due to investments in cleaner technologies and more efficient processes or stakeholder pressure in *High-Emission-Sectors* to reduce emissions, supporting the theoretical framework outlined in this thesis. This finding also support the results of Meng et al. (2023), which found that financial performance enhances carbon performance, and Oestreich and Tsiakas (2023). Firm *SIZE* and *CAPINT* have significant positive impacts on emissions, with coefficients of 1.516 and 1.751 and p-values of 0.000 and 0.008, respectively. This suggests that larger and more capital-intensive companies in *High-Emission-Sectors* have higher emissions, likely due to the nature of their operations, which often involve energy-intensive processes (Ghasemi et al., 2023; Nishitani & Kokubu, 2012). The *GROWTH* variable also shows a small but significant negative effect on *Total GHG* emissions, with a coefficient of -0.200 and a p-value of 0.028, indicating that higher revenue *GROWTH* is negatively linked to GHG emissions, supporting the argument that growing business models are less based on GHG emissions. Environmental and technological innovation of companies have been linked to increasing environmental performance in several studies (Mo, 2022; Muthuswamy & Sharma, 2023; Wedari et al., 2023) and innovation is linked to revenue growth (Angus et al., 1996). This supports the argument that growing companies in *High-Emission-Sectors* might be more innovative or efficient and consequently have lower GHG emissions.

Based on these findings, we fail to reject *H0* for *Hypothesis H1* in *Low-Emission-Sectors*, as profitability does not significantly impact *Total GHG* emissions. However, for firms in *High-Emission-Sectors*, *H0* is rejected for *Hypothesis H1*, as increased profitability correlates with lower *Total GHG* emissions. This divergence underscores the need for sector-specific strategies to manage emissions, recognising that financial performance and its influence on sustainability initiatives differ markedly between low- and high-emission industries. Combining that argument with the findings in Chapter 7.1.2, that most emissions come from a few companies in *High-Emission-Sectors* and few from *Low-Emission-Sectors*. It could be that the GHG emissions from companies in *Low-Emission-Sectors* are not significant enough to establish a noteworthy relationship between some variables in the regression analysis. Furthermore, the results align with findings of a negative relationship between financial performance and GHG emissions from Meng et al. (2023) and support the Slack Resources Theory. Indicating that companies in *High-Emission-Sectors* with higher profitability might invest more money in sustainable business practices, leading to lower emission levels. This regression does not analyse the potential bidirectional relation of both variables mentioned by Busch and Hoffmann (2011) and Testa and D'Amato (2017). Still, the results of the SLR and this regression support the theory that the relationship between environmental performance and financial performance might go both ways. This demands caution when analysing only one direction of this relation in the future and is also a problem in this research.

Results for Hypothesis H2

Hypothesis H2 focuses on the impact of profitability on direct GHG emissions from owned assets, namely *Scope 1* GHG emissions. The regression results are shown in Table 6.

The regression model is statistically significant for *Low-Emission-Sectors*, with an F-statistic p-value of 0.029, but individual variables exhibit limited impact on *Scope 1* emissions. The firm *SIZE* is the only variable with a statistically significant (at 5% level) positive coefficient of 0.254 and a p-value of 0.038. This indicates that larger companies tend to have slightly higher *Scope 1* emissions, potentially due to increased operational activities directly emitting GHGs. *BOARDDIV* also approaches significance with a coefficient of -0.572 and a p-value of 0.054, suggesting a potential negative relationship where more diverse boards may help mitigate direct emissions through improved governance and strategic

Table 6: Regression Results for Hypothesis H2

Dependent variable				
Scope 1	**Low-Emission-Sectors**		**High-Emission-Sectors**	
Independent Variables	Coefficient	P-Value	Coefficient	P-Value
Intercept	3.547	0.185	5.823 **	0.017
ROA	0.358	0.399	0.627 *	0.084
SIZE	0.254 **	0.038	0.281 ***	0.009
BOARDDIV	-0.572*	0.054	-0.435	0.177
CAPINT	0.186	0.537	0.460	0.128
GROWTH	-0.021	0.805	-0.046	0.574
No. Observations:	1,245		1,279	
No. Entities:	267		271	
F-statistic (robust):	2.502		3.830	
P-Value:	0.029		0.002	
R^2 (Between):	0.143		0.122	

decision-making. This adds to similar findings of Hossain et al. (2023) and Muktadir-Al-Mukit and Bhaiyat (2024), which found a negative relation between board diversity and GHG emission levels. The coefficient for *ROA* is positive but not significant, with a p-value of 0.399, indicating that profitability might not have a meaningful effect on *Scope 1* emissions in *Low-Emission-Sectors*, which could be due to the same reason mentioned in *Hypothesis H1*. Namely, the selected variables can only minimally explain the level of *Scope 1* GHG emissions, or the absolute level of these emissions needs to be larger to find further significant relation. These findings suggest that companies' profits in *Low-Emission-Sectors* are not or less linked to business practices causing GHG emissions.

The model is statistically significant in the *High-Emission-Sectors* with an F-statistic p-value of 0.002. However, similarly to the *Low-Emission-Sectors*, the model's explanatory power is limited, as indicated by a lower R^2 value of 0.122. Here, *ROA* shows a positive coefficient of 0.627, which is significant at the 10% level (p-value of 0.084). It is not significant at the targeted 5% significance but still contrasts with its negative impact on *Total GHG* emissions seen in *Hypothesis H1*. This suggests that high profitability may not translate into reduced direct emissions in *High-Emission-Sectors*. Possibly due to the underlying business models, with a continued reliance on carbon-intensive operations, challenging to decarbonise (Cavaliere, 2019). Firm *SIZE* remains significant, with a coefficient of 0.281 and a p-value of 0.009, indicating that larger firms have higher direct emissions. However, the effect size is smaller than its impact on *Total GHG* emissions. This reflects larger companies' inherent challenges in curbing emissions directly tied to their core operational activities. Other variables, such as *BOARDIV*, *CAPINT*, and *GROWTH*, do not significantly impact *Scope 1* emissions in *High-Emission-Sectors*, indicating that these factors might not directly influence operational-level emissions.

Overall, the regression results suggest that *Scope 1* emissions are less sensitive to the independent variables than *Total GHG* emissions in H1. The lack of a significant negative relationship between *ROA* and *Scope 1* emissions in *High-Emission-Sectors* indicates that profitability may not be linked to practices reducing direct emissions. Instead, the results may suggest that increased profit is not driving more sustainable activities but rather associated with more business activities that emit more GHG, in line with the research of L. Wang et al. (2014), which mentioned the strong mining industry in their sample as a potential reason for this relationship. These findings suggest that we cannot reject *H0* for *Hypothesis H2* in both *Low-* and *High-Emission-Sectors*, as *ROA* is not significantly negatively associated with *Scope 1* GHG emissions. These results highlight the mixed findings identified in the SLR and the importance of analysing the three Scopes individually, as differences in their relationships with financial performance were expected.

Results for Hypothesis H3

Scope 2 emissions are indirect emissions from purchased energy, and Table 7 presents the results for *Hypothesis H3*, which examines the link between profitability and these indirect emissions. If available, the LSEG Eikon Database uses location-based *Scope 2* emissions, allowing us to focus on their implications.

The regression analysis for *Low-Emission-Sectors* reveals that the model has limited explanatory power, as indicated by an overall R^2 of 0.121. Despite this, *ROA* is the only statistically significant variable at the 5% level, with a coefficient of 0.518 and a p-value of 0.016. This positive relationship suggests that more profitable firms in *Low-Emission-Sectors* have higher *Scope 2* emissions. This finding contradicts the Slack Resource Theory, which posits that more profitable firms have additional resources to invest in energy efficiency and emission reductions, but could also indicate that location-based *Scope 2* emissions are not easily reduced with higher financial resources due to the challenges of influencing the local grid energy-mix (Karlsson et al., 2009). Other variables such as firm *SIZE, BOARDDIV, CAPINT*, and *GROWTH* do not signifi-

Table 7: Regression Results for Hypothesis H3

Dependent Variable

Scope 2	**Low-Emission-Sectors**		**High-Emission-Sectors**	
Independent Variables	Coefficient	P-Value	Coefficient	P-Value
Intercept	5.895*	0.056	24.135**	0.027
ROA	0.518**	0.016	2.173	0.114
SIZE	0.186	0.172	-0.560	0.246
BOARDDIV	-0.793	0.123	-0.068	0.844
CAPINT	0.219	0.432	0.242	0.498
GROWTH	-0.129	0.143	-0.040	0.903
No. Observations:	1,245		1,279	
No. Entities:	267		271	
F-statistic (robust):	4.185		1.093	
P-Value:	0.001		0.362	
R^2 (Between):	0.121		-0.530	

cantly impact *Scope 2* emissions, suggesting that these factors may not directly influence energy consumption and associated emissions in *Low-Emission-Sectors*.

The regression model's explanatory power for *High-Emission-Sectors* is notably poor, with a p-value of 0.362, indicating a weak link between the dependent and the independent variables. None of the independent variables are statistically significant at the 5% level, and the model fails to effectively explain the variability in *Scope 2* emissions. However, *ROA* displays a positive coefficient of 2.173, which is marginally non-significant at the 10% level (p-value of 0.114). This suggests a potential trend where increased profitability is associated with higher *Scope 2* emissions, although the relationship lacks statistical significance. The absence of significant explanatory variables may imply that factors beyond the scope of the current model, such as energy-sourcing strategies or the local energy mix (Chuang et al., 2018; WRI & WBCSD, 2004), could play a more substantial role in influencing *Scope 2* emissions in *High-Emission-Sectors*. Interestingly, firm *SIZE* does not significantly impact *Scope 2* emissions in either sector, indicating that company *SIZE* alone may not determine energy consumption or indirect emission levels.

Overall, the results indicate that the examined variables less influence *Scope 2* emissions compared to *Total GHG* or *Scope 1* emissions, which was expected from the elaboration of *Hypothesis H3*. The positive relationship between profitability and *Scope 2* emissions in *Low-Emission-Sectors* suggests that more profitable companies rely more on purchased energy creating GHG emissions. Meanwhile, the lack of significant predictors in *High-Emission-Sectors* highlights the complexity of managing energy-related emissions and the differences between the Scopes and industries. Consequently, we fail to reject *H0* for *Hypothesis H3* in *Low-* and *High-Emission-Sectors*. In *Low-Emission-Sectors*, the positive impact of *ROA* contradicts the expectation. In *High-Emission-Sectors*, the model lacks significant explanatory variables, indicating a need for further research to uncover additional factors influencing *Scope 2* emissions.

Results for Hypothesis H4

The last hypothesis of this thesis evaluates the impact of profitability on *Scope 3* GHG emissions, and the regression results are shown in Table 8.

In *Low-Emission-Sectors*, the regression model is statistically significant overall, as indicated by an F-statistic p-value of 0.000, with an R^2 of 0.298. The *ROA* has a negative coefficient of -1.279 with a p-value of 0.034, the largest coefficient for *ROA* in the *Low-Emission-Sectors*, signifying that higher profitability is associated with lower *Scope 3* emissions. This negative relationship suggests that profitable firms might be investing in more sustainable supply chain practices, such as selecting environmentally conscious suppliers (Fagundes Alves et al., 2024), eco-friendly and durable product design (Asif et al., 2022; Booth et al., 2023) or optimising logistics and sourcing (Hertwich & Wood, 2018), reducing Value Chain emissions. Firm *SIZE* also significantly impacts *Scope 3* emissions, with a coefficient of 0.962 and a p-value of 0.002, indicating that larger firms tend to have higher *Scope 3* emissions. This could be due to larger firms having more extensive supply chains and greater product distribution requirements (Bode & Wagner, 2015). Interestingly, *BOARDDIV* has a significant positive impact on emissions, with a coefficient of 2.948 and a p-value of 0.000, suggesting that more diverse boards might face challenges in aligning sustainability objectives across complex value chains (R. B. Adams et al., 2015) or it might reflect diverse perspectives that increase reporting transparency without immediate reduction efforts (Liao et al., 2015; Tingbani et al., 2020).

The model also achieves statistical significance for *High-Emission-Sectors*, with an R^2 of 0.370. The effect of profitability on *Scope 3* emissions is more pronounced here, with an *ROA* coefficient of −6.234 and a p-value of 0.002. This stronger negative impact indicates that firms in *High-Emission-Sectors* might leverage profitability more effectively

Table 8: Regression Results for Hypothesis H4

Dependent variable				
Scope 3	Low-Emission-Sectors		High-Emission-Sectors	
Independent Variables	Coefficient	P-Value	Coefficient	P-Value
Intercept	-10.141	0.137	-33.194***	0.000
ROA	-1.279 **	0.034	-6.234 ***	0.002
SIZE	0.962 ***	0.002	2.106 ***	0.000
BOARDDIV	2.948 ***	0.000	0.463	0.592
CAPINT	-0.974	0.634	1.962 **	0.030
GROWTH	-0.095	0.568	-0.207	0.272
No. Observations:	1,245		1,279	
No. Entities:	267		271	
F-statistic (robust):	6.232		9.339	
P-Value:	0.000		0.000	
R^2 (Between):	0.298		0.370	

to engage in emissions-reduction activities across their value chains, as mentioned above. Firm *SIZE*, with a coefficient of 2.106 and a p-value of 0.000, is positively correlated with *Scope 3* emissions, further highlighting the complexity of the value chain and emissions in *High-Emission-Sectors*. *CAPINT* also exhibits a significant positive relationship with *Scope 3* emissions, with a coefficient of 1.962 and a p-value of 0.030, implying that capital-intensive firms are more likely to have higher other indirect emissions, possibly due to greater consumption of resources and energy throughout their supply chains, a finding supported by (Hertwich & Wood, 2018).

The findings support the rejection of *H0* for *Hypothesis H4*, as profitability is negatively associated with *Scope 3* GHG emissions for firms in both *Low-* and *High-Emission-Sectors*. The results suggest that financially successful companies could be potentially better positioned to implement sustainability initiatives that reduce emissions across their entire value chain. The large negative correlation between *ROA* and *Scope 3* emissions underscores the importance of integrating environmental sustainability into the broader strategic objectives of profitable firms. Overall, the regression analysis underscores the importance of addressing *Scope 3* emissions as part of a comprehensive climate strategy, given their significant contribution to a firm's overall carbon footprint (Matthews et al., 2008). The results also highlight the different relationships between each Scope by showing a significant negative relation with *ROA* for both *Low-* and *High-Emission-Sectors*, contrasting with the findings for *Scope 1* and *Scope 2*. By focusing on value chain emissions, companies can achieve meaningful reductions in their environmental impact, align with global sustainability goals, and enhance their reputation and competitive advantage in increasingly environmentally-conscious markets.

7.2.3. Robustness Tests

To ensure the reliability of the results, a series of robustness tests were conducted to examine the impact of profitability on GHG emissions. These checks focused on the direction and significance of the relationship between profitability and GHG emissions across various dimensions. The results of all robustness checks can be found in Appendix 4 and are only briefly discussed.

Different measures of profitability, such as *ROE* and *ROS*, were employed to test the differences and is a common way for robustness checks in this field (Busch et al., 2022; Hassan & Romilly, 2018). The analysis revealed that while the relationship direction remained consistent, the significance was less pronounced for *ROE* and non-existent for *ROS*. Similar directional results were observed using a GHG metric relative to firm revenues. However, the relationship between *ROA* and all GHG Scopes lacked statistical significance. Furthermore, incorporating the natural logarithm of total assets, instead of revenues, as a *SIZE* control variable did not alter the direction of the relationship between *ROA* and GHG Scopes but significantly diminished model performance and the significance of the findings. These mixed results are common in most studies analysing similar relationships (Busch & Lewandowski, 2018; Lewandowski, 2017), and indicate the high dependence of results on specific metrics, making it challenging to draw definitive conclusions.

Following a procedure similar as Hassan and Romilly (2018) to assess the influence of extreme outliers, the data was truncated at the 1st and 99th percentiles and the 5th and 95th percentiles. This results in outcomes comparable to the primary analysis without outlier removal, albeit with subtle differences in significance levels. Analysing the entire sample without distinguishing between *Low-* and *High-Emission-Sectors* produced results that aligned with both dataset's expectations. The relationship with *Scope 3* emissions was negative and significant, while the relationship with *Scope 2* emissions was positive and significant. In contrast, the relationship with *Scope 1* emissions was positive but not significant, and the relationship with *Total GHG* emissions was negative but not significant. Lastly, considering the significant disruption of business activities and GHG emissions during the COVID-19 pandemic in 2020, the exclusion of this year from the analysis did not alter the main findings. However, it did result in minor changes to the significance levels.

Overall, the robustness checks confirmed the general reliability of the analysis but indicated significant differences depending on the choice of variables. This finding is also consistent with current literature and shows the complexity and difficulties of understanding the relationship between financial performance and GHG emissions.

7.2.4. Limitations

In this chapter, we discuss the limitations encountered during this research, which includes model specification constraints, data limitations and broader contextual challenges. Recognising these limitations is essential for interpreting the findings accurately and understanding the scope of the study.

A significant theoretical limitation of this study is the scarcity of comparable research on the directional relationship between profitability and GHG emissions, as identified in the SLR, which served as the motivation for this thesis. This scarcity makes it difficult to benchmark the findings and highlights the need for further empirical research to validate the results of this thesis. Another challenge is the potential bidirectional relationship between profitability and GHG emissions, mentioned by several scholars (Busch & Hoffmann, 2011; Testa & D'Amato, 2017; Waddock & Graves, 1997). While this study focuses on the impact of profitability on GHG emissions, emissions may also affect profitability, as shown in the literature identified in the SLR. This introduces endogeneity concerns that could bias the results.

The fixed-effects model used in this study assumes that individual-specific effects are time-invariant and uncorrelated with explanatory variables, which may not always be accurate, potentially leading to biased estimates (Wooldridge, 2012, pp. 484–496). Furthermore, the model does not allow to estimate specific time-invariant variables like the company sectors, which are supposedly major determinants of GHG emissions (Ghasemi et al., 2023). The limitations of fixed-effect models or other OLS-based regressions are mentioned in several studies, which support the use of other models like quantile regressions or the Gaussian Mixture Model (Meng et al., 2023; Rodríguez-García et al., 2022). Furthermore, the model assumes linearity, which may not capture the complex, non-linear relationships or tipping points between profitability and GHG emissions identified in the literature (Misani & Pogutz, 2015; Ogunrinde et al., 2022). Since the regression models identify correlations rather than causations, we cannot make definitive causal claims without experimental or quasi-experimental designs. Exploring alternative methods, such as dynamic models or machine learning techniques, could better capture complex interactions and non-linearities, offering richer insights into these dynamics.

The study presents mixed results across different Scopes of GHG emissions and varying explanatory variables. These inconsistencies underscore the complexity of assessing the impact of profitability on GHG emissions and highlight the need for further investigation into potential moderating variables. A fundamental limitation of this study is the risk of omitted variables, particularly those influencing Scope 1, 2 and 3 emissions. Each Scope appears to have distinct determinants, as suggested by the significant variance in model performance across these Scopes. Additionally, classifying companies into low- and high-emissions sectors may be overly simplistic and fail to capture sectoral complexity, potentially leading to misinterpretations. Differentiating effects caused by specific business model characteristics is challenging without extensive detail. Future research should use more granular classifications or focus on individual high-emitting sectors. As discussed in the previous chapter, robustness tests show significant differences when using various measures and profitability metrics, like ROE and ROS, indicating that measurement choice can substantially influence findings. This requires cautious interpretation and more comprehensive robustness checks in future studies. Measurement errors can also result from inconsistencies in reporting standards and estimation methods of companies, which is a highlighted problem for *Scope 3* emissions (Fouret et al., 2024; Patchell, 2018), potentially affecting the study's findings.

The dataset used in this study is based on the STOXX Europe 600 index, which includes the largest 600 European companies. This focus on European companies limits the findings' generalisability to other regions with different regulatory environments, market dynamics, and environmental practices. Furthermore, small and medium-sized enterprises (SMEs) are not included in the sample, limiting the results' applicability to large corporations. SMEs may exhibit different dynamics in profitability and GHG emissions, so future research should include a broader range of companies. Although data availability has improved, the dataset is still unbalanced, with missing information that could introduce bias and affect reliability. As discussed in Chapter 2.2.3, the upcoming CSRD conforming reports are expected to improve data transparency, quality, and availability for both large and smaller firms, especially regarding GHG emissions disclosures across all three Scopes.

In summary, this study's limitations provide critical insights into the constraints and challenges faced during the research process. Acknowledging these limitations helps contextualise the findings and underscores the need for continued research. Future studies should address these limitations by incorporating more comprehensive datasets, exploring alternative model specifications, and cautiously examining the complex interactions between profitability and GHG emissions.

7.2.5. Key Findings and Summary of Results

This chapter aims to synthesise the results of the four previous hypotheses into key findings and a summary. The empirical analysis distinguishes between *Low-* and *High-Emission-Sectors*, uncovering a significant variance in the impact of profitability on GHG emissions depending on the scope and sector type. Table 9 shows the relationship di-

Table 9: Key Findings of Regressions H1-H4

	Correlation with ROA	
Emission Types	**Low-Emission-Sectors**	**High-Emission-Sectors**
H1: Total GHG	Negative, not significant	Negative, significant
H2: Scope 1	Positive, not significant	Positive, not significant
H3: Scope 2	Positive, significant	Positive, not significant
H4: Scope 3	Negative, significant	Negative, significant

rection from each regression and the significance level at 5%.

Profitability shows a significant negative correlation between *Total GHG* and *Scope 3* emissions in *High-Emission-Sectors* and *Scope 3* emissions in *Low-Emission-Sectors*. This aligns with the theoretical framework, indicating that more profitable companies may invest more in reducing GHG emissions to enhance legitimacy or stakeholder satisfaction. However, this could also indicate that more profitable companies inherently have more sustainable business models, which highlights the limitations of these regressions. In order to isolate the effect of profitability more from other factors, it would therefore be advisable to compare the performance of companies that differ as little as possible apart from profitability. This means preferably from the same industry, with the same business model, and the same geographical focus. Conversely, profitability is positively linked to *Scope 1* and *Scope 2* emissions, but only significant for *Scope 2* in *Low-Emission-Sectors*, suggesting that these models do not fully capture the determinants of emissions for these Scopes. Additionally, the models for *Scope 2* emissions are the least significant, implying that factors not included in the regressions, like local grid energy mix, may play a crucial role. The low explanatory power of the models for *Scope 2* emissions underscores the importance of external factors like local energy grids, suggesting that future research should incorporate explanatory variables specific to each Scope to achieve more conclusive results. Control variables present nuanced results: firm *SIZE* positively correlates with *Total GHG*, *Scope 1*, and *Scope 3* emissions across both *Low-* and *High-Emission-Sectors*, while *BOARDDIV* and *CAPINT* show significance only in specific contexts. Unexpectedly, *BOARDDIV* positively correlates with *Scope 3* emissions in *Low-Emission-Sectors*, which may reflect challenges in aligning diverse perspectives with sustainability goals, or increased transparency. Capital intensity is only significantly related to *Total GHG* and *Scope 3* emissions in *High-Emission-Sectors*, consistent with its association with GHG-intensive activities.

Overall, the findings show mixed results, significantly differing between *Low-* and *High-Emission-Sectors* as well as across the specific Scopes of emissions. The results don't allow a definitive conclusion on the impact of profitability on Total, Scope 1, 2 and 3 GHG emissions and indicate the need for further, sector and Scope specific research. The next and last chapter of this thesis is dedicated to the implications of this work and the final conclusion.

8. Implications and Conclusion

Climate change is increasingly causing severe challenges worldwide. One of the critical objectives in combating climate change, as outlined in the Paris Agreement, is the reduction of GHG emissions. Enhancing companies' sustainability reporting requirements is critical to achieving this goal. As sustainability reporting evolves rapidly, new regulations such as the Corporate Sustainability Reporting Directive are making the disclosure of sustainability-related information mandatory, including Scope 1, 2 and 3 GHG emissions. This aligns with the principle of "what gets measured gets managed" (Drucker, 2007), emphasising the importance of transparency and accountability in driving sustainable practices. One question that scholars have asked themselves frequently is whether "it pays to be green". Although findings indicate that it could pay to be green, studies also find mixed results and often describe the problem of potentially reverse causality and bidirectionality of this relation. In line with the Slack Resource Theory, a more profitable company could be spending more money on CSR and emission reduction initiatives. However, only scarce literature exists on the relation whether "profitability drives sustainability". This thesis aimed to close this research gap identified in the systematic literature review and help scholars, businesses, and politics better understand the effect of profitability on GHG emissions of companies. Two research questions were formulated to do the topic justice.

The first research question, "*What are the Scope 1, 2 and 3 GHG emissions levels for European companies from 2017-2023?",* aimed to provide an overview of GHG emissions in Europe across all Scopes, for the largest 600 companies in Europe, based on the STOXX Europe 600 index. The findings indicate a high level of disclosure for all three Scopes, with steady increases over the years. However, while significantly improved, Scope 3 emissions disclosures have not yet reached the level of Scope 1 and 2 disclosures. There remains considerable variability in Scope 3 emissions levels within and between companies, reflecting ongoing calculation, methodology, and comparability challenges. The data reveals that median growth trends for companies are negative for Scope 1 and 2 emissions, while Scope 3 emissions show a slight growth. This pattern is consistent across sectors, underscoring the importance of Scope 3 emissions in understanding the full picture of GHG emissions. The COVID-19 pandemic's effect is evident, with a notable drop in emissions during the major pandemic year and a subsequent recovery in 2021. Additionally, the sector analysis shows that a small number of companies from high-emitting sectors, such as energy, materials, and industrials, are responsible for most GHG emissions, highlighting the disproportionate impact of high-emitting industries and companies on global GHG emissions.

The second research question, "*How does firm profitability impact total and individual Scope 1, 2 and 3 GHG emissions?",* builds on the emissions overview insights and analyses the profitability correlation with all GHG Scopes using fixed-effect regressions. The relationship between profitability and GHG emissions was examined by categorising companies into low-emission and high-emission sectors to capture the differences in emissions profiles accurately. The analysis revealed a negative correlation between profitability and Scope 3 emissions, which was the strongest across all regressions, highlighting the significant impact of profitability on this Scope. Due to the large contribution of Scope 3 emissions, the regression of Total GHG emissions yielded similar but less significant results. Interestingly, the direction of the relationship between profitability and Scope 1 and 2 emissions was unexpectedly positive for both high and low-emitting sectors, though these findings lacked statistical significance in most cases. Overall, the impact of profitability on all Scopes of GHG emissions was more pronounced in high-emitting sectors than low-emitting ones, underscoring the stronger connection of profits and GHG emission in these sectors. Conducted robustness tests generally confirm the reliability of the findings, although using relative measures of GHG emissions and alternative profitability metrics resulted in nuanced results. While these alternative approaches largely pointed in the same direction, they often showed less or no statistical significance. In conclusion to research question two, the relationship varies across each Scope, highlighting the need for further research.

The implications of the findings for scholars, businesses, and policymakers are multifaceted. Scholars must consider the potential bidirectional and reverse relationship between financial performance and GHG emissions. Because it may not only "pay to be green" but "profitability may drive sustainability", recognising this is important and should be accounted for in future research. Additionally, the mixed results between the specific Scopes indicate the need to account for Scope-specific determinants and focus on individual relationships rather than Total GHG emissions. Since business practices less influence GHG emissions in low-emission sectors, and a few sectors produce the most emissions, scholars should focus on the sectors where the most GHG reduction can be achieved first. Businesses must prioritise reducing Scope 3 emissions, as they constitute the majority of GHGs, and ensure accurate carbon accounting to manage emissions effectively. To achieve that, policymakers need to ensure that all material emissions are included, and that the comparability of Scope 3 emissions is improved, especially because Scope 1 and Scope 2 emissions can be shifted to Scope 3 by business practices like outsourcing. Similar to the focus of scholars, GHG reduction policies should focus on reducing emissions from high-emitting companies and sectors to achieve the most impact on the fight against climate change. The findings indicate that the emission of GHG is still part of many business models since profitability is positively, but for most, not significantly correlated with Scope 1 and 2 GHG emissions. This suggests that political measures should be reinforced to hold companies accountable for the environmental damages they cause, while also implementing stricter regulations to reduce or eliminate greenhouse gas emissions. Although carbon taxes and emissions trading are a good start, policies must go further to ensure companies fully internalize the environmental costs of their activities, thereby intensifying the urgency to achieve lower emissions.

However, the findings and implications of this study should be interpreted with caution, and the limitations must be acknowledged. A major theoretical constraint is the scarcity of comparable research on this topic, making it challenging to benchmark findings and emphasising the need for further empirical validation. Additionally, the potential bidirectional nature of the relationship introduces endogeneity concerns, as emissions can also affect profitability, complicating interpretation. Furthermore, the fixed effects model used in the analysis assumes the time-invariance of fixed effects and linearity of the relationship, which may not capture the complex, potentially non-linear relationship between profitability and GHG emissions. Besides, data limitations also impact the study's generalisability. The focus on the STOXX Europe 600 index, comprising the largest European companies, excludes small and medium-sized enterprises (SMEs) and limits applicability to other regions with different regulatory environments. Additionally, the dataset's unbalanced nature and missing information pose challenges to the reliability of the findings. Acknowledging these limitations underscores the importance of future research to validate and expand upon these findings, incorporating more comprehensive datasets and exploring alternative models to understand the intricate relationship between profitability and GHG emissions.

Based on the findings and the implications, a suggestion for future research would be to focus on single high-emission sectors to compare how the profitability of different firms in similar contexts influences Scope 1, 2 and 3 GHG emissions. The results have shown substantial differences between each Scope, and a clear distinction of these in future research is advisable. Furthermore, the mandatory disclosure of emissions across all three Scopes for firms falling under the CSRD is a chance to perform similar research with more and better data in the coming years. Hopefully allowing for extensive analyses over time.

Ultimately, this work highlights the complex relationship between profitability and GHG emissions, underscoring the challenge of drawing definitive conclusions while emphasising society's continued reliance on environmentally harmful business practices for economic gain. Only the efforts of businesses, policymakers, and society can mitigate the adverse effects of climate change and ensure a resilient and sustainable world for future generations. Proper carbon accounting and reporting are essential first steps, but are they enough?

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