Askild Haagensen
Jan Mohammed Ashraf
Tobias Aandstad Nilssen

The Impact of ESG Factors on Financial Performance: Evidence from the Aluminum and Iron & Steel Industries

Master's thesis in Industrial Economics and Technology Management
Supervisor: Stein-Erik Fleten
Co-supervisor: Lars Sendstad
June 2023

Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

NTNU
Norwegian University of
Science and Technology

Askild Haagensen
Jan Mohammed Ashraf
Tobias Aandstad Nilssen

The Impact of ESG Factors on Financial Performance: Evidence from the Aluminum and Iron & Steel Industries

Master's thesis in Industrial Economics and Technology Management
Supervisor: Stein-Erik Fleten
Co-supervisor: Lars Sendstad
June 2023

Norwegian University of Science and Technology
Faculty of Economics and Management
Dept. of Industrial Economics and Technology Management

NTNU
Norwegian University of Science and Technology

Preface

This master's thesis is part of the five-year Master of Science degree program in Industrial Economics and Technology Management at the Norwegian University of Science and Technology (NTNU). The thesis is written in collaboration with Norsk Hydro ASA, hereafter shortened to Hydro, and seeks to enlighten and investigate how ESG factors impact firms' financial performance in the aluminum and iron & steel industries.

We want to express our profound gratitude to our supervisor, Professor Stein-Erik Fleten, for sharing his knowledge, compelling discussions, and valuable guidance throughout the master's thesis. His dedication and encouragement were essential in shaping the direction of this thesis and that it aligned with the required academic standards. We would also like to thank the representatives from Hydro, Lars Sendstad, and Magnus Young, for their guidance and for sharing valuable insight into Hydro's operation. Their encouragement fostered productive discussions and made us understand the market in which Hydro operates. Finally, our deepest gratitude goes to Dr. Malvina Marchese, Professor Sjur Westgaard, and Ph.D. Candidate Rodrigo Graça for their valuable guidance and expertise in empirical finance and contribution to building our empirical model.

Askild Haagensen

Jan Mohammed Ashraf

Tobias Aandstad Nilssen

Trondheim, June 11th 2023

Abstract

The literature remains divided on whether Environmental, Social, and Governance (ESG) have a positive, negative, or no significant impact on financial performance. Thus, this paper examines the influence of ESG on financial performance, measured by Tobin's q, in the aluminum and iron & steel industries. Using a dataset of 31 aluminum and 173 iron & steel firms over a time period from 2012 to 2022, we find that ESG scores, ESG pillar scores and ESG category scores have no significant impact on financial performance. In other words, our study indicates that investors in these energy-intensive and emitting industries are not assigning higher market values to high-performing ESG companies compared to other firms. This result may stem from investors being aware of greenwashing, thus, understanding that sustainability is more than what is reflected in ESG factors. Even though our analysis yields no significant impact, we acknowledge that firm executives may benefit from investing in ESG in the long term, as stakeholders may demand more sustainable operations in the future. Being an early adopter of sustainable investments can facilitate an easier transition to a more sustainable operation, thereby reducing a firm's risk concerning the regulatory framework. Moreover, we find a statistically significant negative impact from the number of years a firm has reported ESG, firm age, and the lag of Tobin's q on financial performance. We examine the relationship between ESG factors and financial performance utilizing the two-step Arellano-Bond general methods of moments (GMM) estimator, which allows us to incorporate the dynamic nature of financial performance. The estimator utilizes reliable instruments that address unobserved simultaneity and heterogeneity, providing validity to our analysis. Overall, this paper presents empirical evidence through an industry-specific analysis. Thus, this research yields insights that are transferable to other industries facing similar environmental challenges. Additionally, we investigate the impact of specific categories within the ESG pillars on financial performance, contributing to the existing literature by exploring more specifically which categories may influence Tobin's q.

Sammendrag

Litteraturen er delt om hvorvidt Environmental, Social, og Governance (ESG) har en positiv, negativ eller ingen signifikant innvirkning på finansiell ytelse. Denne oppgaven undersøker derfor hvilken innflytelse ESG har på finansiell ytelse, målt med Tobin's q, i aluminium- og jern & stålindustriene. Med et datasett bestående av 31 aluminiums- og 173 jern & stålselskaper over en periode fra 2012 til 2022, konkluderer vi med at ESG scorer, ESG pilar scorer og ESG kategori scorer ikke har noen signifikant innvirkning på finansiell ytelse. Med andre ord indikerer vår studie at investorer i disse energikrevende og utslippsintensive sektorene ikke bidrar til høyere markedsverdi til ESG-orienterte selskaper, sammenlignet med andre. Resultatet kan skyldes av at investorer er bevisste på grønnvasking, og at bærekraft er mer enn det som gjenspeiles i ESG-faktorene. Selv om analysen ikke viser signifikant innvirkning, erkjenner vi at bedriftsledere kan få langsiktig nytte av å investere i ESG, ettersom interessenter kan kreve mer bærekraftige løsninger fremover. Å investere tidlig i bærekraftige teknologier kan lette overgangen til en mer bærekraftig drift og dermed redusere selskapets risiko knyttet til statlige regelverksendringer om klima og miljø. Videre finner vi en statistisk signifikant negativ innvirkning fra antall år et selskap har rapportert ESG, selskapets alder og "lagg" av Tobin's q på finansiell ytelse. Vi undersøker forholdet mellom ESG-faktorer og finansiell ytelse ved å bruke two-step Arellano-Bond general methods of moments (GMM)-estimatoren. Estimatoren tar hensyn til den dynamiske naturen i finansiell ytelse og bruker pålitelige instrumenter som tar hensyn til uobservert simultanitet og heterogenitet. Denne oppgaven presenterer empiriske bevis gjennom en bransjespesifikk analyse og gir innsikt som kan overføres til andre bransjer som står overfor lignende miljøutfordringer. I tillegg undersøker vi og bidrar til eksisterende litteratur ved å utforske innvirkningen av spesifikke kategorier innenfor ESG-pilarene på finansiell ytelse.

Table of Contents

Preface **i**

Abstract **ii**

Sammendrag **iii**

1 Introduction **1**

2 Literature Review **4**

2.1 Theoretical Framework 4

2.2 ESG and Firm's Financial Performance 5

2.3 ESG Measurements and Methodology Issues 7

2.4 Research Contribution 8

3 Research Hypotheses **10**

4 Data and Methodology **12**

4.1 Data 12

4.2 Variables 13

4.3 Descriptive Statistics 15

4.4 Framework and Methodology: Dynamic Panel Data Models 19

4.5 Diagnostic Tests 22

5 Results and Discussion **23**

5.1 The Impact of ESG Factors on Financial Performance 23

5.2 Robustness Test 28

5.3 Critical Reflection 28

6 Conclusion **30**

Bibliography **32**

Appendix **35**

A Choosing our Provider of ESG Scores 35

B Refinitiv Eikon's ESG Scores 36

C Description of Variables 38

D Dynamic Panel Model 39

E Dynamic Panel Estimation with GMM 40

F Robustness Results 44

Chapter 1

Introduction

This paper offers valuable insights into the relationship between Environmental, Social, and Governance (ESG) factors and financial performance[1] by expanding on the growing literature in this area. The literature has diverging evidence on the impact of ESG on financial performance. Thus, our research aims to address this current gap. ESG was introduced by United Nations in 2004 and has, in less than 20 years, become the most recognized responsibility metric for companies across the world [Kell, 2018]. ESG refers to the three pillars of measuring a company's sustainability and societal impact. The environmental pillar considers how a company performs as a steward of nature and includes measures for water and energy usage, among more. The social pillar examines the firm's relationships with employees, suppliers, and customers, e.g., the average employee training hours and the degree of women employees. The governance pillar focuses on a company's leadership, audits, internal controls, and shareholder rights [Refinitiv Eikon, 2022]. In short, ESG is an attempt to materialize corporate responsibility that is otherwise unobservable in a company's accounting. When ESG was first introduced, the idea was to ease companies' and investors' ability to understand and consider corporate responsibility in investing. In recent years, it has become more evident to the general public that climate change and the role of companies in contributing to carbon emissions are interconnected. Today, ESG has risen to the top of the corporate executives' agenda, driven by the increasing interest from stakeholders like shareholders, governments, and non-governmental organizations [Baker et al., 2022].

Several countries demand ESG disclosure for all industries in the transition to operating more sustainably. Consequently, many metal companies have implemented ESG strategies into their core business operations [Michaels et al., 2022]. The metals and mining industry is known for its high energy consumption, often resulting in significant greenhouse gas emissions. Thus, our paper provides an industry-specific analysis focusing on the aluminum and iron & steel industries. By doing so, our findings can be applied to other industries with ESG concerns, such as the transport sector or other segments of the metal and mining industries. Furthermore, many metal and mining companies operate in vulnerable regions and have a substantial resource consumption [IEA, 2023]. Due to these factors, most players in the industry recognize the importance of operating sustainably and efficiently to reduce their environmental impact. Moreover, metal firms face increasing pressure from stakeholders to address environmental concerns. As stated by IEA [2023], failing to meet the stakeholder's requirements could have severe consequences for their reputation, social license to operate[2], and the ability to raise capital.

[1] In this paper, we refer financial performance to Tobin's q as Sulkowski [2010]; Fatemi et al. [2018]; Buallay [2019]; Abdi et al. [2022]. Tobin's q is a ratio of a company's market value to its total assets [Lindenberg & Ross, 1981; Chung & Pruitt, 1994].

[2] Social license to operate is the acceptance of a company or industry's standard business practices and operating procedures by its employees, stakeholders, and the general public [Kenton, 2021].

Aluminum and iron & steel are some of the most used metals in the world, with applications in a diverse range of industries and products, including the construction, transportation, and energy industries. Of all non-ferrous metals, the aluminum industry emits the most CO_2 and contributes to 3% of the global emissions [Gregoir et al., 2022]. Similarly, the iron & steel industry accounts for 7% of worldwide CO_2 emissions [Fennell et al., 2022]. Moreover, both industries are substitutes, and aluminum can provide a high-strength, lightweight alternative to steel. Hence, a comparison of the strategies employed by both industries in dealing with the escalating demand for ESG disclosure is of great interest, particularly concerning their potential impact on financial performance.

Several issues within the aluminum and iron & steel industries are unrelated to their impact on the climate. These industries cover a majority of ESG pillars and their categories, meaning they give a good scope of the entire ESG framework. An overview of the ESG pillars and categories is found in Table B.1. Limited research has explored how specific categories within the ESG pillars influence financial performance. Our study will address this gap, providing the industry with a more comprehensive understanding of the specific actions within their ESG strategies that might significantly impact their financial performance. Looking at the bigger picture, it becomes evident that the metals and mining industry affects local habitat and living conditions. Moreover, these industries utilize vast land areas for their operations and transportation of raw materials. For example, some aluminum companies use long pipelines above ground to transport bauxite from their mine to the refinery plant. These pipelines may run directly through indigenous people's territories, resulting in conflicts with the locals. Unfortunately, the adverse effects of these pipes extend beyond the people living in the area and also impact the surrounding biodiversity and ecosystem [Palmer et al., 2010]. These industries are also highly water-consuming, and there are concerns regarding water pollution in mining and metal extraction areas. Moreover, several accidents have been related to the aluminum and iron & steel operations. One example is a spillage from Hydro's plant in Brazil in 2018, which led to toxic waste pollution in the nearby area [Fouche, 2021].

Furthermore, the aluminum and iron & steel industries have a fatality risk as their employees are exposed to hazards such as heavy machinery, high temperatures, and chemicals. However, these industries strides toward enhancing their social and governance impact by engaging with local communities, improving safety and labor standards, and promoting diversity and inclusion. However, there are still issues with corruption and human rights violations. In particular, IEA [2023] highlighted approximately 350 instances of child labor in the mineral industry between 2017 and 2019, emphasizing the work that still needs to be done. For some firms, controlling their entire value chain may prove challenging. Therefore, it is essential to establish better governance and standards for their operations, which can significantly reduce such incidents in the future.

A company can have many reasons to disclose its ESG-related activities, at least when sustainable practices are part of the strategy. To what extent a company chooses to disclose its activities has, as of today, been voluntary [United Nations, 2022], at least on a global scale. However, some topics of ESG disclosure are now mandatory in the EU and are increasingly becoming mandatory in other parts of the world [Sticks, 2020]. Recent literature suggests mandatory disclosure of companies' climate risk is essential to address default risk and prevent stranded assets. Avoiding this may lead to mispricing a company's future value of assets [Carattini et al., 2022].

The literature is divided on whether ESG has a positive, negative, or no significant effect on financial performance. A growing body of research suggests that companies with strong ESG performance may be better positioned to navigate risks and capitalize on opportunities in the long term [Friede et al., 2015; Hartzmark & Sussman, 2019; Giese et al., 2021]. Similarly, Xie et al. [2019] states that ESG disclosure can benefit companies through (i) enhancing and maintaining corporate reputation, (ii) keeping investors from undervaluing a sustainable company, avoiding *The Lemons Problem*[3] and (iii)

[3] The lemons problem refers to issues that arise regarding the value of an investment or product due to asymmetric information possessed by the buyer and the seller [Akerlof, 1970]. In other words: If an investor fails to understand a company's actual excess value compared to its competitors, the investor will pay no more than the average price of similar companies for the company's shares.

preventing investors from regarding undisclosed information as unfavorable. On the other hand, some studies have found a negative relationship between ESG and financial performance. For instance, it may highlight early warning signs of environmental issues within the company or result in implementation costs that outweigh possible benefits [Sulkowski, 2010; Buallay, 2019; Duque-Grisales & Aguilera-Caracuel, 2021]. Nevertheless, Velte [2017] analyzed 412 listed German firms and found no significant impact of ESG on financial performance. McWilliams & Siegel [2000] and Lahouel et al. [2021] argue that the potential benefits, in the long run, can offset any costs associated with ESG activities.

When examining the link between ESG factors and financial performance, it is interesting to see it from two different viewpoints of the company's role in society: shareholder theory and stakeholders theory. Whereas shareholder theory asserts that the primary objective of the company is to maximize shareholder value [Friedman, 1970], stakeholder theory suggests that a company has a broader responsibility and must consider the interests of all stakeholders [Freeman, 2010]. Therefore, examining the link between ESG and financial performance from both perspectives can provide a broader view of a company's impact. Additionally, this might help investors and stakeholders to make better decisions to allocate their financial resources [Qureshi et al., 2020].

This paper contributes with a sector-specific analysis and thoroughly analyzes the different ESG factors, exploring which pillars and categories may impact a company's financial performance. Furthermore, we have constructed an extensive dataset of 204 companies, with data points between 2012 and 2022. Of these, 31 are aluminum and 173 are iron & steel companies. Based on various tests for panel data econometrics and economic theory, the two-step Arellano & Bond [1991] general methods of moments (GMM) estimator is preferred for our panel dataset. The GMM estimator allows us to incorporate the dynamic nature of financial performance and utilize reliable instruments that address unobserved simultaneity and heterogeneity, ensuring the validity of our analysis. Our results show no significant association between ESG-, ESG pillar- and ESG category score, and financial performance, which is consistent with previous studies [McWilliams & Siegel, 2000; Renneboog et al., 2008a,b]. In contrast, we find a statistically significant negative impact from the number of years a firm has reported ESG and firm age on financial performance. Similarly, we find a significant negative association between the lag of our dependent variable, Tobin's q, and financial performance.

Overall, our research aims to address the current gap regarding the relationship between ESG factors and financial performance, focusing on the highly energy-intensive and emitting aluminum and iron & steel industries. By doing so, our findings can be applied to other industries with ESG concerns. Furthermore, we explore how ESG pillars and specific categories within these pillars influence financial performance, providing a more comprehensive understanding of companies' ESG strategies. This will enable firms to identify and prioritize areas that can improve their ESG strategy and financial performance, making it easier to implement targeted strategies to deliver meaningful results. Finally, by applying a well-developed dynamic panel GMM estimator, our paper incorporates the dynamic nature of financial performance. The remainder of this paper is organized as follows. Chapter 2 presents the relevant literature, Chapter 3 presents our research hypothesis, Chapter 4 describes the data and methodology used, Chapter 5 presents the main results and discussion, and Chapter 6 concludes the paper.

Chapter 2

Literature Review

When examining and discussing ESG's impact on financial performance, it is interesting to see it from the two diverging viewpoints of shareholders and stakeholders [Qureshi et al., 2020]. The literature, however, offers contradictory findings regarding the effect of ESG on financial performance. For ESG scores to be credible, standardization, transparency, and high-quality reporting are necessary [Dimson et al., 2020]. The lack of standardization among rating agencies and the fact that firms' financial outcomes vary over time makes it difficult to assess the impact of ESG on financial performance precisely. However, companies prioritizing ESG investments and sustainability may ultimately attract more talented people and gain better customer satisfaction [Fatemi et al., 2015].

2.1 Theoretical Framework

In the process of evaluating the consequences of ESG disclosure on a firm's operations and financial performance, it is compelling to explore two divergent perspectives: shareholder theory and stakeholder theory. Under shareholder theory, a firm's primary obligation is to enhance shareholder value [Friedman, 1970]. From this view, if a firm engages in ESG activities that result in a negative value for shareholders, it breaches its fundamental duty [Qureshi et al., 2020]. Regarding the ESG score, the E and S pillars create more shareholder value since they include factors like resource efficiency and employee engagement that directly impact firms' operations [Abdi et al., 2022]. As such, Friedman [1970] argues that firms investing in social initiatives neglect their responsibilities and should instead focus their resources on activities that benefit their shareholders' best interests. Conversely, stakeholder theory posits that a firm's foremost responsibility is to preserve the interests of all its stakeholders. These stakeholders may include employees, environmental groups, individuals affected by the firm's actions, governments, shareholders, customers, or suppliers [Freeman, 2010]. Stakeholder theory emphasizes that companies should prioritize social welfare. Thus, they should engage in activities that generate positive outcomes, thereby fostering value creation for the firm and its stakeholders [Qureshi et al., 2020].

Giese et al. [2021] developed three theoretical foundations to explain how ESG pillars and categories capture firm characteristics and subsequently affect observed financial performance, stock selection, and portfolio construction. The authors argue that ESG disclosure can be transmitted via economic channels of cash flow, idiosyncratic risk[1], and valuation. Upon examining the cash flow channel, Giese et al. [2021] discovered that companies with higher ESG ratings have a track record of greater profitability, more consistent earnings, and higher dividend yields. This phenomenon can be attributed to the economic rationale highlighting the potential competitive edge conferred by strong ESG ratings. Strong ratings can be associated with better business practices, such as attracting and retaining top-tier talent, developing more robust long-term strategies, and exhibiting superior overall management,

[1] Idiosyncratic risk is a type of investment risk within an individual asset or a group of assets [Chen, 2022].

ultimately resulting in higher customer satisfaction [Fatemi et al., 2015]. Additionally, through the idiosyncratic risk channel, high ESG ratings have been found to lower the frequency of financial drawdowns, which refers to how fast an investment recovers after a dip in the market. Giese et al. [2021] suggest that this outcome is unsurprising, given that companies with more substantial ESG ratings possess better capabilities to mitigate and manage the specific risks they encounter. Through the valuation channel, Giese et al. [2021] argue that high ESG ratings show lower systematic risk[2] and lower cost of capital. Researchers have found that companies with stronger ESG characteristics have experienced less exposure to risks and higher levels of valuation [e.g. El Ghoul et al., 2011; Eccles et al., 2014; Giese et al., 2021]. These companies may be more resilient when faced with changing market environments, such as fluctuations in financial markets and regulatory changes. Fatemi et al. [2015] argued that the lower level of risk of companies with strong ESG characteristics could be explained by them potentially having more loyal employees and customers, a lower chance of facing lawsuits, and, thus, a higher chance for long-term survival.

2.2 ESG and Firm's Financial Performance

In recent times, ESG disclosure has garnered increased importance among firms, driven by several factors such as societal pressure, ethical considerations, and strategic imperatives [Abdi et al., 2022]. The potential impact of ESG on financial performance has been a widespread debate since its inception [Margolis et al., 2009]. Extensive research has been conducted on this topic, and several empirical studies have been published [e.g. Gillan et al., 2007; Friede et al., 2015; Abdi et al., 2022]. However, the literature presents a dichotomy of viewpoints regarding the relationship between ESG and financial performance, with conflicting evidence regarding whether ESG factors exert a positive, negative, or no significant impact.

ESG disclosure has become increasingly important in today's business landscape, with stakeholders' interests being one of its primary drivers [Buallay, 2019]. The connection between stakeholder theory and ESG lies in their shared emphasis on considering the broader impacts of a company's actions beyond its financial performance. By addressing the interests and concerns of all stakeholders, research has shown that companies can improve their overall long-term financial performance [e.g. Jo & Harjoto, 2011; Gillan et al., 2021; Abdi et al., 2022]. A company's ESG focus can further improve its corporate social responsibility (CSR) performance and enhance its reputation when stakeholders prefer sustainable solutions [Clarkson et al., 2008]. Moreover, stakeholder theory asserts that a company's long-term success depends on its ability to balance the interests of all its stakeholders. Having an ESG focus, the company shows a long-term priority with a will to make its operation more sustainable and efficient [Velte, 2017].

The primary objective of firms is to generate high returns. Thus, it is essential to investigate the impact of ESG on financial performance [Fatemi et al., 2018]. Early literature presented a prevailing notion of a negative association between ESG and financial performance [Vance, 1975]. As mentioned, Friedman [1970] argued that a firm's sole social responsibility is to create value by maximizing shareholder profits. Recent studies also concur with this negative association, such as Sulkowski [2010]; Buallay [2019]; Duque-Grisales & Aguilera-Caracuel [2021]. According to the findings of Sulkowski [2010], ESG disclosure may reveal early warning signs of potential environmental problems inside the company, which can further harm financial performance. Buallay [2019] utilized financial and ESG data of the top most sustainable companies from 20 countries and discovered that ESG reporting had an unfavorable effect on financial performance. This argument stems from the belief that the implementation costs would outweigh the potential benefits, and the extensive ESG investment may yield a small contribution to revenue. They also suggest that financial institutions may need to re-evaluate their disclosure policies to align them with their strategies.

[2] Systematic risk refers to the risk inherent to the entire market or market segment [Chen, 2023].

Despite the substantial upfront costs associated with many ESG investments, which may not yield immediate financial returns, ESG investments can create long-term benefits [Abdi et al., 2022]. Several meta-analyses [e.g. Margolis et al., 2009; Friede et al., 2015] have found a positive relation between ESG and financial performance. Margolis et al. [2009] conducted a meta-analysis of 251 individual empirical studies and concluded a positive association between ESG investments and financial performance. Friede et al. [2015] also conducted a meta-analysis of over 2000 empirical studies going back to the 1970s and found that companies with strong environmental and labor practices are better positioned to navigate regulatory risks, capitalize on opportunities in the low-carbon economy, and attract and retain valuable talent. Additionally, firms have the motivation to disclose their sustainability information to comply with regulations, meet standards, satisfy stakeholders, and enhance legitimacy [Deegan, 2014]. Indeed, companies that adopt a stakeholder-oriented approach and prioritize ESG considerations tend to have better long-term financial performance, as they can better manage risks and build stronger relationships with their customers and communities. Furthermore, investors increasingly recognize the importance of ESG factors in their investment decisions, which can lead to increased demand for companies that prioritize sustainability and ethical behavior [Gillan et al., 2021].

Some studies have dissected ESG into the individual pillars, E, S, and G, to evaluate their impact on financial performance. According to Buallay [2019] and Abdi et al. [2022], the E and S pillars positively influence financial performance, as these pillars directly impact firms' operations. This is because improvements in these pillars lead to reduced costs in their operations, which in turn results in greater financial performance. Similarly, Ferrell et al. [2016] finds a positive relationship between CSR (within the S pillar) and shareholder value. However, Abdi et al. [2022] found that the G pillar has a negative impact on financial performance. Additionally, Horváthová [2010] discovered a significant negative correlation between the E pillar and financial performance, while Ziegler et al. [2007] claims that the S pillar has a negative impact. These papers suggest that firms with a CSR strategy may incur significant expenses but may divert management attention. Nevertheless, its effects do not compensate for the higher financial performance. In contrast, Gillan et al. [2007] found no significant impact on financial performance from the G pillar, explained by the difficulty in establishing a causal relationship between governance and shareholder preferences.

Giese et al. [2021] argues that the duration of time has a notable influence on the impact of each ESG pillar. Their research provides evidence that the G pillar, when assessed over a short-term period, has a greater positive impact on profitability, idiosyncratic risk, and systematic risk when compared to the E pillar. Conversely, the E pillar exhibits a slower development rate but shows a positive rate on the stock price over the longer term. Additionally, Giese et al. [2021] found the S pillar to have no significant impact on financial performance.

Even if ESG investments may incur a short-term cost, firms can benefit more in the long run [Carattini et al., 2022; Abdi et al., 2022]. It is worth noting that while some ESG investments may negatively influence financial performance in the short term, there is growing evidence that companies with strong ESG performance can outperform their peers over the longer term [Gillan et al., 2021; Abdi et al., 2022]. Ultimately, the impact of ESG investments on financial performance will depend on various factors, including the specific investments, the industry, and the broader economic and market conditions.

Although the literature is divided, some studies find a nonsignificant association between ESG and financial performance [Renneboog et al., 2008a,b]. For instance, a study conducted on 412 listed German companies between 2010 and 2014 did not find any significant impact of ESG on financial performance, which was surprising for the authors [Velte, 2017]. Moreover, some scholars have argued that the cost of ESG activities will be paid off by their benefits [McWilliams & Siegel, 2000]. However, such uncertainties in the literature suggest a need for more studies to investigate the true relationship between ESG and financial performance. Therefore, this paper aims to reduce the uncertainty gap and explore the relationship between ESG and financial performance in the aluminum and iron & steel industries.

The moderating role of firm characteristics, such as size, age, industry, and ownership structure, may also impact the relationship between a firm's ESG disclosure and financial performance. Thus, exploring the moderating effects of such characteristics can provide a more comprehensive understanding of this relationship. Several studies have examined how firm characteristics moderate the relationship between ESG disclosure and financial performance. Rowley & Berman [2000], for instance, studies the relationship between corporate social performance and financial performance. The paper states that many factors potentially influence this relationship, where the activities related to corporate social performance must affect either the firm's revenue or cost structure to affect financial performance. Consequently, to understand the relationship between these variables, it is necessary to consider under what circumstances they are related [Rowley & Berman, 2000].

In summary, the relationship between ESG and financial performance is still uncertain, and there is a need for more research to explore this topic. Despite the short-term costs associated with ESG investments, the long-term benefits can outweigh them, and companies with strong ESG performance can potentially outperform their peers. Nevertheless, the impact of ESG investments on financial performance depends on several factors and requires careful consideration. Moreover, Table 2.1 summarizes findings from the literature on ESG's impact on financial performance.

Table 2.1: The table summarizes the literature findings in Section 2.2 regarding the impact of ESG and its individual pillars on financial performance, indicating whether they have a positive (+), negative (÷), or no significant effect (n).

Study	**Focus**	**Positive, negative or no effect (+, ÷, n)**
Duque-Grisales & Aguilera-Caracuel [2021]	ESG	÷
Sulkowski [2010]	ESG	÷
Vance [1975]	ESG	÷
Deegan [2014]	ESG	+
Friede et al. [2015]	ESG	+
Margolis et al. [2009]	ESG	+
McWilliams & Siegel [2000]	ESG	n
Renneboog et al. [2008a,b]	ESG	n
Velte [2017]	ESG	n
Abdi et al. [2022]	E & S	+
Buallay [2019]	E & S	+
Giese et al. [2021]	E & G	+
Horváthová [2010]	E	+
Ferrell et al. [2016]	S	+
Ziegler et al. [2007]	S	÷
Giese et al. [2021]	S	n
Abdi et al. [2022]	G	÷
Gillan et al. [2007]	G	n

2.3 ESG Measurements and Methodology Issues

The total ESG score consists of several individual factors, and when examining these, there is a lack of standardization. Rating agencies calculate ESG scores and weigh ESG factors differently, resulting in inconsistent and diverse scores [Dimson et al., 2020]. Moreover, investors can find these scores challenging to comprehend and may question their reliability. Therefore, transparency is crucial in making these scores more reliable. However, The European Commission plans to regulate the ESG rating agencies to ensure that ESG factors are standardized. The proposed regulations include a set of minimum disclosure requirements for rating methodologies and the establishment of a centralized registration system for providers [Pell & Azizuddin, 2023].

Another challenge is establishing the causality of ESG scores on a firm's financial performance. As highlighted in Section 2.2, the literature is divided on whether ESG has a significant positive, negative, or no significant impact on financial performance. However, Dimson et al. [2020] finds no indication of causality, even though some studies found a significant positive association between ESG and financial performance. Furthermore, it is difficult to say if the positive association comes from other unidentified variables that may affect the financials and ratings, like industry trends, market conditions, or company strategy. Dimson et al. [2020] also points out that a weakness in ESG scores is the assumption that a firm's score reflects and measures responsible behavior.

Numerous countries have introduced mandatory disclosure of ESG factors, forcing many firms to produce ESG reports. Such reports have become more important for various stakeholders as they dig deeper into the firms' sustainable operations [Carattini et al., 2022]. However, an issue related to ESG disclosure is that firms report their metrics differently, while other firms might not prioritize producing ESG reports. This inconsistency could result in disparate ESG scores, making comparisons within the same industry challenging. To address this problem, a framework that many firms and industries have adopted is the Task Force on Climate-Related Financial Disclosures. This framework, which the Financial Stability Board developed through G20, is widely respected and recognized. Its primary objective is to encourage consistent ESG disclosure. With such standardized frameworks, comparison among companies will become more manageable [Carattini et al., 2022].

It is essential to emphasize the reliability of firms' reported ESG performance and the quality of the reporting. The report should disclose relevant information, including the firm's ESG risks and opportunities, performance, targets, and goals. Moreover, it is important that their reporting is transparent and clear, meaning that it is easily understandable and accessible to all stakeholders. To enhance the report's credibility and to provide assurance that the information disclosed is accurate and reliable, an independent third party may need to verify their disclosure [Ferri et al., 2023]. Today, many firms use Global Reporting Initiative (GRI) and Sustainability Accounting Standards Board (SASB) frameworks as standards for reporting [GRI, 2021]. Using GRI and SASB increases trust by giving a quality report that is transparent and credible. Additionally, it makes reports more consistent as they use the same framework.

The goal of this paper is to measure the impact ESG has on financial performance. Overall, the exact impact can be challenging to quantify. As mentioned above, there is a lack of standardization within the different rating agencies. Some countries have mandatory and stricter ESG disclosure requirements [Carattini et al., 2022], placing some companies in a more rigid regulatory environment. Moreover, as explained by Gillan et al. [2021], ESG factors may also affect financial performance over different time horizons. For instance, if a significant firm-specific environmental disaster occurs, it might harm their reputation immediately. At the same time, the consequences of climate change on a company's supply chain may take years to be detected.

2.4 Research Contribution

The literature remains divided on whether ESG has a positive, negative, or no significant impact on financial performance. To contribute to the literature and address this gap, we present empirical evidence through an industry-specific analysis of the highly energy-intensive and emitting aluminum and iron & steel industries. Focusing on these industries makes the results more applicable to other industries facing similar environmental challenges. Additionally, our study addresses another gap in the literature by investigating the impact of specific categories within the ESG pillars on financial performance. By identifying the specific actions within their ESG strategy that have a greater impact on financial performance, firms can prioritize and implement effective initiatives to achieve both sustainability and financial goals. Finally, Table 2.2 summarizes other literature's focus and our research contribution.

Table 2.2: An overview of financial literature investigating the relationship between ESG factors and financial performance. The last ten rows are ESG categories within the pillars. Table B.1 describes the ESG pillars and categories.

Author **Year**	Margolis et al. [2009]	Friede et al. [2015]	Renneboog et al. [2008a; 2008b]	McWilliams & Siegel [2000]	Giese et al. [2021]	Abdi et al. [2022]	Buallay [2019]	Horváthová [2010]	Ziegler et al. [2007]	Gillan et al. [2007]	Our Paper [2023]
ESG	✓	✓	✓	✓							✓
E					✓	✓	✓	✓			✓
S					✓	✓	✓		✓		✓
G					✓	✓	✓			✓	✓
Emissions					✓						✓
Environmental Innovation					✓						✓
Resource Use					✓						✓
Community					✓						✓
Human Rights					✓						✓
Product Responsibility					✓						✓
Workforce					✓						✓
CSR Strategy					✓						✓
Management					✓						✓
Shareholders					✓						✓

Chapter 3

Research Hypotheses

The relationship between ESG and the financial performance of companies remains uncertain, and further research is needed to explore this topic. Although ESG investments may incur short-term costs, the long-term benefits could outweigh them, leading to the potential outperformance of peers by companies with strong ESG performance. However, the impact of ESG investments on financial performance is contingent on various factors and requires careful consideration.

As written in Section 2.1, the shareholder and stakeholder theories are two corporate theoretic frameworks. The concept of stakeholder theory suggests that corporations that engage in activities beyond profit maximization can gain rewards in terms of value creation for both the company and its stakeholders [Freeman, 2010; Qureshi et al., 2020]. Porter & Kramer [2002] argue that social improvements in a company's business correspond to economic benefits. Moreover, they state that today, a company's competitiveness is contingent on its productivity in using labor, capital, and natural resources to produce high-quality goods and services. Productivity is a function of having employees who are well-educated, safe, healthy, adequately housed, and motivated by opportunities. In addition, environmental preservation benefits society and companies, as reducing pollution and waste can lead to more effective resource utilization and the production of goods that consumers value. These arguments align with the principles of stakeholder theory, where companies enhance their value by demonstrating greater social responsibility, thus, acquiring a competitive edge [Freeman, 2010]. Moreover, according to Elkington [1994], corporations must actively participate in attaining sustainable development objectives by concentrating on sustainable strategies. Doing so can enhance their profitability, benefit their customers, and improve environmental conditions, resulting in a 'win-win-win' situation. Hence, following stakeholder theory and based on available empirical evidence mentioned in Section 2.2, which favors this theory, we establish our initial hypothesis:

Hypothesis I: *Higher ESG score is positively associated with improved financial performance in aluminum and iron & steel companies.*

According to Qureshi et al. [2020], a company's emphasis on various ESG factors may vary depending on the nature of their business, the context in which they operate, and their management preferences. As mentioned in Chapter 2, empirical studies have shown that the effects of ESG disclosure vary across different dimensions of the three pillars, leading to mixed results. El Ghoul et al. [2011] state that firms adopting environmentally friendly practices reduce investors' perceived risk of the company. Furthermore, the authors argue that firms not being socially responsible may be at higher risk of lawsuits and explicit claims, increasing their expected future costs. From the community's exposure to production hazards and the high number of reported instances of child labor (see Chapter 1), we can assume that investors are willing to pay more for firms with higher E and S scores to avoid this risk. This argument is supported by Abdi et al. [2022], who argue that the E & S pillars create greater value since they directly influence a firm's operation. Considering aluminum and iron & steel companies and building on the insights from prior empirical research, we propose our second hypothesis as follows:

Hypothesis II: *Compared to the governance score, aluminum and iron & steel companies' financial performance is more heavily influenced by the environmental and social scores.*

According to Dimson et al. [2020], studies finding a positive association between ESG pillars and financial performance are weakened by the assumption that the pillar scores measure responsible behavior. To avoid these shortcomings, we consider ESG categories. There is widespread concern regarding water pollution and usage in areas where mining and metal extraction occur. Extracting and separating metals involves crushing and treating the ore with various chemicals. If these chemicals are accidentally released into nearby bodies of water, this can be highly harmful to the environment and human health [Schwarzenbach et al., 2010]. Since water plays a crucial role in the metals and mining industry, addressing water stress concerns and developing sustainable practices is essential. Thus, reducing resource depletion and supporting a more sustainable operation is important. Therefore, there is a broad focus on innovation that can optimize operations and decarbonize supply chains. Numerous companies, like Hydro and Chinalco, have taken steps to mitigate their environmental impact, such as reducing carbon emissions, enhancing energy efficiency, and minimizing waste [IEA, 2023]. To investigate whether these initiatives create a better financial performance for the companies, we propose our third hypothesis as follows:

Hypothesis III: *A better score on the categories within the E-pillar (i.e., Environmental Innovation, Emissions and Resource Use) will improve financial performance.*

Chapter 4

Data and Methodology

By applying a well-developed dynamic panel GMM estimator to a panel dataset, we seek to test and explore ESG factors' impact on financial performance. Based on various tests for panel data econometrics and economic theory, we will see that a two-step Arellano & Bond [1991] GMM estimator is preferred for our dataset compared to the fixed effects and random effects estimators. The GMM estimator allows us to incorporate the dynamic nature of financial performance and utilize reliable instruments that address unobserved simultaneity and heterogeneity, ensuring the validity of our analysis. For a more detailed explanation of a linear dynamic panel data model, see Appendix D. For deriving the two-step Arellano-Bond GMM estimator and corresponding moment conditions, see Appendix E.

4.1 Data

Considering a period from 2012 to 2022, Refinitiv Eikon provides a total of 1161 companies within the aluminum and iron & steel industries. Of these, 180 are aluminum and 981 are iron & steel firms[1]. After removing firms without ESG scores over the entire period, we get 31 aluminum and 173 iron & steel companies. More specifically, we include the firm if it has ESG scores for one or more periods, thus, obtaining an unbalanced dataset. The reason for choosing Refinitiv Eikon as an ESG data provider is explained in Appendix A. Figure 4.1 shows the number of aluminum and iron & steel firms with an ESG score between 2012 and 2022. Missing values of R&D are set to the median of all firms. In contrast, missing dividends are filled in manually where this information is available in the annual reports or set to 0. The firm age is included in the dataset, using 2022 as a reference. We also include ESG reporting dates going back to 2004 to get the total years that the company has reported ESG data. From the financial data, we calculate *Tobin's q* for all companies for each year in the considered time period. Some firms lack financial data to calculate Tobin's q for all years. Hence, these years are not included in the analysis. Overall, given the total dataset between 2012 and 2022 and the removal of companies without ESG scores, we end up with a sample of 1,086 data points of Tobin's q. The distribution of the data points between the aluminum and iron & steel industries are given in Table 4.1.

Table 4.1: The number of firms and observations in each industry in the dataset.

Industry	**Firms**	**Observations**
Aluminum	31	145
Iron & Steel	173	941

[1]Not all firms have data for the entire time period. 1161 is the total number of firms reported to have any financial information in this period, regardless of whether it is for one year or eleven years.

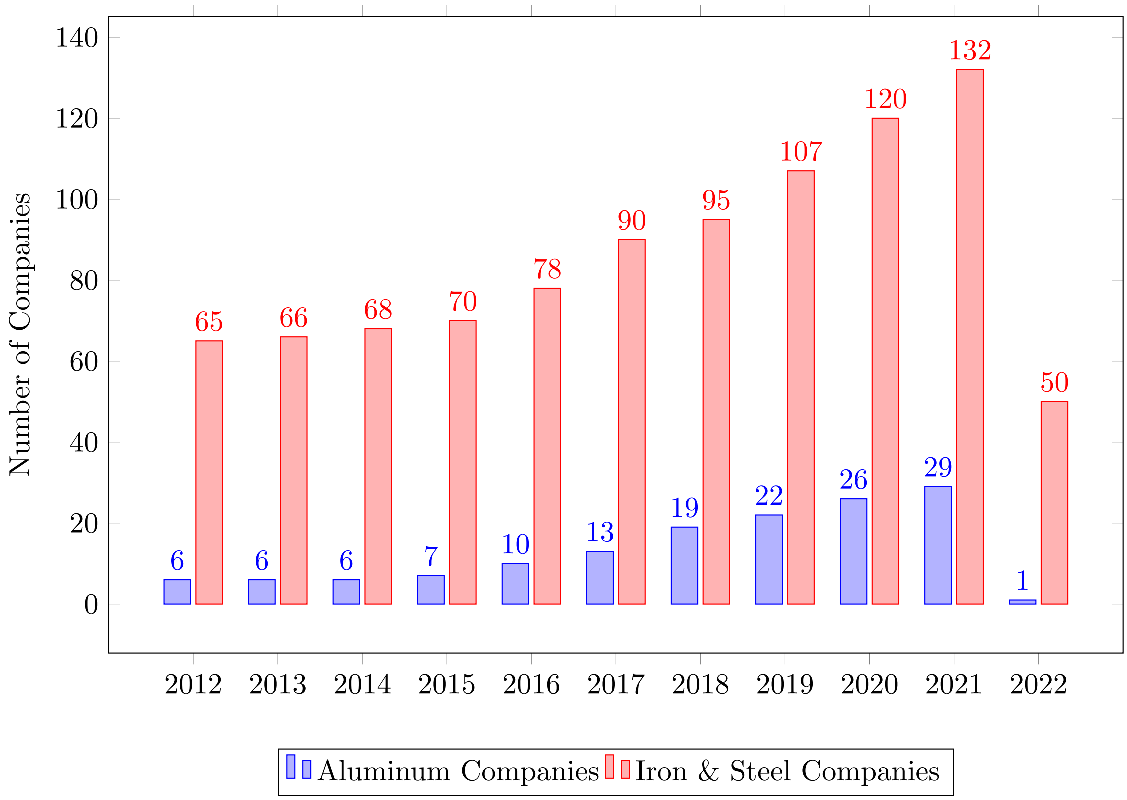

Figure 4.1: The number of aluminum and iron & steel firms that have ESG score for each year between 2012 and 2022.

4.2 Variables

The literature presents numerous indicators for financial performance, among them return on assets (ROA), return on equity (ROE), and Tobin's q [Buallay, 2019]. Tobin's q distinguishes itself from most other indicators by considering the market perception of a firm's value relative to the value of the underlying assets as stated in the financial statements [Lindenberg & Ross, 1981]. Lindenberg & Ross [1981] examines the relationship between accounting and financial market data[2] by developing Tobin's q. Their analysis, which builds on Tobin [1969], introduced it to macroanalysis as a tool to examine the relationship between the market value and total assets. In the literature, Tobin's q has been used to explain various corporate phenomena. This includes cross-sectional differences in investment and diversification decisions, the relationship between managerial equity ownership and firm value, investment opportunities and tender offer responses, and investigating the effects of financing, dividend, and compensation policies [Chung & Pruitt, 1994].

The method employed by Lindenberg & Ross [1981] for the computation of the market value and replacement cost in Tobin's q is often perceived as complex and data-intensive, requiring significant computational effort [Chung & Pruitt, 1994]. However, Chung & Pruitt [1994] introduces a straightforward formula for estimating Tobin's q that relies solely on basic financial and accounting data. It accounts for at least 96.6% of the variability of Tobin's q derived from the more theoretically rigorous model given by Lindenberg & Ross [1981]. This result suggests that approximate Tobin's q values can be reliably used in cases where the data necessary to perform the more exhaustive calculations are unavailable. Therefore, the method applied in this paper for calculating Tobin's q (TQ) is analogous to the approach given in Chung & Pruitt [1994], defined as:

[2]Financial market data reflect the market's valuation of securities issued by firms and the subsequent changes in these values over time. In contrast, accounting data provides information on the resources used by firms [Lindenberg & Ross, 1981].

$$TQ = \frac{MVE + PS + DEBT}{TA} \tag{4.1}$$

where MVE is the product of a firm's share price and the number of common stock shares outstanding, PS is the liquidating value of the firm's outstanding preferred stock, $DEBT$ is the value of the firm's short-term liabilities net of its short-term assets, plus the book value of the firm's long-term debt, and TA is the book value of the total assets of the firm [Chung & Pruitt, 1994].

An advantage of using Tobin's q is the ability to gauge investors' opinions of a company's value and contrast them with the asset value. Wernerfelt & Montgomery [1988] have used Tobin's q to measure a firm's performance by capturing the excess market value of the company beyond the value of assets. In this way, Tobin's q measures how well a company exploits its resources, thus, its financial performance. Pástor et al. [2021] focuses on investors' preferences for holding green assets and shows that they have lower expected returns in equilibrium because investors enjoy holding them. This can change MVE beyond what is reflected in the TA of companies, something captured in Equation (4.1). Another advantage of using Tobin's q is the wide range of literature that has previously used this to capture a firm's performance [Wernerfelt & Montgomery, 1988; Azmi et al., 2021]. As a result, the literature provides insight into which variables usually correlate with Tobin's q, thus limiting the risk of omitted variables[3]. Moreover, since Tobin's q is calculated on the market opinion and tangible assets, it is harder for accountants to manipulate Tobin's q ratio. Therefore, Tobin's q avoids the challenges faced when using a more straightforward metric, like profit to book value of equity [Smirlock et al., 1984].

However, there are also some limitations to Tobin's q. Being influenced by the market value, Tobin's q can be speculative and based on expectations about the future. Hence, it is potentially unstable and prone to higher volatility caused by technological shifts or rumors in the market [Shepherd, 1986]. In the context of our paper, such characteristics can affect the measured ESG impact on financial performance. Moreover, given Equation (4.1), we recognize the presence of inaccuracy in the model arising from the difference between the actual value of a firm's assets and those reported in the financial statement. For instance, intangible assets such as the value of goodwill can be over- or underestimated. Since a large portion of the aluminum and iron & steel industries' assets are tangible, at least compared to, for example, software companies, it can be assumed that the use of TA is more credible in these industries.

By employing ESG scores, pillars, and categories as independent variables, aligned with the three hypotheses formulated in Chapter 3, we can assess their impact on a company's financial performance. For reference, Table B.2 presents the distribution of the most common units found in each of the three pillars (E, S, and G), along with examples of corresponding data points. According to Qureshi et al. [2020], most stakeholders are interested in a company's financial performance, highlighting ESG initiatives' potential influence on financial outcomes. This can raise awareness and encourage using sustainable business practices. As mentioned in Chapter 1, the aluminum and iron & steel industries are accountable for 10% of global emissions, making them very interesting to investigate in today's business landscape. Many firms in these industries have set ambitious goals to reduce greenhouse gas emissions drastically [IEA, 2022a,b]. Moreover, these industries also encompass most of the ESG framework, making them interesting to investigate. This includes innovation to improve efficiency in reducing emissions, optimizing materials and water usage, considering biodiversity, and reducing the risk of workplace accidents.

We choose our control variables to observe different ESG factors' influence on financial performance when all other factors are kept equal (*ceteris paribus*). Thus, we aim to construct a model with sufficient control variables. This is to ensure that we capture the actual effect ESG has on financial performance and not some indirect effect that stems from an omitted variable correlated with ESG

[3] Variables that are not defined as an independent variable yet are correlated with a dependent variable and one or more independent variables. This leads to the risk of endogeneity, where the correlation between the error term and the independent variable will increase since the former captures the effect of the omitted variable. By including the omitted variable in the model, this variable would capture this effect, reducing endogeneity [Nikolaev & Van Lent, 2005].

factors and financial performance. In the case of omitted variables, we risk endogeneity, biased estimates for ESG coefficients, and potentially providing a positive association between ESG score and financial performance when in fact, there are other omitted factors contributing to this relationship.

According to Nikolaev & Van Lent [2005], there are no "fit-for-all" tests for endogeneity. Hence, a criterion of reasonableness must be applied to determine the actual risk of endogeneity by including control variables. What is reasonable in this context is difficult to define but will depend on what has previously been practiced in the literature, logical sense, and peer allegations. A source of endogeneity is simultaneity. This occurs when we have mutual causality between the dependent and one or more independent variables [Nikolaev & Van Lent, 2005]. Evidence of simultaneity has been found when reviewing the literature for control variables. Buallay [2019] measures financial performance using Tobin's q, defined as the sum of the market value of equity and short-term liabilities divided by the book value of assets. At the same time, one of the control variables is total assets. Since it is reasonable to assume that the book value of assets is correlated with the total assets, we argue that their model has a risk for endogeneity.

When building our model, we include several control variables that the literature has identified to influence ESG disclosure and financial performance [Fatemi et al., 2018; Abdi et al., 2022; Aouadi & Marsat, 2018; Qureshi et al., 2020; Jo & Harjoto, 2011; Seoki et al., 2013; Bolton & Kacperczyk, 2021; Javier & Alonso-Conde, 2023]. Among them are the number of years of ESG reporting (YR), leverage ratios (LEV), R&D expenditure (RD), dividend payout ratio ($DivPay$) and firm age, i.e. the number of years in operation ($YrOp$). These variables represent basic categories of firm-level attributes.

The effects of ESG reporting depend on the years the company has been reporting, as the results of sustainable operations are not immediate [Giese et al., 2021]. Furthermore, as a proxy for leverage, we use leverage ratios. Leverage is widely proposed in the literature to control firms' capital structure. According to Abdi et al. [2022], the theoretical basis for using leverage ratios arises from the trade-off theory, suggesting that firms with stable cash flows, tangible assets, and low growth are likelier to incorporate debt into their capital structure. Furthermore, Gordon [1959] states that higher dividends imply higher firm value. Thus, we expect a positive relationship between financial performance and dividends. According to Fatemi et al. [2018], ESG strengths positively correlate with R&D intensity, while Tobin's q is increased by it. Moreover, several papers study firm age's moderating role in financial performance and ESG. In compliance with Peloza [2006], younger firms use CSR for incremental gains to distinguish themselves from their competitors, while mature firms use it to protect their reputations. Regarding the relationship between ESG disclosure and financial performance, D'Amato & Falivena [2020] found age to be a relevant moderator in the ESG and financial performance relationship and concluded that firm age significantly moderates the relationship between CSR and firm value. Overall, the literature highlights the importance of considering relevant dependent, independent and control variables. Table C.1 gives an overview of these variables.

4.3 Descriptive Statistics

GMM estimation allows for using arbitrary unbalanced datasets[4] [Fritsch et al., 2021], significantly increasing the number of firms we can include in our analysis. As visualized in Figure 4.2, a significant number of firms have only ESG scores in the most recent years. In fact, Figure 4.1 demonstrates that there has been nearly a doubling in firms with ESG scores between 2016 and 2021. The notable decline in the number of observations in 2022 can be attributed to companies that had not yet published their financial and sustainability data when we accessed the information. Hence, we assume that the number of firms with ESG scores will also increase in 2022.

According to Dimson et al. [2020], ESG providers handle missing ESG scores either by setting scores to zero or a score aligned with the firms' peers. In contrast, Refinitiv Eikon leaves missing values empty

[4] An unbalanced panel dataset is one in which individuals may be observed a different number of times [Greene, 2012].

[Berg et al., 2022]. Missing scores may originate from the lack of available data or the provider's limited scope. We emphasize that some firms may not provide sustainability-related information to avoid a lower ESG score. However, Refinitiv Eikon has a relatively limited group of analysts (approximately 700 [Refinitiv Eikon, 2022]) that collects ESG information compared to the vast number of firms worldwide. We can therefore assume that the firms they investigate are randomly chosen, while firms with missing ESG scores are not taken into account. Thus, we make the strong assumption that missing ESG values are missing completely at random, meaning that we assume no relationship between the missingness of the values and any other firm characteristic.

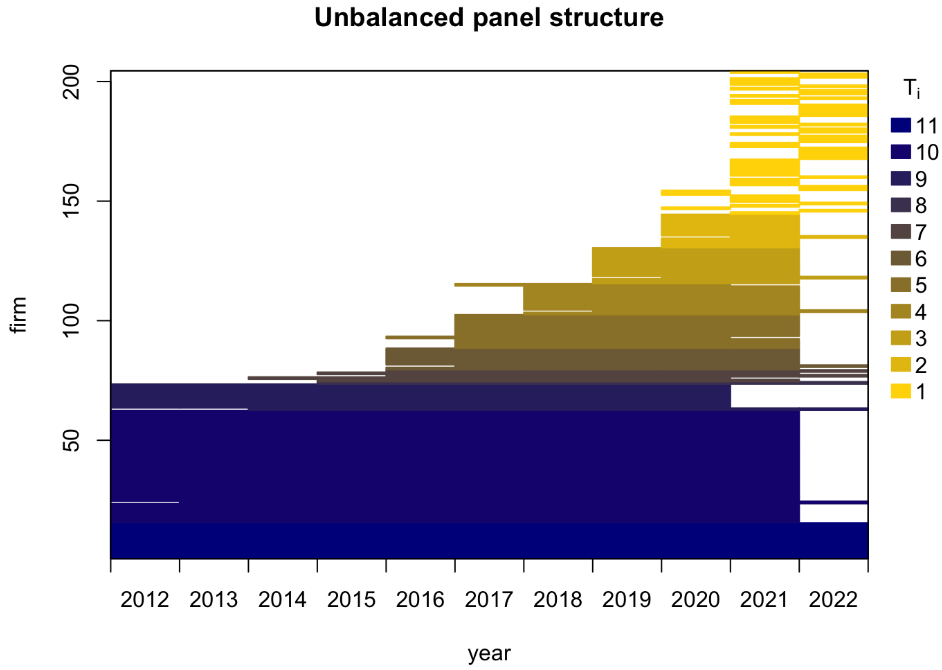

Figure 4.2: The number of firms that have reported ESG scores in each time period. As shown, the number of firms with ESG scores have increased significantly in the last few years, whereas relatively few firms have reported for the entire period. T_i is the number of observations that firm i has and blank spaces indicates missing ESG scores.

Descriptive statistics of our final dataset are presented in Table 4.2. We note that the average and median TQ are below unity, which can be traced back to Equation (4.1). Since we correct the MVE to TA ratio by the difference between short-term liabilities and assets, any firm with more short-term assets than debt will obtain a TQ that is lower than their market value to total assets ratio. This is thus an expected characteristic of our dataset. Regarding the ESG score, pillars, and categories, we register that all, except for EI, ranges between the lower (0) and upper (100) limit.

Table 4.3 shows the correlation between the ESG score, pillars, categories, and control variables. There is a high correlation between the independent variables, which is expected since the ESG score is a weighted average of the pillars and category scores. A positive correlation is also found between RD and several ESG categories, especially EM, EI, and RU. This aligns with Fatemi et al. [2015], who finds a positive association between RD and ESG. Furthermore, RD is positively correlated with CSR, which has also been emphasized by Fatemi et al. [2018].

Table 4.2: Descriptive statistics. Dependent, independent and control variables in the dataset, their number of observations (Obs), mean values (Mean), standard deviation (SD), minimum value (Min), Median, and maximum value (Max). Further description of the variables can be found in Table C.1.

Variable	**Description**	**Obs**	**Mean**	**SD**	**Min**	**Median**	**Max**
TQ	Tobin's q	1,086	0.746	1.124	-0.315	0.530	23.938
ESG	ESG	1,086	44.087	22.230	1.106	44.850	91.923
E	E pillar	1,086	42.784	28.491	0.000	44.211	94.435
EM	Emissions	1,086	47.469	31.798	0.000	49.000	99.892
EI	Environmental Innovation	1,086	19.155	24.369	0.000	0.000	51.250
RU	Resource Use	1,086	43.049	31.578	0.000	41.641	99.889
S	S pillar	1,086	41.123	25.317	0.387	37.881	96.389
C	Community	1,086	46.045	28.334	0.000	46.835	99.460
HR	Human Rights	1,086	30.404	32.385	0.000	18.132	97.845
PR	Product Responsibility	1,086	51.853	31.776	0.000	61.207	99.811
W	Workforce	1,086	48.992	28.737	0.360	48.188	99.825
G	G pillar	1,086	50.850	22.771	0.610	50.969	98.299
CSR	CSR strategy	1,086	39.981	32.469	0.000	36.056	99.655
M	Management	1,086	51.583	28.755	0.340	51.276	99.870
SH	Shareholders	1,086	55.653	28.863	0.336	58.902	99.933
YR	Years of ESG reporting	1,086	7.597	4.962	0.000	7.000	18.000
LEV	Leverage Ratio	1,086	5.049	22.272	0.000	2.319	408.783
YrOp	Years in Operation	1,086	37.697	28.544	0.000	28.000	122.000
ln(RD)	ln(R&D)	1,086	15.160	2.000	0.000	14.491	21.213
DivPay	Dividend Payout Ratio	1,086	0.004	6.953	-219.060	0.070	25.520

Table 4.3: Correlation matrix for all variables.

	ESG	*E*	*EM*	*EI*	*RU*	*S*	*C*	*HR*	*PR*	*W*	*G*	*CSR*	*M*	*SH*	*YR*	*LEV*	*YrOp*	RD	*DivPay*
ESG	1.00																		
E	0.92	1.00																	
EM	0.87	0.95	1.00																
EI	0.46	0.51	0.45	1.00															
RU	0.88	0.95	0.82	0.41	1.00														
S	0.92	0.78	0.74	0.41	0.74	1.00													
C	0.68	0.52	0.50	0.23	0.49	0.76	1.00												
HR	0.78	0.63	0.57	0.36	0.61	0.91	0.56	1.00											
PR	0.60	0.55	0.55	0.36	0.48	0.58	0.41	0.39	1.00										
W	0.87	0.81	0.78	0.37	0.77	0.86	0.57	0.64	0.49	1.00									
G	0.65	0.43	0.40	0.16	0.42	0.45	0.40	0.32	0.34	0.45	1.00								
CSR	0.78	0.74	0.71	0.36	0.70	0.70	0.44	0.57	0.40	0.76	0.48	1.00							
M	0.52	0.30	0.29	0.09	0.29	0.32	0.33	0.21	0.27	0.30	0.95	0.30	1.00						
SH	0.26	0.13	0.09	0.08	0.15	0.19	0.15	0.14	0.16	0.19	0.44	0.15	0.19	1.00					
YR	0.42	0.41	0.42	0.26	0.35	0.42	0.33	0.38	0.23	0.35	0.17	0.32	0.09	0.14	1.00				
LEV	-0.02	-0.02	-0.01	-0.04	-0.02	-0.03	-0.04	-0.03	0.01	-0.01	-0.01	-0.01	0.00	-0.01	-0.02	1.00			
YrOp	0.07	0.11	0.11	0.12	0.09	0.10	0.15	0.08	0.11	0.04	-0.09	-0.01	-0.10	-0.01	0.19	-0.02	1.00		
RD	0.16	0.24	0.24	0.20	0.20	0.08	-0.09	0.03	0.14	0.19	0.05	0.22	0.02	-0.06	0.12	0.01	-0.04	1.00	
DivPay	0.01	0.00	-0.01	0.02	0.01	0.01	0.01	0.02	0.00	0.00	0.02	0.02	0.00	0.06	0.00	0.00	0.01	0.01	1.00

4.4 Framework and Methodology: Dynamic Panel Data Models

The advantage of a panel data set over a cross-section is the flexibility we get by modeling differences in behavior across individuals [Greene, 2012]. Hence, we begin by examining two static models for panel data, namely the fixed and random effects models. Based on various tests for panel data econometrics and economic theory, we will see that a linear dynamic panel data estimator[5] is preferred for our dataset against the fixed effects and random effects approach. We use the following regression model as a basic framework:

$$
\begin{aligned}
TQ_{i,t} &= \boldsymbol{\beta x'_{i,t}} + u_{i,t} \\
u_{i,t} &= \boldsymbol{\alpha z'_i} + \varepsilon_{i,t} = c_i + \varepsilon_{i,t}
\end{aligned}
\tag{4.2}
$$

Here, $TQ_{i,t}$ is Tobin's q for firm i in period t. Furthermore, we let our independent and control variables be in the vector $\boldsymbol{x_{i,t}}$, for firm i in time period t, and $\boldsymbol{\beta}$ be a vector of estimated coefficients. u_{it} is the error term, decomposed into unobserved (e.g., culture or abilities) or observed (e.g., sex or education) time-invariant heterogeneity, c_i ($\boldsymbol{\alpha z'_i}$), and the idiosyncratic error component, $\varepsilon_{i,t}$. More specifically, $\boldsymbol{z_i}$ is a set of individual or group-specific variables, which can be either unobserved or observed, and are constant over time t [Greene, 2012].

Given Equation (4.2) and assuming that the unobserved individual heterogeneity, c_i, is uncorrelated with the included variables, we can formulate the random effects model as:

$$TQ_{i,t} = \boldsymbol{\beta x'_{i,t}} + \alpha + p_i + \varepsilon_{i,t} \tag{4.3}$$

where $\alpha = E[c_i|x_{i,1}, x_{i,2}, \dots]$. The random effects estimator considers p_i to be a group-specific random element, similarly to $\varepsilon_{i,t}$, but constant over time t [Greene, 2012]. On the other hand, given Equation (4.2) where $\boldsymbol{z_i}$ is unobserved and correlated with $\boldsymbol{x_{i,t}}$, the fixed effects model can be formulated as:

$$TQ_{i,t} = \boldsymbol{\beta x'_{i,t}} + \alpha_i + \varepsilon_{i,t} \tag{4.4}$$

where $\alpha_i = \boldsymbol{\alpha z'_i}$ encompass all the observable effects and define an estimable conditional mean. The fixed effects approach takes α_i to be a group-specific constant term in the regression model. Moreover, the term "fixed" is used to indicate the correlation of c_i and $\boldsymbol{x_{i,t}}$ [Greene, 2012].

A crucial distinction between fixed and random effects is whether the observed individual effect contains elements correlated with the regressors, $x_{i,t}$. Like a random effects approach, the fixed effects estimator considers unobserved, entity-specific heterogeneity [Greene, 2012]. As stated by Das [2019], having many entities and a limited number of time periods, as in our case, deciding whether to use a fixed or random effects estimator may be difficult. Hence, logical reasoning and formal testing are necessary to decide which approach to use. In a macro panel dataset, it is more likely that the individual-specific characteristics are correlated with the other regressors. We use the test provided by Hausman [1978] to examine the null hypothesis $H_0 : E(u_{i,t}|x_{i,t}) = 0$ against the alternative hypothesis $H_1 : E(u_{i,t}|x_{i,t}) \neq 0$. By utilizing the random and fixed effects approach and applying the Hausman test, we get a p-value of 0.370, implying that we cannot reject H_0. Hence, a random effects estimator may be more appropriate in our context.

Moreover, we use a Breush-Godfrey Lagrange multiplier test for panel data models, with H_0 implying no serial correlation in idiosyncratic errors. Applying the test to the fixed effects estimator, we get a p-value of 0.464, implying no significant serial correlation in idiosyncratic errors. Testing the random

[5]Estimates linear dynamic panel data models that include lagged dependent variables as covariates alongside unobserved effects (either fixed or random) and exogenous regressors [Das, 2019].

effects estimator, we find a p-value of 0.000, demonstrating a significant serial correlation in the error terms. Hence, even though the Hausman test implies that a random effects estimator is the most suitable for our case study, this approach leads to autocorrelation issues. Thus, we employ a dynamic panel data approach - specifically the two-step Arellano-Bond GMM estimator - for our estimation purposes. To test this estimator for autocorrelation, we use the Arellano & Bond [1991] test for second-order serial correlation in the idiosyncratic remainder components. Here, H_0 implies no serial correlation in the $\varepsilon_{i,t}$. As H_0 is not rejected, we conclude that the selected dynamic panel data approach aligns with the objectives of our paper and the context of our research.

The decision to utilize a dynamic panel data approach instead of a static panel data regression is supported by theoretical frameworks that highlight the dynamic nature of economic relationships. One such framework is the concept of path dependence. According to David [1985], path dependency refers to a series of economic changes where the eventual outcome is significantly influenced by previous events. For instance, Karakaya et al. [2018] describes how the iron & steel industry exhibits path dependency characterized by technological lock-ins[6]. Applying the path dependence theory to the context of the aluminum and iron & steel industries, it becomes evident that the relationship between ESG factors and financial performance is dynamic. As companies gradually adapt and integrate sustainability practices into their operations, the impact of ESG factors on financial performance may change over time. Moreover, the impact of ESG factors on financial performance may not be immediate [Giese et al., 2021]. Hence, there can be delays in observing the effects of improved ESG practices on financial outcomes, explaining the dynamic relationship between financial performance and ESG factors. This delay can be explained by the rational expectations theory, initially introduced by Muth [1961]. According to this theory, individuals are rational and utilize all relevant information, including past events, to form informed and unbiased predictions about future events. Thus, from these theories, one can assume that investors utilize both previous financial performance and factors, such as investments in ESG initiatives. Therefore, it can be argued that lagged dependent and independent variables can explain current financial performance. Overall, given the econometric tests conducted and the underlying economic theory, employing linear dynamic panel data estimation is deemed appropriate for analyzing our panel dataset.

A linear dynamic panel data model allows us to capture the evolving relationship between ESG factors and financial performance while effectively addressing key econometric challenges associated with panel data analysis. To account for the dynamic nature of the data, it is common practice to include lagged values of the covariates, dependent variables, or both within the model [Das, 2019]. We do this in our model by adding a lag of the dependent variable, $TQ_{i,t-1}$, with lag coefficient, α, to Equation (4.2):

$$TQ_{i,t} = \alpha TQ_{i,t-1} + \beta x_{i,t} + \eta_i + \varepsilon_{i,t} \ \forall\ i = 1, \dots, n; \quad t = 2, \dots, T \tag{4.5}$$

where c_i is now denoted as η_i, the unobserved, individual-specific effect. If $TQ_{i,t-1}$ and η_i are correlated, it introduces the problem of endogeneity, resulting in a biased OLS estimate of α and β, known as endogeneity bias. Consequently, the least squares estimation of fixed and random effects becomes biased and inconsistent. To mitigate the endogeneity bias, instrumental variable[7] estimation is one possible approach [Das, 2019]. Anderson & Hsiao [1981] propose an instrumental variable procedure that employs lagged differences as instruments to estimate the dynamic panel model. However, according to Arellano [1989], the instrumental variable method proposed by Anderson & Hsiao [1981] does not leverage all available moment conditions[8], resulting in an inefficient estimator.

[6] Technological lock-in occurs when incumbent technologies gain economic and cultural advantages, creating barriers that hinder the adoption of potentially superior or equally valuable alternatives. This phenomenon arises due to the path dependency of technological innovation and deployment, which takes place amidst uncertainties.

[7] A variable that is correlated with one or more independent variables, but not with $\varepsilon_{i,t}$.

[8] Moment conditions are formulated as functions of both the model parameters and the observed data and are typically derived from the underlying statistical theory and assumptions of the model. Using linear dynamic panel data estimation, we can estimate the independent variables' coefficients from a set of moment conditions. Moreover, they determine the natural instruments available for estimation [Fritsch et al., 2021].

In contrast to the instrumental variable method, the Arellano & Bond [1991] GMM estimator exploits all linear moment restrictions and available information in the sample, potentially leading to more efficient estimates for the dynamic panel data model [Das, 2019]. Furthermore, it extends the applicability to accommodate unbalanced panel data, which aligns with our current research context [Arellano & Bond, 1991]. Hence, given the characteristics of our dataset, including finite time periods and large cross-section dimensions, the Arellano-Bond GMM estimator emerges as a suitable approach. The GMM estimator aims to address the endogeneity issues by adding instrument variables that are correlated with the explanatory variables, but not with the error term. Hence, it effectively addresses endogeneity concerns and provides consistent parameter estimates [Greene, 2012; Das, 2019].

The dynamic panel data approach is usually considered the work of Arellano & Bond [1991], but in fact they popularized the work of Holtz-Eakin et al. [1988]. Under the standard assumptions given in Equation (E.1), which are the basis of the Arellano & Bond [1991] estimator, Holtz-Eakin et al. [1988] propose the following moment conditions with instruments in levels (in our context $TQ_{i,s}$) and equation in differences (see Table E.1 in Appendix E) [Fritsch et al., 2021]:

$$E(TQ_{i,s} \cdot \Delta\varepsilon_{i,t}) = 0, \quad t = 3, ..., T; \; s = 1, ..., t-2 \tag{4.6}$$

These moment conditions, which involves lagged values of $TQ_{i,t}$ and the disturbances $\varepsilon_{i,t}$, are also employed by Arellano & Bond [1991] in their analysis. Hence, by following the methodology of Holtz-Eakin et al. [1988], Arellano & Bond [1991] combines instruments in levels ($TQ_{i,s}$) and equations in differences to create an instrument matrix. Utilizing this matrix, Arellano & Bond [1991] derive the one-step and two-step GMM estimators for parameter estimation [Das, 2019]. In this paper, we will employ the Arellano-Bond two-step GMM estimator[9]. The derivation of this estimator and the corresponding moment conditions are presented in Appendix E. As highlighted by Arellano & Bond [1991], a notable concern is the potential underestimation of standard errors in their samples when employing the two-step GMM estimator. To rectify this issue, Windmeijer [2005] formulated a bias-corrected robust estimator for the two-step standard errors. Hence, the standard errors in this paper are based on the Windmeijer-correction and deviate from the conventional standard errors reported in Arellano & Bond [1991] [Das, 2019; Fritsch et al., 2021].

In the context of this research, employing GMM incorporating lagged TQ can be utilized to control for the influence of previous financial performance on the current financial performance [Wintoki et al., 2012; Lahouel et al., 2019]. Regarding our dynamic panel data model, we have based the model's number of lagged dependent variables on previous literature. Following the approach given by Arellano & Bond [1991], we use two lags of the dependent variable, which is aligned with previous literature investigating financial performance [Glen et al., 2001; Gschwandtner, 2005; Wintoki et al., 2012]. To assess our hypotheses, we employ the following regression models as our primary framework, where the model for testing *Hypothesis I* is defined as:

$$\begin{aligned} TQ_{i,t} = &\alpha_1 TQ_{i,t-1} + \alpha_2 TQ_{i,t-2} + \beta_1 ESG_{i,t} + \beta_2 YR_{i,t} + \beta_3 LEV_{i,t} + \beta_4 YrOp_{i,t} + \beta_5 RD_{i,t} + \\ &\beta_6 DivPay_{i,t} + \gamma_3 d_3 + \cdots + \gamma_T d_T + \eta_i + \varepsilon_{i,t} \; \forall \; i = 1, \ldots, n; \quad t = 3, \ldots, T \end{aligned} \tag{4.7}$$

where $TQ_{i,t}$ is the Tobin's q value of the i-th firm at time t, $ESG_{i,t}$ is the ESG score and the remaining variables represent the control variables given in Table C.1. The α coefficients capture the dynamic effect of the dependent variable, while the β coefficients represent the effects of the independent and control variables. The time dummies $d_3, \ldots, d_T$, with the corresponding γ coefficients, capture the time-specific effects, and η_i and $\varepsilon_{i,t}$ represent the unobserved individual-specific and idiosyncratic remainder terms, respectively. The aim of the empirical analysis is to estimate the lag parameters

[9] To ensure the robustness of our results, we also employ the two-step GMM estimator utilizing the moment conditions as outlined by Arellano & Bover [1995].

α_1 and α_2, and the β coefficients of additional covariates while accounting for unobserved individual-specific heterogeneity and controlling for (unobserved) time effects. Moreover, the model for testing *Hypothesis II* is defined as:

$$\begin{aligned} TQ_{i,t} =& \alpha_1 TQ_{i,t-1} + \alpha_2 TQ_{i,t-2} + \beta_1 E_{i,t} + \beta_2 S_{i,t} + \beta_3 G_{i,t} + \beta_4 YR_{i,t} + \beta_5 LEV_{i,t} + \beta_6 YrOp_{i,t} + \\ & \beta_7 RD_{i,t} + \beta_8 DivPay_{i,t} + \gamma_3 d_3 + \cdots + \gamma_T d_T + \eta_i + \varepsilon_{i,t} \;\forall\; i = 1, \ldots, n; \quad t = 3, \ldots, T \end{aligned} \tag{4.8}$$

where $E_{i,t}, S_{i,t}$ and $G_{i,t}$ are the individual ESG pillar scores of the i-th firm at time t. Moreover, other variables and coefficients have the same application as in Equation (4.7). Lastly, the model for testing *Hypothesis III* is defined as:

$$\begin{aligned} TQ_{i,t} =& \alpha_1 TQ_{i,t-1} + \alpha_2 TQ_{i,t-2} + \sum_{k=1}^{10} \beta_k ESGcat_{k,i,t} + \beta_{11} YR_{i,t} + \beta_{12} LEV_{i,t} + \beta_{13} YrOp_{i,t} + \\ & \beta_{14} RD_{i,t} + \beta_{15} DivPay_{i,t} + \gamma_3 d_3 + \cdots + \gamma_T d_T + \eta_i + \varepsilon_{i,t} \;\forall\; i = 1, \ldots, n; \quad t = 3, \ldots, T \end{aligned} \tag{4.9}$$

where $ESGcat_{k,i,t}$ is the individual ESG category score k of the i-th firm at time t. Other variables and coefficients have the same application as in Equations (4.7) and (4.8). All the ten ESG category variables and respective variables are given in Table C.1.

4.5 Diagnostic Tests

To ensure our dynamic panel data estimator's validity, reliability, and performance, we run diagnostic tests to check for overidentifying restrictions, serial correlation in the idiosyncratic remainder components, and potential biases to ensure the credibility and robustness of the empirical findings.

When the system of equations from which GMM estimates the model parameters is overidentified, i.e., when the number of moment conditions exceeds the number of parameters to be estimated, it is possible to assess the validity of the overidentifying restrictions. We do as Hansen [1982] and test for overidentifying restrictions, i.e., Hansen J-test, where the null hypothesis, H_0, is that the overidentifying restrictions are valid. Additionally, Arellano & Bond [1991] suggest a test for second-order serial correlation in the idiosyncratic remainder components, where the H_0 of the test is that there is no serial correlation in the $\varepsilon_{i,t}$. Suppose the test yields a statistically significant result. In that case, it suggests the presence of serial correlation, indicating that the error terms are correlated across time periods. Finally, we use the Wald test, which considers the H_0 that the parameters of all coefficients included in the model are jointly zero [Fritsch et al., 2021].

Chapter 5

Results and Discussion

5.1 The Impact of ESG Factors on Financial Performance

Utilizing the two-step Arellano-Bond GMM estimator to test *Hypothesis I*, Table 5.1 shows that ESG score (ESG) has no statistically significant impact on financial performance. Hence, *Hypothesis I* is rejected. Our finding is consistent with previous studies [McWilliams & Siegel, 2000; Renneboog et al., 2008a,b], which contradicts papers finding a positive [Margolis et al., 2009; Friede et al., 2015] and negative [Sulkowski, 2010; Duque-Grisales & Aguilera-Caracuel, 2021] association between ESG scores and financial impact. Nevertheless, Dimson et al. [2020] raise criticism to Margolis et al. [2009] and Friede et al. [2015], as one cannot conclude whether the correlation between ESG and financial performance comes from omitted variables impacting both factors. Moreover, Dimson et al. [2020] argues that there is no indication of causality, making it difficult to determine whether companies that engage in responsible practices perform well financially or if financially successful companies tend to prioritize responsible practices. As we do not find any association between ESG and financial performance, the causality concept does not directly apply to our results.

Moreover, looking at the results from testing *Hypothesis II*, we find no statistical significance between the E, S and G pillars and financial performance, meaning E and S do not influence financial performance more than G. Thus, we reject *Hypothesis II.* To our knowledge, no existing literature finds a non-significant relationship between the E pillar and financial performance. However, our results are partly consistent with Giese et al. [2021], which find no impact from the S pillar on financial performance. Similarly, Gillan et al. [2007] find no association between the G pillar and financial performance, complementing our results. Finally, in our context regarding the aluminum and iron & steel industries, Giese et al. [2021] found that the environmental pillar showed vital significance in the materials and energy sectors, which contradicts our results.

According to Dimson et al. [2020], studies finding a positive association between ESG pillars and financial performance are weakened by the assumption that the pillar scores adequately measure responsible behavior. To avoid these shortcomings, we test *Hypothesis III* considering ESG categories, which is rejected. In other words, the E pillar categories, i.e., EM, EI, and RU, have no statistical significance. Giese et al. [2021] discuss that different ESG categories affect financial variables over different periods, where the governance-related risks immediately impact stock prices, while the environmental and social categories develop slowly and have long-lasting financial effects. As we investigate the association between ESG categories and financial performance over ten year period and few firms in our dataset have ESG scores over this period, as seen in Figure 4.2, we cannot test for the long-term effect.

The lagged variable TQ_{t-2} shows a statistical significance at the 1% level for all three hypotheses, implying dynamic properties in our dataset. Hence, a one-unit increase in TQ_{t-2} leads to a 0.147 decrease in the dependent variable in the test for *Hypotheses I* and *II*, and a 0.151 decrease when testing for *Hypothesis III.* Petersen & Strongin [1996] examines why some industries are far more cyclical than others by using variables that consider the durability of output (demand-side conditions) and different elements of market structure (supply-side conditions), i.e., energy prices. The paper discusses that durable goods industries, i.e., aluminum and iron & steel producers, are three times more cyclical than non-durable goods industries. As one can believe that the energy prices are correlated with the market value of equity (MVE) in TQ [Bartram, 2005], this research can explain the significant TQ_{t-2}. Furthermore, Dixit & Pindyck [1994] argue that the prices of commodities, such as metals, should be modeled as a mean-reverting process as these ought to be drawn back towards the marginal cost of production. Both commodity prices and economies move in cycles, where the valuation of companies is tied to the earnings and cash flows reported, which are a function of where we are in the cycle [Damodaran, 2009]. Thus, we believe that the value of an aluminum or an iron & steel company is linked to the price of its commodities. Given that we measure the financial performance by Tobin's q, which reflects MVE, one can argue that the company's market value follows the price cycles of aluminum and iron & steel. Hence, we believe that the MVE of the firms in the aluminum and iron & steel industries fluctuate around an equilibrium similar to those of commodity prices. Our estimation may capture these fluctuations, resulting in the current TQ being negatively correlated with its second-lagged, i.e., every two years.

Concerning the control variables, Table 5.1 shows that YR and *YrOp* are statistically significant at a 5% level in all three hypotheses, with negative coefficients. In other words, younger firms and those with fewer ESG scores have slightly higher TQ. Regarding the years of ESG reporting, YR, a longer period with investments in ESG initiatives may lead to a shortfall in expected returns, which is emphasized in the literature [Dimson et al., 2020]. Moreover, RD also has a statistical significance that affects financial performance negatively under *Hypothesis III.* Similarly to investments in sustainability, RD is a factor that may have short-term negative effects due to the fall in profitability. However, it may increase in the long term due to new technology increasing future profits. Giese et al. [2021] states that excess payoffs from sustainable operations are not immediate, meaning observing possible synergies may take longer. Based on our ten-year period, we believe one should have observed the effects of investments in sustainable technologies. Hence, the arguments from Giese et al. [2021] contradict with our results. Regarding the firm's year of operation (*YrOp*), Coad et al. [2013] finds evidence that firm performance deteriorates with age. More specifically, they state that older firms have lower expected growth rates of sales, profits, and productivity, which can explain our results. Moreover, the aluminum and iron & steel industries are characterized by path dependency and technological lock-ins [Karakaya et al., 2018], which may imply that incumbent firms in our dataset struggle to adopt new technology the younger firms implement, explaining the negative association between age and financial performance.

As mentioned in Section 2.1, the primary goal of shareholder theory is to maximize shareholder value [Friedman, 1970]. The lack of a relationship between ESG and financial performance in our results implies that ESG is not a significant driver of shareholder value. Therefore, from a shareholders' perspective, there is no rationality in ESG investments, as it does not create any significant excess value. Hence, based on the shareholder theory, one can assume that shareholders prioritize immediate financial gains instead of long-term sustainability. That being said, investors are becoming more aware of the potential long-term financial effects of ESG [Fatemi et al., 2015], which may affect future research on this relationship. Furthermore, from a stakeholder theory perspective, it is essential that a firm preserve the interests of all its stakeholders [Freeman, 2010]. Thus, as stakeholders may demand more sustainable firm operations, investments in ESG initiatives will likely be substantial regardless of how it affects financial performance. Additionally, a firm with a broad ESG focus may enhance its reputation, attract talent and increase customer satisfaction as they operate more sustainably. This can create more indirect value for the firm and build long-term resilience [Fatemi et al., 2015].

Dimson et al. [2020] criticizes studies that assume ESG scores are associated with responsible behavior. Lately, the issue of greenwashing[1] has been widely discussed. Thomsen [2023] states that firms with higher ESG scores emit more CO_2 than firms with lower ESG scores. This is reflected in our dataset, as we see aluminum and iron & steel firms with high ESG scores, even though they have substantial emissions. Given our results, we believe that investors are aware of the concept of greenwashing and thus understand that sustainability is more than what is reflected in the ESG factors. Thomsen [2023] also criticizes that firms can easily tweak policies and procedures the rating agency requires to get higher scores. Moreover, Dimson et al. [2020] states that rating agencies weigh ESG factors differently, leading to inconsistent results for the same firm, underpinning the need for standardization to ensure more consistent and reliable ratings. This reflects the importance of a better regulatory framework and transparency in dealing with greenwashing.

To further understand our results regarding the impact of ESG factors on financial performance for the aluminum and iron & steel companies, one has to consider the regulatory framework and market conditions within these industries. Since our dataset consists of 204 companies across different regions, some may be in a more regulated environment than others. Hence, it can be believed that these companies would need to invest more significantly in operational improvements to comply with these regulations, which can negatively impact their financial performance. One example is the implementation of carbon pricing mechanisms or emissions trading schemes. For instance, several of the aluminum and iron & steel companies in our dataset are regulated by the European Emission Trading Scheme (ETS)[2]. These sectors are among the most exposed as they are highly CO_2-intensive and relatively open to international trade [Demailly & Quirion, 2008]. For the iron & steel industry, Demailly & Quirion [2008] quantify the impact of ETS on two dimensions of competitiveness: production and profitability. They conclude that competitiveness losses are small for this sector. This study complements Ellerman et al. [2008], which quantitatively analyzed the shock of a carbon price on short-term competitiveness (including the market share and profitability) of the EU's cement, refining, steel, and aluminum sectors based on historical data of the EU ETS (2005–2007). This paper identified only weak influence of carbon price change on these sectors. As we see in the aforementioned papers, regulatory framework and market conditions only have a neutral influence on both profitability and market share, which aligns with our results. Moreover, further analysis of companies in their respective regions is unnecessary as many of these companies, such as Hydro, operate in several areas, making it difficult to obtain relevant data.

It is also interesting to see our empirical results from the lens of a Chief Financial Officer (CFO) in an aluminum or iron & steel company. The CFO is responsible for the company's financial situation and investments. Hence, if an investment yields a negative or no impact on the company's value, the CFO has no rationality to invest. Thus, one can assume the CFO acts like a shareholder, as they prioritize profit maximization. However, the investments should also align with the company's long-term goals, meaning the board may prioritize sustainable investments to meet governmental regulations and requirements. This becomes important to ensure stakeholders' requirements, who increasingly seek more sustainable investments. In contrast, this may lead to dissatisfaction among shareholders, as the CFO seems to prioritize objectives other than profit maximization. Therefore, the company should have clear long-term goals so investors and the CFO understand what to expect. Thus, highlighting potential growth areas, cost-saving measures, or technological advancements that align with the company's sustainable objectives. Such an approach can support the CFO in identifying possibilities that combine sustainability goals with financial goals, bridging the gap between shareholder interests and the firm's long-term goals.

Overall, our results suggest no significant association between financial performance and the ESG scores, pillar scores, and category scores. However, we find a statistically significant negative impact from the number of years a firm has reported ESG. Similarly, we find a negative association between

[1]Greenwashing refers to an organization that promotes itself as more environmentally or socially friendly than they actually are [Thomsen, 2023].

[2]The ETS is the largest cap-and-trade system worldwide and the most important European climate change mitigation policy in place [Demailly & Quirion, 2008].

firm age and financial performance and a negative impact from the second lag of Tobin's q. Furthermore, our results from a shareholder perspective divert from stakeholders' as they have a greater interest in sustainable operations. While certain companies in our dataset may require significant investments in operational improvements to meet regional regulations, such factors may have a neutral impact on profitability and market share, which aligns with our findings. Finally, based on our results, investors may be aware of the concept of greenwashing and thus understand that sustainability is more than what is reflected in the ESG factors.

Table 5.1: Results for *Hypothesis I, II* and *III* utilizing the two-step Arellano-Bond GMM estimator. The standard errors are given in parentheses.

Variable	*Hypothesis I*	*Hypothesis II*	*Hypothesis III*
TQ_{t-1}	0.089	0.087	0.089
	(0.114)	(0.111)	(0.107)
TQ_{t-2}	-0.147**	-0.147**	-0.151**
	(0.053)	(0.052)	(0.054)
ESG	-0.003	-	-
	(0.003)		
E	-	0.003	-
		(0.002)	
S	-	0.001	-
		(0.002)	
G	-	-0.001	-
		(0.002)	
EM	-	-	0.001
			(0.001)
EI	-	-	0.000
			(0.001)
RU	-	-	-0.003
			(0.001)
C	-	-	0.001
			(0.001)
HR	-	-	0.002
			(0.001)
PR	-	-	-0.001
			(0.001)
W	-	-	0.001
			(0.001)
CSR	-	-	0.001
			(0.001)
M	-	-	0.001
			(0.001)
SH	-	-	-0.001
			(0.001)
YR	-0.098*	-0.099*	-0.105*
	(0.045)	(0.041)	(0.050)
LEV	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
YrOp	-0.098*	-0.099*	-0.105*
	(0.045)	(0.041)	(0.050)
RD	-0.014	-0.016	-0.020*
	(0.010)	(0.009)	(0.010)
DivPay	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
Year dummies	YES	YES	YES
Statistical tests		**p-value**	
Arellano & Bond	0.715	0.670	0.770
J-test of Hansen	0.152	0.152	0.307
Wald Test	0.000	0.000	0.000

Note:*p<0.05;**p<0.01;***p<0.001

5.2 Robustness Test

The impact of ESG factors on financial performance is measured using the two-step Arellano-Bond GMM estimator, as explained in Section 4.4. This estimator has been extended by subsequent studies such as Arellano & Bover [1995] and Blundell & Bond [1998]. A limitation revealed in the Arellano-Bond estimator is the potential ineffectiveness of using variables in levels as instruments for first-differenced equations (see Table E.1) [Das, 2019; Fritsch et al., 2021]. Hence, to validate the robustness of our results, we employ the two-step GMM estimator utilizing the moment conditions as outlined by Arellano & Bover [1995]. They propose a system GMM estimator that uses moment conditions based on equations in levels and instruments in differences (See Table E.2) along with the conventional Arellano and Bond orthogonality conditions mentioned in Section 4.4 [Das, 2019]. Overall, Arellano & Bover [1995] derive the following additional $T-2$ moment conditions, which are further discussed in Appendix E:

$$E(\Delta TQ_{i,t-1} \cdot \varepsilon_{i,t}) = 0, \quad t = 3, ..., T \tag{5.1}$$

Table F.1 provides an overview of the relationship between ESG factors and financial performance in the aluminum and iron & steel industries as given by the two-step Arellano-Bover GMM estimator. Our analysis does not find a significant association between ESG scores and TQ (*Hypothesis I*), and ESG pillar scores and TQ (*Hypothesis II*). In other words, no substantial evidence suggests that ESG- and ESG pillar scores significantly influence financial performance in the aluminum and iron & steel industries, which aligns with the findings discussed in Section 5.1. This shows that our findings are robust regarding the analysis of *Hypothesis I and II.* When examining the impact of ESG categories on financial performance (*Hypothesis III*), Table F.1 reveals that the ESG category *Community* is significant at the 5% level. In contrast, the remaining categories do not show a statistically significant relationship with financial performance. The findings suggest that the aluminum and iron & steel companies' performance in terms of community-related ESG factors, i.e., commitment to being a good citizen, protecting public health, and respecting business ethics (see Table B.1), has an effect on their financial outcomes. However, our two-step Arellano-Bond estimator analysis did not yield significant results for the association between ESG categories and financial performance. The contrasting results may stem from variations in the estimators' underlying assumptions and corresponding moment conditions, where the Arellano-Bover estimator might account for additional dynamics that the Arellano-Bond estimator does not capture. Further analysis of the reasons behind the divergent results is left for future research.

As seen in Figure 4.2, there has been a significant increase in the number of firms with ESG scores in the last few years. Moreover, relatively few firms have reported ESG data for the entire period from 2012 to 2022. Hence, as a final robustness check, we exclude the data from 2012 to 2015 from the panel dataset. This leaves us with 792 firm observations, as seen in Table F.3 and Figure F.1. Table F.2 reports the results from the two-step Arellano-Bond GMM estimator when data from 2012 to 2015 are excluded. The results are consistent with the complete sample, which shows that our results are robust.

5.3 Critical Reflection

After assessing our results, we also acknowledge some limitations. First, we have used Refinitiv Eikon as a proxy for ESG performance. Even though the research analysts reasonably quantify ESG factors (see Appendix B), it is essential to remember that their methodology is based on a subjective assessment as they manually obtain the firm's ESG performance. Moreover, rating agencies may calculate ESG scores differently, as discussed in Section 2.3. Therefore, this raises concerns about the comparability and trustworthiness of ESG scores over time. However, the reasoning for choosing

Refinitiv Eikon can be found in Appendix A. Second, we also have limited data, as ESG reporting is not required in many regions. However, as seen in Figure 4.1, there is a growing body of companies disclosing ESG factors, meaning there most likely will be more ESG data available in the future. Additionally, firms may have incentives only to disclose ESG information that may be favorable, thus leading to potential greenwashing and selective reporting. These factors create uncertainties in the completeness, accuracy, and validity of the ESG data. Finally, we have used Tobin's q as the dependent variable when analyzing financial performance. Hence, our study may need to find other ways to measure the effect of ESG factors on financial performance, like investigating stock returns.

Chapter 6

Conclusion

In recent years, public interest in sustainability has surged, heightening its relevance in today's world. As the corporate world changes, there is a growing expectation that firms contribute to a more sustainable society. Hence, the increased ESG focus from corporations can be seen as a way to showcase awareness toward stakeholders. However, the focus on ESG initiatives raises the question of the underlying financial incentives that drive ESG investments and how they affect financial performance. In the literature, there is diverging evidence on the relationship between ESG and financial performance [Renneboog et al., 2008a,b; Margolis et al., 2009; Sulkowski, 2010; Friede et al., 2015]. To make more consistent results, it becomes essential to expand this research field. To the best of our knowledge, we are the first to apply GMM to empirically investigate how ESG scores, pillar scores, and category scores affect financial performance in the aluminum and iron & steel industries - industries known for high emissions, intensive energy consumption and which covers a majority of the ESG framework.

The independent variables' coefficients are estimated from a dataset of 204 firms with data between 2012 and 2022. This results in 1,086 instances of Tobin's q, our measurement for financial performance, with corresponding ESG scores. Control variables associated with Tobin's q in the literature have been included in the model to compare firms' *ceteris paribus*. To ensure the credibility of our results, GMM estimation is applied to increase robustness towards potential endogeneity and measurement error concerns.

Our results suggest that there is no significant association between financial performance and ESG scores, pillar scores, and category scores. However, we find a statistically significant negative impact from the number of years a firm has reported ESG. This indicates that the additional expenses associated with the disclosure of a firm's ESG capabilities may have a negative impact on financial performance. Alternatively, it may also reflect the investor's perspective, who may prioritize immediate financial gains instead of long-term sustainability. Similarly, we find a negative association between firm age and financial performance. According to the literature, this may stem from older firms being less efficient, thus, leading to underperformance relative to younger firms. In our case, this may correspond to older firms having, for instance, more outdated production lines and less innovative technology than younger firms. Finally, we find a statistically significant negative impact from the second lag of Tobin's q, suggesting that our GMM estimator captures the dynamic properties of our dataset.

We perform robustness tests and obtain the same non-significant relationship between ESG factors and Tobin's q for *Hypothesis I* and *II*. However, applying the Arellano-Bover moment conditions to test ESG categories (*Hypothesis III*), we obtain a significant positive Community score (C) coefficient at the 5% level and a significant first-order lag of Tobin's q. Our second robustness test only contains data between 2016 and 2022 to investigate whether investor preferences were related to the chosen period. The result yielded no significant coefficients for the independent variables.

Overall, our results are consistent with other research papers finding no significant impact from ESG factors on financial performance [McWilliams & Siegel, 2000; Renneboog et al., 2008a,b]. Viewing the results from a shareholder perspective, it is not rational to invest in ESG activities, as it is not significantly associated with excess financial performance. In contrast, the growing interest from stakeholders to operate more sustainably may drive ESG investments further, even though it does not impact financial performance, as it can enhance reputation, attract talent and increase customer satisfaction [Fatemi et al., 2015]. These perspectives support the company's CFO in identifying possibilities that combine sustainability goals with financial goals, bridging the gap between shareholder interests and the firm's long-term goals. In the broader context, since its formation by the United Nations in 2004, ESG has the potential for various long-term impacts due to pressure from governments and other stakeholders. Moreover, since our dataset consists of 204 companies across different regions, some may be in more regulated environments than others. These companies would need to invest more significantly in operational improvements to comply with regulations, which can negatively impact their financial performance. However, as seen in earlier research, such external factors may neutrally influence profitability and market share, which aligns with our results. It might be the case that we do not obtain evidence of significant impact from ESG scores because investors are aware of the concept of greenwashing and thus understand that sustainability is more than what is reflected in the ESG factors. Our study may therefore not capture a potential green premium. Additionally, firms can tweak policies and procedures the rating agency requires to get higher ESG scores. Hence, concerning greenwashing and diverging ESG ratings, a more standardized framework for ESG is necessary to make scores more credible and transparent [Dimson et al., 2020].

Through our study, we have revealed several challenges related to using ESG scores. The availability of firms with scores is limited, especially over extended time periods. Moreover, ESG scores are not standardized, meaning comparing scores from several providers is similar to comparing apples to oranges. Thus, a standardized framework can benefit future research, as it would open up to comparing scores from several providers, creating a more extensive and reliable dataset. New technology, such as artificial intelligence, can also contribute to solving the issue related to divergent ESG ratings. Machine learning is one possible way to automatize ESG scoring, as it could scale up the number of ESG scores using the same framework across rating agencies.

Due to the aluminum and iron & steel industries having a high climate footprint, we emphasize that our dataset contains firms that sustainability-oriented investors may oversee. Since we measure financial performance based on investor preferences (MVE), our estimator may fail to capture ESG's impact on financial performance. Therefore, it is advisable to apply our methodology to other sectors that might be more attractive to these investors. This can extend the research of whether investor preferences for ESG are industry dependent. Finally, other metrics for financial performance may be more appropriate than Tobin's q to capture excess performance from higher ESG scores. Examples are return on assets or cost of debt that capture a company's financial position differently than Tobin's q. Using the latter would shift the focus away from the shareholders to debt holders and their evaluation of firm risk.

Bibliography

Abdi, Y., Li, X., & Càmara-Turull, X. (2022). Exploring the impact of sustainability (ESG) disclosure on firm value and financial performance (FP) in airline industry: The moderating role of size and age. *Environment, Development and Sustainability*, *24*, 5052–5079.

Abhayawansa, S., & Tyagi, S. (2021). Sustainable investing: The black box of environmental, social, and governance (ESG) ratings. *The Journal of Wealth Management*, *24*, 49–54.

Ahn, S. C., & Schmidt, P. (1995). Efficient estimation of models for dynamic panel data. *Journal of Econometrics*, *68*, 5–27.

Akerlof, G. A. (1970). The market for "lemons": Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, *84*, 488–500.

Anderson, T. W., & Hsiao, C. (1981). Estimation of Dynamic Models with Error Components. *Journal of the American Statistical Association*, *76*, 598–606.

Aouadi, A., & Marsat, S. (2018). Do ESG Controversies Matter for Firm Value? Evidence from International Data. *Journal of Business Ethics*, *151*, 1027–1047.

Arellano, M. (1989). A note on the Anderson-Hsiao estimator for panel data. *Economics Letters*, *31*, 337–341.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, *58*, 277–297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, *68*, 29–51.

Azmi, W., Hassan, M. K., Houston, R., & Karim, M. S. (2021). ESG activities and banking performance: International evidence from emerging economies. *Journal of International Financial Markets, Institutions and Money*, *70*, 101277.

Baker, M., Egan, M. L., & Sarkar, S. K. (2022). *How Do Investors Value ESG?*. Technical Report National Bureau of Economic Research.

Bartram, S. M. (2005). The Impact of Commodity Price Risk on Firm Value–An Empirical Analysis of Corporate Commodity Price Exposures. *Multinational Finance Journal*, *9*, 161–187.

Berg, F., Koelbel, J. F., & Rigobon, R. (2022). Aggregate confusion: The divergence of ESG ratings. *Review of Finance*, *26*, 1315–1344.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*, 115–143.

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of Financial Economics*, *142*, 517–549.

Buallay, A. (2019). Between cost and value: Investigating the effects of sustainability reporting on a firm's performance. *Journal of Applied Accounting Research*, *20*, 481–496.

Carattini, S., Hertwich, E., Melkadze, G., & Shrader, J. G. (2022). Mandatory disclosure is key to address climate risks. *Science*, *378*, 352–354.

Chen, J. (2022). Idiosyncratic Risk: Definition, Types, Examples, Ways To Minimize. https://www.investopedia.com/terms/i/idiosyncraticrisk.asp. [Accessed 23-Mar-2023].

Chen, J. (2023). What Is Systematic Risk? https://www.investopedia.com/terms/s/systematicrisk.asp. [Accessed 23-Mar-2023].

Chung, K. H., & Pruitt, S. W. (1994). A simple approximation of Tobin's q. *Financial Management*, *23*, 70–74.

Clarkson, P. M., Li, Y., Richardson, G. D., & Vasvari, F. P. (2008). Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Accounting, Organizations and Society*, *33*, 303–327.

Coad, A., Segarra, A., & Teruel, M. (2013). Like milk or wine: Does firm performance improve with age? *Structural Change and Economic Dynamics*, *24*, 173–189.

D'Amato, A., & Falivena, C. (2020). Corporate social responsibility and firm value: Do firm size and age matter? Empirical evidence from European listed companies. *Corporate Social Responsibility and Environmental Management*, *27*, 909–924.

Damodaran, A. (2009). Ups and Downs: Valuing Cyclical and Commodity Companies. *(Working paper) Stern School of Business, New York University*, .

Das, P. (2019). Econometrics in theory and practice. *Springer*, *10*, 978–981.

David, P. A. (1985). Clio and the Economics of QWERTY. *The American Economic Review*, *75*, 332–337.

Deegan, C. (2014). An overview of legitimacy theory as applied within the social and environmental accounting literature. *Sustainability Accounting and Accountability*, (pp. 248–272).

Demailly, D., & Quirion, P. (2008). European Emission Trading Scheme and competitiveness: A case study on the iron and steel industry. *Energy Economics*, *30*, 2009–2027.

Dimson, E., Marsh, P., & Staunton, M. (2020). Divergent ESG ratings. *The Journal of Portfolio Management*, *47*, 75–87.

Dixit, A. K., & Pindyck, R. S. (1994). *Investment under Uncertainty*. Princeton University Press.

Dorfleitner, G., Halbritter, G., & Nguyen, M. (2015). Measuring the level and risk of corporate responsibility–An empirical comparison of different ESG rating approaches. *Journal of Asset Management*, *16*, 450–466.

Duque-Grisales, E., & Aguilera-Caracuel, J. (2021). Environmental, social and governance (ESG) scores and financial performance of multilatinas: Moderating effects of geographic international diversification and financial slack. *Journal of Business Ethics*, *168*, 315–334.
Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science*, *60*, 2835–2857.
El Ghoul, S., Guedhami, O., Kwok, C. C., & Mishra, D. R. (2011). Does corporate social responsibility affect the cost of capital? *Journal of Banking & Finance*, *35*, 2388–2406.
Elkington, J. (1994). Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development. *California Management Review*, *36*, 90–100.
Ellerman, D., Convery, F., & De Perthuis, C. (2008). The European carbon market in action: Lessons from the first trading period. *Journal for European Environmental & Planning Law*, *5*, 215–233.
European Securities and Markets Authority (2021). ESG ratings: Status and key issues ahead. https://www.esma.europa.eu/sites/default/files/trv_2021_1-esg_ratings_status_and_key_issues_ahead.pdf. [Accessed 03-Mar-2023].
Fatemi, A., Fooladi, I., & Tehranian, H. (2015). Valuation effects of corporate social responsibility. *Journal of Banking & Finance*, *59*, 182–192.
Fatemi, A., Glaum, M., & Kaiser, S. (2018). ESG performance and firm value: The moderating role of disclosure. *Global Finance Journal*, *38*, 45–64.
Fennell, P., Driver, J., Bataille, C., & Davis, S. J. (2022). Cement and steel—nine steps to net zero. *Nature*, *603*, 574–577.
Ferrell, A., Liang, H., & Renneboog, L. (2016). Socially responsible firms. *Journal of Financial Economics*, *122*, 585–606.
Ferri, S., Tron, A., Colantoni, F., & Savio, R. (2023). Sustainability Disclosure and IPO Performance: Exploring the Impact of ESG Reporting. *Sustainability*, *15*, 5144.
Fouche, G. (2021). Brazil group sues Norsk Hydro over alleged pollution. https://www.reuters.com/article/us-norsk-hydro-brazil-idUSKBN2A923Q. [Accessed 10-May-2023].
Freeman, R. E. (2010). *Strategic management: A stakeholder approach*. Cambridge university press.
Friede, G., Busch, T., & Bassen, A. (2015). ESG and financial performance: aggregated evidence from more than 2000 empirical studies. *Journal of Sustainable Finance & Investment*, *5*, 210–233.
Friedman, M. (1970). A Friedman doctrine: The social responsibility of business is to increase its profits. *The New York Times Magazine*, *13*, 32–33.
Fritsch, M., Andrew, A. Y. P., & Schnurbus, J. (2021). pdynmc: A Package for Estimating Linear Dynamic Panel Data Models Based on Nonlinear Moment Conditions. *The R Journal*, *13*, 218.
Giese, G., Nagy, Z., & Lee, L.-E. (2021). Deconstructing ESG ratings performance: Risk and return for E, S, and G by time horizon, sector, and weighting. *The Journal of Portfolio Management*, *47*, 94–111.
Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance*, *66*, 101889.
Gillan, S. L., Starks, L. T. et al. (2007). The evolution of shareholder activism in the United States. *Journal of Corporate Finance*, *19*, 55–73.
Glen, J., Lee, K., & Singh, A. (2001). Persistence of profitability and competition in emerging markets. *Economics Letters*, *72*, 247–253.
Gordon, M. J. (1959). Dividends, earnings, and stock prices. *The Review of Economics and Statistics*, (pp. 99–105).
Greene, W. H. (2012). Econometric Analysis 7th Edition International edition. *Essex, England: Pearson Education Limited*, .
Gregoir, L., van Acker, K. et al. (2022). Metals for clean energy: pathways to solving Europe's raw materials challenge. *Eurometaux, KU Leuven*, .
GRI (2021). GRI and SASB reporting 'complement each other'. https://www.globalreporting.org/news/news-center/gri-and-sasb-reporting-complement-each-other/. [Accessed 10-May-2023].
Gschwandtner, A. (2005). Profit persistence in the 'very'long run: Evidence from survivors and exiters. *Applied Economics*, *37*, 793–806.
Hansen, L. P. (1982). Large Sample Properties of Generalized Method of Moments Estimators. *Econometrica*, *50*, 1029–1054.
Hartzmark, S. M., & Sussman, A. B. (2019). Do investors value sustainability? A natural experiment examining ranking and fund flows. *The Journal of Finance*, *74*, 2789–2837.
Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica: Journal of the Econometric Sciety*, (pp. 1251–1271).
Hausman, J. A., & Taylor, W. E. (1981). Panel data and unobservable individual effects. *Econometrica: Journal of the Econometric society*, (pp. 1377–1398).
Holtz-Eakin, D., Newey, W., & Rosen, H. S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica*, *56*, 1371–1395.
Horváthová, E. (2010). Does environmental performance affect financial performance? A meta-analysis. *Ecological Economics*, *70*, 52–59.
IEA (2022a). Aluminium. https://www.iea.org/reports/aluminium. [Accessed 26-Feb-2023].
IEA (2022b). Iron and Steel. https://www.iea.org/reports/iron-and-steel. [Accessed 12-May-2023].
IEA (2023). Energy Technology Perspectives 2023. https://www.iea.org/reports/energy-technology-perspectives-2023. [Accessed 21-Feb-2023].
Javier, R.-S., & Alonso-Conde, A. B. (2023). Short-run and long-run effects of ESG policies on value creation and the cost of equity of firms. *Economic Analysis and Policy*, *77*, 599–616.
Jo, H., & Harjoto, M. (2011). Corporate Governance and Firm Value: The Impact of Corporate Social Responsibility. *Journal of Business Ethics*, *103*, 351–383.
Karakaya, E., Nuur, C., & Assbring, L. (2018). Potential transitions in the iron and steel industry in Sweden: Towards a hydrogen-based future? *Journal of Cleaner Production*, *195*, 651–663.
Kell, G. (2018). The Remarkable Rise Of ESG. https://www.forbes.com/sites/georgkell/2018/07/11/the-remarkable-rise-of-esg/. [Accessed 29-May-2023].
Kenton, W. (2021). Social License to Operate (SLO): Definition and Standards — investopedia.com. https://www.investopedia.com/terms/s/social-license-slo.asp. [Accessed 23-Feb-2023].
Lahouel, B. B., Gaies, B., Zaied, Y. B., & Jahmane, A. (2019). Accounting for endogeneity and the dynamics of corporate social–corporate financial performance relationship. *Journal of Cleaner Production*, *230*, 352–364.

Lahouel, B. B., Zaied, Y. B., Song, Y., & Yang, G.-l. (2021). Corporate social performance and financial performance relationship: A data envelopment analysis approach without explicit input. *Finance Research Letters*, *39*, 101656.

Lindenberg, E. B., & Ross, S. A. (1981). Tobin's q Ratio and Industrial Organization. *The Journal of Business*, *54*, 1–32.

Margolis, J., Elfenbein, H., & Walsh, J. (2009). Does it Pay to Be Good...And Does it Matter? A Meta-Analysis of the Relationship between Corporate Social and Financial Performance. *(Working paper) Harvard University*, .

McWilliams, A., & Siegel, D. (2000). Corporate social responsibility and financial performance: correlation or misspecification? *Strategic Management Journal*, *21*, 603–609.

Michaels, K., Maréchal, L., & Katz, B. (2022). Why is ESG so important to critical mineral supplies, and what can we do about it? https://www.iea.org/commentaries/why-is-esg-so-important-to-critical-mineral-supplies-and-what-can-we-do-about-it. [Accessed 23-Feb-2023].

Muth, J. F. (1961). Rational Expectations and the Theory of Price Movements. *Econometrica*, *29*, 315–335.

Nikolaev, V., & Van Lent, L. (2005). The endogeneity bias in the relation between cost-of-debt capital and corporate disclosure policy. *European Accounting Review*, *14*, 677–724.

Palmer, M. A., Bernhardt, E. S., Schlesinger, W. H., Eshleman, K. N., Foufoula-Georgiou, E., Hendryx, M. S., Lemly, A. D., Likens, G. E., Loucks, O. L., Power, M. E. et al. (2010). Mountaintop mining consequences. *Science*, *327*, 148–149.

Pástor, L., Stambaugh, R. F., & Taylor, L. A. (2021). Sustainable investing in equilibrium. *Journal of Financial Economics*, *142*, 550–571.

Pell, E. H., & Azizuddin, K. (2023). EC expected to publish ESG ratings regulation proposal in mid-June. https://www.responsible-investor.com/ec-expected-to-publish-esg-ratings-regulation-proposal-in-mid-june/. [Accessed 10-May-2023].

Peloza, J. (2006). Using corporate social responsibility as insurance for financial performance. *California Management Review*, *48*, 52–72.

Petersen, B., & Strongin, S. (1996). Why are some industries more cyclical than others? *Journal of Business & Economic Statistics*, *14*, 189–198.

Pietro Alessandrini (n.d.). Eikon Datastream. https://bigiavi.sba.unibo.it/cataloghi-e-risorse-online/eikon-datastream/#chefcookie__accept_all. [Accessed 10-May-2023].

Porter, M. E., & Kramer, M. R. (2002). The Competitive Advantage of Corporate Philanthropy.

Qureshi, M. A., Kirkerud, S., Theresa, K., & Ahsan, T. (2020). The impact of sustainability (environmental, social, and governance) disclosure and board diversity on firm value: The moderating role of industry sensitivity. *Business Strategy and the Environment*, *29*, 1199–1214.

Refinitiv Eikon (2022). Environmental, social and governance scores from Refinitiv.

Renneboog, L., Ter Horst, J., & Zhang, C. (2008a). The price of ethics and stakeholder governance: The performance of socially responsible mutual funds. *Journal of Corporate Finance*, *14*, 302–322.

Renneboog, L., Ter Horst, J., & Zhang, C. (2008b). Socially responsible investments: Institutional aspects, performance, and investor behavior. *Journal of Banking & Finance*, *32*, 1723–1742.

Rowley, T., & Berman, S. (2000). A brand new brand of corporate social performance. *Business & Society*, *39*, 397–418.

Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., Von Gunten, U., & Wehrli, B. (2010). Global water pollution and human health. *Annual Review of Environment and Resources*, *35*, 109–136.

Seoki, L., Kwanglim, S., & Amit, S. (2013). Corporate social responsibility and firm performance in the airline industry: The moderating role of oil prices. *Tourism Management*, *38*, 20–30.

Shepherd, W. G. (1986). Tobin's q and the Structure-performance Relationship: Comment. *The American Economic Review*, *76*, 1205–1210.

Smirlock, M., Gilligan, T., & Marshall, W. (1984). Tobin's q and the Structure-Performance Relationship. *The American Economic Review*, *74*, 1051–1060.

Sticks, C. . (2020). Carrots and Sticks: Sustainability Reporting Policies Worldwide - Today's Best Practice, Tomorrow's Trends. https://www.carrotsandsticks.net/media/zirbzabv/carrots-and-sticks-2020-june2020.pdf. [Accessed 23-Feb-2023].

Sulkowski, A. (2010). Environmental Disclosure, Environmental Performance, and Firm Characteristics: An Analysis of S&P 100 Firms. *Journal of Academy of Business and Economics*, *10*, 73–83.

Thomsen, S. (2023). CBS-professor: Slip naiv tro på, at esg er bæredygtigt. https://borsen.dk/nyheder/opinion/esg-er-ikke-lig-med-baeredygtighed. [Accessed 25-May-2023].

Tobin, J. (1969). A general equilibrium approach to monetary theory. *Journal of Money, Credit and Banking*, *1*, 15–29.

United Nations (2022). Review of trends in ESG reporting requirements for investors. *Principles for Responsible Investment*, (pp. 1–26).

Vance, S. (1975). Are socially responsible corporations good investment risks? *American Management Associations*, .

Velte, P. (2017). Does ESG performance have an impact on financial performance? Evidence from Germany. *Journal of Global Responsibility*, .

Wernerfelt, B., & Montgomery, C. A. (1988). Tobin's q and the importance of focus in firm performance. *The American Economic Review*, *78*, 246–250.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, *126*, 25–51.

Wintoki, M. B., Linck, J. S., & Netter, J. M. (2012). Endogeneity and the dynamics of internal corporate governance. *Journal of Financial Economics*, *105*, 581–606.

Xie, J., Nozawa, W., Yagi, M., Fujii, H., & Managi, S. (2019). Do environmental, social, and governance activities improve corporate financial performance? *Business Strategy and the Environment*, *28*, 286–300.

Ziegler, A., Schröder, M., & Rennings, K. (2007). The effect of environmental and social performance on the stock performance of European corporations. *Environmental and Resource Economics*, *37*, 661–680.

Appendix

A Choosing our Provider of ESG Scores

As mentioned in Section 2.3, ESG scores are calculated differently, depending on the rating agencies. These providers include MSCI, Sustainalytics, Refinitiv Eikon, and Bloomberg [European Securities and Markets Authority, 2021]. No standard framework for calculation or shared definition of ESG scores exists today, resulting in deviating ESG scores among providers [Dimson et al., 2020; European Securities and Markets Authority, 2021; Berg et al., 2022]. This means that a company with a high score from one rating agency can have a lower score from another. Dimson et al. [2020] found a significant disagreement among the most popular ESG raters. Thus, ESG scores are a provider-dependent metric, making us cautious about choosing this paper's provider of ESG scores.

We find Refinitiv Eikon to be the most suitable ESG score provider for several reasons: (1) Whereas Sustainalytics provides ESG scores based on a mixture of public information and its estimates, Refinitiv Eikon calculates scores solely on publicly available data [European Securities and Markets Authority, 2021]. In this paper, we want to exclude estimated scores as they can be biased or based on the wrong assumptions. (2) Refinitiv Eikon has more individual indicators than any of the other providers of ESG scores [Berg et al., 2022]. This increases the possibility of deep-diving into the ESG score and further investigating firm-specific factors contributing to this score. Also, Refinitiv Eikon provides publicly available information regarding the calculation of ESG scores. However, there are also drawbacks to using Refinitiv Eikon. Berg et al. [2022] states that MSCI has been the most frequently used in academia, meaning that using this scoring system would make it easier to compare the results from our paper to other academic studies. Also, Sustainalytics has approximately 10% more firms in their database than Refinitiv Eikon, which may impact our results. Attempting to collect several providers' ESG scores into one model could have been a possibility to avoid the problem of choosing only one provider. However, we do not attempt this given the risk of comparing "apples to oranges" [Dorfleitner et al., 2015; Dimson et al., 2020; Abhayawansa & Tyagi, 2021].

B Refinitiv Eikon's ESG Scores

Refinitiv Eikon calculates ESG scores using 406 data points based on publicly available information obtained by 700 content researchers [Refinitiv Eikon, 2022]. This appendix will demonstrate examples of data points used in this calculation, their weighting, and how the overall ESG score is calculated. From the screening of annual reports, company websites, Stock Exchange filings, CSR Reports, and News Sources, Refinitiv Eikon searches for information about the firms worldwide. These data points comprise the foundation of 14 calculated scores: one overall ESG score, three pillar scores, and ten category scores, as shown in Table B.1.

Table B.1: Overview of the ESG pillars and categories in Refinitiv Eikon.

Pillar	**Category**	**Definition**
E	Resource use	Capacity to reduce the use of materials energy, water, and to find eco-efficient solutions by improving supply chain management.
	Emissions Reduction	Commitment and effectiveness towards reducing environmental emissions in its production and operational processes.
	Innovation	Capacity to reduce environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed products.
S	Workforce	Effectiveness in terms of providing job satisfaction a healthy and safe workplace, maintaining diversity and equal opportunities, and development opportunities for it's workforce.
	Human rights	Effectiveness in terms of respecting fundamental human rights convention.
	Community	Commitment to being a good citizen, protecting public health and respecting business ethics.
	Product responsibility	Capacity to produce quality goods and services, integrating the customer's health and safety, integrity and data privacy.
G	Management	A company's commitment and effectiveness towards following best practice corporate governance principles.
	Shareholders	Effectiveness towards equal treatment of shareholders and the use of anti-takeover devices.
	CSR strategy	Practices to communicate the integration of economic, social and environmental dimensions into its day-to-day decision making processes.

The ESG category scores are calculated as the average data points within each category. Additionally, the ESG pillars are determined by taking weighted averages of the category scores. The overall ESG score is then derived as a weighted average of the scores from the individual pillars. Moreover, the data points are measured in various units. For reference, Table B.2 presents the distribution of the most common units found in each of the three pillars (E, S, and G), along with examples of corresponding data points.

Of the 406 data points contributing to the overall ESG score, 196 are boolean data points (Yes/No). Hence, a large share of the data points fails to capture nuances in the firm's sustainability characteristics. Overall, using these data points, the final ESG scores are calculated using the following three steps: (I) calculation of the ESG category scores, (II) calculation of the materiality matrix, and (III) calculation of the pillar and overall ESG scores [Refinitiv Eikon, 2022].

Table B.2: An overview of the most common units and themes in the data points [Pietro Alessandrini, n.d.].

Pillar	Unit	Amount	Example
E, 136	Yes/No	39	Does the financial company have a public commitment to divest from fossil fuel? (Polarity: positive)
	Weighted by Revenue	13	Total CO_2 and CO_2 equivalents emission in tonnes divided by net sales or revenue in US dollars in million. (Polarity: negative)
	Tonnes	16	Total amount of hazardous waste produced in tonnes. Hazardous wastes are those waste which poses substantial or potential threats to public health or the environment and generally exhibits one or more of these characteristics: ignitable (i.e. flammable), oxidizing, corrosive, toxic and radioactive. (Polarity: negative)
	Currency	7	Environmental fines as reported by the company divided by net sales or revenue in million. (Polarity: negative)
	Energy	11	Total primary renewable energy purchased and produced in gigajoules. (Polarity: positive)
	Count	2	Number of controversies related to the environmental impact of the company's operations on natural resources or local communities. (Polariy: Negative)
	Percent	5	Percentage of revenue from environmental products and services offered by the company. (Polarity: positive)
	Other	16	Total volume of water discharged in cubic meters: Water discharged for which there is no further use by the company. Treated waste water and discharged information is also in scope. (Polarity: negative)
S, 184	Yes/No	57	Has there has been a strike or an industrial dispute that led to lost working days? (Polarity: negative)
	Weighted by Revenue	1	The total amount of all donations divided by net sales or revenue in million. (Polarity: positive)
	Tonnes	0	
	Currency	9	CEO's total salary (or the highest salary) divided by average salaries and benefits. (Polarity: negative)
	Count	53	Total number of products or services which have been delayed or drugs which have not been approved by regulators or similar official bodies. (Polarity: Negative)
	Energy	0	
	Percent	13	Percentage of women employees. (Polarity: positive)
	Other	18	Total training hours performed by all employees. (Polarity: positive)
G, 146	Yes/No	96	Is the senior executive's compensation linked to CSR Sustainability targets? (Polarity: positive)
	Weighted by Revenue	2	The total compensation paid to all senior executives as reported by the company divided by net sales or revenue in million. (Polarity: negative)
	Tonnes	0	
	Currency	6	Total compensation of the board members in US dollars. (Polarity: negative)
	Count	13	Total number of board members which are in excess of ten or below eight. (Polarity: negative)
	Energy	0	
	Percent	19	Percentage of board members that have a cultural background different from the location of the corporate headquarters. (Polarity: positive)
	Other	10	Average number of years each board member has been on the board. (Polarity: positive)

C Description of Variables

Table C.1: Description of variables used in our dataset.

Variable	Description
TQ	Tobin's q, as defined in Equation (4.1).
ESG	The ESG score which is based on the firm's weighted performance in the underlying pillars and categories.
E	The environmental pillar score.
EM	The emissions score.
EI	The environmental innovation score.
RU	The resource use score.
S	The social pillar score.
C	The community score.
HR	The human rights score.
PR	The product responsibility score.
W	The workforce score.
G	The governance pillar score.
CSR	The CSR strategy score.
M	The management score.
SH	The shareholders score.
YR	The number of years a firm has been reporting ESG.
LEV	The leverage ratio, which is the total debt over EBITDA.
$YrOp$	The number of years in operation, i.e. firm age.
RD	The amount a firm spends on research and development.
$DivPay$	The dividend payout ratio, which is dividend over net income.

D Dynamic Panel Model

Following the explanation given by Greene [2012] and Fritsch et al. [2021], this section briefly describes a linear dynamic panel data model. The principles of a dynamic panel data regression can be derived from the traditional form of linear regression:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + ... + \beta_p x_{pi} + u_i \ \forall \ i = 1, ..., n \tag{D.1}$$

where y_i is the dependent variable, x_i are p independent variables with $\beta_1, \beta_2, ..., \beta_p$ being their coefficients and u_i is the error term for firm i. If y_i extends over several time periods t, we can further rewrite the expression to a static panel data model:

$$y_{i,t} = \beta_0 + \beta_1 x_{1i,t} + \beta_2 x_{2i,t} + ... + \beta_p x_{pi,t} + u_{i,t} \ \forall \ i = 1, ..., n, \ t = 1, ..., T. \tag{D.2}$$

A dynamic panel data model includes lags of the dependent variable, denoted by $y_{i,t-1}, y_{i,t-2}, ..., y_{i,t-r}$, where r is the number of included lags. Similarly, we can have lags of the independent variables, $x_{i,t-1}, x_{i,t-2}, ..., x_{i,t-k}$, where k is the number of lags. The expression can, in a similar fashion to Greene [2012], be written to a linear dynamic panel data model for a given dataset with cross-section dimension n and time series dimension T:

$$y_{i,t} = \boldsymbol{\alpha y_{i,t}} + \boldsymbol{\beta x}'_{i,t} + \eta_i + \varepsilon_{i,t} \ \forall \ i = 1, ..., n, \ t = 2, ..., T \tag{D.3}$$

where α is the coefficients for the lags of the vector of dependent variables $\boldsymbol{y_{i,t}}$, starting at $t-1$, and $\boldsymbol{\beta}$ is a vector of lag coefficients for the independent variables, $\boldsymbol{x_{i,t}}$. The error term $u_{i,t}$ is further separated into one unobserved, individual-specific effect η_i[1] and the remaining error term $\varepsilon_{i,t}$ [Greene, 2012]:

$$u_{i,t} = \eta_i + \varepsilon_{i,t} \tag{D.4}$$

In the context of this paper, we derive the model represented by Equation (4.5), which includes one lagged variable of the dependent variable, *TQ*, by utilizing Equation (D.3):

$$TQ_{i,t} = \alpha TQ_{i,t-1} + \beta x_{i,t} + \eta_i + \varepsilon_{i,t} \ \forall \ i = 1, \ldots, n; \quad t = 2, \ldots, T \tag{D.5}$$

[1]An example of individual fixed effects: If we were to measure the relationship between education and wage, an individual's ambition or abilities, impossible to observe and measure, would be individual fixed effect [Hausman & Taylor, 1981].

E Dynamic Panel Estimation with GMM

Under the assumption that unobserved heterogeneity exists but is fixed or time-invariant, we employ a dynamic GMM panel estimator to estimate the relationship between ESG factors score and firm performance. This estimator was introduced by Holtz-Eakin et al. [1988] and Arellano & Bond [1991], and further developed in a series of papers including Arellano & Bover [1995] and Blundell & Bond [1998] [Wintoki et al., 2012]. The following discussion is substantially based on Wintoki et al. [2012], Das [2019] and Fritsch et al. [2021]. To derive the two-step Arellano & Bond [1991] GMM estimator used in our paper, we consider the set of standard assumptions listed in Equation (E.1) (see Ahn & Schmidt [1995]), which are extensively used in the literature and the basis of the Arellano-Bond estimator [Fritsch et al., 2021].

$$\begin{aligned}
E(\eta_i) = 0 \ \forall \quad & i = 1, \ldots, n, \\
E(\varepsilon_{i,t}) = 0 \ \forall \quad & i = 1, \ldots, n; \quad t = 2, \ldots, T, \\
E(\eta_i \cdot \varepsilon_{i,t}) = 0 \ \forall \quad & i = 1, \ldots, n; \quad t = 2, \ldots, T, \\
E(\varepsilon_{i,s} \cdot \varepsilon_{i,t}) = 0 \ \forall \quad & i = 1, \ldots, n; \quad t \neq s, \\
E(y_{1,t} \cdot \varepsilon_{i,t}) = 0 \ \forall \quad & i = 1, \ldots, n; \quad t = 2, \ldots, T, \\
n \to \infty, \quad & \text{while } T \text{ is fixed, such that } \frac{T}{n} \to 0.
\end{aligned} \tag{E.1}$$

Furthermore, we consider the dynamic model of Equation (4.5), where we use the variable y instead of TQ to facilitate a broader comprehension of the model's dynamics:

$$y_{i,t} = \alpha y_{i,t-1} + \beta x_{i,t} + \eta_i + \varepsilon_{i,t} \ \forall \ i = 1, \ldots, n; \quad t = 2, \ldots, T \tag{E.2}$$

For simplicity and notational convenience, we modify Equation (E.2) by transforming it as a univariate AR(1) model where we include one lag of the dependent variable:

$$y_{i,t} = \alpha y_{i,t-1} + \eta_i + \varepsilon_{i,t} \ \forall \ i = 1, \ldots, n; \quad t = 2, \ldots, T \tag{E.3}$$

The basic estimation procedure consists of two essential steps. The first step is to write the dynamic model of Equation (E.3) in first-differenced form:

$$\Delta y_{i,t} = \alpha \Delta y_{i,t-1} + \Delta \varepsilon_{i,t} \ \forall \ i = 1, \ldots, n; \quad t = 2, \ldots, T \tag{E.4}$$

First-differencing eliminates η_i and thus any potential bias that may arise from time-invariant unobserved heterogeneity. After first-differencing, we estimate Equation (E.4) via GMM using lagged values of the explanatory variables as instruments for current changes in the explanatory variables [Wintoki et al., 2012]. The two-step Arellano & Bond [1991] GMM estimator, where the moment conditions are based on the first-differenced model similar to Equation (E.4), follows this procedure. Thus, by following the approach given by Das [2019], we derive the moment conditions utilized by the estimator. The number of moment conditions depends on T. For $t = 2$, Equation (E.4) becomes:

$$(y_{i,2} - y_{i,1}) = \alpha(y_{i,1} - y_{i,0}) + (\varepsilon_{i,2} - \varepsilon_{i,1}) \tag{E.5}$$

Here, $y_{i,0}$ is a valid instrument and the moment condition is:

$$E(\Delta \varepsilon_{i,2} \cdot y_{i,0}) = 0 \tag{E.6}$$

For $t = 3$, Equation (E.4) is:

$$(y_{i,3} - y_{i,2}) = \alpha(y_{i,2} - y_{i,1}) + (\varepsilon_{i,3} - \varepsilon_{i,2}) \tag{E.7}$$

Here, $y_{i,0}$ and $y_{i,1}$ are valid instruments since they are highly correlated with $(y_{i,2} - y_{i,1})$ while being uncorrelated with $(\varepsilon_{i,3} - \varepsilon_{i,2})$, provided that $\varepsilon_{i,t}$ are not serially correlated. The moment conditions for estimation are as follows:

$$E(\Delta\varepsilon_{i,3} \cdot y_{i,0}) = 0, \quad \text{and} \quad E(\Delta\varepsilon_{i3} \cdot y_{i1}) = 0 \tag{E.8}$$

For $t = 4$, Equation (E.4) is:

$$(y_{i,4} - y_{i,3}) = \alpha(y_{i,3} - y_{i,2}) + (\varepsilon_{i,4} - \varepsilon_{i,3}) \tag{E.9}$$

In this case, $y_{i,0}$, $y_{i,1}$, and $y_{i,2}$ are valid instruments for $(y_{i,3} - y_{i,2})$, and the moment conditions are:

$$E(\Delta\varepsilon_{i,4} \cdot y_{i,0}) = 0, \quad E(\Delta\varepsilon_{i,4} \cdot y_{i,1}) = 0, \quad \text{and} \quad E(\Delta\varepsilon_{i,4} \cdot y_{i,2}) = 0 \tag{E.10}$$

Overall, if $T = 4$, $(t = 2, 3, \text{ and } 4)$, we would have 6 moment conditions:

$$E(\Delta\varepsilon_{i,2} \cdot y_{i,0}) = 0 \tag{E.11}$$
$$E(\Delta\varepsilon_{i,3} \cdot y_{i,0}) = 0, \quad \text{and} \quad E(\Delta\varepsilon_{i,3} \cdot y_{i,1}) = 0 \tag{E.12}$$
$$E(\Delta\varepsilon_{i,4} \cdot y_{i,0}) = 0, \quad E(\Delta\varepsilon_{i,4} \cdot y_{i,1}) = 0, \quad \text{and} \quad E(\Delta\varepsilon_{i,4} \cdot y_{i,2}) = 0 \tag{E.13}$$

In this way, for period T, the set of valid instruments will be $y_{i0}, y_{i1}, \ldots, y_{i,T-2}$, and moment conditions are obtained accordingly. Table E.1 shows the instruments used for each first-differenced equation.

Table E.1: Equations in differences and instruments in levels.

Equation	**Instruments**
$\Delta y_{i,2} = \alpha\Delta y_{i,1} + \Delta\varepsilon_{i,2}$	$y_{i,0}$
$\Delta y_{i,3} = \alpha\Delta y_{i,1} + \Delta\varepsilon_{i,2}$	$y_{i,0}$, $y_{i,1}$
$\vdots$	
$\Delta y_{i,T} = \alpha\Delta y_{i,T-1} + \Delta\varepsilon_{i,T}$	$y_{i,0}$, $y_{i,1}$, $\ldots$, $y_{i,T-2}$

For the GMM estimation, let us now define $g_i(\alpha)$ as:

$$g_i(\alpha) = X_i'[\Delta Y_i - \alpha\Delta Y_{i-1}] = X_i'\Delta\varepsilon_i \tag{E.14}$$

Where the instrument matrix X_i is defined as:

$$X_i = \begin{bmatrix} y_{i,0} & 0 & 0 & \ldots & 0 & \ldots & 0 \\ 0 & y_{i,0} & y_{i,1} & \ldots & 0 & \ldots & 0 \\ 0 & 0 & 0 & \ldots & y_{i,0} & \ldots & y_{i,T-2} \end{bmatrix} \tag{E.15}$$

And ΔY_i and ΔY_{i-1} as:

$$\Delta Y_i = \begin{pmatrix} \Delta y_{i,2} \\ \vdots \\ \Delta y_{i,T} \end{pmatrix}$$
$$\Delta Y_{i-1} = \begin{pmatrix} \Delta y_{i,1} \\ \vdots \\ \Delta y_{i,T-1} \end{pmatrix} \tag{E.16}$$

Here, $g_i(\alpha)$ is a linear function of α. Therefore, the moment condition for exogeneity becomes:

$$E(X_i'\Delta\varepsilon_i) = 0 \tag{E.17}$$

Note that the instrument matrix defined in Equation (E.15) consists of the explanatory variables as instruments. Hence, under the standard assumptions given in Equation (E.1), we can rewrite Equation (E.17) as it is proposed by Holtz-Eakin et al. [1988]:

$$E(y_{i,s} \cdot \Delta u_{i,t}) = 0, \;\; t = 3, ..., T; \; s = 1, ..., t-2 \tag{E.18}$$

Equation (E.18) increases the number of moment conditions by $0.5(T-1)(T-2)$. These orthogonality conditions imply that we can use lagged levels as instruments for our differenced equations. Moreover, equivalent moment conditions can be obtained from the covariate $x_{i,t}$ [Fritsch et al., 2021], which is derived similarly as above. Using the orthogonality conditions of Equation (E.18), we carry out the Arellano-Bond GMM estimation. We define:

$$S = E\left[g_i(\alpha)g_i^{'}(\alpha)\right] = E[X_i^{'}\Delta\varepsilon_i\Delta\varepsilon_i^{'}X_i] \tag{E.19}$$

Where $g_i(\alpha)$ is given in Equation (E.14) and $g_i'(\alpha)$ is it's transposed counterpart. Under conditional heteroscedasticity, a consistent estimate is:

$$\hat{S} = \frac{1}{N}\sum_{i=1}^{N} X_i^{'}\Delta\hat{\varepsilon}_i\Delta\hat{\varepsilon}_i^{'}X_i \tag{E.20}$$

Here, $\Delta\hat{\varepsilon}_i = \Delta Y_i - \hat{\alpha}_1\Delta Y_{i-1}$. The sample moments used for GMM estimation are:

$$g_N(\alpha) = \frac{1}{N}\sum_{i=1}^{N} X_i^{'}\left(\Delta Y_i - \alpha\Delta Y_{i-1}\right) = S_{x\Delta y} - S_{x\Delta y-1}\alpha \tag{E.21}$$

Here, $S_{x\Delta y} = \frac{1}{N}\sum_{i=1}^{N} X_i^{'}\Delta Y_i$ and $S_{x\Delta y-1} = \frac{1}{N}\sum_{i=1}^{N} X_i^{'}\Delta Y_{i-1}$.

The efficient GMM estimator is obtained by solving the following minimization problem:

$$\min_{\hat{\alpha}_1} Ng_N^{'}(\alpha)\hat{S}^{-1}g_N(\alpha) = N(S_{x\Delta y} - S_{x\Delta y-1}\alpha)^{'}\hat{S}^{-1}(S_{x\Delta y} - S_{x\Delta y-1}\alpha) \tag{E.22}$$

The solution is:

$$\hat{\alpha}_1 = \left(S'_{x\Delta y-1}\hat{S}^{-1}S_{x\Delta y-1}\right)^{-1}\left(S'_{x\Delta y-1}\hat{S}^{-1}S_{x\Delta y}\right) \tag{E.23}$$

This estimator is known as the two-step Arellano-Bond GMM estimator [Das, 2019] or as the "difference" GMM estimator [Wintoki et al., 2012].

Arellano & Bover [1995] suggest that variables in levels may be weak instruments for first-differenced equations. According to Arellano & Bover [1995] and Blundell & Bond [1998], it is possible to address the limitations of the GMM estimator by also utilizing first-differenced variables as instruments for the equations in levels such that a system of equations can be created, consisting of both first-differences and level equations. This approach leads to a "system" GMM estimator, which offers an improved estimation methodology [Wintoki et al., 2012]. Table E.2 shows the instruments in differences used for equation in levels.

Table E.2: Equation in levels and instruments in differences.

Equation	**Instruments**
$y_{i,2} = \alpha y_{i,1} + \varepsilon_{i,2}$	$\Delta y_{i,0}$
$y_{i,3} = \alpha y_{i,1} + \varepsilon_{i,2}$	$\Delta y_{i,0}$, $\Delta y_{i,1}$
$\vdots$	
$y_{i,T} = \alpha y_{i,T-1} + \varepsilon_{i,T}$	$\Delta y_{i,0}$, $\Delta y_{i,1}$, $\ldots$, $\Delta y_{i,T-2}$

By making the assumption that the correlation between the unobserved effect and our explanatory variables is constant throughout the time period covered by our dataset, we have the following additional set of orthogonality conditions [Wintoki et al., 2012]:

$$E(\Delta y_{i,t} \cdot \eta_i) = 0 \;\forall\; i = 1, \ldots, n. \tag{E.24}$$

From this assumption, Arellano & Bover [1995] derive $T - 2$ additional moment conditions [Fritsch et al., 2021]:

$$E(\Delta y_{i,t-1} \cdot u_{i,t}) = 0, \quad t = 3, \ldots, T. \tag{E.25}$$

Overall, the orthogonality conditions of Equation (E.25) imply that we can use lagged differences as instruments for the levels equations.

F Robustness Results

Table F.1: Results for *Hypothesis I, II* and *III* from the two-step GMM estimator utilizing the moment conditions as outlined by Arellano & Bover [1995]. The standard errors are given in parentheses.

Variable	*Hypothesis I*	*Hypothesis II*	*Hypothesis III*
TQ_{t-1}	0.604***	0.610***	0.564***
	(0.052)	(0.052)	(0.062)
TQ_{t-2}	0.008	0.000	-0.026
	(0.056)	(0.053)	(0.068)
ESG	-0.001	-	-
	(0.001)		
E	-	0.000	-
		(0.001)	
S	-	0.000	-
		(0.001)	
G	-	0.000	-
		(0.001)	
EM	-	-	0.000
			(0.001)
EI	-	-	0.000
			(0.001)
RU	-	-	0.000
			(0.001)
C	-	-	0.002*
			(0.001)
HR	-	-	0.000
			(0.001)
PR	-	-	-0.001
			(0.001)
W	-	-	-0.002
			(0.001)
CSR	-	-	0.000
			(0.001)
M	-	-	0.000
			(0.001)
SH	-	-	0.000
			(0.001)
YR	0.005	0.004	0.005
	(0.004)	(0.004)	(0.004)
LEV	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
YrOp	-0.001	0.000	-0.001
	(0.001)	(0.001)	(0.001)
RD	0.008	0.006	0.011
	(0.005)	(0.005)	(0.006)
DivPay	-0.001	-0.001	-0.001
	(0.000)	(0.000)	(0.001)
Year dummies	YES	YES	YES
Statistical tests		**p-value**	
Arellano & Bond	0.393	0.316	0.061
J-test of Hansen	0.742	0.933	0.963
Wald Test	0.000	0.000	0.000

Note:*p<0.05;**p<0.01;***p<0.001

Table F.2: Results for *Hypothesis I, II* and *III* using the two-step Arellano-Bond GMM estimator when only including observations between 2016 and 2022. The standard errors are given in parentheses.

Variable	*Hypothesis I*	*Hypothesis II*	*Hypothesis III*
TQ_{t-1}	-0.188	-0.183	-0.150
	(0.217)	(0.210)	(0.197)
TQ_{t-2}	-0.062	-0.060	-0.044
	(0.131)	(0.130)	(0.116)
ESG	0.003	-	-
	(0.003)		
E	-	0.001	-
		(0.002)	
S	-	0.002	-
		(0.002)	
G	-	0.001	-
		(0.002)	
EM	-	-	0.002
			(0.002)
EI	-	-	-0.001
			(0.001)
RU	-	-	0.000
			(0.003)
C	-	-	0.001
			(0.003)
HR	-	-	0.003
			(0.002)
PR	-	-	0.001
			(0.001)
W	-	-	-0.003
			(0.003)
CSR	-	-	-0.001
			(0.001)
M	-	-	0.000
			(0.001)
SH	-	-	0.001
			(0.001)
YR	-0.007	-0.007	-0.006
	(0.007)	(0.006)	(0.007)
LEV	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)
YrOp	-0.007	-0.007	-0.006
	(0.007)	(0.006)	(0.007)
RD	-0.010	-0.010	-0.017
	(0.010)	(0.010)	(0.008)
DivPay	-0.001	-0.001	0.000
	(0.000)	(0.001)	(0.001)
Year dummies	YES	YES	YES
Statistical tests		**p-value**	
Arellano & Bond	0.323	0.316	0.061
J-test of Hansen	0.148	0.933	0.963
Wald Test	0.000	0.000	0.000

Note:*p<0.05;**p<0.01;***p<0.001

Table F.3: The distribution of 792 firm observations over the time period from 2016 to 2022.

Year	2016	2017	2018	2019	2020	2021	2022
Aluminum	10	13	19	22	26	29	1
Iron & Steel	78	90	95	107	120	132	50
Total	88	103	114	129	146	161	51

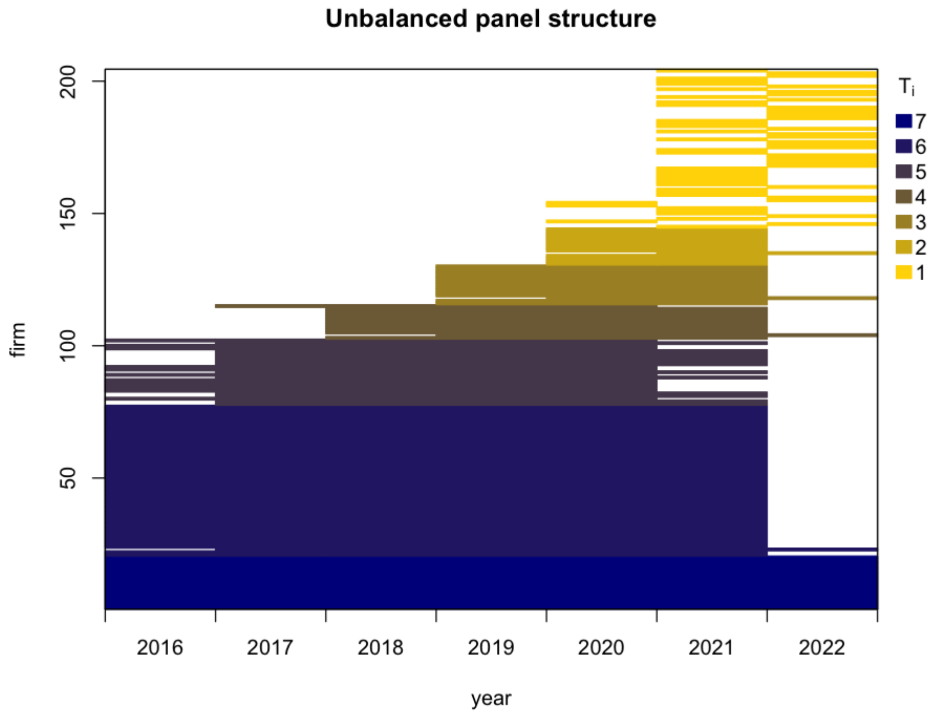

Figure F.1: The number of firms that have reported ESG scores in each time period from 2016 to 2022. T_i is the number of observations that firm i has and blank spaces indicates missing ESG scores.

NTNU

Norwegian University of
Science and Technology