



UNIVERSIDADE CATÓLICA PORTUGUESA

ESG Framework and Financial Performance:

*A Principal Component Analysis and Challenges
for Small Investors in Noise Reduction*

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Católica Porto Business School

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Final Assignment in the modality of Dissertation presented to Universidade
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by

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In the midst of chaos, there is also opportunity.

– Sun Tzu.

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RESUMO

Esta pesquisa propõe uma forma eficaz de reduzir o ruído nas pontuações ESG, permitindo que pequenos investidores compreendam rapidamente o impacto da sustentabilidade no desempenho financeiro das empresas. Começa com uma revisão abrangente das estruturas de sustentabilidade e da ascensão de ESG como um conceito fulcral na literatura atual. Em particular, indiquei a importância de modelos de CSR como a Pirâmide de *Carroll*, a Teoria de *Triple Bottom Line* e a Teoria de *Stakeholder* na explicação da atual estrutura ESG. Posteriormente, analisei a conexão entre cada pilar ESG e a estrutura ESG em finanças. Nomeadamente, explorei o impacto da sustentabilidade nos retornos das ações, denotando as incoerências entre diferentes investigadores e os problemas com as pontuações ESG. No final da Revisão de Literatura, mostrei os desafios que os pequenos investidores enfrentam ao avaliar ESG. Para explorar o ruído ESG, utilizei como amostra o *S&P 500* em 2022, com cinco pontuações ESG diferentes: *Bloomberg*, *Refinitive*, *Sustainalytics*, *Truvalue* e *FTSE Russell*. A análise mostrou que diferentes avaliadores apontam para uma relação diferente entre ESG e retornos das ações. Por exemplo, o *Truvalue* e o *Sustainalytics* apontam para um resultado negativo, enquanto os restantes para uma relação positiva. Para classificar a situação e obter uma relação única, apliquei uma Análise de Componentes Principais (PCA) para reduzir o ruído nos dados, terminando com uma relação positiva entre o desempenho financeiro e sustentável das empresas.

Palavras-Chave: Ruído ESG; Impacto no mercado; Pontuação ESG; Regulação de ESG; Quadros de Sustentabilidade; Análise de Componente Principal.

Número de Palavras: 9 802 words

ABSTRACT

This research proposes an effective way of reducing noise in Environmental Social and Governance (ESG) Scores, allowing small investors to quickly understand the impact of sustainability on financial performance. It starts with a comprehensive review of sustainability frameworks and the rise of ESG as a critical concept in today's literature. Specifically, I have denoted the importance of CSR models like Carroll's Pyramid, Triple Bottom Line Theory and Stakeholder Theory in explaining the current ESG framework. Afterwards, I analysed the connection between each ESG pillar and the ESG framework in finance. Mainly, I have explored the impact of sustainability in stock returns, denoting the incoherencies across different researchers and problems with the ESG Scores. By the end of the literature review, I have shown the challenges that small investors face when assessing ESG. To exploit noise in ESG, I have used a cross-section of the S&P 500 in 2022 with five different ESG scores: Bloomberg, Refinitive; Sustainalytics, Truvalue and FTSE Russell. The analysis have shown that different raters point to a different relation between ESG and stock returns; precisely, Truvalue and Sustainalytics both point to a negative outcome while the remaining point is a positive relation. To sort the situation and get a single relation, I have applied a principal component analysis (PCA) to reduce noise in the data, ending up with a positive relation between firms' financial and sustainable performance.

Key Words: ESG Noise; Market Impact; ESG Score; Regulatory Standardization of ESG; Sustainability Framework; Principal Component Analysis.

Word Count: 9 802 words

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INTRODUCTION

In the 20th century, the neoclassical theory defined a *firm* as an organization built to create wealth for its shareholders. For Friedman (1970), firms should refrain from engaging in environmental and social policies if it implies a decrease in the organization's profitability, as he saw that those types of responsibilities should be taken care of by the individuals and not the enterprise.

However, there has been a significant shift in this paradigm in recent years, driven by a series of environmental catastrophes that have highlighted the need for increased *Environmental, Social, and Governance (ESG) Consciousness*. One example is the explosion of the offshore drilling rig Deepwater Horizon in 2010, operated by BP, the biggest accidental oil leak of all time [1].

Moreover, in a survey conducted by Deloitte [2], in 2023, 2 016 Chief Experience Officers (CxOs) from 24 countries ranked the issues most pressing to their organisations and rated climate change as a “top three issue”, ranked ahead of seven others, including innovation, competition for talent, and supply chain challenges. Also, around 75% of CxOs said their organisations had increased their sustainability investments in 2022. The survey also points out that companies feel moderate-to-large pressure to act on climate change from many stakeholders, from the board/management to customers to employees.

This shift is evident in finance through the increasing demand for *ESG Investments*, also known as *Sustainable* or *Responsible Investments*. It refers to an investment approach that takes traditional financial considerations plus a non-financial part that captures the externalities of a business and how they are internalized. In October 2022, asset managers expected to increase their ESG investments by 84% until 2026 [3].

One key indicator critical in evaluating ESG in *Sustainable Finance* is the *ESG Score*, a metric that captures and assesses a company's sustainability and ethical performance. Yet, unlike Credit Ratings with a 0.99 correlation, ESG Scores have different correlations (Berg *et al.*, 2022). In other words, there is a degree of dissimilarity or need for alignment across different ratings. Such variability and lack of consistency make ESG Scores a noisy metric.

Windolph (2011) identifies six causes that hinder a transparent and objective rating, such as lack of standardisation, lack of credibility of information, bias, trade-offs, lack of transparency, and lack of independence. The key reason for the differences across the scores is rater's methodology, making every score unique with a different interpretation.

In finance, information is crucial, and according to classical literature, more information is better than less. However, humans are limited and cannot analyse vast amounts of data, transforming the decision-making process in a complex situation, especially when the data is incoherent and elaborate. Thus, perceiving ESG data becomes challenging for individual investors aiming to achieve a sustainable portfolio.

Hence, I will be conducting research that can be split into two main parts: (i) Creating a less noisy metric; and (ii) Analysing the impact of that metric on stock returns. To create the new variable, I will be conducting a *Principal Component Analysis* (PCA) introduced by Pearson (1901) and further developed by Hotelling (1933). The PCA transforms the original variables into a new set of uncorrelated variables known as *Principal Components*. These main components are ordered so that the First Component captures the maximum variance in the data, the Second Component takes the following maximum variance orthogonal to the first, and so on. By doing so, PCA reduces dimensionality while preserving the most significant variation in the data. Such a process will allow a noise reduction by capturing the dominant patterns in the dataset and visualising the critical drivers of noise in a lower dimensional space, facilitating the identification of clusters, trends and outliers that might not be easy to identify in the original high-dimensional area.

Therefore, CHAPTER I of the project will be the Literature Review, which will focus on previous studies regarding various sustainability frameworks to comprehend the significance of ESG. This will be followed by an analysis of how ESG impacts stock returns and current ESG investment strategies. This chapter aims to provide a clear understanding of why ESG stands out as the primary framework for evaluating a firm's sustainability and to emphasize the importance of obtaining a reliable measure of it.

CHAPTER II will comprehensively explore the primary dataset utilized in this study. Specifically, it will explore the distinct aspects of ESG Scores, highlighting their

critical characteristics in conjunction with the pertinent financial data. S&P 500 Index during the year 2022 was selected as the basis for this study due to its popularity and industry diversity.

Moving forward, CHAPTER III will offer an in-depth examination of the applied methodology and the subsequent empirical analysis. This chapter will explain the principal component analysis and the creation of a straightforward instrument to assess the ESG factor.

In the subsequent section, CHAPTER IV, I will present and dissect the outcomes derived from the empirical analysis. This chapter's central focus will be on the comprehensive interpretation and discussion of the results.

In the CONCLUSION I will summarise the project and critically appraise certain limitations encountered during the research process and extend its horizon to suggest potential avenues for future research exploration.

CHAPTER I: LITERATURE REVIEW

In this chapter, thanks to the previous empirical and theoretical research, I will review four significant discussions in the ESG field: (1) the emergence of sustainability frameworks; (2) the current ESG regulations; (3) the impact of ESG in equity markets; and (4) ESG investment strategies.

1. Emergence of a Sustainability Framework

In recent decades, the global business landscape has witnessed a paradigm shift in its corporate responsibility and sustainability approach. This evolution has given rise to a comprehensive framework encompassing various theories and principles, all aimed at fostering ethical business practices and addressing the complex challenges of the modern world.

Following Singhania and Saini (2023), it will be provided an integrative overview of the first big sustainability framework, Corporate Social Responsibility (CSR), including three theories that expanded the concept of sustainability in businesses and represent three key milestones for the conception of ESG: (i) Carroll's Pyramid of CSR; (ii) Triple Bottom Line (TBL) theory; and (iii) Stakeholder Theory. Afterwards, it will be presented ESG's framework.

1.1. Corporate Social Responsibility

The origins of CSR can be tracked to 1953 when Howard R. Bowen (1953) published the book "Social Responsibilities of the Businessman", where CSR was defined as *the obligations of businessmen to pursue those policies, to make those decisions, or to follow those lines of action which are desirable in terms of the objectives and values of our society*. Hence, given this ambiguous definition, corporations struggle to implement CSR strategies into their business models (Cochran, 2007).

Therefore, CSR research has been focused on preparing a practical and usable framework to implement CSR strategies (Lindgreen *et al.*, 2012; Ingham and Havard, 2017; Baumann-Pauly *et al.*, 2013). According to Brin and Nehme (2019) the three main CSR theories are: (i) The Carroll Theory, (ii) The Triple Bottom Line Theory, and (iii) The Stakeholder Theory.

1.1.1. Carroll's Pyramid of CSR

Carroll (1991) developed a specific theory to describe how corporations interact with their community, known as *Carroll's Pyramid of CSR*. This pyramid comprises four obligations that form the basis for a business's responsibility towards society: (i) *Economic Responsibility*, which is the obligation of a business to generate profits, emphasising that profits must be reinvested to sustain business growth; (ii) *Legal Responsibility*, that involves respecting laws and regulations and accepting the rules for fair business practices; (iii) *Ethical Responsibility*, corporations are expected to act as good citizens in society, making decisions that benefit the community even if not legally mandated; (iv) *Philanthropic Responsibility*, this is a voluntary activity driven by a business's desire to participate in social initiatives that go beyond legal requirements. It demonstrates the company's commitment to giving back to society, enhancing its reputation, and exposing a positive image of good citizenship.

The main idea is to apply CSR projects sequentially, starting with Economic Responsibility as the foundation and then progressively incorporating Legal, Ethical, and Philanthropic Responsibilities.

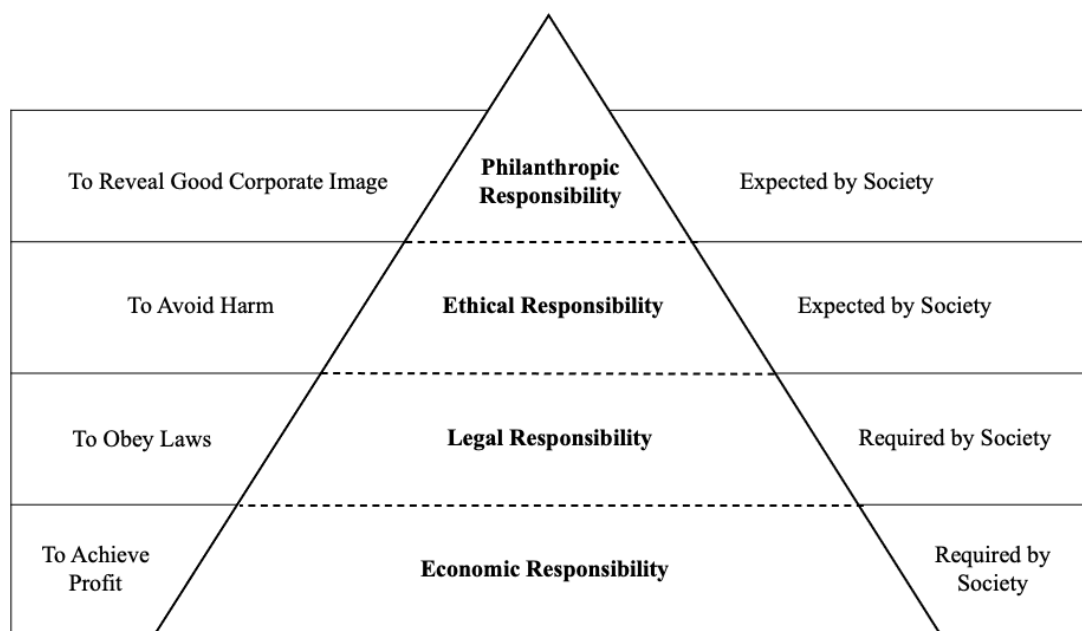


Figure 1 (Carroll's Pyramid of CSR. Carroll, A.B., 2016)

However, this theory encompasses various challenges, like the lack of emphasis on environmental concerns, which is one of the main focuses of today's literature (Billio, 2020). Furthermore, there is also a lack of integration since Carroll's CSR Pyramid often treats Economic, Legal, Ethical, and Philanthropic Responsibilities as separate

categories¹, leading to inefficiency, as different departments will operate in isolation, missing opportunities to optimize resources and increase risk management challenges.

1.1.2. Triple Bottom Line Theory

John Elkington (1988) created the TBL Theory, a CSR framework with three dimensions of performance: (i) *Economic*, (ii) *Social* and (iii) *Environmental*, each obtaining sustainable results. According to Andrew Savitz (2006), the TBL *captures the essence of sustainability by measuring the impact of an organisation's activities on the world (...) including both its profitability and shareholder values and its social, human, and environmental capital*. This diverges from conventional reporting frameworks since it encompasses environmental and social indicators that can challenge determining suitable measurement means (Slaper and Hall, 2011).

The TBL dimensions, also known as the 3Ps (People \approx Social, Planet \approx Environmental, and Profits \approx Economic), do not have a shared way of being measured. Profits are measured in dollars, but no standard unit for measuring social capital or environmental health exists. Finding a common way to measure them is challenging. Thus, although the TBL concept allows flexibility to implement sustainable strategies when putting them into practice, some challenges may arise, mainly regarding measuring each category, finding applicable data, and calculating the policy's contribution to sustainability (Slaper and Hall, 2011).

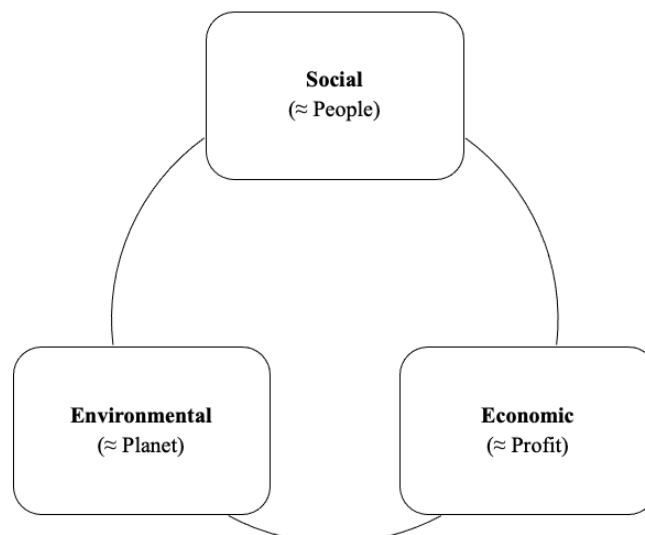


Figure 2 (Triple Bottom Line)

¹ In contrast, the ESG framework integrates these aspects into a cohesive whole, emphasizing that sustainability and responsible practices should be embedded throughout a company's operations.

1.1.3. Stakeholder Theory and Social Responsibility

Stakeholders are *groups with a stake in or claim on the firm* (Edward Freeman and Evan, 1990). Examples include suppliers, customers, employees, stockholders, the local community, and managers. According to the theory, a company's success depends on its ability to integrate and manage stakeholder relationships (Freeman and McVea, 2005). As a descriptive theory, stakeholder theory has been widely used to describe the nature of the firm and how managers think about the interests of corporate constituents (Brenner and Cochran, 1991).

From an instrumental perspective, the theory is used to identify the connection between stakeholder management and the CSR approach (Kotter, 1992). A firm's board of directors should incorporate at least one person from each stakeholder group to align all interests. This alignment ensures that the firm's strategy is fully attuned to all stakeholders' goals (Brin and Nehme, 2019).

Still, there are some points of improvement. Firstly, the theory can be vague and lacks a clear framework for prioritizing conflicts across stakeholders. And secondly, the theory does not provide a mechanism for holding companies accountable for their stakeholder considerations.

1.2. ESG Framework

ESG framework captures: (i) *Environmental* aspects and climate changes, such as energy consumption and CO₂ emissions; (ii) *Social* aspects like the relationships of an entity with people and institutions in the respective communities; and (iii) *Governance* concerns as business ethics and corruption (Henisz, Koller and Nuttall, 2019) which has been wide spreading global implications on business sustainability (Singhania and Saini, 2023).

It is difficult to track where ESG framework started, however, according to Kaempfer, Lehman and Lowenberg (1987) the concept caught momentum since 1985 after a series of divestments in the US stock market followed by a divestment bill in the pension fund industry in support of the South Africans' fight against unjust apartheid.

Ever since then, most of the global initiatives have been confined to environmental conservation for ensuring sustainability. Some important milestones were the *Kyoto Protocol* [5], in 1997, the introduction of the *Principles of Responsible Investment* (PRI) [6], in 2005, the *Sustainable Development Goals* (SDGs) [7],

introduced by the United Nations (UN) in 2015, and the *Paris Agreement* [8], published in 2016.

A country's Legal, Social, and Environmental landscape has strong impacts on a business ideology and practices (Ortas *et al.*, 2015; Baldini *et al.*, 2018). Also, these factors affect the mindset of individual and institutional investors, both carrying a heavy weight in influencing and stimulating the process of ESG (Dyck, Walker and Caza, 2019; Clementino and Perkins, 2021). In the PWC *Consumer Intelligence Series Survey on ESG* [9], in 2021, 83% of consumers agreed that firms should actively be shaping ESG best practices.

Thus, if the stakeholders' expectations form the basis for business sustainability and are reflected in the firm's actions, there is a clear link between ESG Reporting and Stakeholder Theory (Freeman and McVea, 2005). Firms must publish information related to accountability and sustainability actions to satisfy shareholders' demands (Aras and Crowther, 2009).

A complete analysis between ESG and all the previous CSR theories can be found on Appendix A: CSR and ESG Theories

2. Navigating ESG Regulations

In a PWC Report in 2021 [9], 91% of managers believe that their company has the duty to act on ESG issues. Hence, *Corporate Responsibility Reporting* has reflected positive signs of improvement around the world due to the adoption of mandatory and voluntary regulations.

Regarding the financial field, widely accepted benchmarks, as Global Reporting Initiative (GRI) and Sustainability Accounting Standards Board (SASB) have contributed to an increase sustainability within financial reports (Singhania and Saini, 2023).

2.1. Global Reporting Initiative (GRI)

The Global Sustainability Standards Board (GSSB) [10] issues the GRI framework to ensure transparency in an organization's contributions to sustainable development. This framework allows organizations to publicly disclose their foremost impacts on the economy, environment, and society, including their effects on human rights and how they manage these impacts. This process enhances the visibility of an organization's effects and reinforces its responsibility.

The GRI Standards are rooted in responsible business conduct expectations outlined in authoritative intergovernmental instruments, such as the Organisation for Economic Cooperation and Development (OECD) Guidelines for Multinational Enterprises and the United Nations (UN) Guiding Principles on Business and Human Rights. It is important to emphasize that the GRI Standards do not establish benchmarks, thresholds, goals, targets, or value judgments regarding performance.

Structured as an interconnected system, the GRI Standards comprise three categories: GRI Universal Standards, GRI Sector Standards, and GRI Topic Standards. An organization might identify numerous impacts warranting reporting. When employing the GRI Standards, organizations prioritize reporting on subjects that hold most significance regarding their effects on the economy, environment, society, and human rights.

2.2. Sustainability Accounting Standards Board (SASB)

SASB [46] is an independent non-profit organization founded in 2011 that has developed a set of industry-specific standards for publicly traded companies' disclosure of material sustainability information in their financial filings. SASB's goal is to help companies identify and report on the sustainability factors that are most relevant to their industry and business model. More precisely, SASB standards are available for 77 industries, identifying the sustainability-related risks and opportunities most likely to affect an entity's cash flows, access to finance and cost of capital over the short, medium, or long-term and the disclosure topics and metrics that are most likely to be helpful to investors.

Since 2022, the SASB has played an essential role in the first two IFRS sustainability standards: (i) IFRS S1, General Requirements for Sustainability-Related Disclosures, and (ii) IFRS S2 Climate-Related Disclosures.

On the one hand, IFRS S1 outlines general prerequisites for divulging financial data related to sustainability, and on the other hand, IFRS S2 focuses on disclosures related to climate factors. These standards include stipulations demanding the revelation of crucial data regarding an organization's notable sustainability-linked risks and opportunities, a critical aspect for investors to assess the entity.

Both standards are slated for implementation for reporting periods commencing on or after January 1, 2024. Nonetheless, early adoption is permissible. The obligatory application of these standards is contingent on their incorporation into relevant laws within a jurisdiction.

3. ESG and Stock Returns

The United Nations Global Compact Initiative [12] settled the goal of regrouping three of the main ethical finance pillars: (1) *Environmental*; (2) *Social*; (3) *Governance*. Since then, efforts to understand the impact of ESG on the stock market have grown exponentially.

In this section, I will address the Noise problem in ESG, looking at all the challenges in assessing the effect of sustainability in the equity markets. Initially, the analysis will focus on each pillar, and then I will go through the effect of the entire framework on financial markets.

3.1. ESG Pillars and Financial Returns

Currently, much of the literature is trying to define the relationship between *Environmental* and *Financial Performance* (Billio, 2020). Most conclusions point to a positive relationship between greener firms and stock returns, showing that eco-friendly firms benefit from higher stock returns than the lesser green competition (Manrique and Martí-Ballester, 2017; Derwall *et al.*, 2005). The positive relation can be explained from a regulatory point of view, since most governments punish those who do not comply with the legally established thresholds (Darnall, Henriques and Sadorsky, 2008) by fining or even removing operating licenses (Sarkis, Gonzalez-Torre and Adenso-Diaz, 2010). Such legislation is common in developed countries but sometimes weak in emergent economies (Berliner and Prakash, 2013; Cui, Liang and Lu, 2015). Weak Environmental Regulation, denoted by a lack of solid and effective penalties, does not incentivise firms to change their actions, making results differ between developed and developing economies (Manrique and Martí-Ballester, 2017).

Furthermore, not only legislators are concerned with the Environment, but Financial Institutions² and Investors are starting to increase Sustainable Investments aiming for the mitigation of the Environmental Risks³ in their portfolios (Chan and Welford, 2005). Hence, Investors react positively to news regarding superior environmental performance and badly to the opposite scenario differentiating firms from

² Banks in wealthy and developing nations already have systems in place to take Environmental Risks into account, refrain from funding operations that cause pollution, and have loans available to finance green transactions.

³ The Environmental Risk is the likelihood of injury, disease, or death from exposure to a potential environmental hazard [13].

developed and developing economies⁴ (Endrikat, 2016; Cordeiro and Tewari, 2015).

Regarding the *Social Pillar*, Edmans (Edmans, 2011) found a significantly positive relation between employees' satisfaction and long-term stock return, leaning the social pillar in the same direction as the Environmental Pillar. Even human relation theories argued in favour of the previous findings, as they saw satisfaction might benefit shareholders through two mechanisms: (1) *Motivation* and (2) *Retention*.

In traditional manufacturing firms, *Motivation* was easily observed through workers' output (Taylor, 1911). However, such view is obsolete. *Motivation* is commonly defined as the activation or energization of goal-oriented behaviour, which is affected by environmental forces (e.g., organizational reward systems, the nature of the work being performed) or forces inherent in the person (e.g., individual needs and motives). The Expectancy Theory, first introduced by Vroom and Deci (edited by Victor H. Vroom and Edward L. Deci, 1970), offers valuable insights into the connection between work motivation and enhanced performance since motivation is a multiplicative function of (i) *Valence*⁵; (ii) *Instrumentality*⁶; (iii) *Expectancy*⁷. Thus, in the workplace context, when workers perceive a strong correlation between their efforts, performance, and eventual rewards, their motivation to excel increases, driving them to acquire the necessary skills, knowledge, and resources, contributing to improved job performance. Consequently, better performance on corporate social initiatives leads to better financial performance (Vong and Wong, 2013).

The second mechanism, *Retention*, can benefit shareholders in many ways, for example: (i) *reducing turnover costs* since high employee turnover results in substantial costs associated with recruitment, training and onboarding (Hom *et al.*, 2012); (ii) *increasing productivity*, because retained employees tend to have a deeper understanding of their roles and the company's operations, which leads to higher productivity levels, contributing to improved overall performance (Delaney and Huselid, 1996); or (iii) *having a positive impact on organizational culture*, since a strong culture improves employee satisfaction, engagement, and alignment with company

⁴ All these previous statements suit the Stakeholder Theory, as firms change their attitude to fit the needs of the different stakeholders, accordingly government and investors.

⁵ Defined as the value of perceived rewards.

⁶ Defined as the belief that acceptable performance will produce desired rewards.

⁷ Defined as the perceived probability that effort will lead to good performance goal.

goals, ultimately enhancing performance and shareholder value (Denison and Mishra, 1995).

Governance is also a very popular pillar among researchers. Firms with *Clean Governance Practices* like the independence of the board of administration tend to have better stock performance (Gompers, Ishii and Metrick, 2003; Velte, 2017; Tarmuji, Maelah and Tarmuji, 2016), and tend to be more transparent regarding their operations which builds confidence among investors pushing stock prices to higher levels (Bhagat and Bolton, 2008). Furthermore, firms with more demanding governance frameworks are more likely to have stronger risk management practices, reducing the likelihood of adverse events that could negatively impact stock returns (Black, Jang and Woochan Kim, 2006).

3.2. ESG Framework and Financial Returns

Most studies stress the positive impact of ESG in line with the individual pillars analysis (Billio *et al.*, 2021). For example, Zhao *et al.* (2018) found that ESG significantly positively impacts financial performance in China. Brogi and Lagasio (2019) draw the same conclusions in the US, denoting a stronger effect in the banking sector. Such findings can be explained by the reduction in the cost of capital and higher expected growth caused by ESG practices (Ould Daoud Ellili, 2020). Both factors arise due to better ESG risk management (Ioannou and Serafeim, 2015). This makes firms avoid costly legal disputes, regulatory penalties, and reputation damage, ultimately leading to a more stable business.

However, some studies point to different conclusions. For example, Landi and Sciarelli (2019) pointed out the absence of statistical impact and Miralles-Quirós *et al.* (2019) for a fragile effect.

These controversies emerge due to several factors:

- i. *ESG Data Variability*: ESG data is gathered from various sources, such as company disclosures, outside vendors, and regulatory filings. However, there can be wide variations in the accuracy, reliability, and scope of ESG data. While some businesses provide ESG data in great depth and transparency, others make bare-bones or ambiguous disclosures.
- ii. *Materiality Dilemma*: materiality involves identifying ESG issues most relevant to a company's financial performance and stakeholder interests.

However, material concerns vary depending on the sector, region, and business strategy. Carbon emissions, for instance, can be crucial to an energy company but not as much to a software company. When assessing which ESG issues are material, companies must consider their situation. This complexity makes it challenging to develop a universally applicable method for materiality assessments.

- iii. *Market Conditions*: ESG's financial impact is influenced by outside variables like societal trends, legislative changes, and economic conditions. Favourable or unfavourable external developments might influence investor perception of ESG issues. For instance, more demand for businesses that practice environmental responsibility may result from growing awareness of climate change. In contrast, investors may place less emphasis on ESG during economic downturns as they seek immediate financial security.

3.3. Noise in ESG Scores

The most popular mechanism of measuring ESG is the *ESG score*, where raters offer a commercial service to investors by providing third-party assessments of firms' ESG Performance (Berg *et al.*, 2022).

The information used by rating agencies is gathered from various sources, including company disclosures, regulatory filings, news, articles, and third-party suppliers. Depending on their significance to the rating agencies, different ESG aspects are given varying weights. Moreover, defining what constitutes material can differ, resulting in conflicting evaluations of the ESG Performance of the same company. Each rating agency uses a different formula, including intrinsic algorithms and qualitative assessments, to determine ESG Scores.

Hence, Berg *et al.* (2022) argue that ESG ratings are noisy and can contain errors or inconsistencies due to various factors such as subjective judgments, varying methodologies, or lack of standardized criteria. The Noise makes it difficult to assess the relationship between ESG Performance and Stock Returns accurately.

Furthermore, Li (2022) argued that as credit raters move to this field, there will

be an increase in the conflict of interests⁸ that will bias the scores making them even more noisy. They arrive at this conclusion by looking at the Viego Eiris and RobecoSAM acquisition by Moody's and S&P, respectively. The results were evident: firms with previous relations with the raters were issued higher ESG Scores than those without.

So, due to all the controversies and complexity around evaluating ESG, ESG Scores have been highly criticised by regulators [14], practitioners [15], and academics (Christensen, Serafeim and Sikochi, 2022).

Still, ESG Scores provide helpful information for investors regarding a firm's sustainability. Berg *et al.* (2022) argued that removing the noise from the scores will show a powerful effect between a firm's Financial and Sustainability Performance. Therefore, investors must consider ESG in their valuation models.

⁸ Credit rating agencies have faced various conflicts of interest in their operations. For example, since they rely on issuer fees for their income, they may be motivated to provide favourable ratings to maintain and attract business from issuers. Plus, the financial dependence on issuers can compromise the independence and objectivity of credit rating agencies. This conflict of interest came under intense scrutiny during and after the global financial crisis of 2008. At that time, credit rating agencies were criticized for assigning high ratings to complex financial products that ultimately proved to be extremely risky. These favourable ratings contributed to the mispricing of assets and played a role in the crisis. In response to these concerns, regulatory reforms were introduced to enhance transparency, reduce conflicts of interest, and improve the accountability of credit rating agencies.

4. ESG Investments

This section will show the differences between *Individual* and *Institutional Investors* to demonstrate the challenges of Individual Investors when assessing the *ESG Factor*.

4.1. Individual Investors vs. Institutional Investors

It is possible to split investors into two categories: (1) *Individual Investors* and (2) *Institutional Investors*. On the one hand, we have the *Individual Investor*, or *Retail Investor*, a person who invests their own money, usually through an online broker, bank, or mutual fund [16]. On the other hand, *Institutional Investors* are corporations, trusts or other legal entities that invest in financial markets on behalf of groups or individuals, including current and future generations [17].

Some common characteristics of *Individual Investors* are:

- i. *Limited Resources*: individual investors often have limited financial resources when compared to institutional investors, which might impact their ability to diversify their portfolios.
- ii. *Emotional Factors*: individual investors may be more prone to emotional decision-making, leading to behaviours like buying at market peaks due to FOMO (Fear of Missing Out) or selling during market downturns out of fear.
- iii. *Lack of Expertise*: many individual investors need more expertise and research capabilities of institutional investors, which can affect their investment strategies and outcomes.

While some critical characteristics of *Institutional Investors* are:

- i. *Professional Expertise*: these institutions employ experienced investment professionals, analysts and researchers who conduct in-depth analyses to exploit market opportunities.
- ii. *Diversification*: due to the available funds, they can build highly diversified portfolios across different asset classes minimising the idiosyncratic risk.

- iii. *Market Impact*: these investors are responsible for more than US\$70 trillion in investable assets wielding significant influence over capital markets [17].

In conclusion, they differ in size, approach, and impact. Thus, it is notorious the advantage of Institutional Investors in wealth maximisation. The difference is even more significant in the ESG field because Institutional Investors are experts who can easily retain and examine large amounts of noisy information. In contrast, due to the lack of resources, Individual Investors might need help cleaning the ESG Ratings to analyse a company's sustainability performance due to all the materiality issues around it.

A summary of the information can be found in Appendix B: Individual vs. Institutional **Investors**.

4.2. Sustainable Investment Strategies

According to the Global Sustainable Investment Alliance (GSIA) [18] in 2020, the principal strategies in ESG were:

- i. *Impact (or Community) Investing*: private investments dedicated to specific projects solving social and environmental issues, such as renewable energy use and social housing investments.
- ii. *Positive (or Best-in-Class) Screening*: selection of the best ESG-performing companies within a specific business sector, all other conditions being equal. It corresponds to the exclusion of companies not meeting certain performance thresholds.
- iii. *Sustainability-Themed Investing*: targeted investments, including only activities related to the chosen theme (e.g., clean energy, pollution reduction, low carbon emissions, water resources management, sustainable agricultural activities).
- iv. *Norm-Based Screening*: investing only in stocks respecting minimum thresholds of ethical business practices based on international principles.
- v. *Corporate Engagement and Shareholder Action*: exercise the shareholders' rights to influence corporate behaviour through direct dialogue with corporate management and proposal submissions.

- vi. *Negative (or Exclusionary) Screening*: excluding specific unacceptable or controversial sectors or companies whose activities may harm the environment or society.
- vii. *ESG Integration*: systematic and explicit inclusion of ESG factors into financial analysis. Given this type of evaluation's qualitative and subjective character, the role of ESG rating agencies is crucial.

Global Growth of Sustainable Investing Strategies 2016-2020

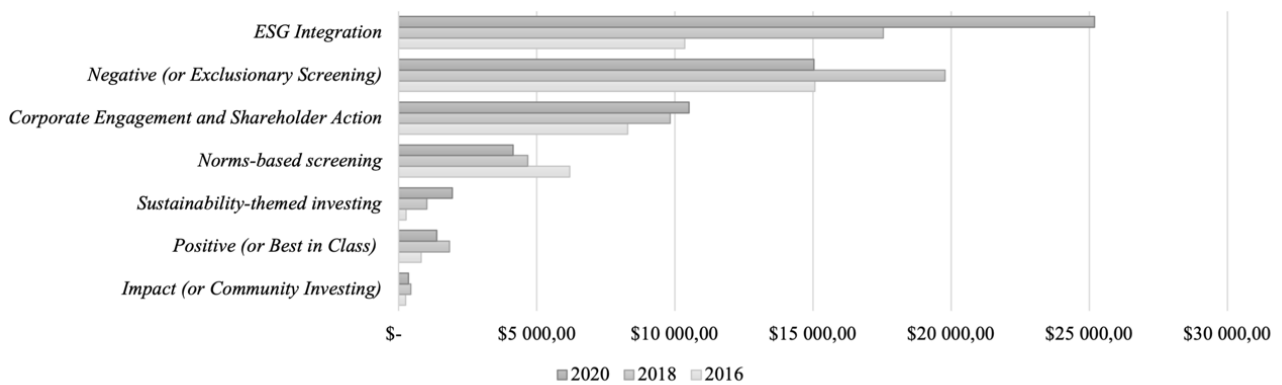


Figure 3 (“Global Growth of Sustainable Investing Strategies 2016-2020”, *Global Sustainable Investment Review 2020*, asset values are expressed in billions of US dollars)

According to the most recent GSIA Report [18], published in 2020, the highest peaked strategy for open funds is the *ESG Integration* (gathering US\$ 25.195 billion), with a 43% growth from 2018 to 2020. These only emphasise the importance of building a clean and straightforward measure to analyse the ESG Factor, namely the ESG Scores, allowing investors to build a reliable and robust financial analysis.

CHAPTER II: DATA

5. ESG Ratings and Scores

To maximise the depth and breadth of my dataset, I aggregated data from multiple ESG Scores providers. TruValue and FTSE Russell ESG Scores were accessed via FactSet, Refinitive ESG Score was obtained through Eikon Refinitive, and information sourced from Sustainalytics and Bloomberg scores was accessed through the Bloomberg platform.

Due to the differences in methodology across raters, this first section will be dedicated to examining the five ESG Scores used in this research: Bloomberg, FTSE Russel, Refinitiv, Sustainalytics and Truvalue.

5.1. Bloomberg⁹

The collaboration between Bloomberg and SASB in 2008 led to the development of the *Bloomberg ESG Score* which provides investors with valuable insights into companies' sustainable practices. This score serves as a metric for assessing *ESG Performance*¹⁰. The evaluation process involves an extensive search across various public documents, and sources companies use to communicate their ESG Information, such as CSR or Sustainability Reports, Annual Reports, and more. Additionally, direct engagement with companies is used to evaluate the disclosure of quantitative and policy related ESG data.

The amassed data is then categorized into 120 ESG Indicators¹¹ covering qualitative and quantitative aspects. Bloomberg's team of researchers examines the comprehensiveness of reporting across these 120 indicators, culminating in the annual issuance of a single numerical value – the *ESG Disclosure Score*. This score, ranging from 0 to 10, measures the depth and breadth of reporting.

⁹ Information sourced at [19], [20], [21] and [22].

¹⁰ Defined as how well a company integrates sustainability into its business practices and decision-making to create positive outcomes for the Environment, Society, and its long-term viability.

¹¹ Such as carbon emissions, climate change effect, pollution, waste disposal, renewable energy, resource depletion, supply chain, political contributions, discrimination, diversity, community relations, human rights, cumulative voting, executive compensation, shareholders' rights, takeover defense, staggered boards and independent directors.

To ensure accuracy, Bloomberg assigns varying weights to each data point based on its significance. Factors like greenhouse gas emissions hold more weight than others. Moreover, the scoring system is fine-tuned to accommodate different industry sectors and entities not covered by Bloomberg's ESG analysis or those that choose not to disclose their ESG-Related Information.

In essence, the Bloomberg ESG Score Scale, can be described as follows:

LAGGARD		AVERAGE			LEADER	
CCC	B	BB	BBB	A	AA	AAA
(0 – 1.429)	(>1.429 – 2.857)	(>2.857 – 4.286)	(>4.286 – 5.714)	(>5.714 – 7.143)	(>7.143 – 8.571)	(>8.571 – 10)

Figure 4 (Bloomberg ESG Score Scale)

SASB and GRI standards can be used by third parties such as Bloomberg to inform ESG Scores. However, the ranking is not primarily based on whether a company uses a standard or not; the ranking/rating is based on whether there is an ESG Disclosure and whether the information disclosed is transparent and detailed.

5.2. FTSE Russel¹²

FTSE Russell's ESG Scores and data model allow investors to understand a company's exposure to management of ESG issues in multiple dimensions. The pillars and themes are built on over 300 individual indicator assessments that are applied to each company's unique circumstances. Scores are calculated using an Exposure-Weighted Average, meaning that the most material ESG issues are given the most weight when determining a company's scores. The data model is designed for customization by the user to enable the data to be "sliced and diced" to meet each user's needs.

The score relies only on publicly disclosed information and is overseen by an independent external committee comprising experts from the investment community, businesses, NGOs, unions, and academia.

¹² Information sourced at [23] and [24].

The FTSE Russell ESG Score Scale goes from 0 to 5 and can be described as follows:



Figure 5 (FTSE Russell ESG Score Scale)

5.3. Refinitiv¹³

Refinitiv's ESG Scores are designed to offer a clear and unbiased assessment of a company's relative ESG Performance, commitment, and effectiveness. This assessment is rooted in data reported by the companies themselves. The evaluation encompasses 10 key themes, from emissions and environmental innovation to human rights and shareholder practices. Additionally, an overarching *ESG Combined* (ESGC) Score is provided, which accounts for notable ESG controversies that might impact the covered corporations. These scores extend to more than 12,500 public and private companies worldwide, with historical data dating back to 2002. Percentile rankings are presented in percentage form and letter grades range from D- to A+.

Additionally, Refinitiv's ESG Scores are data-driven, considering the most pertinent industry metrics. The database undergoes continuous updates in line with corporate reporting cycles, and product data is refreshed weekly, including recalculations of ESG Scores.

Thus, the model encompasses two ESG Scores: (i) the *ESG Score*, which assesses the company's ESG Performance based on verifiable publicly reported data, and (ii) the *ESGC Score*, which overlays the ESG Score with ESG controversies to offer a complete evaluation of the company's sustainability influence and behaviour over time. By doing this, users can adopt and implement the scoring that aligns with their specific needs, mandates, or investment criteria.

¹³ Information sourced at [25] and [26].

Hence, the Refinitiv ESG Score Scale goes from 0 to 100 and can be described as follows:

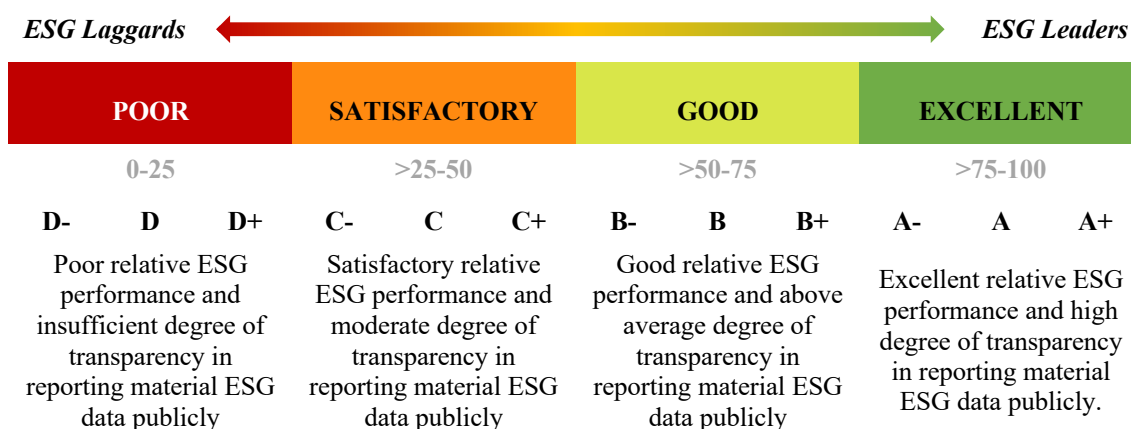


Figure 6 (Refinitiv ESG Score Scale)

5.4. Sustainalytics¹⁴

Through their ESG Risk Ratings, Sustainalytics employs a dual perspective, initially by measuring a company's *Exposure* to industry-specific material ESG risks and secondly by measuring how well a company is *Managing* those risks.

Exposure reflects a company's vulnerability or susceptibility to ESG risks. Sustainalytics differentiates between 138 sub-industries with different risk profiles based on their level of exposure to various ESG issues.

The *Management* dimension refers to actions taken by a company to manage a particular ESG issue. This can include a company's ESG programs and policies, for example, health and safety certification, or quantitative Key Performance Indicators (KPIs) like lost time injury frequency rate. Controversies can negatively impact a company's management score because they signal that management initiatives are insufficient or ineffective.

Subsequently, Sustainalytics combine these dimensions (Management and Exposure) to arrive at an absolute risk assessment or a company's overall ESG Risk Rating. The quantitative score represents units of Unmanaged ESG Risk¹⁵, with lower scores representing less unmanaged risk.

¹⁴ Information sourced at [27].

¹⁵ Unmanaged Risk is measured on an open-ended scale starting at zero (no risk) and, for 95% of cases, a maximum score below 50.

Based on their quantitative scores, companies are grouped into one of five risk categories (negligible, low, medium, high, or severe). Risk categories with “high risk” assessment, for example, reflects a comparable degree of unmanaged ESG risk across all subindustries covered. This means that a bank, for example, can be directly compared with an oil company or any other type. Thus, the Sustainalytics ESG Score Scale can be described as follows:



Figure 7 (Sustainalytics ESG Score Scale)

5.5. TruValue¹⁶

FactSet's Truvalue product suite applies machine learning to uncover risks and opportunities from companies' ESG behaviour, which are aggregated and categorized into continuously updated, material ESG Scores. It focuses on company ESG behaviour from external sources and includes both positive and negative events that go beyond traditional sources of ESG risk data.

The company uses more than 100 000 data sources in over 30 languages including news, NGOs, industry publications and social media. These large sets of data are aggregated into 26 categories defined by the SASB across five different areas: Business Model and Innovation; Leadership and Governance; Environment; Social Capital and Human Capital. The score goes from 0 to 100 and can be analysed as follows:



Figure 8 (TruValue ESG Score Scale)

¹⁶ Information sourced at [28].

6. Financial Data

All the financial data was retrieved from FactSet and is represented in USD, the local currency of the S&P 500. Following Berg *et al* (2022) I will be using the following financial variables: (i) *Return* is the simple return of the stock price between the last day of 2021 and the last day of 2022, excluding dividends; (ii) *Beta*, the market beta estimated from an average of the last three years before 2022; (iii) *Dividends* is the average dividends per share in 2022. (iv) *Market Value* is the logarithm of the market capitalisation at the end of 2022; (v) *Book-to-market* is book equity over market capitalisation; (vi) *Asset growth* is the growth in total assets during the year of 2022 (vii) *ROA* is the income before extraordinary items divided by average total assets in the prior fiscal year (viii) *Volatility* represents the monthly volatility of the previous three years.

7. Descriptives

To explore the previous variables, I have selected the S&P 500 index during the year 2022 as the basis for my study due to its popularity and industry diversity [29].

Still, during my research, there were inconsistencies regarding the composition of the S&P 500 Index across different data providers. Specifically, Advance Auto Parts Inc. (AAP), part of the Eikon Refinitive database, was absent from the others. Similarly, Constellation Energy Corporation (CEG), GE Healthcare Technologies Inc. (GECH), and Kenvue, Inc. (KVUE) were identified in the datasets of Bloomberg and FactSet but absent in the Refinitive dataset.

In response to these disparities, I decided to include all companies listed in my sample, regardless of the inconsistencies observed among the rating agencies, ending up with 504 companies. Yet, after aggregating the data and removing the missing entries, I have reached a sample of 380 observations. The breakdown of the 380 companies across various NAICS Sectors [30] is as follows:

NAICS'S SECTOR	COUNT
<i>Accommodation and Food Services</i>	12
<i>Administrative and Support and Waste Management and Remediation Services</i>	7
<i>Arts, Entertainment, and Recreation</i>	1
<i>Construction</i>	5
<i>Finance and Insurance</i>	53
<i>Health Care and Social Assistance</i>	6
<i>Information</i>	33
<i>Manufacturing</i>	147
<i>Mining, Quarrying, and Oil and Gas Extraction</i>	10
<i>Other Services (except Public Administration)</i>	1
<i>Professional, Scientific, and Technical Services</i>	22
<i>Real Estate and Rental and Leasing</i>	22
<i>Retail Trade</i>	16
<i>Transportation and Warehousing</i>	15
<i>Utilities</i>	22
<i>Wholesale Trade</i>	8
TOTAL	380

Table 1 (Count of Observations Considered per NAICS'S Sector)

Data aggregation into an industry classification is crucial when analysing ESG Scores because raters tend to concede ratings based on different benchmarks across each of the previous categories. Most of the firms in the sample are part of the manufacturing industry. Such a fact might arise due to the current disruption in the supply chain because of the COVID-19 Crisis and the Ukraine War, which have left gaps that can be exploited

for new or even existing companies within the sector.

As mentioned earlier, different scores employ varying scales, making direct comparisons problematic. Therefore, I have placed them on a range from 0 to 100, where 100 signifies the best ESG Performance in the industry. In other words, a firm with 100 points is better hedged against ESG risks. Truvalue and Refinitive naturally align with this scale. FTSE employs a scale of 0 to 5, so I multiplied it by 20. Bloomberg follows a similar scale from 0 to 10, so I multiplied it by 10. Lastly, Sustainalytics utilizes the most distinct scale among all the raters, with firms closer to 0 considered to perform better. To compare it, I multiplied it by -1 and added 100. To make the process easier to follow let's name these new variables *Grades*.

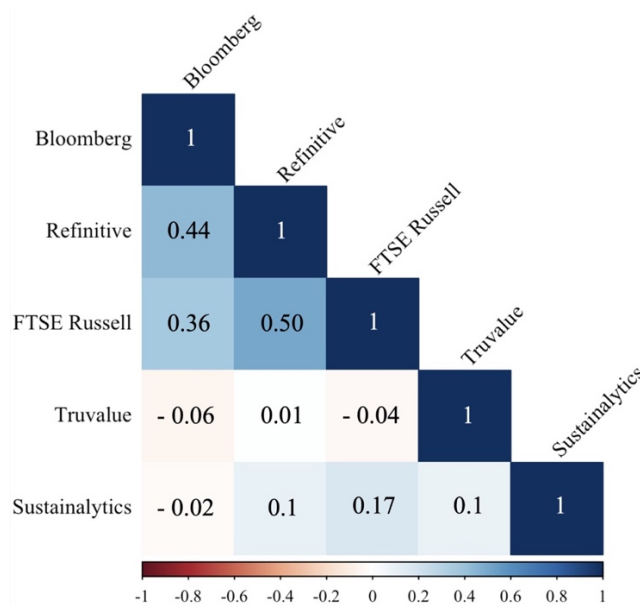
Table 2 (Descriptive Statistics) presents the descriptive statistics for the ESG Grades and Financial Variables. The inconsistencies described in the Literature Review are already evident, as basic values such as the Mean, Maximum, and Minimum significantly differ across raters. For instance, Sustainalytics has the lowest grade at 54.14, while Bloomberg's lowest rating is 12.4. At first glance, it appears that Bloomberg is the most conservative rater in their methodology, as they provide the smallest Mean and Maximum values across the dataset.

Regarding Financial Data, the average return for stocks in the S&P 500 from the end of 2021 to the end of 2022 was -10.7%, indicating that most firms experienced negative performance. However, on average, assets have grown by 5.5%. Such a phenomenon can be attributed to various factors. Firstly, it's essential to consider the broader economic and market conditions in 2022, such as the Ukraine War. Additionally, the company's decision to increase assets may be part of a deliberate growth strategy. For instance, firms could have been pursuing acquisitions, making capital investments, or engaging in research and development initiatives to strengthen their long-term competitive position following the peak of the COVID-19 Crisis.

	MEAN	MEDIAN	SD	MAXIMUM	MINIMUM
<i>Refinitive</i>	69.297	71.338	12.368	93.419	29.049
<i>Truvalue</i>	56.059	56.790	13.000	91.276	3.796
<i>FTSE</i>	63.005	64.000	12.003	96.000	18.000
<i>Sustainalytics</i>	78.447	78.820	7.262	92.890	54.140
<i>Bloomberg</i>	45.678	46.200	11.836	73.400	12.400
<i>Returns</i>	-0.107	-0.142	0.277	1.173	-0.714
<i>Beta</i>	0.978	0.974	0.387	2.604	-0.031
<i>Dividends</i>	2.103	1.513	2.316	19.520	0.000
<i>Market Value</i>	10.532	10.417	1.088	14.542	8.556
<i>Book To Market</i>	0.365	0.286	0.358	2.304	-0.701
<i>Assets Growth</i>	0.055	0.018	0.229	2.892	-0.312
<i>ROA</i>	0.071	0.054	0.082	0.389	-0.359
<i>Volatility</i>	8.962	8.292	3.021	29.834	4.146

Table 2 (Descriptive Statistics)

Graph 1 (Correlations Between ESG Grades) displays the correlation among the ESG Grades. Once again, in line with Berg *et al.* (2022), the correlations are far from 0.99. In some cases, the correlations are even negative, particularly with TruValue. This discrepancy may be attributed to differences in methodology between the rating agencies. As previously explained, Truvalue relies on machine learning, allowing it to analyse a significantly larger dataset and consider a more extensive range of parameters. It is important to note that this does not necessarily imply greater reliability than the others, as it depends on the artificial intelligence's ability to identify accurate and trustworthy information.



Graph 1 (Correlations Between ESG Grades)

CHAPTER III: METHODOLOGY

In this chapter, I will discuss the Methodology applied to build a clean and concise measure of a Final ESG Score that is capable of explaining the relationship between sustainability and stock returns. The methodology can be split into two main parts: (i) *ESG Grades Regression* (ii) the *Principal Component Analysis (PCA)*.

8. ESG Grades Regression

The regression analysis will focus exclusively on the cross-sectional data from the year 2022 with the previous 380 observations. This choice is motivated by several compelling reasons. Firstly, ESG Scores Methodologies have undergone significant changes in recent years, introducing variations in scoring criteria and data sources. Secondly, the emergence of new rating agencies, such as Truvalue, presents a unique landscape for ESG assessment that warrants dedicated analysis. By restricting the study to a single year, specifically 2022, we ensure a coherent and consistent examination of ESG Scores across a specific timeframe, minimizing the potential confounding effects of historical discrepancies or evolving methodologies. This approach enables us to capture the most up-to-date insights into the relationships between ESG factors and financial performance within a stable analytical framework.

The equation I will be using to capture the effect of ESG Performance in Financial Return is the following (Berg *et al.*, 2022):

$$\begin{aligned} Return_i = & \beta_0 + \beta_1 ESGRating_i + \beta_2 Beta_i + \beta_3 Dividends_i + \\ & \beta_4 MarketValue_i + \beta_5 BookToMarket_i + \beta_6 AssetGrowth_i + \beta_7 ROA_i + \\ & \beta_8 Volatility_i + \varepsilon_i^{17} \end{aligned} \quad (1)$$

¹⁷ In this case, I will adopt the following significance scale: * p < 0.1; ** p < 0.05; *** p < 0.01.

The regression analysis serves two distinct objectives: (i) *Perception of Sustainability Impact on Stock Returns* and (ii) *Examination of Raters Methodologies*. The first objective is the validation of arguments outlined in the Literature Review regarding the perceived incoherence of ESG impact in Financial Returns. Specifically, I aim to rigorously assess the extent to which these assertions hold true by examining the impact of varying ESG Grades from different rating agencies on stock returns. By undertaking this validation process, I not only contribute to the robustness of the Literature but also fortify the foundational premise of the research. Second, this analytical pursuit serves as a crucial diagnostic tool, enabling to assess the relevance and influence of these differing methodologies within the dataset. By discerning the tangible impact of these methodologies on the data, we gain invaluable insights into their significance. This exploration allows us to ascertain whether the idiosyncrasies in rater methodologies are a meaningful factor affecting our research outcomes.

9. PCA

The PCA will allow a dimensionality reduction by transforming the original variables into a smaller set of uncorrelated principal components. These principal components are ordered by the amount of variance they explain, with the first component explaining the most variance and subsequent components explaining decreasing amounts. As the sample comprises 5 ratings, I will end with 5 principal components. These components will be crucial to get a single ESG Score with less noise.

Take in consideration a random matrix, that can be written as:

$$X_{m \times n} = \begin{bmatrix} x_{1\ 1} & x_{1\ 2} & \cdots & x_{1\ n} \\ x_{2\ 1} & x_{2\ 2} & \cdots & x_{2\ n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m\ 1} & x_{m\ 2} & \cdots & x_{m\ n} \end{bmatrix}$$

Where:

- m is the number of rows;
- n is the number of columns.

To compute a PCA the data must be centered¹⁸. Thus, we start with the original data matrix $X_{m \times n}$ and calculate the mean (μ_j) creating a vector of means, where each element represents the mean value for a specific feature:

$$\mu_j = \frac{1}{m} \sum_{i=1}^m X_{ij}$$

Where:

- μ_j is the mean of feature n ;
- X_{ij} is the element in row i and column j of the matrix.

¹⁸ In practice this does not hold, because the function *princomp* in R, that is responsible for computing the PCA, automatically performs this transformation, which means that users must not do it, otherwise they would be making the mistake of centering twice.

Therefore, the matrix \bar{X} can be defined as:

$$\bar{X}_{m \times n} = \begin{bmatrix} \mu_1 & \mu_2 & \cdots & \mu_n \\ \mu_1 & \mu_2 & \cdots & \mu_n \\ \vdots & \vdots & \ddots & \vdots \\ \mu_1 & \mu_2 & \cdots & \mu_n \end{bmatrix}$$

To calculate the centered matrix of X we simply follow:

$$X_{centered} = X - \bar{X}$$

After creating $X_{centered}$, it is necessary to compute the covariance matrix that represents the relationships between all pairs of features in $X_{centered}$. Mathematically, the covariance matrix can be computed as follows:

$$C = \frac{1}{m} X_{centered}^T * X_{centered}$$

Where:

- $X_{centered}^T$ is the transpose of the centered data.

The next step will be performing an *Eigen Decomposition* on the covariance matrix (C) to find its *eigenvectors* (v) and *eigenvalues* (λ)¹⁹. These *eigenvectors* will become the *principal components*, and the *eigenvalues* will represent the *variance* explained by each principal component.

Subsequently, the highest Principal Components (eigenvectors) (k) that are capable of explaining a large proportion of the variance must be selected and aggregated to create a new matrix (W) that will contain the eigenvectors as columns:

$$W = [v_1 \quad v_2 \quad \dots \quad v_k]$$

Now that everything is completed, to obtain a less noisy ESG metric, we only need to project the centered data matrix onto the selected eigenvectors.

$$X_{PCA} = X_{centered} \cdot W$$

¹⁹ An eigenvector is a vector that remains unchanged in direction when a linear transformation is applied to it, except that it may be scaled by a scalar factor (eigenvalue).

In summary, X_{PCA} constitutes a novel representation of ESG Grades, creating a new ESG Score offering several significant insights: (i) *Dimensionality Reduction*, reproducing n ESG Grades in k principle components; (ii) *Noise Mitigation*, achieved through the prioritization of principal components with the highest eigenvalues, effectively diminishing the influence of data noise. In this specific context, this analytical approach grants ordinary investors a lucid perspective on the genuine influence of a company's sustainability efforts on its financial performance.

CHAPTER IV: RESULTS

The last chapter of the dissertation will follow the steps of the methodology, providing results for the two previous parts: (i) *ESG Grade Regressions* (ii) the *PCA*.

10. ESG Grade Regressions

The complete tables with all the detailed information regarding the cross-section analysis for the 380 companies with the 5 different ESG Grades can be found from Appendix C: ESG Scores to Appendix H: *Truvalue*. By looking at the results, the first thing that jumps to the eyes are the Betas of the ESG Grades. Different ESG Grades have very different values that range from negative to positive, some significant and others not. The coefficient represents the impact of an increase by one unit of the grade in the stock returns. Considering that all the ESG grades range from 0 to 100, where 100 is the better ESG performance or smaller exposure to ESG risks, a positive coefficient indicates a positive relation between ESG and financial performance, and a negative coefficient points to the opposite scenario.

There are two significant negative coefficients, Sustainalytics and Truvalue, the same two that have shown a very small or even negative correlation with the others. As explained in the CHAPTER II: DATA, the raters responsible for these two grades employ a very different methodology when assessing sustainability. Sustainalytics uses a dual perspective focus, separating the grade from ESG risk with the grade the way they are hedged, and Truvalue is entirely run by artificial intelligence. Being both highly significant, they show that companies with lower ESG risk provided smaller returns for investors in 2022, which perfectly aligns with the classical financial theory of risk compensation, which states that smaller risks yield smaller returns. Sustainalytics is the grade that provides a higher level of significance, in other words, a smaller probability of being committed a type I error. This can be justified due to the longevity of the rater, who was a pioneer in the field and for the comprehensive ESG Framework used in its methodology.

Still, the other 3 grades, FTSE Russel, Refinitive and Bloomberg, denote a positive relationship. Of the three, Bloomberg is the only rater with a significant grade. This might happen due to its importance to the financial world by providing comprehensive coverage from different classes of assets and reliability. The positive point of view is not in line with the classical risk-return theory. Instead, such fact might be explained from: (i) Firms with higher ESG grades are more desirable than firms with lower ESG grades, and assuming a downward-sloping demand curve for this type of securities, the high-ESG firms are capable of an outward-shift of the demand curve for their equity, thus driving up the price and the returns; (ii) ESG compliance (higher ESG grades) have become a mean of signalling company quality and profitability, in this case there is shift in the demand curve as in (i) but not because investors prefer ESG stocks but because they know there is a cost associate to the performance and therefore issues credibility to the firm; and (iii) Reduction in the cost of capital, due to decrease in the risk profile and access to sustainable funds.

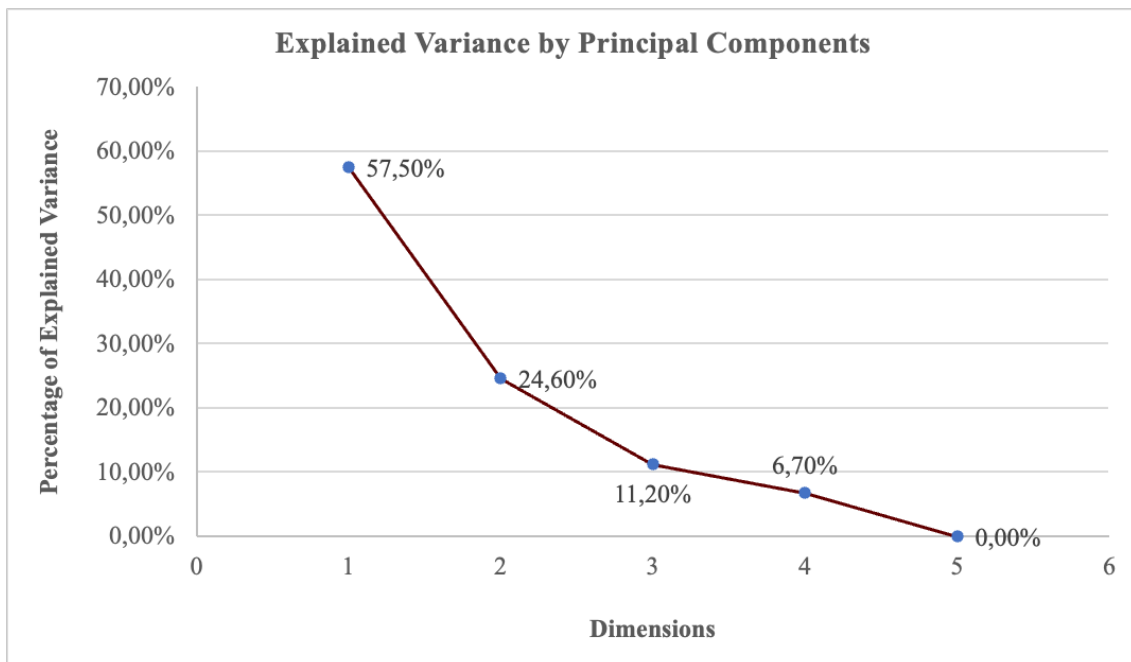
These differences in results are aligned with Berg *et al.* (2022)'s findings. Furthermore, the control financial variables are also in accordance with the Classical Literature, namely ROA and Volatility, which are always significant at 1%. ROA has a positive relationship that is justified by the profitability effect, which highlights traits of a healthy company capable of generating returns using its assets. Volatility is also positive across the different regressions, pointing out the risk and reward trade-off. Assets with higher volatility, commonly an indicator of risk, provide higher returns to compensate investors for the additional risk.

11. PCA

The PCA was applied to the previously mentioned 5 ESG grades with 380 observations each. Following the previous methodology, I have ended up with 5 principal components, the same number as variables, that are comprised in the following table and graph:

PARAMETER	PC1	PC2	PC3	PC4	PC5
<i>Standard Deviation</i>	0.6304935	0.4125372	0.2785643	0.21545971	0
<i>Proportion of Variance</i>	0.5746781	0.2460309	0.1121797	0.06711129	0
<i>Cumulative Proportion</i>	0.5746781	0.8207090	0.9328887	1.00000000	1

Table 3 (Importance of Components)



Graph 2 (Explained Variance by Principal Components)

Considering this, I have decided to pick the first two components that can capture 82% of the total variation in the dataset. Also, as stated in CHAPTER III: METHODOLOGY, the first component is responsible for about 57% of the variation, while the second accounts for nearly 25% and decreases as we move to the 5th and last component.

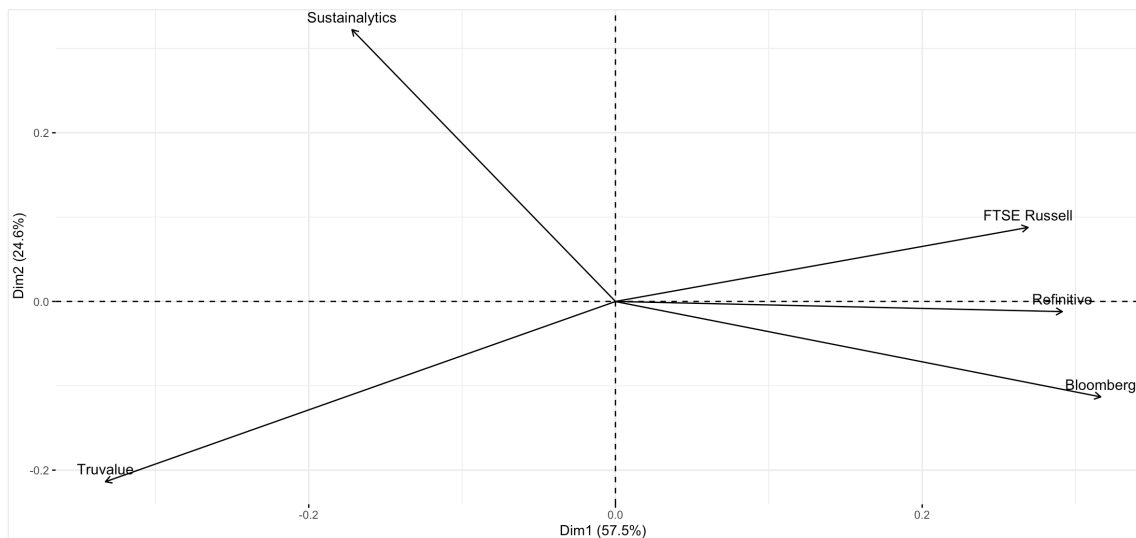
The eigenvectors for the first two principal components are:

ESG SCORE	PC1	PC2
<i>Refinitive</i>	0.4621238	0.02915196
<i>Truvalue</i>	-0.5274621	0.51806879
<i>FTSE Russell</i>	0.4267107	-0.21267202
<i>Sustainalytics</i>	-0.2725047	-0.78121550
<i>Bloomberg</i>	0.5018809	0.27427696

Table 4 (Eigenvectors and Eigenvalues)

Through the previous table, we can check the eigenvalues associated with PC1 and PC2 that show how much of the total variance in the ESG grades is explained by each component. The correlation between PC1 and PC2 is 0.02, indicating that they are not correlated with each other, which means they are orthogonal and capture distinct patterns and dimensions within the sample. The eigenvector matrix shows that the first principal component has high values for Refinitive, Truvalue and Bloomberg. However, the values for Truvalue and Sustainalytics are relatively negative.

These two dimensions can be visualised as:



Graph 3 (Eigenvalues Spectrum for Dimensions 1 and 2)

The plot displays each variable as a point in the space defined by the first two principal components (PC1 and PC2). The position of each variable point on the plot indicates how strongly it contributes to the principal components. Variables closer to the origin (0,0) have lower loadings, while variables farther from the origin have a higher impact. The direction of the variable also shows its alignment with the principal components. Variables close to each other have similar patterns (for example, methodology) while those separate present different patterns.

Taking this information, I have ended up with 2 X_{PCA} matrixes, X_{PC1} and X_{PC2} , that will be named ESG Score 1 and ESG Score 2, respectively. Both these metrics already have less noise than the original ESG grades. Consequently, by applying them to regression number 2, that is based in regression number 1, we are capable of finding, or at least being closer, to the true relationship between ESG and stock returns.

$$\begin{aligned} Return_i = & \beta_0 + \beta_1 ESGScore1_i + \beta_2 ESGScore2_i + \beta_3 Beta_i \\ & + \beta_4 Dividends_i + \beta_5 MarketValue_i + \beta_6 BookToMarket_i \\ & + \beta_7 AssetGrowth_i + \beta_8 ROA_i + \beta_9 Volatility_i + \varepsilon_i \end{aligned} \quad (2)$$

Residuals

MIN	1Q	MEDIAN	3Q	MAX
-0.75689	-0.14040	-0.01622	0.13066	0.88949

Coefficients

	ESTIMATE	STD. ERROR	T VALUE	PR(> T) ²⁰
<i>(Intercept)</i>	-0.0652095	0.1434548	-0.455	0.649689
<i>ESG Score 1</i>	0.0029459	0.0008406	3.504	0.000514***
<i>ESG Score 2</i>	0.0051463	0.0013883	3.707	0.000242***
<i>Beta</i>	-0.4808675	0.0481095	-9.995	2E-16***
<i>Dividends</i>	0.0042781	0.0055139	0.776	0.438319
<i>Market Value</i>	0.0117636	0.0120746	0.974	0.330572
<i>Book-to-Market</i>	-0.0548893	0.0374167	-1.467	0.143233
<i>Asset Growth</i>	0.0028435	0.0542684	0.052	0.958241
<i>ROA</i>	0.5783125	0.1645598	3.514	0.000496***
<i>Volatility</i>	0.0383324	0.0063344	6.051	3.52E-09***

RESIDUAL STD. ERROR	MULTIPLE R ²	F-STATISTICS	ADJUSTED R ²	P-VALUE
0.2319	0.3137	18.79	0.297	2.2e-16

Table 5 (ESG Score 1 and ESG Score 2 Regression Output)

Based on the previous steps, the results indicate a positive and highly significant relation between ESG Performance and stock returns. This result aligns with Berg *et al.* (2022)'s findings. Even though they used a different methodology (a second stage least square (2SLS) as a mechanism to reduce noise), they achieved the same significant

²⁰ *p<0.1; **p<0.05; ***p<0.01

positive relation.²¹

Still, both scores, even capturing different dimensions, pointed to a weak correlation that might come due to the negative scenarios that occurred in the year 2022, specifically the Ukraine war and the post covid situation, that have brought a massive increase in inflation that triggered a rise in interest rates.

Nevertheless, the simple fact that we still have a positive relationship after these circumstances, where investors usually run for safe investments, signals that ESG is no longer perceived as gambling and firms with higher ESG performance are better prepared to face unexpected situations.

Some reasons to justify the positive relation were already presented in CHAPTER II: DATA regarding the shifts in the demand curve. Another possible reason for the positive relation is the long-term orientation. Companies that focus on ESG often prioritize long-term sustainability over short-term profit maximization. While this can lead to more stable returns over time, it does not necessarily mean lower overall returns. In fact, as stock prices are based on future cash flows, they may face higher value increases over time, increasing investors' returns.

²¹ The complete code to achieve these results can be found in Appendix I: R Code in a simple and organised way, so the individual investor or even researcher might use the same technique to extract noise and have a concise measure of an ESG Score.

CONCLUSION

In conclusion, this research has proposed a simple method to evaluate the ESG factor using ESG scores. During the investigation, I have focused on why ESG is the most suitable framework for sustainability. Specifically, I have run into the principle theories of CSR, another essential sustainability framework, and shown how it is built from CSR and surpasses its challenges. Of all the significant CSR theories, Stakeholder Theory is the most important to explain ESG, as companies are embracing the welfare of different stakeholders now more than ever.

As the project aims to analyse ESG in the financial field, I have also comprised a summary of how ESG is being regulated in this field, where SASB and GRI tend to dominate the criteria for a more transparent and objective information disclosure regarding sustainability.

After providing this insight, I have analysed previous literature regarding ESG pillars' effect on financial returns. The environmental factor is currently the hot topic of financial research, and most papers point to a positive and strong correlation between green firms and stock returns. The relation can be explained using the stakeholder theory, specifically from a regulatory point of view and from the investors' side. The social pillar also points to a positive relation justified by the expectancy theory. Regarding the last pillar, governance is also positively related to better financial performance because better governance is usually connected with better risk management practices and production efficiency.

As all the individual factors point to a positive relation, It would be expected that the results from the complete framework would point in the same direction. However, this conclusion is hard to make due to the measuring mechanisms. The most popular instrument to evaluate ESG performance is the ESG score. However, it carries vast amounts of noise that can be justified by the different methodologies that each rater employs and the existent conflicts of interest as credit raters move to this field.

All this information might be helpful for institutional investors capable of filtering and making a robust and solid measure out of all the noise. However, small investors without the resources of institutional investors might struggle to get a single and clean ESG score. Yet, understanding ESG has never been so crucial as today in the investment world, as shown by the Global Growth of Sustainable Investing Strategies,

where the ESG factor is a critical parameter in financial analysis. Hence, in this research, I proposed a PCA that anyone in R (a free and open-source programming language and software) can use to reduce noise.

Firstly, I have tested the incoherencies by attempting to perceive the relation between ESG and stock returns, using five scores that I have previously graded on a scale from 0 to 100, called grades. Where 100 means a better ESG performance, or in other words, less exposure to ESG risks. The regressions have shown different signs across the rating agencies. Sustainalytics and Truvalue pointed to a negative significant relation, while Bloomberg, FTSE Russel and Refinitive pointed to a positive relation, where only Bloomberg was statistically significant.

Secondly, after figuring out the eigenvectors and eigenvalues, I created two new measures: ESG Score 1 and ESG Score 2. These are the products of the ratings with the eigenvalues of the first and second principal components, respectively. By applying these new metrics, I ended up with two scores pointing to a positive and highly significant relation between ESG and financial returns, in line with the individual analysis of each pillar and previous literature regarding ESG noise. The relation is not so high as the one described in others papers, which I assume to be due to the Ukraine War and increased inflation in 2022.

One of the most significant limitations of the research is the limited data regarding ESG. ESG has indeed been around for almost 20 years. However, the methodologies of raters have changed significantly in the last years, making values challenging to compare across time. Likewise, some ESG scores have only been created in the last two years, for example, Truvalue.

It might be interesting to perform this analysis using a panel dataset with more ESG scores in the future, as I expect that ESG will be the predominant framework for sustainability in finance for many years to come. Also, I have pointed out a positive relation against the traditional trade-off between risk and return. I assume that the positive relation might be connected with firms with higher ESG grades being more desirable than firms with lower ESG grades, making an outward shift of the demand curve for ESG equity. Another hypothesis is that ESG might have become a signalling mechanism for good companies. One possible future research might be to evaluate the significance of both these arguments.

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Appendix A: CSR and ESG Theories

CSR Theory	Characteristics of CSR Theories		How does ESG comprises and improves each Theory?
	Strength of the Theory	Challenges in Applying the Theory	
<i>Carroll CSR Theory</i>	<ul style="list-style-type: none"> - Clarity and Prioritisation: helps organisations prioritise their CSR efforts by delineating responsibilities into four distinct levels, making it easy to identify which areas need more attention based on the organisation's circumstances and values. - Continual Improvement: The pyramid implies a progressive nature of CSR. 	<ul style="list-style-type: none"> - Limited Emphasis on Environmental Concerns: The absence of a distinct environmental responsibility category in the pyramid might not adequately reflect the urgent need for businesses to address their ecological footprint. - Subjectivity and Interpretation: The interpretation of what constitutes ethical and philanthropic responsibilities can vary widely depending on cultural, societal, and individual perspectives 	<ul style="list-style-type: none"> - ESG expands the scope of Carroll's CSR Theory by considering not only economic, legal, ethical, and philanthropic responsibilities but also encompassing a broader range of environmental, social, and governance factors. This holistic approach provides a more comprehensive view of a company's impact on society and the environment.
<i>TBL Theory</i>	<ul style="list-style-type: none"> - Balanced Approach: By considering social, environmental, and economic factors together, the TBL framework encourages organizations to strike a balance between financial profitability, social equity, and environmental responsibility. - Risk Management: Addressing social and environmental concerns can help mitigate potential risks related to regulatory changes, resource scarcity, reputational damage, and other sustainability-related challenges. 	<ul style="list-style-type: none"> - The absence of standardized guidelines for incorporating social and environmental factors into business practices makes it difficult to compare performance across different companies, industries, and regions. 	<ul style="list-style-type: none"> - ESG provides more standardized metrics and reporting guidelines for measuring environmental, social, and governance impacts in line with the approach of TBL Theory. This offers clarity and consistency, making comparing performance across companies and industries easier.
<i>Stakeholder Theory</i>	<ul style="list-style-type: none"> - Stakeholder Engagement: The theory fosters engagement with a diverse set of stakeholders, improving relationships, enhancing transparency, and gaining insights into various perspectives. 	<ul style="list-style-type: none"> - Conflicting interests: Balancing diverse interests across stakeholders, while making sustainable decisions, can be challenging and require careful negotiation and trade-offs. 	<ul style="list-style-type: none"> - ESG incorporates stakeholder considerations by providing a structured way of considering all stakeholders' interests. It also prioritizes and focuses on the most relevant sustainability issues for their industry and context, eliminating potential conflicts of interest.

Appendix B: Individual vs. Institutional Investors

Characteristics	Individual Investors	Institutional Investors
<i>Definition</i>	Retail investors who invest their personal savings in the financial market	Corporations, trusts, entities that invest large amounts of money on behalf of their clients or shareholders
<i>Financial Resources</i>	Limited resources	Substantial resources and funds
<i>Decision-making Expertise</i>	May be emotionally driven Generalised lack of specialised investment knowledge	Data-driven, expert analysis Employ professional analysts and researchers
<i>Diversification</i>	Limited due to resource constraints	Highly diversified portfolios across asset classes due to expertise and resources
<i>Market Impact</i>	Small	Significant
<i>Portfolio Size</i>	Usually small	Large
<i>Access to Investments</i>	Through online brokers, banks, mutual funds	Direct access to various investment opportunities
<i>Influence on Companies</i>	Limited influence	Can drive changes in corporate behaviour
<i>Regulatory Scrutiny</i>	Less regulatory scrutiny compared to institutions	Subject to higher regulatory oversight

Appendix C: ESG Scores

	Refinitiv	Sustainalytics	Bloomberg	FTSE Russell	Truvalue
Rating Score	0 to 100	0 to 100	0 to 10	0 to 5	0 to 100
History	2002	1992	2008	2001	2013
Headquarter	Toronto, Canada	Amsterdam, Netherlands	New York, United States of America	London, United Kingdom	California, United States of America
Sources	Company websites, Company reports, NGO websites, Media and news, Stock Exchange filings	Public Disclosure, Media and news, NGO reports	Company reports, publicly available information, company direct contact.	Publicly available information, company direct contact, other sources (governments and NGOs)	Disclosed information: financial statements, press releases, broker research Non-disclosed information: news, NGOs, watchdogs, trade journals, independent reports
Main Risk Factors	Environmental: resource use, emission, innovation. Social: workforce, human rights, community, product responsibility. Governance: management, shareholders, CSR strategy.	Industry-specific indicators. Factors change according to the industrial group to which a company belongs.	Environmental: carbon emissions, climate change effect, pollution, waste disposal, renewable energy, resource depletion Social: supply chain, political contributions, discrimination, diversity, community relations, human rights. Governance: cumulative voting, executive compensation, shareholders' rights, takeover defence, staggered boards, independent directors.	Environmental: biodiversity, climate change, pollution & resources, water security, supply chain. Social: labour standards, human rights & community, health & safety, customer responsibility, supply chain. Governance: tax transparency, risk management, corporate governance, anti-corruption.	Business Model & Innovation: Product Design & Lifecycle Management; Business Model Resilience; Supply Chain Management; Materials Sourcing & Efficiency; Physical Impacts of Climate Change. Leadership & Governance: Business Ethics; Competitive Behaviour; Management of the Legal & Regulatory Environment; Critical Incident Risk Management; Accident and

					<p>Safety Management.</p> <p><i>Social Capital:</i> Human Rights & Community Relations; Customer Privacy; Data Security; Access & Affordability; Product Quality & Safety; Customer Welfare; Selling Practices & Product Labelling.</p> <p><i>Human Capital:</i> Employee Engagement, Diversity & Inclusion; Employee Health & Safety; Labour Practices.</p> <p><i>Environment:</i> GHG Emissions; Air Quality; Energy Management; Water & Wastewater Management; Waste & Hazardous Materials Management; Ecological Impacts.</p>
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Appendix D: *Bloomberg* Regression Output

Residuals

MIN	1Q	MEDIAN	3Q	MAX
-0.72441	-0.15732	-0.00845	0.12784	0.94658

Coefficients

	ESTIMATE	STD. ERROR	T VALUE	PR(> T)
<i>(Intercept)</i>	-0.329255	0.135592	-2.428	0.015645**
<i>Bloomberg</i>	0.002191	0.001065	2.058	0.040259**
<i>Beta</i>	-0.518123	0.048137	-10.763	2.00e-16***
<i>Dividends</i>	0.005971	0.005610	1.064	0.287882
<i>Market Value</i>	0.020324	0.012143	1.674	0.095023*
<i>Book-to-Market</i>	-0.045457	0.038137	-1.192	0.234045
<i>Asset Growth</i>	-0.028659	0.054802	-0.523	0.601321
<i>Roa</i>	0.569899	0.168122	3.390	0.000775***
<i>Volatility</i>	0.042411	0.006372	6.655	1.02e-10***

RESIDUAL STD. ERROR	MULTIPLE R ²	F-STATISTICS	ADJUSTED R ²	P-VALUE
0.2365	0.2831	18.41	0.2687	2.2e-16

*p<0.1; **p<0.05; ***p<0.01

Appendix E: *FTSE Russell* Regression Output

Residuals

MIN	1Q	MEDIAN	3Q	MAX
-0.72213	-0.16548	-0.00864	0.12350	0.96376

Coefficients

	ESTIMATE	STD. ERROR	T VALUE	PR(> T)
<i>(Intercept)</i>	-0.2306446	0.1425915	-1.618	0.1066
<i>FTSE Russell</i>	-0.0009921	0.0010511	-0.944	0.3458
<i>Beta</i>	-0.5240536	0.0483188	-10.846	2.00e-16***
<i>Dividends</i>	0.0070698	0.0056161	1.259	0.2089
<i>Market Value</i>	0.0266740	0.0121455	2.196	0.0287**
<i>Book-to-Market</i>	-0.0468144	0.0383345	-1.221	0.2228
<i>Asset Growth</i>	-0.0495530	0.0551386	-0.899	0.3694
<i>Roa</i>	0.5313430	0.1689575	3.145	0.0018***
<i>Volatility</i>	0.0429658	0.0063937	6.720	6.86e-11***

RESIDUAL STD. ERROR	MULTIPLE R ²	F-STATISTICS	ADJUSTED R ²	P-VALUE
0.2375	0.2777	17.83	0.2621	2.2e-16

*p<0.1; **p<0.05; ***p<0.01

Appendix F: *Refinitive* Regression Output

Residuals

MIN	1Q	MEDIAN	3Q	MAX
-0.72939	-0.15733	-0.01041	0.12435	0.95731

Coefficients

	ESTIMATE	STD. ERROR	T VALUE	PR(> T)
<i>(Intercept)</i>	-0.327979	0.143002	-2.294	0.02238 **
<i>Refinitive</i>	0.001030	0.001024	1.006	0.31500
<i>Beta</i>	-0.523280	0.048295	-10.835	2.00e-16 ***
<i>Dividends</i>	0.006491	0.005633	1.152	0.24995
<i>Market Value</i>	0.022749	0.012176	1.868	0.06249 *
<i>Book-to-Market</i>	-0.050428	0.038295	-1.317	0.18871
<i>Asset Growth</i>	-0.036292	0.054971	-0.660	0.50953
<i>Roa</i>	0.548533	0.168437	3.257	0.00123 ***
<i>Volatility</i>	0.043482	0.006400	6.794	4.35e-11 ***

RESIDUAL STD. ERROR	MULTIPLE R ²	F-STATISTICS	ADJUSTED R ²	P-VALUE
0.2375	0.2779	17.85	0.2624	2.2e-16

*p<0.1; **p<0.05; ***p<0.01

Appendix G: *Sustainalytics* Regression Output

Residuals

MIN	1Q	MEDIAN	3Q	MAX
-0.81046	-0.14033	-0.02114	0.12791	0.83598

Coefficients

	ESTIMATE	STD. ERROR	T VALUE	PR(> T)
<i>(Intercept)</i>	0.566655	0.195983	2.891	0.00406***
<i>Sustainalytics</i>	-0.009682	0.001698	-5.701	2.43e-08***
<i>Beta</i>	-0.447083	0.048233	-9.269	2.00e-16***
<i>Dividends</i>	0.006443	0.005391	1.195	0.23280
<i>Market Value</i>	0.018880	0.011562	1.633	0.10334
<i>Book-to-Market</i>	-0.057295	0.036771	-1.558	0.12005
<i>Asset Growth</i>	-0.021301	0.052580	-0.405	0.68562
<i>Roa</i>	0.496733	0.161892	3.068	0.00231***
<i>Volatility</i>	0.033205	0.006378	5.206	3.20e-07***

RESIDUAL STD. ERROR	MULTIPLE R ²	F-STATISTICS	ADJUSTED R ²	P-VALUE
0.228	0.3343	23.29	0.3199	2.2e-16

*p<0.1; **p<0.05; ***p<0.01

Appendix H: *Truvalue* Regression Output

Residuals

MIN	1Q	MEDIAN	3Q	MAX
-0.7318	-0.1647	-0.0071	0.1236	0.9259

Coefficients

	ESTIMATE	STD. ERROR	T VALUE	PR(> T)
<i>(Intercept)</i>	-0.1724376	0.1420644	-1.214	0.22560
<i>Truvalue</i>	-0.0020259	0.0009574	-2.116	0.03501**
<i>Beta</i>	-0.5202083	0.0480840	-10.819	2.00e-16***
<i>Dividends</i>	0.0077253	0.0055997	1.380	0.16854
<i>Market Value</i>	0.0261820	0.0119527	2.190	0.02911**
<i>Book-to-Market</i>	-0.0420525	0.0382249	-1.100	0.27199
<i>Asset Growth</i>	-0.0538725	0.0546344	-0.986	0.32475
<i>Roa</i>	0.5162173	0.1681232	3.070	0.00229***
<i>Volatility</i>	0.0421251	0.0063784	6.604	1.39e-10***

RESIDUAL STD. ERROR	MULTIPLE R ²	F-STATISTICS	ADJUSTED R ²	P-VALUE
0.2364	0.2846	18.45	0.2629	2.2e-16

* p<0.1; **p<0.05; ***p<0.01

Appendix I: R Code

```
#Set Directory
setwd("/Users_File_location")

#Using data in Excel format

install.packages(readxl)
library(readxl)

Data <- read_excel("data.xlsx")
str(data)

#Clean empty entries
Data_1 <- na.omit(Data)

## PRINCIPAL COMPONENT ANALYSIS

install.packages("corr")
library(corr)

install.packages("ggcorrplot")
library(ggcorrplot)

install.packages("FactoMineR")
library(FactoMineR)

install.packages("factoextra")
library(factoextra)

#Check correlation across different scores
corr_matrix <- cor(data)
mean(corr_matrix) # Average correlation across the ratings

#Importance of components
data.pca <- princomp(corr_matrix)
summary(data.pca)

#Check the eigenvectors and eigenvalues
data.pca$loadings[, 1:k]
```

```
#Visualization of the principal components
```

```
fviz_eig(data.pca, addlabels = TRUE)
```

```
# Graph of the variables
```

```
fviz_pca_var(data.pca, col.var = "black")
```