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TESI DI LAUREA

THE RELATIONSHIP BETWEEN THE CREDIT RISK & THE ESG SCORE:

EVIDENCE FROM THE STOXX EUROPE 600

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ABSTRACT

This study aims to analyze and assess the effect of Environmental, Social, and Corporate Governance (ESG) practices on credit risk with the objective of implementing the literature and academic research on this increasingly relevant issue. The study first provides a comprehensive view of the ESG subject to then evaluate and estimate the relationship between a firm's ESG score and its creditworthiness, in this case, measured by the Altman Z-score.

The analysis was conducted by using the Refinitiv Eikon platform to collect the dataset and the statistical software Stata to process it. Moreover, a cross-sectional descriptive analysis and a multivariate regression were used to analyze the sample of 498 companies selected from the Stoxx Europe 600 index. In particular, the results show an aggregate negative and statistically significant effect of the ESG practices on the Altman Z-score, and how such effect may vary depending on the individual pillars. Furthermore, a series of variables with a control function in relation to the financial and ESG performance were also included to improve the estimation of the general analysis.

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INTRODUCTION

Increasing environmental concerns, stakeholder expectations, the adaptation of legal regulations, investor demand, and higher reporting requirements have led to the rising significance of ESG issues in recent years. Therefore, understanding the importance of Environmental, Social, and Corporate Governance considerations is critical for companies that want to effectively manage risks and create long-term value (Silvola & Landau, 2021). For this purpose, this study aims to contribute to the literature by adding a comprehensive view of the ESG issues and by describing the effect that they have on credit risk, and consequently on corporate's financial performance.

Therefore, to present and describe the increasing importance of the ESG factors integration into investment decisions and companies' value creating process the study will be divided into five main chapters that will describe and then provide an empirical analysis of the relationship between the financial Credit Risk, and the corporate's Credit Ratings and ESG scores. In order to give a comprehensive view of the subject, the study will start by describing and presenting the ESG subject to then analyze the evolution of the change of perception that it had over time. Then, the dissertation focuses on the characteristics of the issue and the relationship that it has with Corporate Identity and Corporate and Social Responsibility to then look further into the effect that the subject has on the financial investments world. In particular, it focuses on the Sustainable Responsible Investing theory and the Principles of Responsible Investments to then describe the current regulations and directives provided by the European Union in recent years in order to oversee and regulate this increasingly important phenomenon.

The second chapter presents the methodology through which the ESG ratings are provided. Therefore, by focusing on the framework provided by Li & Polychronopoulos, (2020), the study will present the different categories of ESG data providers to then assess the rating divergencies mainly due to the different weights, scope, and methodologies used and other external relevant factors, such as the Rater effect and the investors' considerations. Moreover, in the third chapter, the study presents the fundamentals of the Credit Risk subject to then focus on the credit risk management process and the different measurement methodologies that can be adopted while assessing such phenomenon. In particular, the dissertation stresses the importance of traditional methodologies which then will be used in the empirical analysis.

The study then focuses on an analysis of the academic literature, specifically emphasizing the various perspectives of academia on the research topic and the methodologies by which these were obtained. The dissertation, in particular, refers to the various indicators used to measure the phenomenon in the academic literature and how the choice of different indicators can often lead to different results. Therefore, the fourth chapter continues by presenting the different variables, and the dataset that was chosen for the empirical analysis to then conclude with the formulation of the hypotheses that will then be tested in the final examination.

The last section of the study presents the empirical analysis of the relationship between credit risk and different ESG factors. In particular, the analysis goes on to test the hypotheses that were found in the literature review, thus: the presence of a correlation between the variables, the hypothesis that not all ESG components have the same effect on credit risk, and the presence of a negative relationship between the Environmental, Social and Corporate Governance scores and the Altman's Z score, namely the credit risk indicator. The analysis is then divided into two main sections the descriptive statistics section and the regression analysis. For what concerns the former is then subdivided into three main parts: a Panel Data analysis from 2012 to 2023 over the entirety of the Stoxx Europe 600 index, then followed by a cross-sectional analysis over a selected pool of 498 companies, and then a correlation analysis of the selected variables. The regression analysis then focuses on testing through the use of different models of the formulated hypotheses. In particular, the research found how the linear regression analysis does not reflect the main relationship between the variables, and how a log-linear regression presents a higher goodness of fit as well as a better explanation of the outcome's variance through the various model tested.

In conclusion, the study affirms the existence of a negative and statistically significant relationship between the Environmental, and Corporate Governance factors in a short-term period. Hence, indicating different effects from the distinct ESG pillars on the credit risk variable. In addition, the analysis further estimates a positive and significant relationship between the Credit Ratings and Altman's Z score, thus indicating the presence of a significant effect that increases the goodness of fit of the regression.

1. THE ESG SUBJECT

1.1 ESG definition and first notions

The acronym ESG is used in the economic and financial fields to describe all those activities that are related with responsible activities and investments (IR) that pursue the typical objectives of financial management by taking into consideration environmental, social and governance aspects. According to (Cambridge Dictionary, s.d.), this term can also be definded as a methodology of judging a company by factors that differ from the mere financial performamce. Therefore, these factors are central in measuring the sustainability and the environmental and social impact of a business or an investment in a company.

The first appearance of the ESG term can be found in a United Nations (UN) 2004 report, for which the former UN Secretary invited a joint initiative of financial institutions, that stated: *"to develop guidelines and recommendations on how to better integrate environmental, social and corporate governance issues in asset management, securities brokerage services and associated research functions"*(Eccles, Lee, & Stroehle, 2020).

The ESG expression consists of three words that describe three different universes of social sensitivity:

- *E: Environmental*
- *S: Social*
- *G: Governance*

The first aspect (Environmental), is connected with the Environment which includes risks such as climate change, air and water pollution, carbon dioxide emissions, waste and deforestation. These issues have become increasingly popular in the last 20 years and not only from a mere economical point of view, all the members of the United Nations have increased their focus on these crucial issues driving countries to embrace greener alternatives. An example of that is represented by the 2015 climate change conference that was held in Paris (COP21) that invites countries to formulate and submit by 2020 long-term low greenhouse gas emission development strategies (LT-LEDS) (UNFCCC, s.d.).

The second universe (Social), includes more the societal aspect so it concerns more topics such as human rights, labor standards, gender equality, and civil community relations.

Lastly, the third universe of social sensitivity (Governance) relates to corporate governance practices, including top management and corporate behavior in terms of compliance with laws and ethics and which procedures should take place for stability and control (Silano, 2016).

1.2 ESG perception over time

Although ESG is fairly recent concept, its roots roots find foundation in a much deeper and complex context. The origin of sustainable investing started with different religious groups such as Muslims, Quakers, and Methodists who set ethical parameters on their primitive and rudimental investment portfolios.

On the one hand, Muslims used this method to develop investments that comply with the Islamic law (Townsend, 2020). This particular way of investing included various prohibitions, for instant the investment in weapons and other war machineries. On the other hand, the Methodists and Quakers launched the first ethical associations and unit trusts in the United Kingdom and in the US. Furthermore, they mainly use negative screening for their investments, avoiding businesses that dealt in alcohol, gambling, and tobacco (Townsend, 2020). Therefore, as a result it is possible to say that ethical codes and religious beliefs shaped the earliest notions and instances of sustainable investing.

In recent years, the ESG topic has increasingly become a dominant factor, especially for what concerns the financial investments. During the years the importance of this matter has become increasingly popular that even the perception has changed. The point of view shifted from a negative screenning approach to a more proactive one. In the beginning, the main focus was to remove those investments that are not considered socially acceptable, for instance the ones that invole the exchange of securities tied with the weapons and alcoholic sectors (Silano, 2016). Nowadays, the main focus is to have a proactive commitment towards the environmental, the societal and into the corporate governace topics.

Direct activities and decisions must be a crucial aspect of a corporation's long term strategy. In order to achieve a sustainable envolvement and commitment over time a company must take into account proactive strategies while allocating resource and assets into the business activity. Furthermore, from the investors point of view, this approach focuses on improvement of the business practices through the dialogue with the realities in which one invests in and by incorporating the ESG (environmental, social and governance) criteria into the portfolio construction process (Silano, 2016).

1.3 ESG from the Corporate Perspective

Responsible investment (or ESG management) is an influential component to the decision making process. It's based on the belief that addressing ESG issues will protect and enhance portfolio returns, especially over the longer term (PwC, n.d.). As it is possible to see, there are two main different dimensions that cover the ESG management, one based on the investors point of view and another one focused more on the corporate managing side. As follows, both perspectives will be analysed, starting with the latter.

1.3.1 ESG and CSR

Corporate actions are often referred to as Environmental, Social and Governance (ESG), or Corporate Social Responsibility (CSR) (Gillan, Koch, & Starks , 2021). Therefore, before analysing the corporate role regarding the involvement with the underlying topic, it is necessary to consider these two terminologies and their evolution. It is necessary to clarify that these two acronyms were not coined at the same time, instead they represent an evolution of the way by which sustainability is considered in the economic dimension.

As we proceed to analyse the evolution of this concept it is still important for this study to clarify the extent to which these two concepts are different. On the one hand, ESG is an acronym that refers to how corporations and investors integrate environmental, social and governance concerns into their business models. While, on the other hand, CSR traditionally refers to corporations' activities that aim to be socially responsible (Gillan, Koch, & Starks , 2021).
The main difference between the two concepts is that ESG includes governance explicitly while CSR includes indirectly the governance issues as they relate to the environmental and social considerations. Furthermore, the approaches to the CSR and ESG strategies and objectives can either be cathegorized as "self-regulated" or "meta-regulated". The former one refers to those practices that are internal to the company and those corporate governance mechanisms that can be adopted on a regular basis. For instance, corporate codes of conduct are among the most softest forms of self regulated CSR strategies. The latter category refers more to external measurements and ratings on the company's sustainable and proactive strategies. Both form of strategies are complements and thus, can be implemented due to voluntary decisions or externl social pressures (Pollman, 2019).

1.3.2 Sustainability and Corporate identity (CI)

The increasing attention for firms's performance as well as the environmental and social practices has highlighted the importance of the relationship between sustainable activities and the company's ability to manage intangible assets. The increasing competitiveness in the market has emphasized the need for an unique Corporate Identity that should also be enlightened by an efficient communication strategy. Hence, in order to capture the industry's opportunities firms should be able to understand the relationship between CSR and CI.

According to (Tourky, *et al*., 2020), it is necessary to understand how these concepts are interlinked in order to develop effective strategies of differentiation and achieve competitive advantage. Therefore, defining and connecting CSR to other concepts such as Branding, Corporate Image, Corporate Identity and Corporate Reputation is as important as defining efficient communication strategies, and selecting the optimal communicating channels. In addition, Lu, *et al.*, (2019) have discovered how CSR constitutes an integral part of the Corporate Identity and how communication represents the key strategy to enhance and integrate its principles within the identity.

According to Tourky, *et al*., (2020), Corporate Identity helps identify the internal drivers that can set the vision for CSR as part of a company. Therefore, elements such as the founders's view, the firm's core values, mission and culture have a strategical impact on the CSR strategies. Furthermore, from an operational point of view, CI factors such as the communication and leadership styles can be crucial for implementing CSR, since they can influence the employees' behaviour. Employees identify themselves into the organizational values and goals and, by doing so, they embrace also the corporate CSR strategies.

Therefore, the relationship between CSR and CI should vert on two basic concepts. First of all, as Tourky, *et al*., (2020) state, CSR strategies are driven by CI aspects, such as: the values, the culture, the senior management, the employee behaviour, the organization's mission and the communication and leadership style adopted. Furthermore, the second aspect that characterizes this relationship is that institutionalizing CSR represents an effective way to integrate its principles within the Corporate Identity and the business core processes.

1.3.3 Sustainable Divelopment Goals

In the 2015 the United Nations adopted the Sustainable Development Goals (SDGs) with the objective of encouraging an universal call to action to protect the planet, reduce poverty, and ensure by 2030 a peaceful and prosperous environment to live in (United Nations Development Programme, s.d.).

There are a total of 17 Global Goals and they are integrated in such a way that the action in one area can affect also the outcome in others. Furthermore, the UN established that, the development of a specific goal must balance the social, economic and environmental sustainability. Therefore, this system is strictly connected with all the ESG and CSR dimensions. Given the large-scale intervention of SDGs, it is possible to say that this system was designed precisely to be adopted by different types of actors, from singular enterpirses to entire countries, and, by doing so, the UN made sure that the creativity, knowhow, technology and financial resources from all of society is necessary to achieve the SDGs in every context (United Nations Development Programme, s.d.).

Therefore, the commitment to the SDGs shows the intent of prioritizing progress for those who're furthest behind. As shown in *Figure 1.*, some of the SDGs are designed to end poverty, hunger, AIDS, and discrimination against women and girls.

Figure 1. *The SDGs (United Nations Development Programme, s.d.)*

1.4 ESG from the Investment perspective

Environmental, social and governance factors (ESG) are set to influence the financial investments sector in the years to come (Bain & Company, 2022). As consumers, employees and communities raise their support for ESG initiatives, companies that exploit and stand out on these issues will differentiate more giving them the opportunity to gain a sustainable competitive advantage.

As follows, key aspects of the ESG dimensions in the investing world will be presented. Firstly, the Sustainable Responsible Investing (SRI) and its origins will be analyzed, consequently, the Principles for Sustainable Investing issued by the United Nations will be introduced, and finally the paper will focus on the regulations provided by the EU for what concerns the ESG issue.

1.4.1 Sustainable Responsible Investing (SRI)

When considering ESG issues for financial and (Townsend, 2020)investing purposes it is common to use the term Sustainable Investing. This expression refers to a broad concept that usually considers a form of investing that has evolved over time (*as shown in Figure 2*). Nowadays, it is commonly associated with how a company performs regarding the environmental, social and governance wide-ranging areas of concern (Statista, 2022).

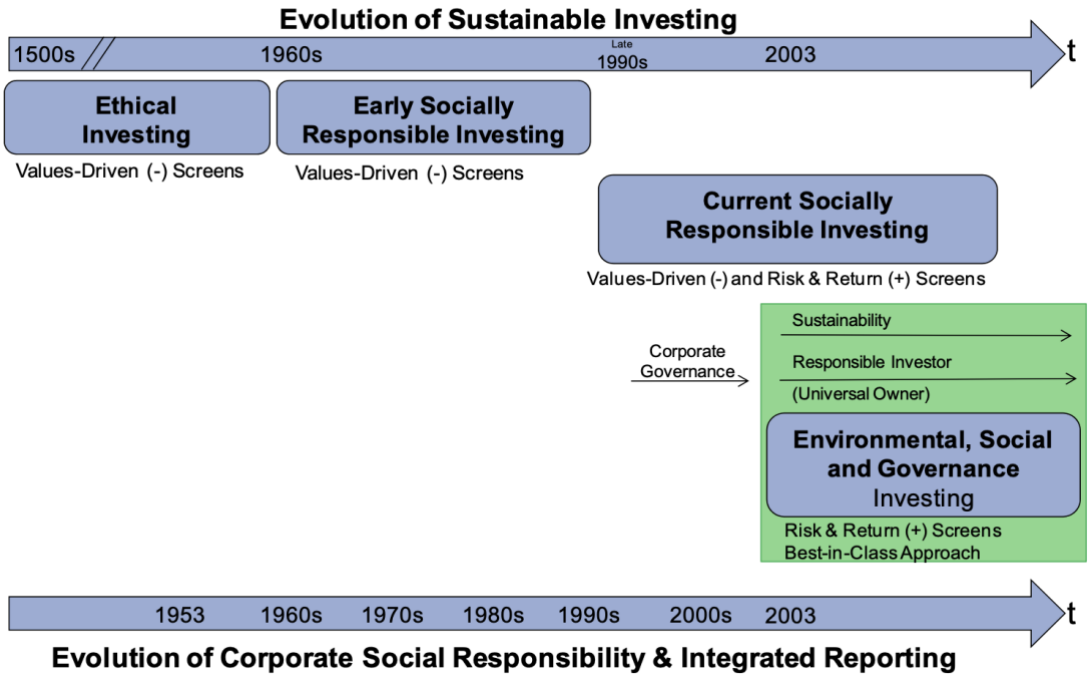


Figure 2. *Evolution of SI* and CSR (Deutche Bank, 2012)

However, this definition of Sustainable Investing raises some doubts when it comes to quantify whether the investment is sustainable or not and whether to integrate these aspects into the investments decisions. For these purposes, there are some general methods and tools that are considered useful, such as: ESG scores, Screening techniques and Impact investments.

ESG scores represent the simplest way to incorporate ESG concerns into investment strategies because they provide standardized values that can be used by investors to assess and compare companies' performance on ESG concerns. This approach is similar to how financial performance is usually measured. Hence, thanks to ESG scores, investors can then choose to only put money into companies that are performing well in terms of ESG issues. Furthermore, the other two major forms of sustainable investment tools are screening and impact investment.

Screening can be either positive or negative. Positive screening refers to choosing only to invest in companies with the best ESG performance. For instance an example of this would be investing in electric car manufacturing companies over other car manufacturers, thus including and prioritizing the focus on electric vehicles in the investment parameters. In contrast, negative screening excludes investments in companies that perform in certain activities, such as weapon manufacturing or coal power generation (Statista, 2022).

Impact investing is similar to positive screening but is more focused and targeted as it involves investments in companies that work directly address a specific ESG concern, such as renewable energy installations or a specific social program (Statista, 2022).

In conclusion, according to the Global Sustainable Investment annual Review, (2018), sustainable investing has grown in both absolute and relative terms in recent years and it has become increasingly accessible. Furthermore, negative screening, ESG scores and impact investments are popular and oftenly used tools for quantifying the ESG integration into the investors strategies and the corporate engegement. Therefore, it is possible to say that, by incorporating sustainable investments as part of their decisions and work, investors are able to achieve social and environmental benefits that will help them to pursue and fulfill their mission (Global Sustainable Investment Alliance, 2018).

1.4.2 Principles of Responsible Investment (PRI)

From the investing standpoint another crucial aspect that influences both CSR and ESG strategies is represented by the Principles of Responsible Investment, also called PRI.

The Principles of Sustainable Investment consists of a United Nations-supported international network of financial institutions have the objective of working together to implement an effienct and sustainable long-term value creation (UN Principles for Responsible Investment, s.d.). Hence, for the United Nations the PRI are an increasingly popular instrument (as shown in *Figure 3.*) through which promote the integration of ESG and sustainable actions.

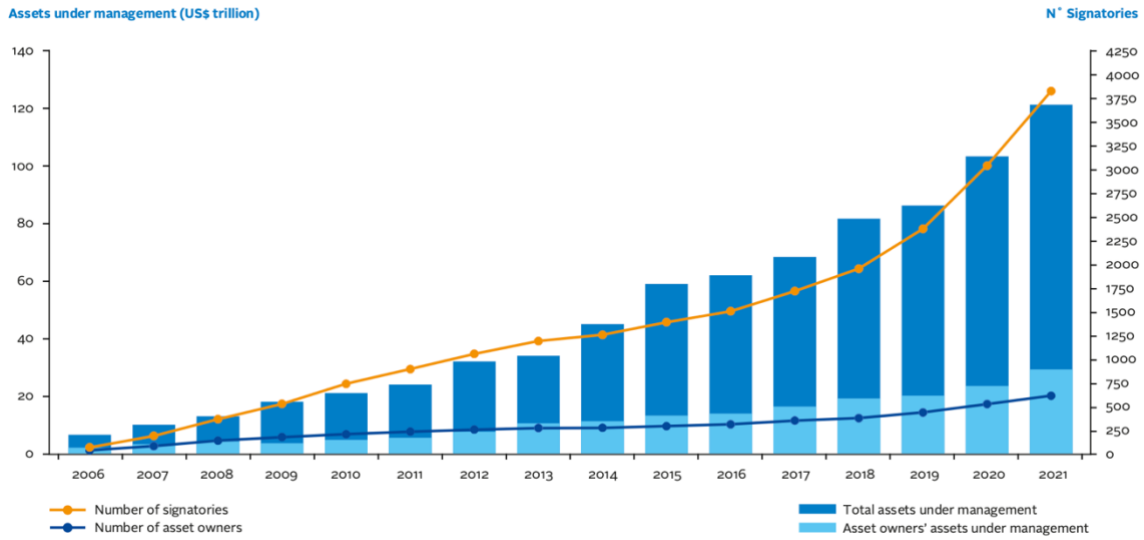


Figure 3. *PRI growth since 2006 (as of April 2021) (United Nations PRI, 2021).*

Therefore, these principles define responsible investment as a strategy and practice that allow companies to incorporate environmental, social and governance (ESG) factors in investment decisions and active ownership.

Responsible Investment is a broad concept that not only makes moral or ethical goals as a primary purpose, but it also guides those investors whose sole focus is financial performance, as well as those looking to build a bridge between financial risk, opportunities and the outcomes. Consequently, according to United Nations PRI, (2021), asset owners are not competing against each other and should work together to make capital markets more sustainable. Therefore, the six Principles of Sustainable Investment are represented as follows:

1. The incorporation of ESG issues into the investment analysis and decision-making processes. For what concerns this first principle there are seversl actions that could be taken to incorporate the ESG issues, for instance: developing the ESG related tools, assessing the

capabilities of either internal and external investment managers, encouraging academic and professional research, advocating ESG training for investment professionals and investing in policy statements and service providers (such as as financial analysts, consultants, brokers, research firms, and rating companies) (United Nations PRI, 2021).

2. The second principle relates to taking an active role as owners and incorporating ESG issues into the firm's ownership policies and practices. In order to enhance and implement this concept, investors could, for instance: disclose an active and sustainable ownership policy, participate in collaborative engagement initiatives, file shareholder resolutions consistent with long-term ESG considerations and engage with companies on ESG issues while developing an engagement capability (either directly or through outsourcing) (United Nations PRI, 2021).

3. Seeking an appropriate disclosure on ESG issues by the entities in which the capital is invested in. In this regard, investors could ask to include the ESG into the annual financial reports, ask for information from companies for what concerns the adoption of relevant norms, codes of conduct or initiaves and, lastly, they could support shareholder initiatives and resolutions to promote ESG disclosure (United Nations PRI, 2021).

4. Promoting the acceptance and the implementation of the PRI within the investment industry. One of the main actions that could be undertaken to incorporate ESG issues is represented by the possibility of supporting the development of tools and policies related to the benchmarking and the implementation of ESG related issues (United Nations PRI, 2021). Furthermore, the proper alignment of the monitoring procedures and the performance indicators could also be helpful for the incorporation of ESG issues.

5. Working together with institutions to enhance the effectiveness in implementing the Principles represents another important step for the depletion of ESG related issues. Therefore, supporting and participating in information networks and platforms while sharing tools and resources could develop new sources of learning (United Nations PRI, 2021).

6. Lastly, the final PRI stimulates the participation in reporting all the activities and the progress in implementing the Principles. As a result, there are several actions to be taken in this instance, for example: disclosing how ESG issues are integrated within investment practices, sharing active-ownership activities, determing the impact of the PRIs as well as reporting on progress and achievements (United Nations PRI, 2021).

1.4.3 ESG investments: sustainable funds

Nowadays it is possible to see some trends on how ESG issues are considered and integreated into investors' considerations and decisions. An emerging trend that is possible to see in financial markets is given by the spread of sustainable funds. Such instruments use environmental, social, and corporate governance (ESG) criteria to evaluate investments or assess their societal impact. They may pursue a sustainability related theme or a specific aim, usually associated with an SDG (Hale, 2018).

In recent years, the global market for sustainable funds experienced a consistent growth, which was mainly driven by developed markets. According to Morningstar data (Hale, 2018), the number of sustainable funds reached 5,932 by the end of 2021, which increased up to 61 per cent from the previous year *(as shown below in Figure 4.)*. Furthermore, investment inflows to sustainable funds also accelerated. The net investment in 2021 has grown up to 58 per cent from the previous year, reaching a total of $557 billion (Hale, 2018). These trends reflect an increasing interest from institutional investors, which are increasingly integrating sustainability in their portfolios to mitigate long-term climate and other environmental and social risks while tapping into opportunities offered by the energy transition. However, it is necessary to report how the risk of sustainability or ESG washing constitutes a severe challenge to the future growth of the sustainable funds market.

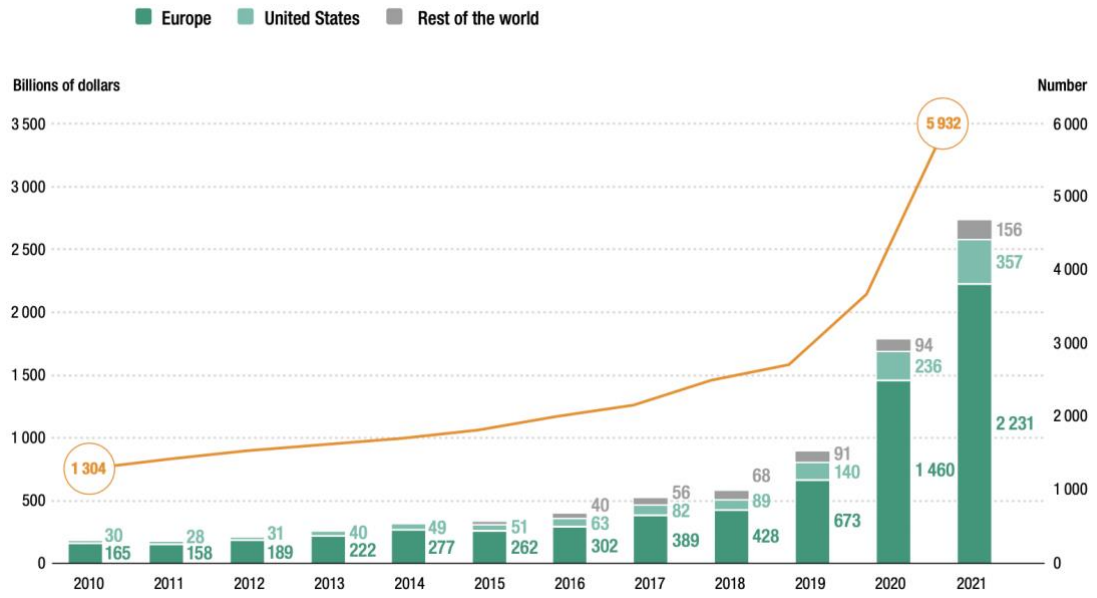


Figure 4. *Sustainable funds and assets under management (Billions of dollars and number), 2010–2021 (United Nations Conference on Trade and Development, 2022)*

According to the annual report of the United Nations Conference on Trade and Development, (2022), so far, sustainable funds have been self-labelled. In fact, usually, Labels and ratings are all aimed at either certifying and promoting sustainable investments by providing simplified

choices for investors. However, labels requirements are not usually standardised and therefore do not provide like-for-like comparison across funds (EFAMA - European Fund and Asset Management Association, 2017). Although several economies, such as the European Union (EU) and Hong Kong (China), have introduced regulations on sustainability disclosure by issuers at the product level, there are still no industry standards for qualifying sustainable funds at the national or international level. Furthermore, the United Nations report a lack of high-quality sustainability data along with an inconsistency and unrealiability for what concerns companies' sustainability ratings, which will be analysed deeply in the following chapters. Hence, these deficiencies make it challenging to evaluate the sustainability performance of these funds (United Nations Conference on Trade and Development, 2022).

All these issues have led to a growing concern about the credibility of the sustainable funds' matket, which could not only limit its potential by holding back further growth of the market but it could also damage the investors' confidence. However, as shown in the annual report of the United Nations Conference on Trade and Development, (2022), the growth momentum of sustainable funds is expected to continue. Demand is expected to remain strong and governments in both developed and emerging economies have stepped up their efforts to support the growth of sustainable investment.

1.5 Sin Stocks

Sin stocks represent a specific type of shares that regards companies involved in activities that are considered unethical, such as alcohol, tobacco, gambling, adult entertainment or weapons (Robeco, s.d.).

This type of shares represent a relative concept since it's though to evaluate, since, different cultures and people have different considerations on what effectively constitutes a sin. For instance, an example is represented from the fact that Sin Stocks usually include alcohol and weapons manufacturers, but in some countries producing a fine wine or serving the military can be considered a noble tradition. In fact, as Fauver & McDonald, (2014), analyzed, Sin Stocks are treated differently among different countries depending on the social norms present in the country, hence, this confirms that, for example, a tobacco company in China will be treated differently by investors than a tobacco company in the US. However, ethical investors tend to exclude Sin Stocks because they incolve companies that are making profits while exploiting human vices and weaknesses.

In general, various studies have shown how sin stocks deliver better returns than other kind of more ethical stocks. For this reason there are many explanations, first of all, usually sin stocks

are undervalued because many investors try to avoid them, another one is that usually sin industries present an increased reputation risk and for this investors are often compensated with a risk premium (Robeco, s.d.).

However, a recent study conducted by Blitz & Fabozzi, (2017), shows how the outperformance of sin stocks can be explained by two main factors: "profitability" and "investment". High operating profitability usually leads to better stock returns, while the investment factor explains how organizations with high total asset growth perform worse. Therefore, by using this model it is possible to see how sin stocks tend to be highly influenced to both factors. For example, cigarette and tobacco makers tend to have a high price margin, dur to tekative price inelasticity, but on the other hand they are restricted in how they can grow their assets (Blitz & Fabozzi, 2017).

1.6 EU Regulations

In the summer of 2020, the European Council and Parliament signed the EU Taxonomy Regulation with the intent of standardizing the definition and processes of ESG factors (EU regulation 2020/852, 2020). The objective of the Taxonomy is to delineate a classification system that regards all the activities that can be defined as sustainable. As the *"EU Taxonomy Guide"* report provided by Sustainalytics, (2022), shows, all of these activities will have to satisfy minimum requirements and securities in order to meet six environmental objectives liked to ESG, which are represented as follows:

i. Climate change mitigation
ii. Climate change adaptation
iii. Sustainable use and protection of water and marine resources
iv. Transition to a circular economy, waste prevention and recycling
v. Pollution and prevention control
vi. Protection of healthy ecosystems

Moreover, in order to assess a company's alignment to the EU Taxonomy, three main factors are taken into consideration (Sustainalytics, 2022):

- Substantial Contribution. The first factor regards the company involvement in activities that positively contribute to the six objectives already mentioned. For example, a company that constructs green buildings.

- Do No Significant Harm (DNSH). After assessing if the company activities respect the first factor, it is necessary to determine if the detrimentally affect the other five environmental objectives. For example, when constructing green buildings, it is necessary to establish if it is done in a sustainable way or whether it cause excessive pollution, hence not respecting the objective number five.

- Minimum Safeguards. The last factor concerns the compliance of the global standards for responsible conduct. Therefore, continuing with the previous example, if the company respects the rights of its employees and the local community.

Furthermore, when considering the standardization process, also the european Non-Financial Reporting Directive (NFRD) should be taken into account (European Union Directive 2013/34/EU, 2014). This directive establishes non financial reporting requirements for large public interest companies that employee more than 500 people. The Directive applies to approximately 11,700 companies divided into: insurance and listed companies, banks and other companies which are designated as public interest entities by national authorities (European Union Directive 2013/34/EU, 2014).

These organizations are required to present in their their consolidated non financial statement information necessary for an understanding of the group's development, performance, position, and impact of its activity, relating to ESG matters, including: a brief description of the group's business model, the non-financial key performance indicators relevant to the business, the policies adopted in relation to the ESG issues, the results of such policies and the principal risks that the group incurs into while adopting such policies (European Union Directive 2013/34/EU, 2014). Furthermore, where the group or the organization does not pursue policies in relation to one or more of those matters, the consolidated non financial statement must provide a clear and reasoned explanation for not doing so.

In addition, on the 5th of January 2023, the Corporate Sustainability Reporting Directive (CSRD) entered into force. With this new regulation, the European Parliament and the Council of the European Union found an agreement on what concerns the sustainability reporting law. This new directive broadens the sustainability reporting duty to all large companies as well as listed SMEs (European Union Directive 2022/2464, 2022). The new regulation has the objective of ensuring that investors and other stakeholders have access to the information

needed to assess investment risks linked with climate change and other sustainability issues. Moreover, according to the European Union Directive 2022/2464, (2022), the CSRD implementation will foster a culture of transparency about companies' impacts on people and the environment, while making it mandatory for companies to audit the sustainability information that they report. Thus, providing also the digitalization of sustainability information among firms. Furthermore, the rules introduced with the previous 2014 NFRD directive will remain in force until companies will have to apply the new CSRD directive. In particular, the first companies will have to apply the newer directive starting from the fiscal year 2024, whereas the reports will be then published in the fiscal year 2025 (European Union Directive 2022/2464, 2022)

2. THE ESG RATINGS

2.1 ESG Data Landscape Framework

After the presentation of the fundamental aspects and dimensions of the ESG core principles, it is suitable to proceed the analysis by presenting the methodologies and the specialists that are involved in the ESG performance assessment.

Most publicly traded firms, as well as some of the privately held ones, have their environmental, social, and governance performance measured and assessed by a variety of independent rating agencies and reports. With the use of these ratings, stakeholders may follow the company's ESG performance over time and evaluate it against that of its rivals.

The increased quality and availability of systematic ESG ratings data has helped the rise in popularity of both the interest in sustainable and passing investing, in fact, as Li & Polychronopoulos, (2020) state, a lack of robust data is the most significant barrier to greater adoption of ESG strategies. However, it is necessary to notice how the methodologies used by ESG data providers are often not consistent and this can lead to drastically different outcomes when constructing a portfolio (Li & Polychronopoulos, 2020).

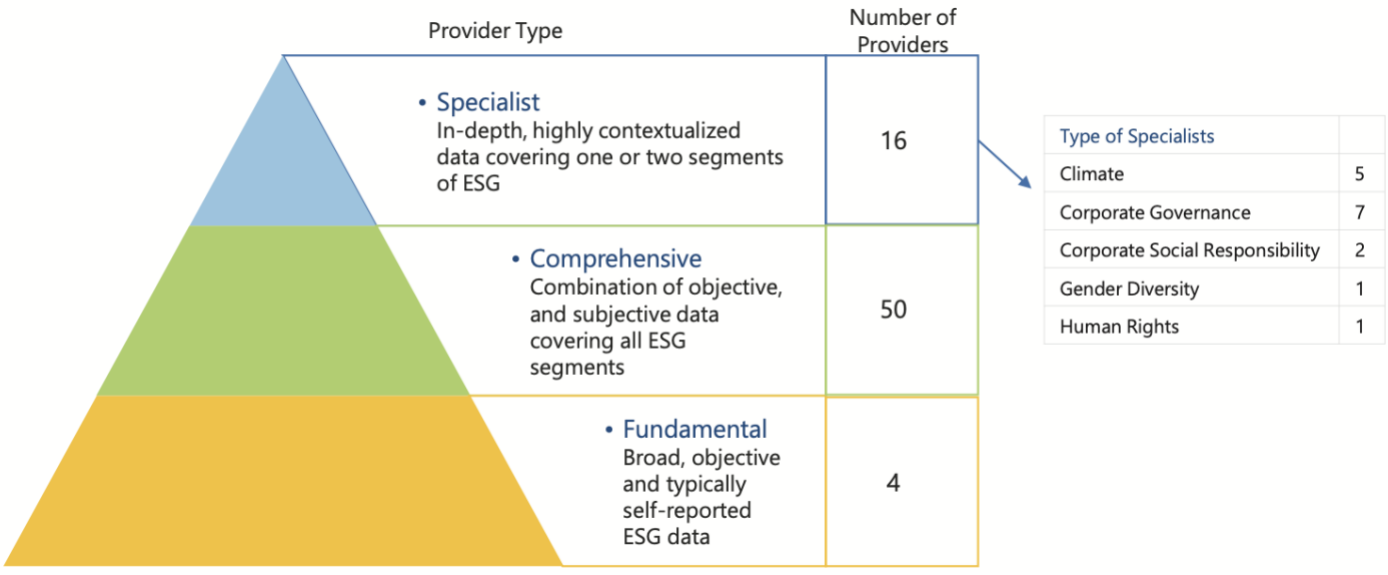


Figure 5. *ESG Data Framework (Li & Polychronopoulos, 2020)*

As a result, ESG investors should start by correctly classifying the different forms of data accessible according to the information they are looking for.

This study adopts the conceptual framework presented by Li & Polychronopoulos, (2020), in order to facilitate the distinction between the data provided by the several rating providers. Therefore, the presented system was developed with the purpose of helping investors 1to understand adequately the various tipes of ESG ratings data by dividing them into three main categories. As shown in *Figure 5.,* (Li & Polychronopoulos, 2020), the three main categories for ESG ratings data are: Fundamental, Comprehensive and Specialist.

2.1.1 Fundamental ESG Data providers

This first category represents all those ESG data providers which gather and collect publically accessible data to then systematically providing it to end customers. These suppliers frequently use information from business websites, corporation records, and non-governmental organisations. Bloomberg ESG Data Service and Thomson Reuters ESG Research Data constitute the two main examples of fundamental providers.

2.1.1.1 Bloomberg ESG Data Service

Bloomberg's Environmental, Social & Governance (ESG Data) dataset provides ESG metrics and ESG disclosure scores for more than 14,000 companies in more than 100 countries (Bloomberg, s.d.). The offering includes sector and country specific data points as well as as reported statistics and calculated ratios. ESG data from Bloomberg is divided into more than 2,000 fields and covers a range of important sustainability subjects, such as: Air Quality, Climate Change Water & Energy Management, Materials & Waste, Health & Safety, Audit Risk & Oversight, Compensation, Diversity, Board Independence, Structure & Tenure and Shareholders' Rights (Bloomberg, s.d.).

Since ESG data isn't yet standardized, Bloomberg data must be compatible also with other third parties' existing dataset. In order to achieve that and to enhance integration and interoperability, Bloomberg links these two forms of data by using common identifiers and symbiology (Bloomberg, 2022). Furthermore, in order to meet ESG regulatory needs or to make investment decisions, it's not enough to just have company reported data. Thus, to fill this gap Bloomberg provides to its own customers almost 1,000 points of third party content along with their own unique proprietary scores (Bloomberg, 2022).

Asset managers may occasionaly struggle to manage the volume of ESG data generated by the whole industry. Hence, organizations around the world must find ways to integrate environmental, social and governance data into their operating models in order to report it accurately on their own internal ESG data, which will be shared with external governing bodies and shareholders (Bloomberg, 2022). In order to do so, they have to rely on accurate and precise data which has to be retrieved from trusted sources. Therefore, Bloomberg demonstrates transparency in three main ways:

i. With representative data.

Company reported statistics must reflect at least 80% of operations and 80% of the workforce in order to be included in Bloomberg's proprietary rating (Bloomberg, 2022). This is how Bloomberg makes sure a score accurately reflects the business activity.

Users can then review the grading procedure and examine the company reported data underlying each score.

ii. With reported and estimated carbon data.

Bloomberg gathers carbon emissions data reported by the companies and uses a multiple modelling approach. By doing so, the provider is able to estimate results also for companies that do not report such data.

Bloomberg’s GHG emissions estimates model provides a distribution of estimates and a confidence score showing the quality and availability of such data. This allows Bloomberg to handle a wide coverage range, including over 100,000 companies, with data going back to 2010 (Bloomberg, 2022).

iii. With a high quality ESG Fund Analytics offering.

Bloomberg's ESG Fund Analytics offering delivers standardized and objective ESG Data for over 61,000 worldwide Mutual Funds and 10,000 Exchange Traded Funds (Bloomberg, 2022). This data includes basic ESG issues, such as: carbon emissions, waste management, resource consumption, business policies, diversitiy and governance inclusion. Therefore, this practice helps to address the lack of transparency by helping customers to quickly compare funds and make investments based on their ESG goals and preferences.

2.1.1.2 Thomson Reuters ESG Research Data

The Thomson Reuters ESG Scores were design to measure a company ESG performance based on ten different themes, including: emissions, environmental product innovation, human rights and shareholders rights (Thomson Reuters, 2017).

The TR environmental, social and governance scores are available for over six thousand companies located all around the world, across more than 400 different ESG metrics with history going back to 2002 (Thomson Reuters, 2017). Furthermore, for all the ESG dimesions, the provider presents both the percentages and the letter grades scores, which go from D-, being the lowest grade, to A+, being the maximum.

Thomson Reuters ESG scores consists of percentile ranked estimates benchmarked against their TRBC (which stands for The Refinitiv Business Classification) Industry Group. As a result, they are compared to other businesses in the same sectors since environmental and social issues tend to be more relevant and similar to companies within the same industries (Thomson Reuters, 2017).
Such scores represent a replacement to the existing ASSET4 ratings and they were implemented to reduce the company size and transparency biases at the minimum level possible while reflecting the Thomson Reuters ESG framework. The major key enhancements over ASSET4 ratings consists of:

1. The ESG controversies overlay.
2. Benchmarks for industries and countries at the data point scoring level.
3. Automatically adjusted Category ratings in accordance with the importance and size of each category.
4. The Percentile Rank scoring system, which eliminates hidden layers of calculations.

Nowadays, Thomson Reuters offers two overall ESG Scores calculated per company, per fiscal year in the model:

1. Thomson Reuters ESG Score is the measure of a company's ESG performance based on reported data in the public domain. The provider captures and calculates over 400 company level ESG measures, to then carefully select a subset of 178 most relevant data points to power the overall company assessment and scoring process. The underlying metrics are grouped into

ten different categories and they are influenced by factors such as: data accessibility, materiality, and industry relevance (Thomson Reuters, 2017).
Therefore, the final ESG score is based on a mix of the ten categories and is a representation of the company's ESG performance based on publicly disclosed information.

2. The Thomson Reuters ESG Controversy (ESGC) Scorecombines the Thomson Reuters ESG Score with ESG controversies to provide a thorough assessment of the company's sustainability impact and conduct (Thomson Reuters, 2017). The main objective of this score is to reduce the ESG performance score based on adverse media coverage because as this increases the impact of significant, material ESG controversies on the overall ESGC score.

It follows that the availability of both evaluations allows users to adopt and apply the score that fits best their process, assessment or investment criteria.

2.1.2 Comprehensive ESG Data providers

Comprehensive ESG data suppliers combine both factual and subjective information from all ESG market areas to then create their own grading methodologies. In order to do so, they blend publicly accessible data with information gathered by their own analysts through business interviews, questionnaires, and independent research.

A company's total ESG score is then calculated through the application of an established, systematic methodology which analyses hundreds of criteria related to environmental, social, and governance issues (Li & Polychronopoulos, 2020). These firms often retrieve data from public websites and publications in order to complement corporate ESG ratings with extra information, such as controversy evaluations relating to company-specific concerns. They also create reports on regional and sectoral trends. S&P Global ESG Score, MSCI ESG Research & Ratings and Sustainalytics Company ESG Reports are a few examples of comprehensive providers.

Furthermore, there are providers like, for instance, TruValue Labs and RepRisk which are comprehensive data suppliers that instead of using conventional ESG experts to produce firm evaluations, like S&P Global and the others mentioned previously, they use mainly algorithms (Li & Polychronopoulos, 2020).

2.1.2.1 S&P Global ESG Score

S&P Global ESG Scores are based on a combination of verified company information, media and stakeholder analysis. Furthermore, S&P employs a unique approach called Global Corporate Sustainability Assessment (CSA) to enhance in depth engagement with the organizations. Therefore, this system separates S&P from ESG datasets that merely rely on publicly available information and enables the provider to disclose access to ESG insights before they reach other competitors (S&P Global, s.d.).

The S&P Global ESG Scores thus provide an in depth view of companies' ESG performances, with accurate assessments that are not easily biased by misleading accessible data. The provider plays also a major role in shaping the sustainability landscape, introducing new topics and supporting the improvement of disclosures and information (S&P Global, 2023). S&P analysts validate disclosures for both accuracy and relevance, discuss methodologies and measurement best-practices, and provide ongoing feedback. S&P Global ESG Scores combined with the CSA research process represent the basis of a unique ecosystem that actively drives corporate disclosures with the objective of raisng the standard on sustainability over time (S&P Global, s.d.).
The CSA does not simply determine how transparent companies are, but also it uncovers how well they really manage the ESG risks and opportunities they face. Therefore, this process offers unmatched insights into corporate sustainability practices, relying on decades of engagement with thousands of companies each year.

Furthermore, S&P Global divisions help customers to meet their unique needs, by offering them a comprehensive coverage across global markets. In order to power investment decisions and client workflows with precision and clarity the provider offer includes also: material environmental, social and governance criteria scores for up to 30 focus areas across different sub-industries; question level scores covering 130 sustainability topics; and an additional 1,000 underlying data points per company (S&P Global, 2023).

2.1.2.2 MSCI ESG Ratings

MSCI ESG Ratings are designed to help investors understand ESG rfactors that generatre risks and opportunities and can affect the the long-term risk-and-return profile of investment portfolios. MSCI Research Global Team of over 200 experienced research analysts assess thousands of data points across 35 ESG Key Issues, primarily focusing on the intersection

between a company's core business and industry issues that can create significant risks and, or, opportunities for a company (MSCI ESG Research LLC, 2022). Companies and management are typically exposed in several ways to ESG risks and opportunities, hence, to assess this issue, MSCI collects data from a variety of sources, including: data gathered at the geographic level from academic and NGOs' datasets; companies' disclosures and Government databases.

Therefore, to integrate these factors into their portfolio construction and management process companies are rated on a AAA, being the maximum, to CCC, being the minimum, scale relative to the standards and performance of their industry peers. The provider's ESG ratings aim to measure a company's resilience to long-term, financially relevant ESG risks by taking into consideration both the negative externalities generated by the industry and how these ESG issues may turn into opportunities for the companies (MSCI ESG Research LLC, 2022).
More specifically, the MSCI ESG Ratings model seeks to answer four key questions about companies:

- What are the most significant ESG risks and opportunities facing an industry or a particular company?
- How exposed is the company to those key risks and/or opportunities?
- How well is the company managing key risks and/or opportunities?
- What is the overall picture of a company and how does it compare to its global industry peers?

The MSCI ESG Ratings system only considers issues that have been assessed to be material for each industry (MSCI ESG Research LLC, 2022). Companies in a specific sector affected by a material risk may incur in expenditures because of it, thus material risks are the ones that originate consistent and tangible effects. On the other side of the spectrum it is possible to identify as material opportunities for an industry the ones that, if exploited, will be more likely to generate profits for the companies in that business area.

MSCI Research identifies such risks and opportunities through a quantitative model that utilizes average values and the range value for each industry to assess the externalized impacts. Other than identifying and assigning these "Key issues" to each industry, MSCI conducts formal in-depth quality review processes at each stage of analysis. Such procedures include: quality reviews of data and rating publications; industry and market lead supervision of ratings and reports; and the approval of rating disallowances or major rating changes by the ESG Ratings Methodology Committee (MSCI ESG Research LLC, 2022).

In order to identify the emerging issues and to pinpoint the ones that became less significant, MSCI Research conducts both an annual review of the "Key Issues", and their respective weights, assigned to each industry, as well as a proactive reach to companies with the purpose of implementing its feeback and communication system (MSCI ESG Research LLC, 2022).

2.1.2.3 Sustainalytics Company ESG Reports

The ESG Risk Ratings offered by Sustainalytics are intended to assist investors in recognizing and comprehending financially significant ESG risks at the security and portfolio levels, as well as how they may impact both equity and fixed income assets' long-term performance (Sustainalytics, 2020).

Furthermore, the provider has developed a specific four steps system to effectively measure company's exposure to ESG risks. First, the provider measures a company's exposure to industry-specific material ESG risks. Then, ESG risks are separated into two types of risks, the manageable risks, which can be addressed through policies and programs; and the unmanageable ones, which consists of idiosyncratic type of risks and the risks that can't be addressed by a firm's policies. Idiosyncratic Risk consists of additional exposure to risk caused by an issue that was not deemed material at the subindustry level but becomes a material ESG issue for a company based on the occurrence of an unpredictable and extraordinary event (Sustainalytics, 2020).

Sustainalytics, then, indentifies a management gap which represents all the risks that could be managed by a particular company through initiatives and governance policies, but which are not yet being managed effectively (Sustainalytics, 2020). As a result, by combining the management gap and the unmanaheable risks, the provider issues a quantitative ESG Risk Rating that places companies into five distinctive risk categories:

- Negligible Risk (Score between 0-9.99 points): Enterprise value is considered to have a negligible ESG driven material risk of being impacted financially.
- Low Risk (Score between 10-19.99 points): Enterprise value is considered to have a low risk of material financial repercussions from ESG concerns.
- Medium Risk (Score between 20-29.99 points): Enterprise value is believed to face a medium risk of significant financial repercussions brought on by ESG issues.

- High Risk (Score between 30-39.99 points): Enterprise value is thought to be at high risk of major financial impact due to ESG concerns.
- Severe Risk (Score equal to 40 or higher points): Enterprise value is considered to have a severe risk of material financial impacts driven by ESG factors.

2.1.3 Specialist ESG Data providers

ESG data providers who specialize on a single ESG problem fall under this category. Therefore, specialist suppliers focus on a singular ESG issue like, for instance, environmental and carbon scores, or social issues regarding human rights, or gender diversity (Li & Polychronopoulos, 2020).

Investors that want to handle a specific issue and advance in that area might benefit from these providers' experience in that subject. Examples of such suppliers include the non-profit Carbon Disclosure Project (CDP) and Equileap. Given the vast volume of ESG data that comprehensive providers collect and manage, they frequently have the ability to offer end customers also specialized data (Li & Polychronopoulos, 2020).

2.1.3.1 CDP

CDP (Carbon Disclosure Project) is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts (Carbon Disclosure Project, 2022). The main objective of this provider is to support investors, companies, cities and governments in order to contribute to the formation of a thriving economy for the planet in the long term. CDP is one of the main provider of environmental disclosure systems, each yeat the provider support thousands of different entities to measure and manage their risks and opportunities for what concerns climate change, water security and deforestation.

The focus of CDP is driven by the interest and the request of investors, purchaser and city stakeholders. Every year, CDP provides an annual reporting process which discloses data later used to evaluate firms and cities (Carbon Disclosure Project, 2022). Therefore, CDP promotes action on climate change, deforestation and water security through its independent scoring system. The evaluation process is focused on the progress that these entities obtain toward environmental leadership.

CDP scores companies in a scale that goes from "D-", being the lowest value, to "A", being the maximum. By disclosing scores over consecutive years, organizations can understand the trajectory of their environmental journey and their progress for what concerns proactive environmental actions (Carbon Disclosure Project, 2022).

CDP scores provide a snapshot of a company's disclosure and environmental performance. Such evaluations are determined using a standardized methodology that analyzes the quality of a company's responses to a determined questionnaire.

Four levels of evaluation are used to estimate each organization's performance. The process starts by disclosing the current status of the entity, then it carries on by establishing the company's awareness of its environmental impact, and it concludes by examining the management and leadership style adopted by the firm (Carbon Disclosure Project, 2022). Therefore, it is possible to say that, by achieving a high CDP score, an organization demonstrates not only to be aware of its environmental footprints, but also, to be able to adopt an advanced sustainability management, and leadership styles able to address environmental concerns.

2.1.3.2 Equileap

Equileap is an independent, specialized data provider focused on gender metrics. Equileap was founded in 2016 by Diana van Maasdijk (CEO) and Jo Andrew with the objective of taking a leap towards gender equality in the workplace, and laying out the data to show why that leap was important (Equileap, 2023). Therefore, in order to do so, provider assesses over 4,000 companies globally on 19 criteria including gender balance, the gender pay gap, paid parental leave and anti-sexual harassment policies.

Many organizations use Equileap data for portforlio analysis, ESG integration, stewardship and managing reputational risk. Furthermore, various indices have also been designed in collaboration with Solactive and Morningstar, to track companies leading in gender equality. These indices are used both as benchmarks, as well as underlyings for financial instruments (Equileap, 2023).

Equileap is proprietary of the Gender Equality Scorecard, which is basically the methodology used to assess a company's gender equality performance comprehensively. It is based on a variety of factors, including workforce gender balance, the gender pay gap, paid parental leave and anti-sexual harassment policies (Equileap Gender Scorecard, s.d.).

2.2 ESG ratings divergencies

2.2.1 Scope, Weights and Methodologies

The growing focus in finance on sustainability issues has led to a proliferation of environmental, social, and governance indicators and rating providers, resulting also in ESG ratings disparities (Capizzi, *et al*., 2021). Some of these providers were presented in the previous paragraph, following a specific pretermined framework developed by Li & Polychronopoulos, (2020) that helps understanding and categorizing all the different sorts of ESG raters.

Hence, by following the ESG Landscape scheme (Li & Polychronopoulos, 2020) it is possible to see how all different raters have diverging interpretations and methodologies to assess ESG data.

Rating agencies generally tend to have a high level of transparency for what concerns their ESG scores, however, they generally tend to use different interpretations and attribute diverging weights on the data that stands behind their rating processes and methodologies. Thus, for a better understanding it is necessary to define what they intend to measure and how they measure it.

Berg, *et al.,* (2022), define as scope and weight what an ESG score provider intends to measure, whereas measurement refers to the methodology used to estimate and evauate the data. As the authors analyze in their study (Berg, Kölbel, & Rigobon, 2022), the main divergence that impacts the ESG ratings is due to measurement differences adopted by the providers. In particular, they examine how the main aspect that stands out from the analysis is that the discrepancies in the ESG ratings are not due to the adoption of different definitions, instead, the main divergence is due to a fundamental disagreement about the underlying data.

If the main dispute was mainly about the definition there would be less divergencies in the evaluation. Given the heterogeneity that affects scope and weight preferences, different views on the subject, in some cases, may even be more desirable. Instead, measurement and methodology divergences could be considered as problematic if every provider took the same definition on weight and scope for granted. In that way, there would be an underlying reasoning metrics that would consider as ascertain and objective the ESG observations, which at this point is not yet feasible (Berg, *et al.*, 2022). According to Capizzi, *et al*., (2021), in order to obtain a standardized process for ESG ratings, the contribution and the introduction of new directives and requirements form the policymakers. In fact, as of now, even though some rating agencies show a high level of transparencies in their ESG rating processes, some of them are still keeping detailed descriptions and data on scores and weights as confidential.

2.2.2 The Rater Effect and Investors considerations

Another interesting aspect is represented to what Berg, *et al.,* (2022), have discovered to be the so called "Rater Effect". In essence, providers' ratings tend to be correlated across categories, thus when a rating agency gives a firm a high rating in one category, it tends to give that company high ratings in other categories as well. Therefore, this effect implies that measurement differencies and patterns are likely to influence how organizations are evaluated. In addiction, the authors have found difficulties in explaining and identifying what are the causes and reasons behind such effect. However, further into the analysis, the authors discoverd that one plausible explanation could be related with the fact that ESG raters tend to split analysts' work by firm rather than by category, allowing thus, that their overall perspective of a particular company would be spreaded into different rating categories (Berg, *et al.,* 2022).
Furthermore, as discovered by Zumente & Lace, (2021), the availability of ESG ratings is much higher when measured by the market capitalization, hence, this consideration implies also that there is a trend in favor of the companies with a larger market capitalization. Therefore, this tendency to award higher ESG scores to larger companies can be problematic considering the fact that it could further deviate the investor from the smaller firms with fewer resources to devote to sustainability implementation.

In conclusion, the different ways used to gather data and the several methodologies used by rater providers show a clear need for standardizion and more transparency. ESG ratings measurement is still too heterogeneous and the indicators used for the underlying data change based on the provider's intentions (Capizzi, *et al*., 2021). Therefore, these divergencies, as well as the inefficiencies in the evaluation process examined by the literature, show how the choice of a particular rating provider can affect the investing decisions of the investors in unpredictable ways. In fact, for what oncerns investors, according to Berg, *et al.,* (2022), an easy way to eliminate measurement divergencies seems to be represented by averaging the indicators from different providers. In fact, indicators are the main drivers in the measurement differences, and thus, the averaging process represents the most logical strategy to minimize such divergencies.

However, the Rater Effect suggests that this approach may be problematic because the discrepancies are not randomly distributed. Instead, it shows how providers' ratings tend to be correlated across categories. Therefore, as an alternative, investors may consider to rely only on one rating agency, after having examined that scope, the measurement, and the weights used are in line with their objectives (Berg, *et al.,* 2022).

3. THE CREDIT RISK

3.1. Credit Risk first notions

In the last few decades, nearly all the major international organizations considerably in human and technology resources to reorganize their approaches of evaluating and controlling credit risk. This process concerned mainly the banking sector, in which, the reorganization process was mainly focused in the development of credit risk measurement models capable of assessing the degree of risk associated with different credit exposures. These models aim to estimate the risk level of a specific credit exposure, such as a loans, bonds, or of an entire exposure portfolio (Resti & Sironi, 2007).

In this chapter will be presented, firstly, the definition and and the different typologies of Credit Risk, to then assess what organizations and entities can control do in order to control it. As a result, the study will start by presenting the principles for Credit Risk Management, to then continue by analysing the managing process of the risk and the methodologies used to quantifying it.

3.1.1 Credit Risk Definition and characteristics

The possibility that an unexpected change in a counterparty's creditworthiness may result in a corresponding unexpected change in the market value of the associated credit exposure is what Resti & Sironi, (2007) refer to as "credit risk". Moreover, this definition contains three different concepts that need further explaination, since they are not obvious nor generally accepted.

1. Default risk and migration risk

First of all, credit risk entails more than just the threat of a counterparty defaulting, in fact, it also includes a mere decline in its trustworthiness. In the case of a fixed-interest loan, for instance, the market value of the loan, which is defined by the present value of the associated cash flows, will undoubtedly decrease if the borrower's trustworthiness declines. The explanation behind this is given by the fact that the present value of future flows should be calculated using a discount rate which includes a spread (risk premium) that represents the probability of the borrower's default in addition to the risk-free rate for the corresponding maturity (Resti & Sironi, 2007).

A reduction of the creditworthiness enhances that probability, resulting in an increase in the spread and a decrease in present value. This would also apply to a variable-rate loan in which the borrower's spread above the market rate is fixed and not adjustable.

Generally speaking, the higher the variation in spread and the greater the residual life of the debt, therefore, the value of a credit exposure often decreases more dramatically when the borrower's credit rating declines.

To summarize, credit risk is divided into two categories: default risk and migration risk. The first indicates the loss risk related with the borrower's real bankruptcy, in which payments are delayed, while the second represents the risk of loss due to a mere decrease in its credit rating.

In conclusion, the only way to define both risk categories properly is by basing credit risk management and evaluation on a discrete or continuous distribution rather than basing them on a binomial one in which the only two possible events are assessed as “default” or “non-default”. As a result, by using a continuous distribution, in the cases in which the borrower remains solvent, the future probability of default gradually increases and default itself represents just the extreme event (Resti & Sironi, 2007).

2. Risk as an unexpected event

The original definition also included a second assumption that regards the fact that a variation in the counterparty's credit rating must be unexpected for it to be considered as a risk.

As it follows, for instance, if a bank issues a loan knowing that the counterparty's quality would deteriorate in the future, such degradation will have been adequately reviewed and considered into the loan decision and pricing process, therefore it would have applied a different interest rate. In this case, the real risk is represented by the fact that, even though, these situations are known and they are taken into consideration, there’s still a slightly probability that those evaluation could be proven incorrect. Thresrefore, there is a deterioration in the counterparty unforeseen by the lender (Resti & Sironi, 2007). In this regard, it is possible to affirm that true risk only concerns events that are considered unexpected, despite being foreseeable.

3. Credit exposure

A third factor to consider is the issue of credit exposure. Credit risk is not limited to traditional forms of credit granted by a bank, like for instance on-balance-sheet loans and securities, but also includes off-balance-sheet operations such as: guarantees, transactions in securities, foreign currencies, and OTC derivative contracts, for which substitution risk or pre-settlement risk is incurred. Lastly, it should be noted that the the definition presented above refers to the market value of credit exposures and this leads to two main issues.

Firstly, many credit exposures are recorded in the books of financial institutions at historical value rather than market value. However, accurate quantification of credit risk and its effects necessitate values that are based on the economic value of the exposure, for instance, the price that an arms-length purchaser or a secondary market would assign to the exposure if the bank

sold it. Secondly, the majority of a financial institution's credit exposures are composed by illiquid assets for which there is no developed secondary market. Thus, in this case, the market value can only be assessed using an internal asset-pricing model (Resti & Sironi, 2007).

3.1.2 The main types of Credit Risk

According to Resti & Sironi, (2007), credit risk includes the following major risks:

i. Default risk:

This is the risk associated with the counterparty declaring bankruptcy, going into liquidation, or otherwise defaulting on the loan; such a risk results in a loss equal to the product of the exposure at default, also called EAD, and loss given default, known also as LGD.

ii. Migration risk:

As previously stated, this is the risk associated with a deterioration in the counterparty's creditworthiness; it is also referred to as the "*downgrading risk*" when the borrower has a public credit rating and may be lowered by the rating agency that issued it.

iii. Spread risk:

This is the risk connected to a rise in the spreads that the market expects from borrowers, like for instance bond issuers. In the event that investors become more risk-averse, the spread associated with a given probability of default, and hence a certain rating class, may rise. In such a scenario, the market value of the securities decreases, without a corresponding reduction in the issuer's credit rating.

iv. Recovery risk:

In this case, the risk is represented by the fact that the actual recovery rate recorded following the liquidation of the insolvent counterparty's assets would be lower than the amount initially projected, either because the liquidation value was lower than estimated or simply because the recovery process took longer than planned.

3.2 Credit Risk Management

As specified above, credit risk represents the potential that a contractual party will fail to meet its obligations in accordance with the agreed terms. Furthermore, credit risk can also variously referred to as: default risk, migration risk, spread risk and recovery risk. All these different typologies of risk fundamentally refer to the same underlying idea: the impact of credit effects on a firm’s transactions (Brown & Moles, 2014).

Therefore, managing credit risk represents a complex multidimensional problem that can be further assessed through the adoption of several methodologies, including both quantitative technicques as well as qualitative judgements. However, despite the methodology used, the most crucial part is to understand the behavior and anticipate the probability of particular credits to default on their obligations (Brown & Moles, 2014). As a result, this paragraph will attempt to gain a better grasp of credit risk management, starting off with the principles for the management of credit risk, to then look at the managing process and the measuring technicques.

3.2.1 The Basel Committee: Principles for Credit Risk Management

For what concerns the management of credit risk in the banking sector, the are mainly two risks that banks need to manage, the risk inherent in the entire portfolio, as well as the risk in individual credits or transactions. Banks should also evaluate the interdependence of credit risk and other risks. Credit risk is an essential component of a successful risk management strategy and is critical to the long-term performance of any financial organization (Basel Committee on Banking Supervision, 2000).

Therefore, to enhance financial stability by improving the quality of banking supervision worldwide, in 1975 it was established the Basel Committee. Headquartered at the Bank for International Settlements in Basel, the Committee had also the objective to serve as a forum for regular cooperation between institutions and countries on banking supervisory matters.
The Committee was founded by the central bank governors of the Group of Ten nations, G10, and it has since produced a series of worldwide standards for bank regulation, most notably its publications on capital adequacy known as Basel I, Basel II, and, most recently, Basel III (Bank for International Settlements, n.d.).

The Committee also issued a document in September 2000 to encourage banks regulators worldwide to adopt effective credit risk management methods. Although the principles in this paper are most clearly applicable to the lending sector, according to the committee, they should be applied to any operations where credit risk exists (Basel Committee on Banking Supervision, 2000). Furthermore, these practices adress the role of boards of directors and senior management; policies and procedures for managing interest rate risk; mechanisms for measuring and monitoring risk, as well as internal controls; and periodic reporting to supervisory authorities. These guidelines also include advice on organizational difficulties, making them much more than just methodological instructions. Therefore, this method reflects the authorities' intention to delegate risk measurement to bank managers and to encourage

organizations to support such process with suggestions and feedbacks. Thus, allowing them to focus mainly on developing an effective well organized risk management system (Resti & Sironi, 2007). As a result, according to the Basel Committee on Banking Supervision, (2000), the principles are divided in five different areas based on the issues they need to assess:

i. *Establishing an appropriate credit risk environment;*

The first area of concern involves the creation of a proper credit risk environment and thus, in order to do so, it outlines the roles of the board of directors and the senior management of an organization as well as the role of the bank. As a result, the board of directors should have responsibility for approving and periodically reviewing the credit risk strategy and policies of the bank, while the senior management should have responsibility for implementing such strategy and for developing procedures to identify, measure, monitor and control credit risk. Lastly, banks should identify and manage credit risk inherent in all products and activities.

ii. *Operating under a sound credit - granting process;*

The second area of concern involves the implementation of a well defined credit-granting process for banks. Hence, such process should follow a set of criteria aimed to specify the bank's target market, the purpose and structure of the credit, and its source of repayment. Then the principles in this area of concern establish some conditions for the bank activity, including: credit limits, new credits approval, re-financing strategies for existing credits and credit extension guidelines.

iii. *Maintaining an appropriate credit administration, measurement and monitoring process;*

Maintining an appropriate credit administration process requires an ongoing system for the administration of banks' various credit risk-bearing portfolios. Furthermore, banks should develop and use an internal rating system to manage risk. The rating system should be consistent with the nature, size and complexity of a bank's activities. Hence, such systems require analytical technicques to measure and keep track of the credit risk inherent activities, both on – and off – balance sheet. Moreover, in order to sustain an appropriate credit administration and monitoring process, banks should take into consideration also potential future changes in economic conditions while assessing their individual credits and credit portfolios.

iv. *Ensuring adequate controls over credit risk;*

The fourth area involves principles that ensure that banks' credit-granting functions are being properly managed and that credit exposures are within the internal limits and are consistent with

the levels of prudential standards. Therefore, banks need to establish a system for the ongoing assessment of the their credit risk management processes.

v. The role of supervisors

Lastly, the fifth area of concern involves just one principle that reports the role of supervisors. Such figure should require that banks have an effective system in place while conducting an independent evaluation of a bank's strategies, policies, procedures and practices related to the granting of credit and the ongoing management of the portfolio.

Even though specific credit risk management practices may differ among banks, due to the the type and complexity of their credit activities, a comprehensive credit risk management should cover all these areas. These methods should be used in conjunction with the practices for assessing asset quality, adequacy of provisions and reserves, and credit risk disclosure, all of which have been addressed by the Basel Committee, in its publications (Resti & Sironi, 2007).

3.2.2 Credit Risk Management Process

According to Van Gestel & Baesens, (2009), the credit risk management process involves the following several steps:

i. Identification:

The first step consists of defining a perimeter and scope of the risk management process in order to identify all potential risks. The identification process requires a good knowledge of the financial products and it generally starts with the analysis of potential risk sources or with the identification of threats.

ii. Measurement:

After having identified the sources of risk, the next important step is to quantify it. For what concerns credit risk, this means, for instance, that the actual default probability has to be determined. Risk measurement generally requires a statistical analysis of past events, or in the cases in which past events are only available to a limited extent, theoretical models and expert knowledge to quantify the risk are applied. Furthermore, in the following paragraphs these aspects will be analyzed in a more comprehensive and deeper context.

iii. Treatment:

Once the risk has been quantified and examined, the next step is to treat it. In general, according to Van Gestel & Baesens, (2009), risk can be processed via one of the following four ways:

1. Risk avoidance: One of the simplest treatment for risk is to avoid it. Therefore, this implies that one should not try to avoid all risks, instead, it refers to the strategy of selecting the good counterparts, thus, not investing in counterparts with too high default, loss or exposure risk.

2. Risk reduction: In order to reduce or mitigate risk, one could accept to take part to just some of the risk, thereby reducing exposure. For high-risk counterparts, collateral may be required that the bank can sell in the event of default. The value of such collateral reduces the actual risk, although it is important to note that Risk reduction may not always be feasible.

3. Risk acceptance: In general, in this case, one accepts or retains the risk that must taken as part of the business strategy. Risk acceptance typically applies to low-risk activities, whereas if the risk is higher, it is more likely to be accepted when it is well diversified.

4. Risk transfer: Lastly, in this case, one chooses to transfer the risk to other financial guarantors, typically another bank, an insurance company, or a company. These entities provide guarantees to credit risk. Certain types of credit derivatives, like credit default swaps, are an example of an option contract in which the buyer gets compensated in the event that the underlying counterpart fails to meet its obligations.

iv. Implementation:

The implementation step follows the definition of the risk management plan. The risk of current and future investments is evaluated by people, statistical models, and IT infrastructure. The implementation is supervised by senior management and the risks of the bank are continuously reported and monitored. In this case, guidelines for the risk treatment define: the counterparts in which one decides to invest in; the exposure limits used for the riskiest products; if acquiring protection from a financial guarantor or providing collateral is required for some loans.

v. Evaluation:

The evaluation process of the effectiveness of the risk management strategy occurs regularly. The verification process aims to assess whether the resulting risk assumption is in line with the strategy, applying corrections where necessary. This step involves the evaluation: of the

relevant risk drivers; of the result of the risk treatment strategy; and of the actual implementation of the measurement process itself, for instance through backtesting procedures.

3.3 Credit Risk Measurement methodologies

As discussed previously, credit risk represents a crucial aspect for financial instiurtions, especially for what concerns the bank activities. This importance has enhanced the research of the literature and of academicians to develop several credit risk measuring methods.

According to (Qiang & Qian, 2018), credit risk evaluation refers to the process by which financing institutions, like for instance commercial banks or credit evaluation institutions, examine the target's contract fulfillment ability and trustworthiness in order to determine the credit grade of the evaluation target.

As of today, there are two main risk evaluation approaches which are widely used in the academic world and in the financial industry: the "Traditional" and the "Modern" approach. This paragraph aims to present the main differences in these two approaches while pointing out the importance of the credit risk measurement methodologies. Hence, in order to give a further comprehensive view on the subject, several examples of traditional and modern approaches will be presented below.

3.3.1 Traditional measurement methodologies

Traditional credit risk evaluation refers to the process employed by commercial banks and other financial institutions to conduct a qualitative study on a particular target based on prior experience. Most of these theories and methods are accumulated by commercial banks in their credit lending practice (Qiang & Qian, 2018). Therefore, traditional approaches to credit risk measurement aim to define the probability of default based on historical accounting data.

One of the most frequently utilized methodology in the traditional approach to credit risk measurement is represented by the so called Credit Scoring models. These are multivariate models that use economic and financial data of an organization as input while assigning to each variable a weight that represents its relative significance in predicting default. As a result, the final outcome represents a creditworthiness idex, which is displayed as a numerical score and it aims to indirectly calculate the probability of default of the borrower (Resti & Sironi, 2007). According to Resti & Sironi, (2007), the are three main categories of credit scoring models:

linear discriminant analysis models, regression models, and heuristic inductive models. In order to explain the economic causes of default, the first two categories require a deductive methodology, while, the third category uses an entirely empirical inductive approach.

As shown in *Figure 6.* below, the linear discriminant analysis approach focuses on identifying variables which can be used to discriminate performing companies and abnormal ones. Furthermore, such variables are typically represented by economic and financial ratios that can be found in an organization's financial statements. The discrimination process can be definied in several ways, for instance by identifying companies that gone into liquidation or that are facing a situation of financial distress. The discriminant function represents a good example of linear discriminant analysis method. In general, it consists of a classification technique which uses data obtained from a sample of companies in order to draw a function able to separate reliable firms from the group of insolvent ones.

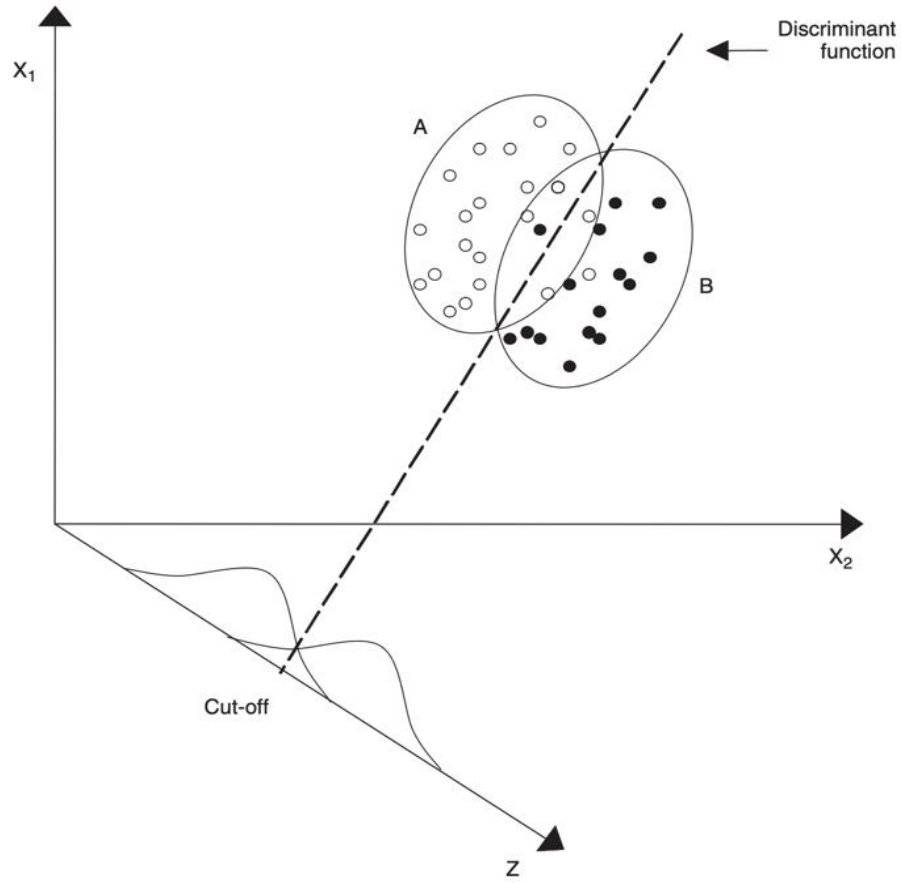


Figure 6. *The linear discriminant analysis approach (Resti & Sironi, 2007).*

This model was developed by Fisher (Resti & Sironi, 2007), and in its simplified case it describes by using two variables, "x_1" and "x_2",the two group of companies, thus identifying with "A" the group of reliable ones and with "B" the insolvent ones. Furthermore, the score generated by combining rhe two original variables is shown in the Z axis.

Moreover, the Z-Score developed by Altman, (1968), represents another linear discriminant analysis method. This method consists of widely used metrics to assess the financial health and solvency of a company. In this case, the discriminant score is a function of five independent ratios, including for instance: a company's total working capital divided by the total amount of its assets and the level of turnover divided by the value of the company's assets. As a result, the final Z score is a weighted average of all these ratios, and it gives a precise idea of a company's situation by setting a particular cut-off point. Such value is the result of the average between the mean value of Z for a sample of healthy and distressed companies. Furthermore, in the following chapters, more of this method will be analyzed deeply.

Another traditional methodology, to estimate the level of credit risk, is represented by the regression models. In particular, there are various regression models that fall into the "Traditional approach" category. The first one that comes into mind is represented by the linear probabilistic model, which uses varibables that lead to the default of a company, and their weights are identified as a linear regression (Resti & Sironi, 2007). However, this apparently simple and effective model has a major drawback, given by the fact that the dependent variable of the linear regression, which generally represents the probability of default, may take also into consideration values outside the zero to onehundred percent interval and the residuals of the 2model may suffer form heteroskedasticity. For this reason, other regression models can be applied to measure the general level of risk, for instance the logit and probit models. These model are considered to have a traditional approach too. For instance, in the Logit model the linear relationship is adjusted through exponential transformation, thus ensuring the dependent variable to take values always within the 0 – 100 % range (Resti & Sironi, 2007). Lastly, inductive models are also considered to have a traditional approach to credit risk measurement. In this case, models such as the Neural netwoek use a completely different process, switching from a deductive to an inductive one. Therefore, the measurement process starts by analysing a data sample, and within such sampl a certain regularity, for instance it has been found that abnormal companies in the sample present values above a certain cut-off point for a certain variable "x", in this case the regularity is used to forecast future defaults also for other

companies (Resti & Sironi, 2007). Therefore, this method uses a purely empirical approach, relying solely on deductive determined rules.

3.3.2 Modern measurement methodologies

The development of Financial engineering, the increasing mathematical expertise, the enhancement of computing tools and theoretical knowledge have all contributed to the quantitative assessment of customers' credit risk. Therefore, this progress has given birth to modern approaches, which, measure the probability of default using mainly current market data of debt and equity (Qiang & Qian, 2018). This approach includes models that use the price of stocks and bonds as an input to assess the chance of the issuing firm defaulting.

The first set of models is based on bond spreads, in this case, higher yields that investors demand for “risky” bonds, reflect market expectations as to the likelihood of issuer default. Hence, the spread between such bonds and securities of the same maturity that are not subject to default risk provide an overview of all information that is currently known about the elements, both systemic and particular, that affect the probability of default. In general, models based on bond spreads are known as reduced models since they ignore the causes that lead to insolvency. Usually, they simply acknowledge the fact that insolvency is possible, hence by simply estimating its probability through the use of bond spreads. Nonetheless, reduced models need as an input several data, including the curve of the spreads between the yields of the zero-coupon corporate bonds of a given company and the zero-coupon yields of risk-free securities, such as treasury bonds; and an estimate of the expected recovery rate on corporate bonds in the event of default. Based on this data, these modelds then calculate the data related to expected default rates for each future period using either the spreads on long-term bonds or the spreads implied by forward rates (Resti & Sironi, 2007).

As it follows, the second set of models is therefore based on information gathered from capital markets, rather than relying solely on bond spreads. These models are based on the pricing model originally developed by Black and Scholes in 1973 and on the contingent claims analysis that was first adopted by Robert Merton in 1974 to analyze default risk (Resti & Sironi, 2007).

The assumption behind Merton's model is that a company defaults when the value of its assets becomes lower than the value of its liabilities. In fact, when the investments made by a company using funds lent by other entities are unable to generate the cash flows that were originally expected, shareholders suffer a loss on the risk capital they invested in the company. Therefore,

in the case in which the value of liabilities is greater than the value of the company's assets, shareholders have the option of defaulting and giving the company to the creditors, rather than repaying the debt.

This model uses stock prices as input with the objective of estimating the probability of default and determinining the equilibrium bond spread. Hence, by adopting the CCA (contingent claims analysis), this approach analyzes the contingent stakeholders' claims on the future uncertain cash flows that derive from a particular firm's operations. As a result, this set of models is generally referred as structural models as it focuses on structural traits of a company that eventually determine its probability of default (Resti & Sironi, 2007). For instance, such traits usually consists of the organization's degree of leverage, given by the value of assets and debt, and the volatility of the firm's assets. Structural models generally measure both financial and business risk, since the first one is connected with the financial leverage and the latter is depends on the volatility of the assets.

4. THE RESEARCH METHODOLOGY

4.1 Literature Review

4.1.1 The literature perspective on the Credit Risk and ESG relationship

As seen in the previous chapters the raising concerns for the ESG factors has grown also in the corporate finance sector. In fact, according to (Wang, Liao, & Zhang, 2022), the importance of responsible investments has progressively come to light in recent years as a result of frequent adverse events, including, for instance, the climate change, the environmental pollution and also the financial fraud. As a result, a growing number of investors started to think more about the long-term performance of a company's environmental, societal, and governmental impact when making asset allocation decisions. Therefore, the Environmental, Social and Governance integration allowed investors to assess the risk associated with a particular firm, and how such firm intends to manage the future risks (Hua Fan & Michalski, 2020).

As presented in *Figure 7.*, in the early 1970s, researchers began looking for a relation between corporate financial performance (CFP) and environmental, social, and governance (ESG) factors. According to Friede, *et al*., (2015), since then, more than 2000 empirical research and numerous review papers on this relationship have been published by academics and investors. Furthermore, for what concerns this relation, the first reviews on the literature considered just a portion of the existing studies and this resulted on a fragmentation of the comprehensive knowledge regarding the ESG criteria and its the financial effects.

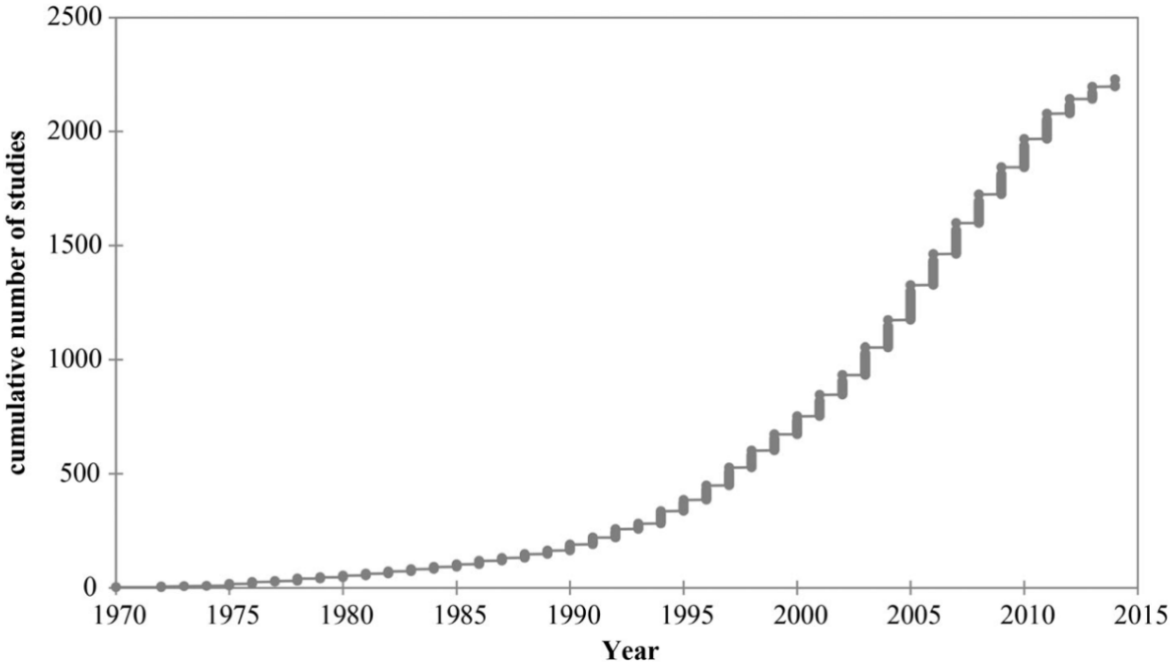


Figure 7. *Estimated number of empirical studies on the ESG–CFP relation over time.* (Friede, *et al.*, 2015)

Friede, et al., (2015), adopted a two-step research method to provide a more complete and comprehensive view of academic research on this topic, so as to enhance the development of generalizable statements for future research. Hence, it follows that, the method adopted analyzed primary studies, as well as existing reviews, to then aggregate the findings of econometric studies. Furthermore, this method included also the findings from those studies in which the number of non-significant and significant results, both positive and negative, are counted. This study combined findings of over 2200 individual studies and the results show that the large majority of them reports positive findings, thus showing the existance of a positive and stable ESG impact on the corporate financial performance over time (Friede, et al., 2015).

Initial studies on the topic, however, offered a different view, according to Orlitzky, *et al.,* (2003), ESG factors do not significantly affect a company's value or provide additional financial rewards. Furthermore, according to Revelli, (2017), investors do not value ESG metrics and do not take them into account when making investment choices. Nonetheless, latest evidence has changed this perspective, in fact as de Sousa, *et al.*, (2021), and Zeidan, *et al*., (2013), examined, ESG aspects can be relevant in risk assessment and they should be taken into consideration in credit policies. Additionally, Kim & Zhichuan, (2021) discovered a positive correlation between these two variables. The study first shows how, on average, the total ESG score has a positive impact on corporate profitability to then demonstrate how different components within the ESG score variable create different effects. In fact, despite the difficulty to generalize the impact of ESG factors on financial performance, it is demonstrated how corporate governance has the most significant impact on corporate profitability. However, it is important to notice how these effects may vary across different dimensions such as the ESG categories, the strengths and weaknesses of the company, and the firm size. In addition, it is possible to find how other academics support this thesis. According to Brogi, *et al.*, (2022), a higher ESG awareness is strongly associated with better creditworthiness. In this econometric study the authors checked the the robustness of their hypothesis by using the Probability of Default as a dependent variable and the Altman Z-score as a proxy for creditworthiness. Consequently, the findings suggest how ESG variables have a critical effect in determining a borrower's creditworthiness and also they have the potential to influence several other aspects and measures in both qualitative and quantitative credit analysis.
As stated by Chodnicka-Jaworska, (2021), the literature results seem to confirm a significant impact of ESG factors on the financial performance and on firms' credit ratings.

Nonetheless, it is important to note that there are also other completely opposite views in the literature. In particular, as presented by Bebbington, *et al.,* (2017), ESG factors can impact financial performance by affecting the cost of capital, reputation, and operational efficiency. Eventually, by following such implication it is possible to understand how these measures can also impact a company's risk profile, and therefore its creditworthiness. The effect of ESG factors on the Altman Z-score, a widely used metric to assess the financial solvency of companies, was examined in a recent study by Massari*, et al.*, (2021). According to the analysis, ESG factors have a negative effect on Altman Z-score, making it more likely for companies with strong ESG performances to have a lower Z-score. Furthermore, according to Anagnostopoulou*, et al*., (2020), this is due to the fact that organizations with strong Environmental, Social and Corporate Governance performances frequently invest more in long-term sustainability projects, which may reduce their immediate profitability and financial stability.

Overall, these studies suggest that ESG issues might have an adverse effect on Credit Risk, and consequently the Altman Z-score, meaning that firms with high ESG performance may face additional financial risks in the short term. However, investments in ESG initiatives may have long-term advantages for firms, such as higher reputation and operational efficiency, which can lead to greater financial performance in the long run.

In conclusion, the main objective of this study is to asses whether the impact of such methodologies may result relevant or not for what concerns the financial performance of a firm. Hence, by taking into consideration the several perspectives presented in the literature analysis, it is logical to identify two main different views on the subject. On the one hand, a first school of thought can be associated with the results presented by Orlitzky, *et al.,* (2003), in which ESG factors are considered as unlikely to influence the firm's value creation process. On the other hand, evidence presented by Sousa, *et al.*, (2021), and Zeidan, *et al*., (2013), shows how ESG elements are critical for a firm's credit quality. In particular, according to Höck, *et al.*, (2020), this relationship may either be positive or negative due to the level of the reputational, financial, regulatory and event risks associated with the firm’s creditworthiness. As a result, this study will take a critical approach, with the main objective of determining which line of thought is better represented in the dataset.

4.1.2 How different indicators affect the ESG & Credit Risk relationship

The next step in the analysis process is to understand and identify which are the variables that affect these two measures the most, as well as which are the best indicators to use to track down their performance. This is done in order to better understand the relationship and connection between credit risk and, consequently, the financial performance of a firm, and the general level of its Environmental, Social, and Governance scores. Therefore, as the study conducted by Velte, (2017), suggests, during the analysis of the three different components of the ESG score, the governance performance has the strongest impact on the general financial performance of the firm. Thus, as it is sustained also by Kiesel & Lücke, (2019), in comparison to environmental and social performance, corporate governance seems to be the most impacting measure.

According to Bahaaeddin & Allam, (2020), Corporate Governance is positively affected by the firm operational and market performance, thus, in this case, to the ROA and a market performance indicator, which, in the study is represented by the Tobin's Q. This suggests that, according to Bahaaeddin & Allam, (2020), corporate governance increases the asset efficiency, represented by the return on the assets and the firm's market value. However, Velte, (2017), finds that ESG performance generates a positive impact on the ROA indicator but no impact on the market performance indicator, which also in this case is represented by the Tobin's Q.

Moreover, as analyzed by Gregory, (n.d.), ESG factors affect the productivity and capital structure decisions of a firm, and this can lead to biases in some measures, especially into the ROA, ROE and the Tobin's Q. As a result, such biases can generate substantial measurement errors, correlated also to evaluation inaccuracies in the Environmental, Social and Governance factors. Due to this bias and statistical inconsistency, the influence of ESG factors on the company financial performance as measured by regression can be flawed.

Furthermore, other findings from different studies reveal the use of different variables to measure credit risk. In such cases different approaches were adopted, for instance Barth, *et al.,* (2022), Höck, *et al.*, (2020), and Kiesel & Lücke, (2019), all adopted CDS spread as a measure for financial performance and credit risk.

However the relationship between these two phenomena does not always guarantee a positive effect. For instance, in the case of Barth, *et al.,* (2022), the author shows how, in the pre-pandemic period, more precisely between 2007 and 2019, the relationship between ESG and credit risk was statistically significant and negative. Moreover, based on a sample of 33,909

observations of months of activity of 470 U.S. and European companies, the author shows how this relationship can be represented graphically by a U-shaped relationship.

Another interesting perspective proposed by Prol & Kiwoong, (2022), is given by the adoption of other types of measures into the analysis. For instance, in this case instead of adopting CDS spreads to capture a firm's exposure to risk, and thus its financial performance, the authors chose to use the Sharpe Ratio to analyze and compare different portfolios. The main interesting finding, that differs from the thesis presented above by Bahaaeddin & Allam, (2020), is such that, in this case, the relationship between performance and ESG is homogeneous across all the Environmental, Social and Governance components. Hence, it seems to be that, by adopting a different measure, there is no a predominant impact by the Corporate Governance over the other ESG factors on the firm's financial performance. From this perspective it is possible to perceive how different variables and indicators can give different results in the analysis of the relationships between the two target variables, being financial performance and sustainability effects. Hence, as shown in the study presented by Allen & Powell, (2011), there are no best varibles or models to use in the analysis, since each of them can offer a different view on the topic.

In the end, it all depeds on the approach that one plans to adopt. As seen in the previous chapters of this study, also the models adopted to examine credit risk are very different, each one with its strengths and weaknesses. For instance, on the one hand, models based on external ratings and accounting models provide a comprehensive analysis of the firm's financial strength, but they are static and don't fluctuate with the market, while, on the other hand, structural models generally provide the opposite result (Allen & Powell, 2011). In conclusion, based on the purpose of this study, and on the comprehensive view that it intends to give to the subject, the analysis will be based on a more traditional type of approach.

4.2 Sample composition and Variables Description

This paragraph aims to present and explore the dataset and the set of variables selected for the analysis. The first part will focus on introducing the dataset and its main characteristics. Subsequently, the variables will be presented by following their division between independent, dependent, and control variables.

4.2.1 Dataset and sample sourcing

For the purpose of the analysis, all the financial and ESG data was retrieved from the Thomson Reuters provider. The final dataset was collected through the use of the Refinitiv Eikon database, that provides information for several market indices, macroeconomic trends, ESG scores and financial data for the stock and bond markets.

As a result, thanks to the use of the Refinitiv suite, a variety of indicators were used, including the StarMine Structural Credit Risk Model and the StarMine SmartRatios Credit Risk Model. Such measures are widely used to evaluate the equity market's view of the structural default prediction of a company's equity and to have a comprehensive analysis of a firm's financial health (StarMine Research Team, n.d.).

The companies evaluated in this study are constituents of the Stoxx Europe 600 Index which represents large, mid and small capitalization companies among 17 European countries, covering approximately 90% of the free float market capitalization of the European stock market (Stoxx Ltd, 2023).

The index, however, has not been taken in its entirety because it has been filtered to remove possible outliers and distorting effects. Furthermore, the analysis excluded also insurance companies and banks, due to their different capital structure. It is critical to note also how all all the industry segmentation was conducted following the Global Industry Classification Standard (GICS), which is a standard classification methodology widely accepted as an industry analytical framework for investment research, portfolio management, and asset allocation (Refinitiv, 2023).

4.2.2 Dependent Variable

The Altman Z-score was used in the analysis as dependent variable of the model. The Z-score is a multivariate formula that measures the financial health of a company and predicts the probability of bankruptcy within two years. The Z-score combines five common business ratios using a weighting system calculated by Altman to determine the likelihood of bankruptcy. The general theory behind the score is that ratios, if analyzed within a multivariate framework, will take on greater statistical significance (Altman, 1968).

In Refinitiv, the score is calculated in its model for the fiscal period, this means that, in this study, the actual Z-score was calculated for each of the fiscal years taken into consideration in the analysis.
According to Altman, (1968), the Z-score can be determined as it follows:

$$Z = 1{,}2\ X_1 + 1{,}4\ X_2 + 3{,}3\ X_3 + 0{,}6\ X_4 + 1{,}0\ X_5$$

Where:

- Z represents the overall Altman Z-score.

- X_1 corresponds to the Working Capital over Total Assets ratio, also called the current ratio, it is a measure of the net liquid assets of the firm relative to the total capitalization. Where working capital can be defined as the difference between the current assets and the current liabilities of the company (Altman, 1968).

- X_2 represents the Retained Earnings over Total Assets ratio. This measure takes into consideration the cumulative profitability of a firm over time, therefore implicitly including also the age of the firm into consideration. For instance, theoretically, a younger firm will have a lower ratio due to the fact that it has not had time to build up cumulative profits. According to Altman, (1968), this may show the tendency of having a lower Z-score for newer firms, resulting also in a higher probability of default. Furthermore, as the author then specifies, this tendency is also represented in the real world where firms will have a higher probability of being classified as bankrupt in the early stages of their existance (Altman, 1968).

- X_3 equals the Earnings Before Interest and Taxes (EBIT) over Total Assets ratio. It represents the true productivity of the firm's assets, excluding any tax or leverage effects. This ratio seems to be particularly suitable for evaluating the business bankruptcy, as the earning potential of a firm's assets ultimately determines whether or not the company will last (Altman, 1968).

- X_4 indicates the Market Value of Equity over the Book Value of Total Debt ratio. In this case, the equity value reflects the combined market value of all shares of stock, preferred and common, while debt includes both current and long-term. Overall, this measure generally shows how much the firm's assets can decline in value, before the firm becomes

insolvent. Hence, before the general level of liabilities exceeds the total level of the assets (Altman, 1968).

- X_5 corresponds to the Sales over Total Assets ratio. This measure demonstrates the ability of a firm to generate revenues from its assets. Therefore, this ratio is significant on an individual basis, since it demonstrates the company's investing abilities while operating in competitive conditions (Altman, 1968). Furthermore, on the one hand, a high ratio indicates that the management only needs to make small investments to generate sales, therefore raising the company's overall profitability. Whereas, a low ratio, on the other hand, indicates that management will need to use more resources to generate adequate sales, thus reducing the company's overall profitability.

Moreover, the general level of the Altman Z score can be identified within three distinct areas, defined by two benchmark values. A score below 1.88 denotes a low level of financial stability, whereas a score above 2.99 indicates that company taken into consideration is less likely to experience bankruptcy. If the score falls between these two benchmark values, enters the so-called grey area. Therefore, in this case, the company's overall financial health, and thus its likelihood of bankruptcy can be considered questionable.

4.2.3 Independent Variables

The two main independent variables considered in the analysis are the company's overall ESG score, which can then be isolated into the three main distinct pillars (Environmental, Social, and Governance), and the agency equivalent Credit Rating determined by Eikon's StarMine combined credit risk model.

As far as the ESG evaluation is concerned, the analysis adopted the Refinitiv ESG Score, which is an overall company score based on the information in the environmental, social and corporate governance pillars. In addition, by analyzing more specifically the subject, the ESG score was then broken down into the three main pillars scores.

The Environmental pillar measures a company's impact on living and non-living natural systems, including air, land, and water, as well as complete ecosystems. It reflects a company's ability to adopt best management practices, while avoiding environmental risks and capitalizing on environmental opportunities, with the objective of generating long-term shareholder value.

Moreover, the Social pillar measures a company's capacity, through the use of best management practices, to generate trust and loyalty with its workforce, customers and the society at large. It is a reflection of the company's reputation and the health of its license to operate, which are key factors in determining its ability to generate long term shareholder value. Lastly, the Corporate Governance pillar measures the company's systems and processes. This serves the purpose to ensure that the firm's board members and executives act in the best interests of its shareholders. The Governance pillar score reflects also a company's capacity to direct and control its rights and responsibilities through the creation of checks and balances as well as incentives in order to generate long-term shareholder value.

In conclusion, all the measures taken into consideration into the analysis as independent variables are provided by using the Thomson Reuters Eikon data provider. On the one hand, all of the ESG measures are expressed in a 0 to 100 scale, where 100 is the maximum value and it indicates a remarkable ability of the firm to use the best management practices while generating long-term sustained value for its shareholders. On the other hand, the Credit Rating measure indicates the firm's ability to meet its debt obligations. Hence, a lower rating corresponds to a higher probability of default whether a higher rating indicates a higher creditworthiness. In addition, in order to use the Credit Rating in the following analysis, the score was coded into a scale, where 0 corresponds to the worst score and it identifies a NR-rated (non-rated or no longer rated) company, while 100 is the best score and identifies an AAA-rated firm[1].

4.2.4 Control Variables

In addition to the independent and depenent variables, a series of control variables with a control function in relation to the financial and ESG performance were also included to improve the general analysis.

The first control variable is represented by the Size ratio, this measure represent the Market Capitalization of a company over the general level of Market Capitalization of the firms taken into consideration from the Stoxx Europe 600 Index. The value of Market Capitalization is provided by Thomson Reuters' Eikon, which can be calculated as the total market value of the default shares (outstanding, listed, or issued) of a publicly traded company. Furthermore, according to Drempetic, *et al.*, (2020), if an ESG score depends on the firm's size and resources, it can challenge how comparable the sustainability is between different sectors and portfolios,

[1] Appendix A., *Table 1*. shows the Credit Smart Ratios Implied Ratings conversion

therefore affecting the general analysis outcome and the comparability between firms evaluated with the same measures in the same sample.

The second control variable used in the analysis is the R&D over Sales Ratio, which is also provided by Eikon and it represents the expenses for research and development of new products and services by a company in order to obtain a competitive advantage. According to Xu, *et al*., (2021), R&D investments have a positive impact on green innovation and ESG performance, hence this can increase the number of green invention patents giving companies an advantage over competitors.

Another control variable used in this study is represented by another measure provided by Eikon which consists of the CO2 over Revenues ratio. This measure was included with the objective of better explaining the theorethical knowledge according to which a more polluting company may generate a competitive advantage (Meng, *et al.*, 2022). Hence, this may reflect negatevely the ESG score, especially the Environmental pillar score. Moreover, the indicator provided by Eikon takes into consideration the total CO2 and CO2 equivalents emission in tonnes divided by net firm's sales, all of which is then subsequently divided by the revenues from all of a company's operating activities after deducting any sales adjustments and their equivalents.

The last, and fourth, control variable is represented by the Fixed over Total Assets ratio. This measure was calculated as the general level of fixed assets of a firm, including the net value of Property, Plant and Equipments, then divided by the total value of the company's assets. This measure tends to explain how, as stated by Alkaraana, *et al.*, (2022), the firm's ESG performance can be affected by the renewal level of its assets. Furthermore, in their study Alkaraana, *et al.*, (2022), analyze how the adaptation to the industry 4.0 and its disclosure tends to strengthen firms' ESG and financial performances. For instance, a compay that tends to renew its assets more frequently, and thus uses more performing and newer technology, will logically tend to increase also its operative performance. Therefore, affecting not only its financial results but also improving its environmental footprint and its sustainability impact (Alkaraana, *et al.*, 2022).

4.3 Hypothesis development

In light of what has been disclosed in the previous chapters, the main purpose of this study is to analyze the impact and the correlation between the Environmental, Social and Governance factors, the Credit Risk and the company's financial performance. Therefore, due to the increasing importance of ESG factors in credit risk and value assessment, it is possible to expect an existing relationship between the Credit Rating of a determined company and its ESG evaluation.

Another important aspect that the analysis aims to estimate is how different pillars within the ESG measure may affect such relationship in different ways. For instance, according to (Velte, 2017), Corporate Governance seems to be the most impacting pillar.

Consequently, it is logical to assume that, as stated by Massari*, et al.*, (2021), there is an inverse type of relationship between credit risk and a company's Environmental, Social and Corporate Governance performance. In fact, as Anagnostopoulou*, et al*., (2020), investigate, more sustainable companies will tend to be affect by reputational, financial, regulatory and event risks in the short term. In the analysis such implication is reflected by a lower Z-score. In particular, it is logical to expect that companies that frequently invest more in long-term sustainability projects, and thus with high ESG performances, will exhibit lower Z score values, due to the reduction of profitability and financial stability in the short to medium term.

Therefore, by taking into consideration the variables and the dataset presented, the next chapter will test the following hypotheses:

- 1st Hypothesis: Given the increasing importance of ESG factors in the assessment of companies' financial performance, this study predicts the existence of a correlation between a firm Credit Risk measure and its ESG and Credit ratings.

- 2nd Hypothesis: The different pillars within the ESG measure will affect Credit Risk in different ways. Therefore, the Environmental, Social, and Governance scores of a company will have different effects on the Z-score.

- 3rd Hypothesis: The analysis further assumes a negative correlation between the ESG factors and the company's Credit Risk, measured by the Altman Z-score.

5. THE ANALYSIS

5.1 Descriptive Analysis

This paragraph will analyze the descriptive statistics of the dataset by starting with a Panel Data Analysis over the last twelve fiscal years, then moving into a Cross-Sectional Analysis and finishing with a Correlation Analysis.

5.1.1 Panel Data Analysis

For what concerns the Panel Data Analysis, in order to have a more comprehensive view over the last twelve fiscal years, it was chosen to select all the Stoxx Europe 600 database. Therefore, the graph in *Figure 8.* shows the trend of the Altman Z score for the entirety of the index from 2012 to 2023. The overall trend seems to be positive by assuming an average value that is above the Z score threshold for performing companies. Hence, it is possible to assume that, on average, the Stoxx Europe 600 had an overall increasing and positive trend in such a period, assuming values that are above the threshold of the credit risk grey area (Altman, 1968). (Altman, 1968).

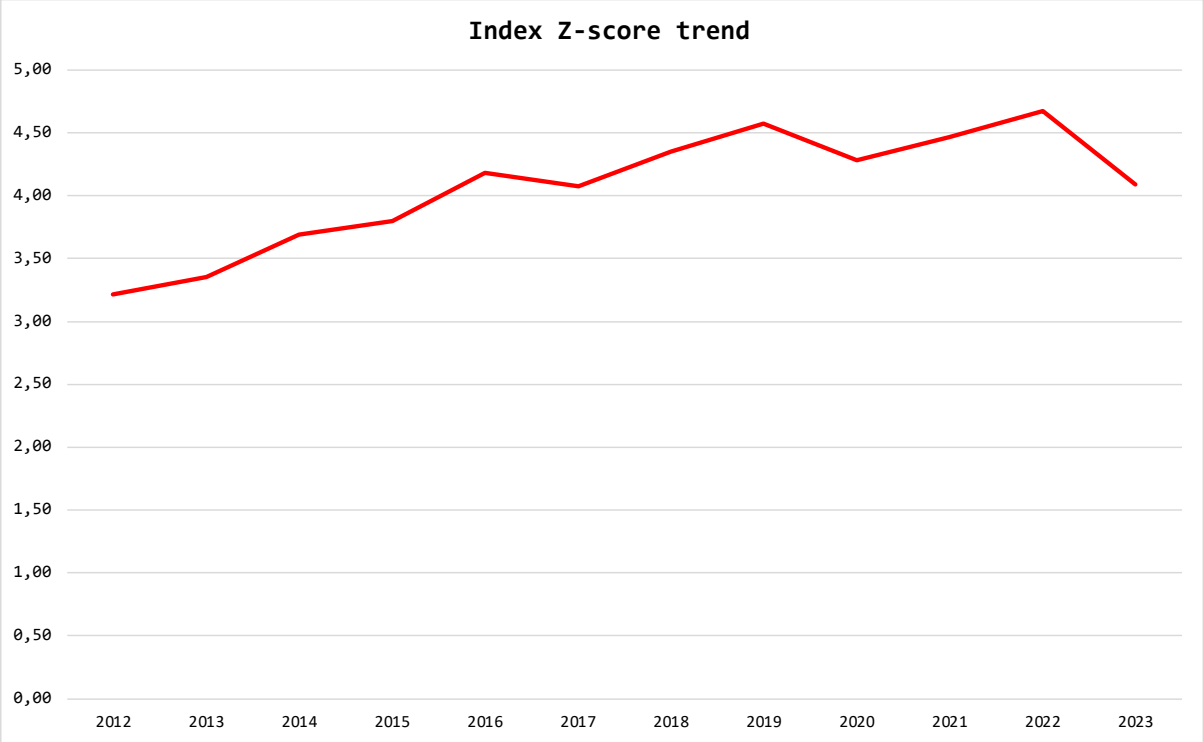


Figure 8. *Z-score Trend of the Stoxx Europe 600 over the last 12 FYs. Source: personal processing*

Moving forward, *Figure 9.* displays the Stoxx Europe 600's Environmental, Social, and Corporate Governance rating trends as provided by Eikon for the Stoxx Europe 600 Index. Moreover, as can be seen, ESG trends are linear throughout all data, and the various pillars appear to be moving in the same pattern. The fact that the general trend of the ESG scores appears to be increasing rather than being influenced by the Covid-19 epidemic represents another pertinent observation. Hence, this may be a result of the ESG issue receiving more broad attention in recent years.

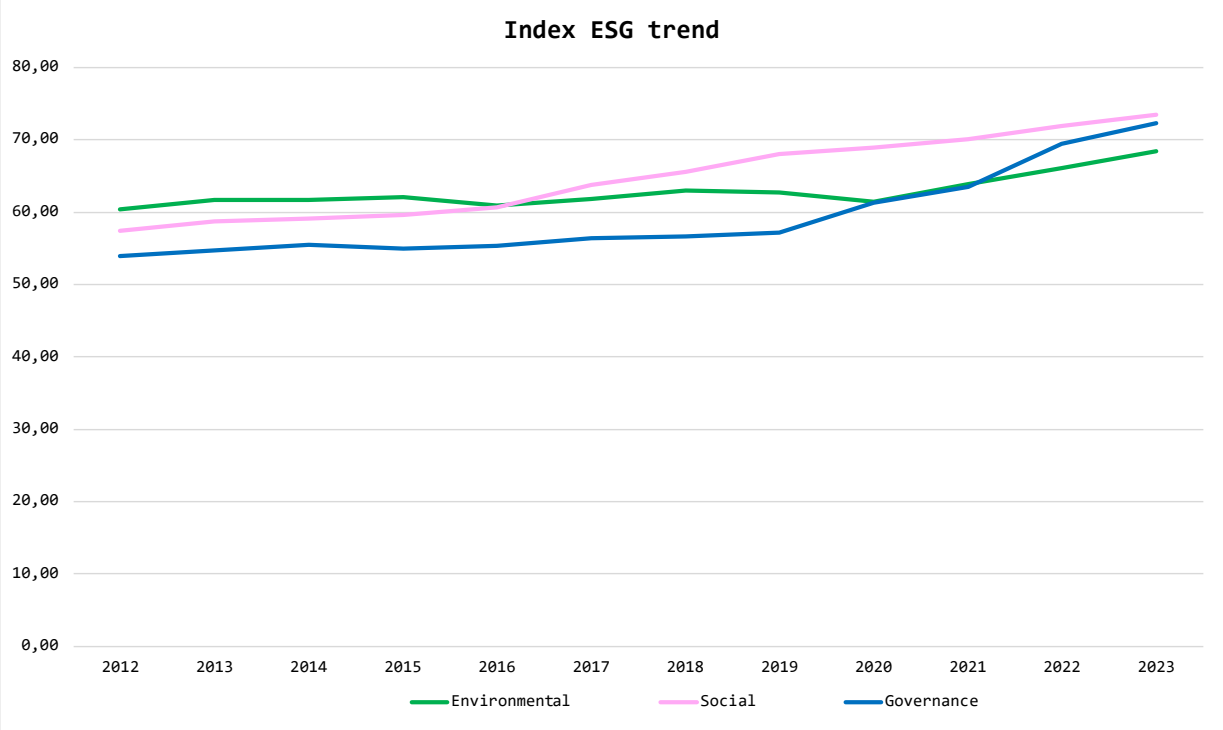


Figure 9. *ESG Trend of the Stoxx Europe 600 over the last 12 FYs. Source: personal processing*

5.1.2 Cross-Sectional Analysis

As mentioned in the previous chapter, a selction was made in order to avoid distorting effects and possible outliers. As a result, this narrowed the sample down to 498 companies, of which a descriptive analysis was conducted based on the geographical area and GICS classification.

The total dataset may thus be represented in accordance with the economic sector in which the sample firms operate. Therefore, as shown in *Figure 9.*, the first thing that stands out is how deeply diversified and homogeneous the dataset is.

In particular, the industries with the largest concentration of businesses are the Machinery and Chemicals sectors, with 30 and 25 observations respectively[2]. Whereas, the least represented industries are the Health Care Technology and the Technology Hardware industries both with just one observation.

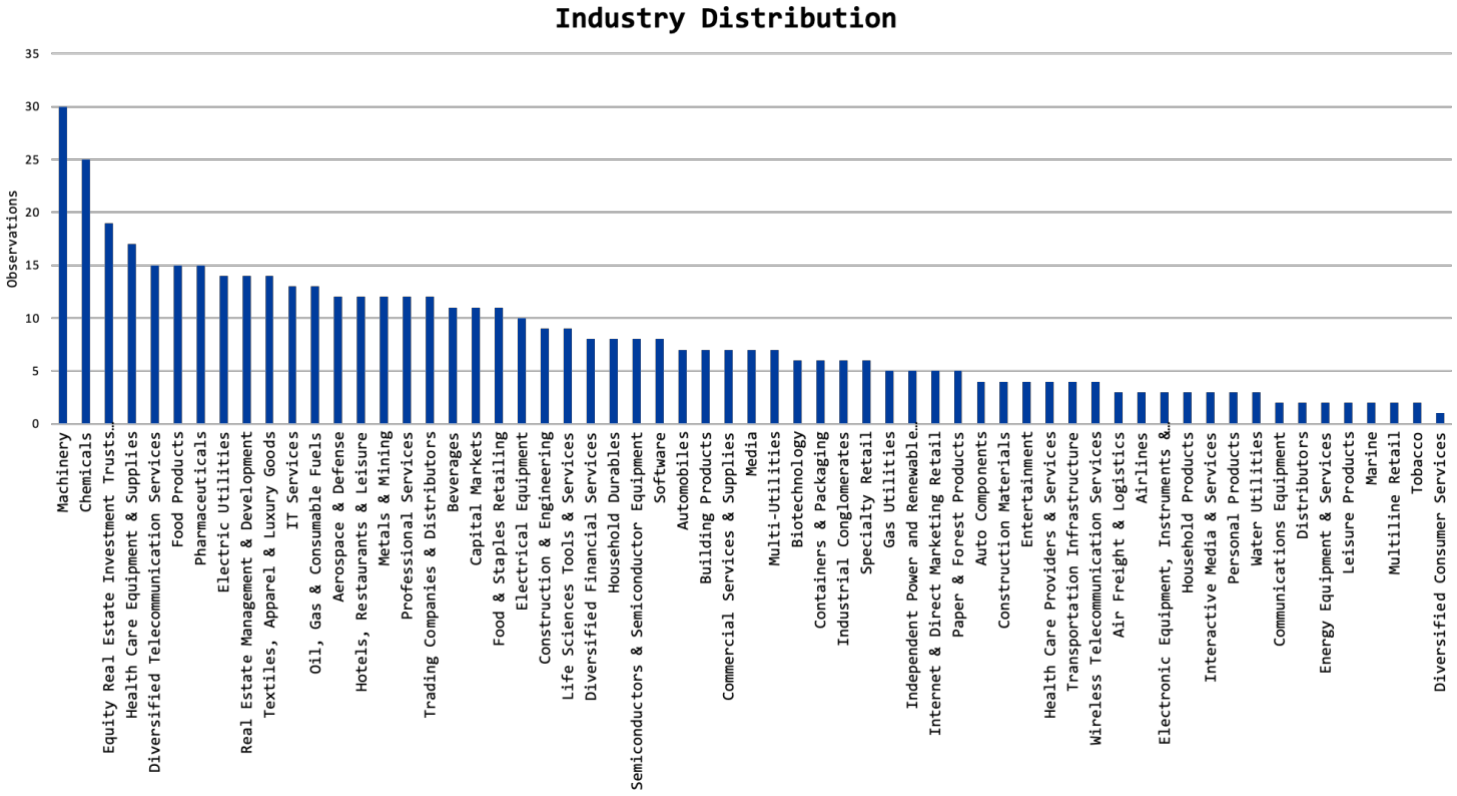


Figure 9. *Industry Distribution of the selected companies from the Stoxx Europe 600. Source: personal processing*

The distribution by geographical area is well represented amongst the major European countries, although, as shown in *Figure 10.* below, it is also critical to note how smaller countries are displayed, such as: Malta, the Faroe Islands and even the Isle of Man.

Furthermore, as shown more specificly also in *Table 3.*[3]*,* the sample presents a clear majority of British companies (111), then followed by French and German businesses, (respectively 65 and 62). Therefore, these three countries combined represent almost half of the dataset, whereas the remaining part is divided more homogeneously.

[2]Appendix B., *Table 2.* shows the industry distribution of the Stoxx's Europe 600 selected companies

[3]Appendix C., *Table 3*. shows the country distribution of the Stoxx's Europe 600 selected companies

Another interesting aspect is that, given favourable government regulations and strong economies, even smaller countries such as Luxembourg, Austria, Belgium, the Netherlands and Switzerland are represented in the analysis with a considerable number of observations.

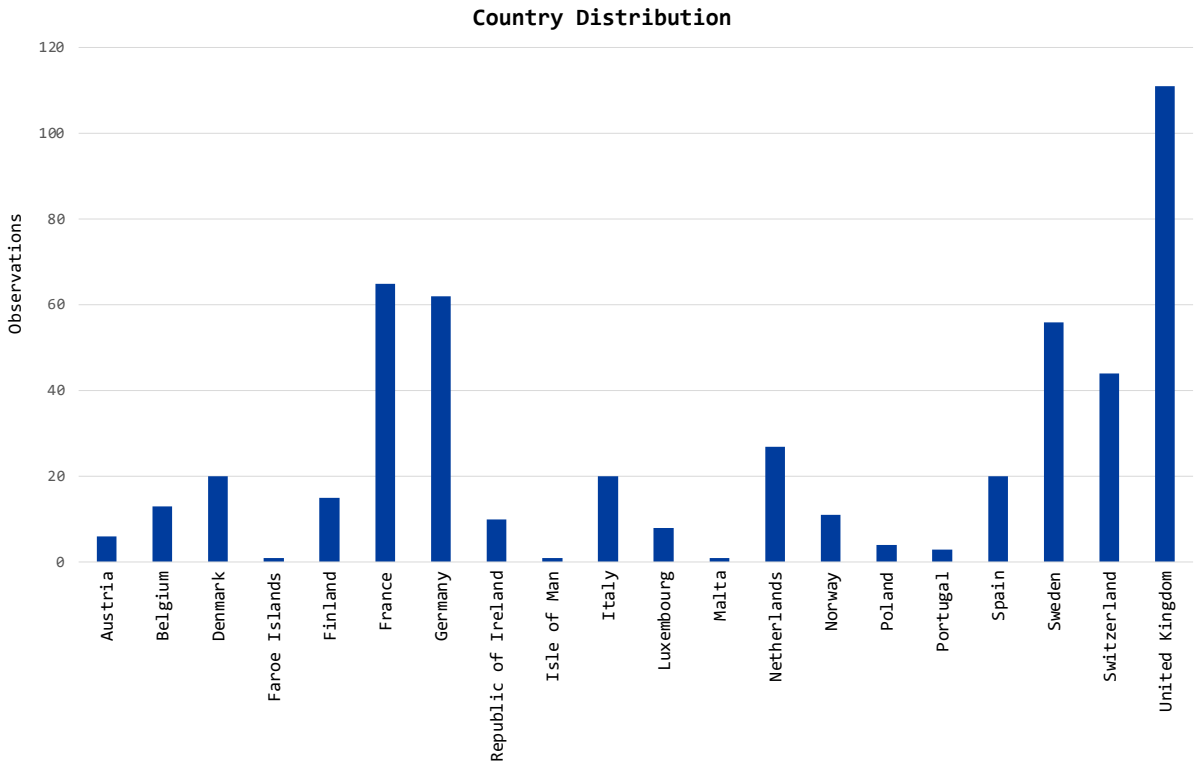


Figure 10. *Country Distribution of the selected companies from the Stoxx Europe 600. Source: personal processing*

In addition, *Table 4.* shows the descriptive statistics used in the cross-sectional analysis. For the purpose of the analysis, the average value of the last 12 fiscal years was taken for both Z-score and ESG ratings. This choice represents the objective of standardizing the values of the indicators, as they could have taken misleading values in recent years, especially after the 2020 pandemic.Therefore, as displayed below, the Altman Z score presents a maximum value of 49.62 and a minimum of 0.28, whether the mean stands at 4.51. From this, it follows that the mean value of Altman's score is above both its critical thresholds. In particular, it may be possible to assume that, on average, the mean value of such variable it's above the grey area, meaning that, for instance, the average performing company in the index may not incur high risks and default probability.

For what concerns the independent variables, the ESG value are represented both with the unified score and the individual sparated pillars. In particular, by looking closely to the values displayes in *Table 4*., it is visible how the unified score presents similar but yet different values compared with the distinct pillars. For instance, the Social pillar score seems to be the nost performing one , out of the three scores, meaning that it hhas a higher average value, at 69.46, and a higher median, which is equal to 76.33. Furthermore, another relevant remark is given by the fact that it seems that the standard deviation of the distinct pillar tends to assume higher values than the unified score. Hence, this can represent the tendency of the data to assume more spread values if taken separately rather than with a unified score.

Overall, *Table 4.* shows that both the ESG scores and the Credit Ratings assume performing values, being in the upper half of the evaluation scale. Thus, this may indicate that companies in the Stoxx Europe 600 Index may assume performing values for what concerns both Sustainability and Credit Risk performances, therefore reflecting also what has been disclosed previously in the Panel Data Analysis by looking at the two indicators over the years.

	Zscore AVG	ESG AVG	ENVIRONMENTAL AVG	SOCIAL AVG	GOVERNANCE AVG	Credit Rating
Mean	4,51	65,30	62,25	69,46	61,18	61,05
Median	3,00	68,14	64,58	73,66	64,71	60,00
Minimum	0,28	17,63	9,33	9,63	15,69	25,00
Maximum	49,62	92,51	96,26	96,10	92,63	90,00
St. Deviation	5,10	16,25	22,12	17,94	18,36	12,77

Table 4. *Descriptive statistics of the selected companies from the Stoxx Europe 600. Source: personal processing*

Furthermore, for the purpose of the analysis, this study takes into consideration the fifty most performing companies in the index for both the ESG and the Z-score indicators. As *Table 5.* and *Table 6.* respectively show below, for such observations the values of the descriptive analysis change a lot. The first aspect that comes up by looking at both tables is that, if a single variable is taken into consideration the other indicator, on average, will not show respectively performing values.

On the one hand, starting with the most performing Z-score companies, the mean value of the ESG indicator for such subset of observations is respectively lower than the average on the entire Index, displayed in *Table 4.*

Best 50 performing Z-Score Companies	Zscore AVG	ESG AVG
Mean	15,77	47,61
Median	11,17	47,52
Minimum	8,18	5,30
Maximum	62,40	83,76
St. Deviation	10,32	17,67

Table 1. Top 50 performing Z-score companies in the Stoxx Europe 600.
Source: personal processing

Best 50 performing ESG Companies	Zscore AVG	ESG AVG
Mean	2,49	85,92
Median	2,19	85,56
Minimum	-0,12	81,44
Maximum	10,12	92,51
St. Deviation	1,84	3,02

Table 6. Top 50 performing ESG companies in the Stoxx Europe 600.
Source: personal processing

On the other hand, the same thing happens when most performing ESG companies are taken into consideration. That is, the average Z-score value for the best performing ESG companies is below the critical threshold indicated by Altman, (1968), and therefore, this means that, on average, such firms may be exposed to higher levels of risk, thus leading into insolvency or bankruptcy.

From this, it can be seen that, at first glance, the relationship between Esg and Z scores is not positive, as assumed in the previous chapter in the third hypothesis. Therefore, by selecting the best-performing observations for each of these indicators, it is possible to see how the counterpart values tend not to be as positive, if at all, lower than average.

5.1.3 Correlation Analysis

The last step of the descriptive analysis concerns the study of the correlation between all the variables considered in the study. Moreover, *Table 7.* displays the simple correlation matrix of such variables, where the statistically significant results are indicated with a star at the end of the correlation score for the level: $p\text{-}value < 0.05$.

As it possible to see, *Table 7.* seem to confirm the different hypotheses formulated in the previous chapter. At a first glance, it appears how all the ESG variables have a statistically significant effect on the average Z-score, thus partially confirming the first assumption of a correlation between these indicators. Moreover, it appears how the ESG scores have a negative type of effect on the performance of the company, and how such effects are not the same for all the pillars. Hence, indicating that not all of the values within the ESG scores have the same weight on the credit risk.

	Zscore~G	ENV_AVG	SOC_AVG	GOV_AVG	Credit~g	SIZE_t~X	FIX_TO~s	RDtoSA~S	CO2toR~s
Zscore_AVG	1.0000								
ENV_AVG	-0.3120*	1.0000							
	0.0000								
SOC_AVG	-0.2178*	0.7269*	1.0000						
	0.0022	0.0000							
GOV_AVG	-0.1710*	0.3618*	0.4711*	1.0000					
	0.0165	0.0000	0.0000						
Credit_Rat~g	0.3841*	0.0138	-0.0092	-0.0443	1.0000				
	0.0000	0.8474	0.8979	0.5374					
SIZE_to_INDX	-0.0193	0.3491*	0.3657*	0.1983*	0.2053*	1.0000			
	0.7885	0.0000	0.0000	0.0053	0.0039				
FIX_TOTass~s	-0.2653*	0.0095	-0.1487*	-0.1242	-0.1905*	0.0295	1.0000		
	0.0002	0.8950	0.0375	0.0828	0.0075	0.6817			
RDtoSALES	0.0626	-0.1233	-0.2301*	-0.1264	0.0452	-0.0050	0.1966*	1.0000	
	0.3833	0.0850	0.0012	0.0775	0.5295	0.9447	0.0057		
CO2toReven~s	-0.1592*	0.0912	0.0382	0.0786	0.0048	-0.0628	0.1873*	-0.1299	1.0000
	0.0258	0.2038	0.5947	0.2733	0.9465	0.3822	0.0086	0.0696	

** p<0.05*

Table 7. *Correlation Matrix. Source: personal processing*

Additionally, the Credit Rating variable has a major impact on the Z-score, being statistically significant at the 5% level and having a large positive effect on the firm's performance. Moreover, it is possible to see how only two other control variables are statically significant at that level and both affect negatively the Z-score, being the "Fixed over Total Assets" ratio and the "CO2 to Revenues" indicator.

Moreover, *Figure 11.* and *Figure 12.* represent the scatter plots between the Z-score and the ESG Refinitiv rating, and between the Z-score and the Thomson Reuters Credit Rating. On the one hand, as the scatter plot in *Figure 11.* shows, it seems to be a strong presence of observations in the southeast quadrant. Hence, this may show a downward linear trend in the Z-score as the ESG score increases, although the relationship doesn't seem so clear and strong through this type of analysis. Furthermore, the presence of outliers seems to help emphasize the general pattern.

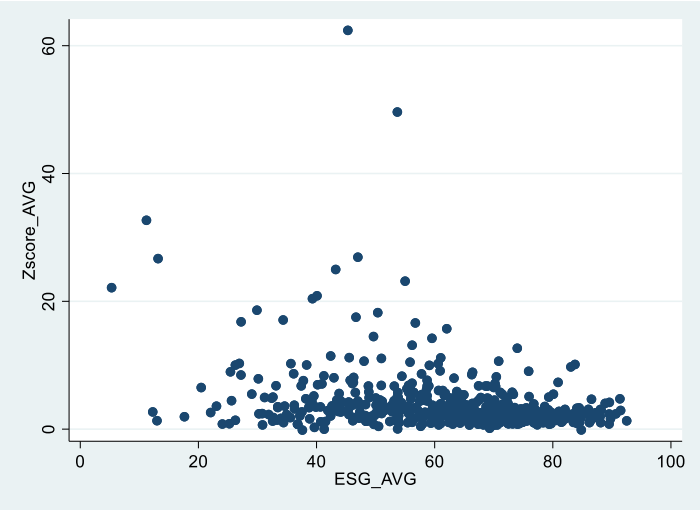


Figure 11. *Scatter plot between the average Z and ESG scores of the last twelve FYs. Source: personal processing*

On the other hand *Figure 12.* represents the scatterplot between the average Z-score and the Credit Rating measure provided b Thomson Reuters' Eikon. In this case, the graph shows a positive linear relationship between the two variables, with most of the observations populating the lower half of the graph due to the different scale of measures between the indicators.

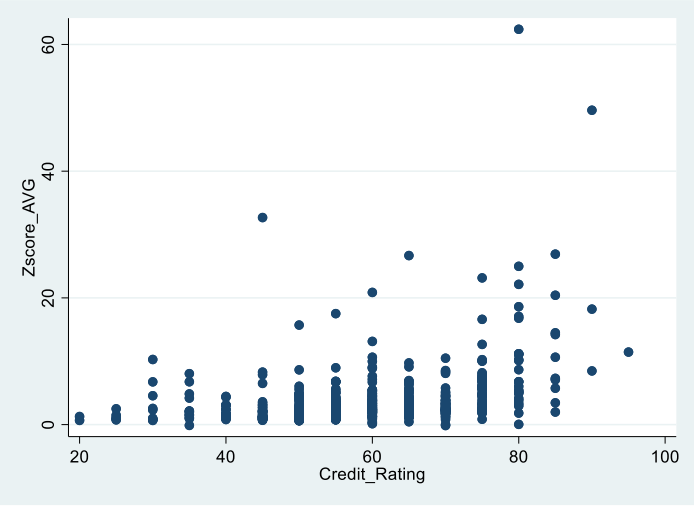


Figure 12*. Scatter plot between the average Z-score and the Credit Rating. Source: personal processing*

5.2 Regression Analysis

Moving deeply with the analysis it was chosen to further test the hypotheses through a regression analysis. Therefore, this paragraph will analyze different models by utilizing two different regression methods, hence starting with a linear regression to then move to a logarithmic-linear type of regression.

5.2.1 Linear Regression

The potential relationship between Z score and credit and ESG ratings was analyzed using OLS linear regression through three different models, as listed below:

(1) $$Z_{avg} = \alpha + \beta_1 ESG_{avg} + \beta_2\ CR\_Rating + \varepsilon$$

(2) $$Z_{avg} = \alpha + \beta_1 ENV_{avg} + \beta_2 SOC_{avg} + \beta_3 GOV_{avg} + \beta_4 CR\_Rating + \varepsilon$$

(3) $$Z_{avg} = \alpha + \beta_1 ENV_{avg} + \beta_2 SOC_{avg} + \beta_3 GOV_{avg} + \beta_4 CR\_Rating + \beta_5 SIZE + \beta_6 FIX\_TOTAssets + \beta_7 RDtoSALES + \beta_8 CO2Rev + \varepsilon$$

Where:

- Z_{avg}: corresponds to the average Altman Z-score of the last twelve fiscal years.
- ESG_{avg}: indicates the average Thomson Reuters Refinitiv ESG score of the last twelve fiscal years.
- ENV_{avg}, SOC_{avg}, GOV_{avg}: represent the individual Environmental, Social and Corporate Governance pillars separated. Furthermore, also these variables refer to the average score provided by Thomson Reuters of the last twelve fiscal years.
- CR_Rating: Credirt Smart Ratios Implied Ratings provided by Thomson Reuters.
- $SIZE$: indicates the firm's market capitalizaion over the total market capitalization of selected companies from the Stoxx Europe 600 Index.
- $FIX\_TOTAssets$: corresponds to the ratio between the amount of Fixed over Total Assets of the company.
- $RDtoSALES$: represents the R&D over Sales ratio provided by Thomson Reuter Eikon.
- $CO2Rev$: indicates the ratio between the total amount of CO2 emitted by the firm in tonnes, over the companies' revenues expressed in millions.

In addition, as follows are displayed the results of the linear analyses for the three models indicated previously. The regression was carried out on a sample of 498 firms selected from the Stoxx Europe 600 index. In this case, the analysis expects the existence of a correlation between a company's credit risk measure and its ESG and Credit ratings, as theorized in the literature review, and in particular, it is further assumed a negative type of relationship between the Z-score and the ESG factors, whereas the Credit Rating it is expected to affect positively the Altman's indicator.

Moreover, *Table 8.* presents the regression of the first model indicated previously. In particular, it is possible to see that, regardless of the values assumed by the independent variables, in this model, the Z-score tends to be positive, as indicated by the coefficient of the constant (1.60). Whereas, if all variables are taken as a whole, they appear to be statistically significant, according to the F-Test.

Furthermore, on the one hand, the relationship between Altman's score and the Credit Rating is positive, since the Confidence Intervals do not include zero and the coefficient of the Z variable is positive (0.124). On the other hand, the ESG unified rating affects negatively the Z-score, since both the Confidence Intervals and the estimated coefficient are negative (– 0.08). In addition, both independent variables are statistically significant (*p-value* < 0.05), whereas the overall model presents a relatively low percentage of the outcome's variance being explained by the predictor variables, since the R-squared is equal to 0.1841 and the Adjusted R-squared equals 0.1808.

```
      Source |       SS           df       MS      Number of obs   =       498
-------------+----------------------------------   F(2, 495)       =     55.84
       Model |  2462.29217         2  1231.14608   Prob > F        =    0.0000
    Residual |  10914.5697       495  22.0496358   R-squared       =    0.1841
-------------+----------------------------------   Adj R-squared   =    0.1808
       Total |  13376.8619       497   26.915215   Root MSE        =    4.6957

------------------------------------------------------------------------------
   Zscore_AVG | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+---------------------------------------------------------------
      ESG_AVG |   -.080071   .0127828    -6.26   0.000    -.1051863   -.0549556
Credit_Rating |   .1241517   .0161975     7.66   0.000     .0923274    .1559761
        _cons |   1.603713   1.336165     1.20   0.231    -1.021542    4.228967
------------------------------------------------------------------------------
```

Table 8. *Stata regression output results for the testing of Model (1). Source: Personal processing*

The second model presented reflects the same parameters as the first one, with a single exception. In this case, the independent variables change, since the unified ESG score has been divided into the three individual pillars with the objective of better understanding and explaining how different ESG values affect the Z-score.

As can be seen in *Table 9.,* in this case dividing the independent variable has helped to moderately increase the percentage of the outcome's variance being explained in the model since the R-squared is now equal to 0.206. However, the major implication of this model is to see how the different individual pillars affect Altman's Z score.

All three variables present a negative estimated coefficient, but just the Environmental pillar score seems to be statistically significant (*p-value* < 0.05). Whereas the Social and Corporate Governance indicators seem to be less statistically significant, since their 95% Confidential Interval may include also positive values.

```
      Source |       SS           df       MS      Number of obs   =       498
-------------+----------------------------------   F(4, 493)       =     32.03
       Model |  2759.34029         4  689.835072   Prob > F        =    0.0000
    Residual |  10617.5216       493  21.5365549   R-squared       =    0.2063
-------------+----------------------------------   Adj R-squared   =    0.1998
       Total |  13376.8619       497   26.915215   Root MSE        =    4.6407

------------------------------------------------------------------------------
   Zscore_AVG | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+---------------------------------------------------------------
      ENV_AVG |  -.0615616   .0134363    -4.58   0.000     -.087961   -.0351621
      SOC_AVG |  -.0063015   .0167314    -0.38   0.707    -.0391751    .0265722
      GOV_AVG |  -.0062054   .0131754    -0.47   0.638    -.0320922    .0196815
Credit_Rating |   .1267866   .0160338     7.91   0.000     .0952836    .1582896
        _cons |   .9488919   1.363099     0.70   0.487    -1.729308    3.627091
------------------------------------------------------------------------------
```

Table 9. *Stata regression output results for the testing of Model (2). Source: Personal processing*

Furthermore, *Table 10.* presents the regression results for the third model specified above. The aim of this model is to represent more precisely the relationship between the variables. Therefore, by taking into consideration not only the indivial distinct pillars of the ESG scores, but by also including a series of control variable which are seemingly external to the relationship between the Z-score and the ESG and the Credit Ratings.

Source	SS	df	MS	Number of obs	=	196
Model	1381.12849	8	172.641062	F(8, 187)	=	10.02
Residual	3222.16813	187	17.2308456	Prob > F	=	0.0000
Total	4603.29662	195	23.6066493	R-squared	=	0.3000
				Adj R-squared	=	0.2701
				Root MSE	=	4.151

Zscore_AVG	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
ENV_AVG	-.0628907	.0202419	-3.11	0.002	-.1028225	-.0229589
SOC_AVG	-.0008947	.0274964	-0.03	0.974	-.0551377	.0533482
GOV_AVG	-.0187148	.0186021	-1.01	0.316	-.0554117	.0179821
Credit_Rating	.1297539	.0247123	5.25	0.000	.0810033	.1785045
SIZE_to_INDX	.248925	.6720645	0.37	0.712	-1.076877	1.574728
FIX_TOTassets	-4.85014	1.662844	-2.92	0.004	-8.130484	-1.569795
RDtoSALES	.856433	1.847825	0.46	0.644	-2.788828	4.501694
CO2toRevenues	-.0014154	.0010466	-1.35	0.178	-.0034801	.0006494
_cons	3.834027	2.492306	1.54	0.126	-1.082623	8.750677

Table 10. *Stata regression output results for the testing of Model (3). Source: Personal processing*

At a first glance, the major effect that the inclusion of such variables into the regression reflected into a higher R-squared, meaning that the overall inclusion of these new indicators has helped the regression to explain the outcome variance. In particular, by looking at the distinct indicators the ones that are statistically significant for this model are the Environmenatal Score, the Credit Rating and the Fixed over Total Assets ratio.

Another interesting aspect derives from the overall performance of the distinct individual ESG pillars. As it appears from the results of the various models not all of the ESG scores seem to have the same effect. In this case, only the Environmental component is statistically significant, in the analysis, and by looking at the estimated coefficient it is clear how the relationship between the ESG scores and Alman's Z is negative, whereas the Credit Rating has a strong positive effect on the independent variable.

Moreover, as shown in *Table 9.* and *Table 10.*, the effect of the individual Environmental, Social, and Governance scores and the Credit Rating doesn't change with the inclusion of the control variables. Of which, just the Fixed over Total Assets ratio is statistically significant, thus indicating that, despite the initial assumption, asset renewal does not increase the overall company performance. On the contrary, for instance, having a large number of fixed investments helps to avoid potential risks.

In conclusion, as demonstrated by the R-squared and the Adjusted R-squared the third model explains better the variance of the regression's outcome. However, the overall values of the goodness of fit of the various models seem not to be as satisfactory as expected. Therefore, it would be correct to assume that the multivariate linear regression is not the best performing tool when assessing the relationship between the Z-score and the ESG scores and the firm's Credit Rating.

Furthermore, *Figures 13.* and *14.*, represent respectively the fitted values of the regressions for what concerns the relationship between the average Z-score and ESG values and the relationship between the Altman's indicator and the Credit Rating.

As can be seen, the graphs below reflect what was found in the regressions' outcome and in the descriptive statistics. Hence, the fitted values of the relationship between the Z-score and the Environmental, Social and Governance scores shows a clear donward trend, whereas the relationship between the Credit Rating and the Credit Risk presents a positive tendency. However, in the end, what appears to be consistent is that the there is a strong presence of observations in the in the lower half of both graphs.

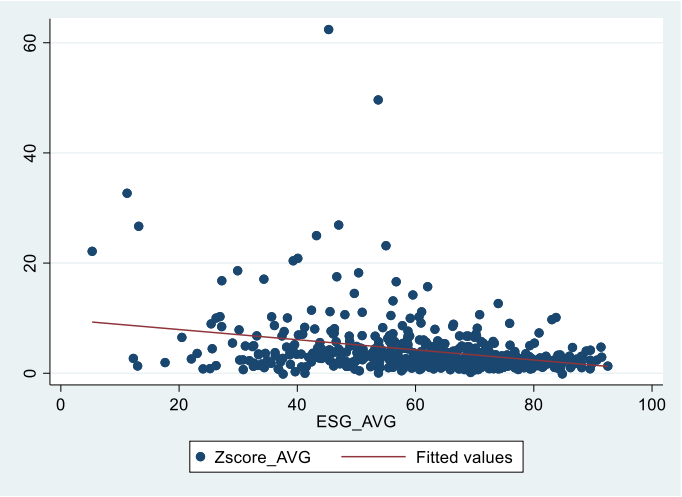


Figure 13. *Fitted values between the average Z-score and the average ESG score. Source: personal processing*

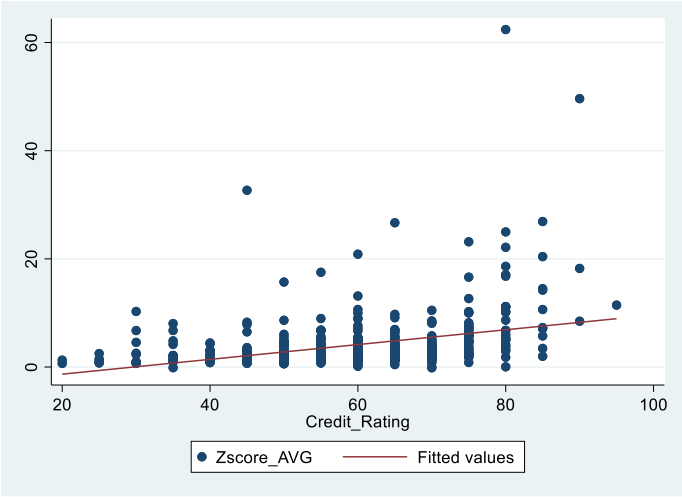


Figure 14. *Fitted values between the average Z-score and the Credit Rating. Source: personal processing Source personal*

5.2.2 Linear Regression limitations

The regression analysis, for now, has consisted of simple linear regression to estimate the relationship between variables, but as seen in the results, this methodology does not capture all types of relationships. Therefore, other models may better estimate the variables and thus be preferred to a multivariate linear regression. In particular, one of the main reasons why other types of regressions may be preferred is the presence of non-linear relationships. It is logical and reasonable to assume that not all relationships between variables can be explained through a linear model. Instead, in cases where the relationship between indicators takes on an exponential or logarithmic pattern, a log-linear regression would allow for a more flexible and accurate representation of the underlying relationship.

Furthermore, linear regression models can encounter heteroscedasticity-related problems. In particular, this represents the violation of the assumption, in a linear model, that error terms have constant variance across different levels of the predictors. Therefore, heteroscedasticity, in a linear regression model, may generate estimates that are biased and ineffective. Hence, in such cases, a log-linear regression could address heteroscedasticity, since it could stabilize the variance using the logarithm of the independent variable, which would make the hypothesis of homoscedasticity more acceptable.

Last but not least, a multivariate linear regression may encounter difficulties in handling non-normally distributed independent variables. In such cases, the normality assumption, with the linear model, may not be met and the log transformation may help normalize the distribution of

the response variable. This would also apply in the case in which the distribution would not be centered in its mean.

Figures 15. and *16.* show respectively the Symmetry Plots of that represent the distribution of both the Altman's Z score and the logarithmic of the Z-score, averaged over the last twelve fiscal years. In particular, based on the fit of the symmetry plots over the median it is possible to understand how good the assumptions of the model are, including also the normality assumption. As can be seen, the distribution of the logarithmic seem to be more symmetrical over the median, whereas in the linear Z-score distribution the data seem to be less symmetrical and more oriented to one side of the distribution.

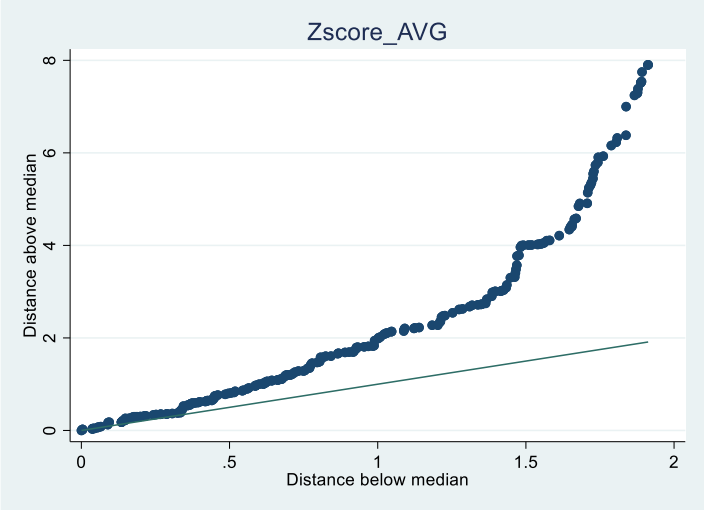


Figure 15. *Simmetry Plot of the Zscore_AVG variable*
Source: Personal procesing

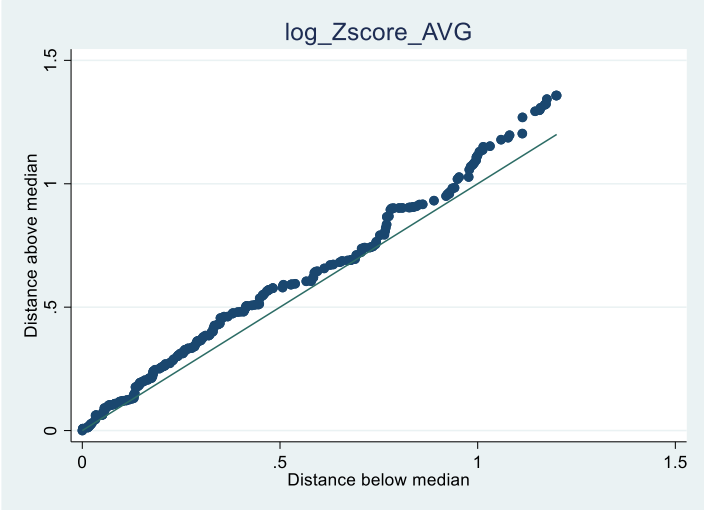


Figure 16. *Simmetry Plot of the logarithmic of the Zscore_AVG variable*
Source: Personal procesing

At a first glance, it appears that the logarithmic helps to redistribute the observations' values by spreading the data and making it more symmetrical. Such assumption can be seen clearly by looking at the Box Plots of the Z-score and the logarithmic of the Altman's indicator.

As it appears from *Figures 17.* and *18.*, the values for what concerns the distribution of the logarithmic Z-score are more centered in the median and more equally distributed on both sides. Furthermore, the outliers assume lower and more equally distributed values with the logarithmic variable.

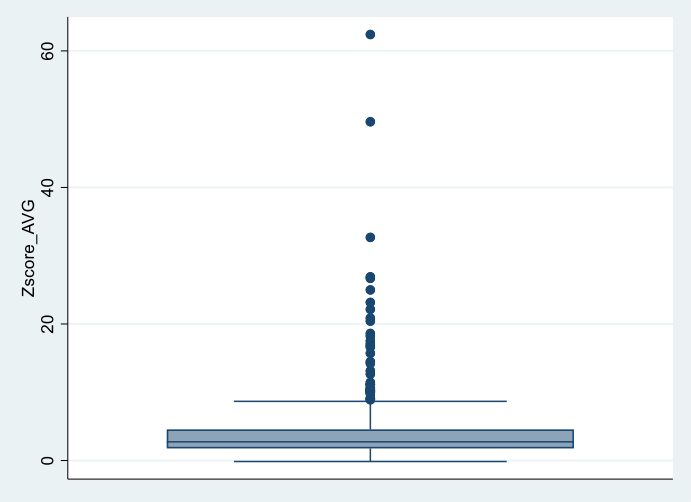


Figure 17. *Box Plot of the Zscore_AVG Variable*
Source: Personal processing

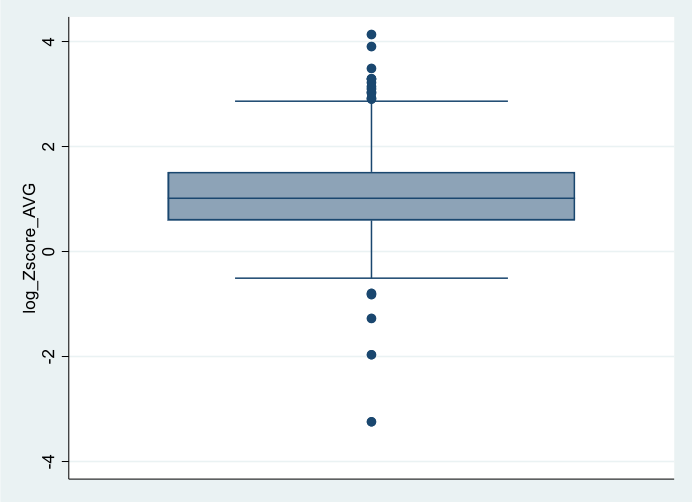


Figure 18. *Box Plot of the logarithmic of the Zscore_AVG Variable*
Source: Personal processing

In addition, the coefficients of a multivariate linear regression describe the change in the dependent variable associated with a one-unit change in the predictor variable, assuming that all other independent variables remain constant. In contrast, the coefficients of a log-linear regression represent the percentage change or multiplicative effect on the response variable for a one-unit change in the predictor. Hence, this can often lead to more meaningful and intuitive interpretations of the correlation between variables. However, it is important to note that the choice between log-linear and multivariate linear regression depends on the specific characteristics of the data and the research question at hand. Therefore, in this case, since Z-score is a variable that tends to take positive values, the transformation of the independent variable of the model into its logarithmic may help the regression redistributing the data. For this purpose, *Figures 19.* and *20.*, present the scatter plot between the logarithmic of the Z-score with the independent variables of the previous regression models, hence showing how the logarithmic transformation of the independent variable helps redistributing the values of the observations.

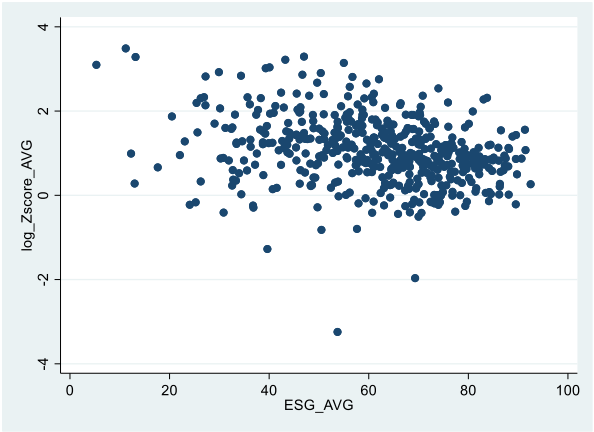


Figure 19. *Scatter Plot of the Zscore_AVG and the ESG_AVG variables. Source: Personal processing*

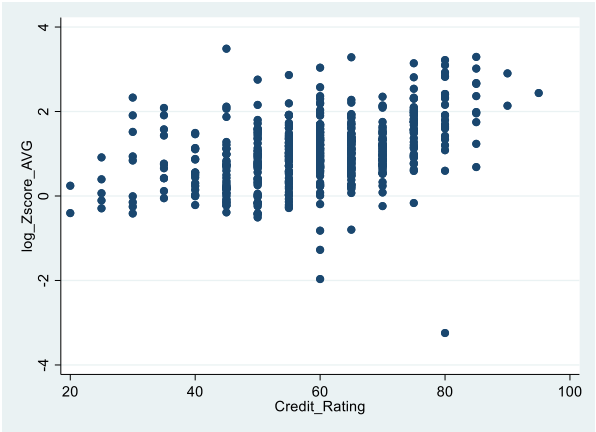


Figure 20. *Scatter Plot of the Zscore_AVG and the Credit Rating variables. Source: Personal processing*

5.2.3 Log - Linear Regression

The relationship between the Z-score and the explanatory variables was further analyzed by using three log-linear regressions.

(4) $$\ln(Z_{avg}) = \alpha + \beta_1 ESG_{avg} + \beta_2\ CR\_Rating + \varepsilon$$

(5) $$\ln(Z_{avg}) = \alpha + \beta_1 ENV_{avg} + \beta_2 SOC_{avg} + \beta_3 GOV_{avg} + \beta_4 CR\_Rating + \varepsilon$$

(6) $$\ln(Z_{avg}) = \alpha + \beta_1 ENV_{avg} + \beta_2 SOC_{avg} + \beta_3 GOV_{avg} + \beta_4 CR\_Rating + \beta_5 SIZE + \beta_6 FIX\_TOTAssets + \beta_7 RDtoSALES + \beta_8 CO2Rev + \varepsilon$$

Where:

- $\ln(Z_{avg})$: corresponds to the logarithmic of the average Altman Z-score of the last twelve fiscal years.

Moreover, as follows the results of the log-linear models will be displayed by using a sample of 495 observations. In this case, the analysis expects an improved R-squared and Adjusted R-squared value, therefore indicating better goodness of fit of the models.

Table 11. presents the regression of the first log-linear model indicated previously. As can be seen, the transformation of the independent variable has helped the regression of the independent variables to explain the outcome's variance. Hence, the R-squared now is equal to 0.2438, therefore being six percentage points above the respective linear regression model (1). In particular, by looking at the individual variables, it appears that all of the independent indicators are statistically significant for the regression (*p-value* < 0.05). Furthermore, the F-test indicates still a statistical significance of all the variables, if taken as a whole.

However, it is important to denote how, with a log-linear regression, the coefficients of the predictors represent the percentage change on the independent variable for a one-unit change in the explanatory variables. In fact, the possible effect of a one-unit change of the explanatory variables on the Altman's score can be calculated as follows:

- Percentage effect of a one-unit change in the ESG_AVG on the logarithmic Z-score:

$$(e^{\beta_1} - 1)\% = (e\ \hat{}\ (\beta_1) - 1)\% = (e\ \hat{}\ (-0.0119996) - 1)\% = (0.988 - 1)\% \approx -1.19\%$$

- Percentage effect of a one-unit change in the Credit Rating on the logarithmic Z-score:

$$(e^{\beta_2} - 1)\% = (e\ \hat{}\ (\beta_2) - 1)\% = (e\ \hat{}\ (0.0251877) - 1)\% = (1.025 - 1)\% \approx +2.55\ \%$$

In particular, as one can see, a one-unit change in the ESG variable affects negatively the Z-score approximately by -1.2%. Whereas, the same unitary change in the Credit Rating measure affects the independent variable positively by + 2.5%. Therefore, it is possible to assume that, in this particular model, the effect of the change in the Credit Rating variable is stronger than the equivalent change in the Environmental, Social, and Governance indicator.

Source	SS	df	MS	Number of obs	=	495
Model	80.6717382	2	40.3358691	Prob > F	=	0.0000
Residual	250.179611	492	.508495144	R-squared	=	0.2438
Total	330.851349	494	.669739573	Adj R-squared	=	0.2408
				Root MSE	=	.71309

log_Zscore_~G	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
ESG_AVG	-.0119996	.00195	-6.15	0.000	-.015831	-.0081682
Credit_Rating	.0251877	.0024692	10.20	0.000	.0203362	.0300392
_cons	.2864648	.2030921	1.41	0.159	-.1125701	.6854996

Table 11. *Stata regression output results for the testing of Model (4). Source: personal processing*

Moving forward with the analysis, *Table 12.* presents the results for the regression outcome of Model (5), thus considering the logarithmic of Alman's score as the independent variable and the Credit Rating and the individual distinct ESG pillars score as explanatory variables. In particular, by taking into consideration the individual pillars the regression improved in the explanation of the outcome's variance since the R-squared and the Adjusted R-squared are respectively equal to 0.2955 and 0.2897. Furthermore, the transformation of the independent variable and the split of the Environmental, Social, and Governance scores has revealed a surprising trend. As can be seen from the estimated coefficients of the ESG variables,

represented in *Table 12.*, not all of the distinct pillars present the same effect. Contrary to the initial hypotheses, the Social component has a positive effect on the logarithmic Z-score. Therefore, it is possible to imagine that the logarithmic transformation has improved the ability of the regression to offer a more detailed and meaningful correlation between the variables and the Z-score. However, while positive, the effect of the Social indicator in the regression is not statistically significant (*p-value* > 0.05), while the effect of the Environmental component still appears to be negative and statistically significant. The effect of the statistically significant components on the logarithmic Z-score is represented as follows:

- Percentage effect of a one-unit change in the ENV_AVG on the logarithmic Z-score:

$$(e^{\beta_1} - 1)\% = (e\ \hat{}\ (\beta_1) - 1)\% = (e\ \hat{}\ (-0.01448) - 1)\% = (0.9856 - 1)\% \approx -1.43\ \%$$

- Percentage effect of a one-unit change in the Credir Rating on the logarithmic Z-score:

$$(e^{\beta_2} - 1)\% = (e\ \hat{}\ (\beta_2) - 1)\% = (e\ \hat{}\ (0.0259663) - 1)\% = (1.0263 - 1)\% \approx +2.63\ \%$$

```
      Source |       SS           df       MS      Number of obs   =       495
-------------+----------------------------------   F(4, 490)       =     51.38
       Model |  97.7580945         4  24.4395236   Prob > F        =    0.0000
    Residual |  233.093255       490   .47570052   R-squared       =    0.2955
-------------+----------------------------------   Adj R-squared   =    0.2897
       Total |  330.851349       494  .669739573   Root MSE        =    .68971

------------------------------------------------------------------------------
log_Zscore_~G | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+---------------------------------------------------------------
      ENV_AVG |  -.0144784   .0020044    -7.22   0.000    -.0184167   -.0105401
      SOC_AVG |     .00578   .0024884     2.32   0.021     .0008908    .0106692
      GOV_AVG |  -.0020988   .0019623    -1.07   0.285    -.0059544    .0017569
Credit_Rating |   .0259663    .002392    10.86   0.000     .0212665    .0306662
        _cons |   .1125141   .2026963     0.56   0.579    -.2857471    .5107752
------------------------------------------------------------------------------
```

Table 12. *Stata regression output results for the testing of Model (5). Source: personal processing*

Moreover, the last model tested represents the logarithmic transformation of the independent variable as well as the distinct ESG components and the inclusion of the control variables. In particular, as represented in *Table 13.*, the entirety of the model is statistically significant, as indicated by the F-test. Whereas the individual variables seem to improve the goodness of fit of the model, since both the R-squared and the Adjusted R-squared increased, respectively now equal to 0.4270 and 0.4025. Furthermore, as happened with the linear regression of Model (3) and with the log-linear regression of Model (6), the total number of observations decreased to accommodate the inclusion of a consistent number of information for the control variables.

As seen from *Table 13.*, the single T-test for each independent variable presented a higher number of statistically significant indicators compared with Model (3). In particular, as it appears from the regression's outcome, the Corporate Governance component of the ESG variables became statistically significant in this model, indicating a probable strong relationship with the logarithmic Z-score.

Furthermore, by including the control variables in the regression, it is possible to notice how the CO2 over Revenues ratio is statistically significant for the analysis of this model. The hypothesis behind the inclusion of this indicator was to explain the theoretical knowledge according to which a more polluting company may gain a competitive advantage over the competitors. However, as it occurs from the regression's outcome, the general effect of the variable on the logarithmic Z-score appears to be negative. Thus, indicating that a more polluting company may face a higher credit risk and, consequently, a higher probability of default, in the course of its lifespan. As follows, are calculated the percentage effect on the logarithmic Z-score of a one-unit change in the independent statistically significant variables:

- Percentage effect of a one-unit change in the ENV_AVG on the logarithmic Z-score:

$$(e^{\beta_1} - 1)\% = (e\ \hat{}\ (\beta_1) - 1)\% = (e\ \hat{}\ (-0.0142) - 1)\% = (0.9858 - 1)\% \approx -1.41\ \%$$

- Percentage effect of a one-unit change in the GOV_AVG on the logarithmic Z-score:

$$(e^{\beta_3} - 1)\% = (e\ \hat{}\ (\beta_3) - 1)\% = (e\ \hat{}\ (-0.005953) - 1)\% = (0.9940 - 1)\% \approx -0.59\ \%$$

- Percentage effect of a one-unit change in the Credit_Rating on the logarithmic Z-score:

$$(e^{\beta_4} - 1)\% = (e\ \hat{}\ (\beta_4) - 1)\% = (e\ \hat{}\ (0.0205042) - 1)\% = (1.0207 - 1)\% \approx +2.07\ \%$$

- Percentage effect of a one-unit change in the FIX_TOTassets on the logarithmic Z-score:

$(e^{\beta_6} - 1)\% = (e\ \hat{}\ (\beta_6) - 1)\% = (e\ \hat{}\ (-0.52479) - 1)\% = (0.5917 - 1)\% \approx -40.83\ \%$

- Percentage effect of a one-unit change in the CO2toRevenues on the logarithmic Z-score:

$(e^{\beta_8} - 1)\% = (e\ \hat{}\ (\beta_8) - 1)\% = (e\ \hat{}\ (-0.000577) - 1)\% = (0.9994 - 1)\% \approx -0.06\ \%$

```
      Source |       SS           df       MS      Number of obs   =       196
-------------+----------------------------------   F(8, 187)       =     17.42
       Model |  43.0591253         8  5.38239066   Prob > F        =    0.0000
    Residual |  57.7889809       187  .309031983   R-squared       =    0.4270
-------------+----------------------------------   Adj R-squared   =    0.4025
       Total |  100.848106       195  .517169775   Root MSE        =    .55591

------------------------------------------------------------------------------
log_Zscore_~G | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------+---------------------------------------------------------------
      ENV_AVG |  -.0142187   .0027108    -5.25   0.000    -.0195664    -.008871
      SOC_AVG |    .006299   .0036823     1.71   0.089    -.0009652    .0135633
      GOV_AVG |   -.005953   .0024912    -2.39   0.018    -.0108675   -.0010386
Credit_Rating |   .0205042   .0033095     6.20   0.000     .0139755    .0270329
 SIZE_to_INDX |   .0953981   .0900035     1.06   0.291    -.0821546    .2729508
FIX_TOTassets |  -.5247977   .2226896    -2.36   0.019    -.9641044   -.0854909
    RDtoSALES |   -.118085   .2474624    -0.48   0.634    -.6062617    .3700917
CO2toRevenues |   -.000577   .0001402    -4.12   0.000    -.0008535   -.0003004
        _cons |   1.028901   .3337719     3.08   0.002     .3704584    1.687343
------------------------------------------------------------------------------
```

Table 13. *Stata regression output results for the testing of Model (6). Source: personal processing*

In conclusion, the logarithmic transformation of the independent variable has helped the regression in the estimation of the relationship, and the effects that derive from it, between the credit risk, measured by the Altman's Z score and the ESG and Credit Rating components. In particular, through the use of a specific set of variables, the analysis estimated that the Environmental, Social, and Governance components did not present the same effect. The Environmental component, throughout the analysis, has always been the ESG pillar that had

the major impact on the relationship, thus presenting negative and statistically significant coefficients in all the models.

Furthermore, the inclusion of the control variables after the logarithmic transformation of the Z-score has presented some compelling insights in comparison with the linear model. Indeed, the logarithmic transformation has helped re-establishing the normality assumption of the independent variable, since also from the descriptive statistics appeared how the distribution of the Z-score seemed not to be centered in its mean. Hence, the logarithmic transformation has redistributed the values assumed by the independent variable, thus revealing further links with the predictors in the model. For instance, variables like the Corporate Governance factor, in the linear analysis were not statistically significant, whereas, in the log-linear regression, they became significant, thus further insights for the analysis and the estimation of the relationship of the variables.

Moreover, *Figure 21.* and *Figure 22.* present the fitted values of the regression models between the logarithmic Z-score and the Credit Rating scores. In this case, this type of graph is used to evaluate how well the regression model matches the observed data in the regression. The figures reflect the outcomes of the regression indicating a negative relationship between Alman's score and the Environmental, Social, and Corporate Governance factors and a positive trend between the logarithmic Z and the Credit Rating.

In particular, the graphs below show that the scatter points align much better along a diagonal 45-degree line, thus, indicating that the log-linear regression model explains a large portion of the variability in the Credit Risk variable. Therefore, it is possible to assess that the logarithmic transformation increased the fit of the models presenting a more defined and clear trend compared with the fitted values of the respective linear models.

Figure 21. *Fitted values between the logarithmic Z-score and the average ESG score. Source: personal processing*

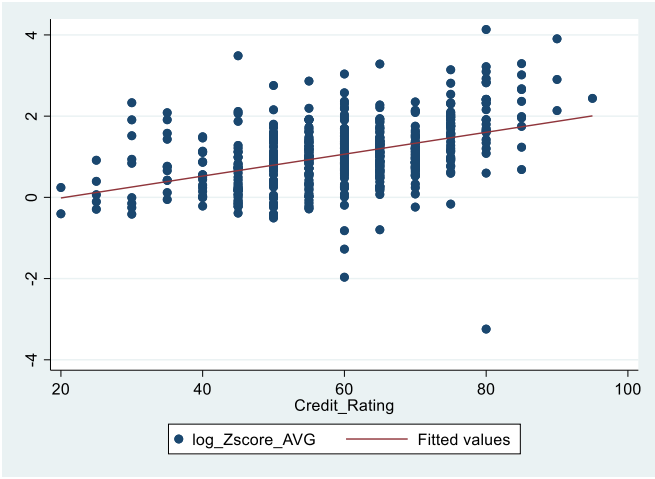


Figure 22. *Fitted values between the logarithmic Z-score and the Credit Rating. Source: personal processing*

CONCLUSIONS

Environmental, Social, and Corporate Governance (ESG) factors in recent years have become increasingly important. This increase in popularity may be mainly due to the increasing awareness about climate change and Environmental concerns, or perhaps due to the importance of Social Responsibility and stakeholders' expectations. Furthermore, ESG issues have gained recognition as long-term value-creating indicators for companies' sustainability and financial performance. Therefore, this study aimed to assess the relevance of the relationship between the Environmental, Social, and Corporate Governance factors and the Credit Risk, measured by Altman's Z score, associated with firms' financial performance. Moreover, it was chosen to analyze such correlation by using a selected dataset of performing companies belonging to the Stoxx Europe 600 index. The choice of the dataset had the purpose of selecting a series of performing and publicly traded firms such that the data was publicly retrievable, and the dimensions of the companies were such that it made it easier to identify particular details and insights during the analysis.

This paper first started by focusing on the theoretical knowledge of the ESG world and how this phenomenon has developed over the years. Then the analysis verted on the ESG providers, thus the subjects who provide an estimation for the Environmental, Social, and Corporate Governance components of companies. Furthermore, to provide a comprehensive study of the issue, the thesis then took into consideration the Credit Risk, to establish the financial aspect related to companies' performances and how this component is related to management methodologies, and how it influences the decision-making process of firms. In particular, the study then analyzed a series of academic papers and theories to capture the academic view and the doctrine's ideology on how these two measures may be related. In the end, the study provided a series of assumptions then estimated through the use of Stata statistical software.
Therefore, the study mainly verted on a series of focal hypotheses, including the representation of the existence of a correlation between a company's credit risk measure and its ESG and credit ratings, the different effects that the ESG measures may have on the Z-score, and the assumption of a negative correlation between the Credit Risk and the ESG components.

Furthermore, to evaluate these hypotheses, the research was divided into two main sections, a descriptive statistics analysis, and a regression study. Therefore, in terms of descriptive statistics, this section of the analysis was then structured into three main subsections: a panel data analysis, a cross-sectional analysis, and a correlation analysis. Firstly, through a Panel Data

analysis, the study examined all of Stoxx's Europe 600 index observations trends over the last twelve fiscal years to give a comprehensive view of the tendencies over the recent period. Then, the study focused on a Cross-Sectional analysis where a variable-specific examination was exhibited. In particular, this section focused on assessing the descriptive statistics for the selected sample of companies of the index and on providing a two-sided descriptive analysis for the best-performing Z-score and ESG companies. In particular, this analysis provided a peculiar view of how the values of the top-performing observations didn't match. From this, it follows that the top-performing companies for the Z-score value tend to have low Environmental, Social, and Corporate Governance values. In addition, the same happened for the other side of the analysis, where the best-performing observations of the index for sustainable and environmental values tend to have lower corporate financial performance measures, thus resulting in higher risks and, consequently, a higher probability of facing default or insolvency-related issues.

Moreover, the descriptive statistics section concluded with a correlation analysis where the scatter plots graphics and the correlation matrix between the variables were presented. The scatterplots evidenced an inverse relationship between Altman's score and the ESG values, then confirmed by the fitted values of the linear regression analysis. Thus, indicating that, by taking the consideration the average values of the last twelve fiscal years, the relationship between such variables tends to be negative. Whereas, the relationship between the Credit Risk measure and the credit ratings provided by Thomson Reuters seems to be positive. Although in this descriptive statistics section, it appeared that the graphic representation of the values seems to be concentrated in the lower part of the graph, thus indicating a disproportion between the Z-score and the ESG and Credit Rating values. This observation was then confirmed by the fitted values of the regression models, thus indicating that the correlation between the variables may be difficult to be explained by a linear relationship. Furthermore, the correlation matrix provided some particular insights, since through the analysis, it appeared how all of the Environmental, Social, and Corporate Governance components seemed to have a negative and statistically significant (*p-value* < 0.05) relationship with the Altman's score, whereas the relationship between the Z score and the Credit Rating measure appeared to be positive and statistically significant (*p-value* < 0.05). Furthermore, with the inclusion of the control variables into the correlation matrix also the "Fixed over Total assets" ratio and the "CO2 to Revenues" indicator presented a negative and statistically significant trend with the Credit Risk measure. Consequently, it seemed rational to encounter such relations and trends also in the regression analysis, whereas, on the opposite, the linear regression provided a different outcome. In particular, the Credit Rating measure respected the expectations, being statistically significant

and having a positive effect on the Credit Risk measure. Whereas, on the contrary, not all of the ESG measures seemed statistically significant, in fact only the Environmental component presented a negative and significant influence on the dependent variable. Hence, confirming that not all of the ESG pillars have the same effect on Altman's score.

Furthermore, the control variables did not perform as expected, only the "Fixed over Total assets" ratio appeared to be significant and negatively impacting the dependent variable. Nevertheless, the linear regression presented some flaws in explaining the relationship between the credit risk with the ESG and the Credit ratings. In particular, the distribution of the values for the dependent variable appeared to violate the normality assumption, since the distribution of the average Z-score did not appear to be centered in its mean, as shown by the symmetry and box plots. The linear regression, moreover, could have encountered some other challenges. For instance, the study predicted the possibility of a non-linear relationship between the variables or the presence of heteroscedasticity-related issues. Therefore, due to the natural tendency of the Z-score in assuming positive values, it seemed logical to adopt a logarithmic transformation of the response variable. As analyzed in the second section of the regression, this choice helped the general analysis in redistributing and spreading the observations of the independent variable, thus restoring the normality assumption. In addition, this increased the goodness of fit of the log-linear models and in a better explanation of the outcome's variance by the predictor variables, measured with the R-squared.

In conclusion, this study provides an empirical study based on publicly available data that aims to contribute to the literature by presenting a comprehensive view of the relationship between Credit Risk with Credit Ratings and Environmental, Social, and Corporate Governance scores. Therefore, this study supports the theory of the existence of a log-linear negative relationship between the Z-score and the ESG scores, as well as a positive log-linear relationship between Altman's credit risk indicator and the Credit Ratings. Furthermore, the study supports also the assumption that the individual ESG pillars affect credit risk in different ways. In particular, by predicting a negative and statistically significant relationship between the Environmental and Corporate Governance pillars and Altman's Z-score. Therefore, the increase of a one-unit change in the Environmental and Corporate Governance issues will result in a negative percentage change in Altman's indicator, thus resulting in a lower financial performance of the company and a higher Credit Risk and probability of default of the firm.

LIMITATIONS & FURTHER RESEARCH

The choices made in the analysis have, however, generated some limitations that may be implemented in other future studies. In particular, for the way in which the Stoxx Europe 600 index is structred, the choice of the dataset presents some implied considerations. In fact, the index takes into consideration only some of the best performing companies of European developed countries.

Therefore, this limited the analysis in two different ways. On the one hand, this choice limited the ability to select a pool of different and eterogeneous companies that may varied largely for the structure and the size, therefore implying a large difference for what concerns their market capitalization. This choice would have given the opportunity to study firms that are vastly different from one another, therefore giving the possibility to the analysis to find different and insightful considerations. This logic also applies, on the other hand, to another limitatition derived form the selection of the Stoxx Europe 600 index as dataset. More precisely, the index takes into consideration only European companies, and this, consequrntly, gives the opportunity to have a more homogeneous set of observations, but it also excludes the possibility of studying firms located in fast developing countries. Therefore, also in this instance, precluding the possibility to obtain a vastly differentiated set of companies for the analysis. Such implications, should therefore be taken as inspiration for future research.

Furthermore, in the analysis, it was chosen to select the average value for Altman's Z-score and the ESG variables over the last twelve fiscal years. This choice had the objective of making the variables less susceptible to variations due to unexpected events, thus providing more stable data. However, such a decision did not provide a set of values such that it could be helpful also in predicting long-term values. Therefore, the results of the analysis are to be considered valid only for a short-term period, and future research could investigate such implications even in the long run. Moreover, this study finds another limitation in the data selection process, since only one provider, Thomson Reuters' Eikon, was used for the analysis. Consequently, using the same provider for the dataset and the fact that some of the variables, like ESG scores and Credit Ratings, are not standardized for all the data sources could potentially implicate that the information retrieved, and thus the outcome of the analysis, can potentially vary based on the selected data source. In addition, as presented by Barth, *et al*., (2022) in their theory of a U-shaped relationship between credit risk and ESG factors, and as discovered in this study, the relationship between these variables should not always be considered linear.

Furthermore, another interesting subject that could be the object of further analysis is the fact that, in the end, Altman's score is a representation of a weighted average of several distinct accounting ratios. Therefore, it would be interesting to further examine the relationship between credit ratings and ESG factors with each of the distinct elements that create the Z-score indicator. Therefore, further analyses should investigate the relationship between such variables to broaden the knowledge on the subject.

APPENDIX

A. ***Table 1.*** *Credit Smart Ratios Implied Ratings conversion.*

Source: StarMine Research Team, (n.d.)

Credit Smart Ratios Implied Ratings	*Numeric Equivalent*
AAA	100
AA+	95
AA	90
AA-	85
A+	80
A	75
A-	70
BBB+	65
BBB	60
BBB-	55
BB+	50
BB	45
BB-	40
B+	35
B	30
B-	25
CCC+	20
CCC	20
CCC-	20
CC	15
C	10
D	5
NR	0

B. ***Table 2.*** *Industry distribution of the selected observations of the Stoxx Europe 600. Source: personal processing*

Industry	Observations	Industry Weights
Machinery	30	6,02%
Chemicals	25	5,02%
Equity Real Estate Investment Trusts (REITs)	19	3,82%
Health Care Equipment & Supplies	17	3,41%
Diversified Telecommunication Services	15	3,01%
Food Products	15	3,01%
Pharmaceuticals	15	3,01%
Electric Utilities	14	2,81%
Real Estate Management & Development	14	2,81%
Textiles, Apparel & Luxury Goods	14	2,81%
IT Services	13	2,61%
Oil, Gas & Consumable Fuels	13	2,61%
Aerospace & Defense	12	2,41%
Hotels, Restaurants & Leisure	12	2,41%
Metals & Mining	12	2,41%
Professional Services	12	2,41%
Trading Companies & Distributors	12	2,41%
Beverages	11	2,21%
Capital Markets	11	2,21%
Food & Staples Retailing	11	2,21%
Electrical Equipment	10	2,01%
Construction & Engineering	9	1,81%
Life Sciences Tools & Services	9	1,81%
Diversified Financial Services	8	1,61%
Household Durables	8	1,61%
Semiconductors & Semiconductor Equipment	8	1,61%
Software	8	1,61%
Automobiles	7	1,41%
Building Products	7	1,41%
Commercial Services & Supplies	7	1,41%
Media	7	1,41%
Multi-Utilities	7	1,41%
Biotechnology	6	1,20%
Containers & Packaging	6	1,20%
Industrial Conglomerates	6	1,20%
Specialty Retail	6	1,20%
Gas Utilities	5	1,00%
Independent Power and Renewable Electricity Producers	5	1,00%
Internet & Direct Marketing Retail	5	1,00%
Paper & Forest Products	5	1,00%
Auto Components	4	0,80%
Construction Materials	4	0,80%
Entertainment	4	0,80%
Health Care Providers & Services	4	0,80%
Transportation Infrastructure	4	0,80%
Wireless Telecommunication Services	4	0,80%
Air Freight & Logistics	3	0,60%
Airlines	3	0,60%
Electronic Equipment, Instruments & Components	3	0,60%
Household Products	3	0,60%
Interactive Media & Services	3	0,60%
Personal Products	3	0,60%
Water Utilities	3	0,60%
Communications Equipment	2	0,40%
Distributors	2	0,40%
Energy Equipment & Services	2	0,40%
Leisure Products	2	0,40%
Marine	2	0,40%
Multiline Retail	2	0,40%
Tobacco	2	0,40%
Diversified Consumer Services	1	0,20%
Health Care Technology	1	0,20%
Technology Hardware, Storage & Peripherals	1	0,20%
Tot.	498	100,00%

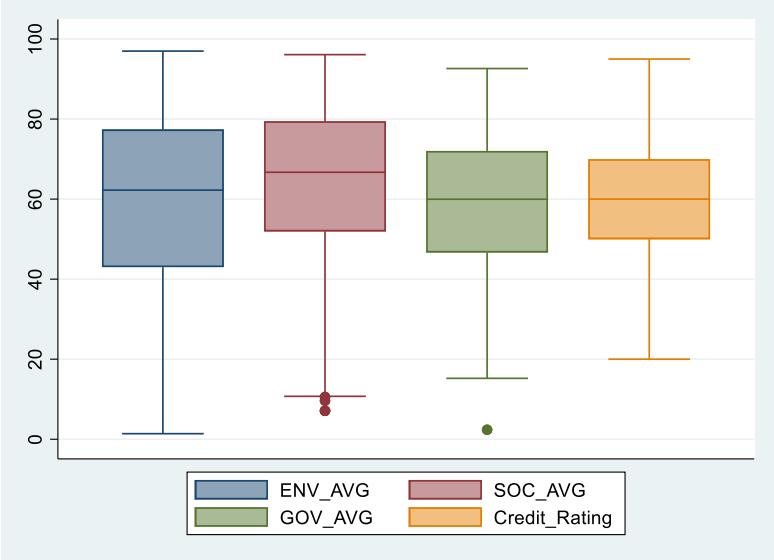
C. *Table 3.* *Country distribution of the selected observations of the Stoxx Europe 600*

Source: personal processing

Country	Observations	Country weights
Austria	6	1,20%
Belgium	13	2,61%
Denmark	20	4,02%
Faroe Islands	1	0,20%
Finland	15	3,01%
France	65	13,05%
Germany	62	12,45%
Republic of Ireland	10	2,01%
Isle of Man	1	0,20%
Italy	20	4,02%
Luxembourg	8	1,61%
Malta	1	0,20%
Netherlands	27	5,42%
Norway	11	2,21%
Poland	4	0,80%
Portugal	3	0,60%
Spain	20	4,02%
Sweden	56	11,24%
Switzerland	44	8,84%
United Kingdom	111	22,29%
Tot.	498	100%

D. *Figure 23.* *Box Plot of the independent variables of the Regression Analysis*

Source: Personal processing



E. *List of the selected companies from the Stoxx Europe 600 used in the analysis*

Source: personal processing

ams Osram AG
Andritz AG
OMV AG
Verbund AG
Voestalpine AG
Wienerberger AG
Ackermans & Van Haaren NV
Aedifica NV
Anheuser-Busch Inbev SA
Cofinimmo SA
D'Ieteren Group NV
Elia Group SA
Groep Brussel Lambert NV
Lotus Bakeries NV
Sofina SA
Solvay SA
Ucb SA
Umicore SA
Warehouses de Pauw NV
ALK-Abello A/S
Ambu A/S
AP Moeller - Maersk A/S
Bavarian Nordic A/S
Carlsberg A/S
Chr Hansen Holding A/S
Coloplast A/S
Demant A/S
DSV A/S
Genmab A/S
GN Store Nord A/S
ISS A/S
Novo Nordisk A/S
Novozymes A/S
Orsted A/S
Pandora A/S
Rockwool A/S
Royal Unibrew A/S
Simcorp A/S
Vestas Wind Systems A/S
P/F Bakkafrost
Elisa Oyj
Fortum Oyj
Huhtamaki Oyj
Kesko Oyj
Kojamo Oyj
Kone Oyj
Metso Outotec Corp
Neste Oyj
Nokia Oyj
Orion Oyj
Stora Enso Oyj
Tietoevry Oyj
UPM-Kymmene Oyj
Valmet Oyj
Wartsila Oyj Abp
Accor SA
Aeroports de Paris SA
Alstom SA
Alten SA
Arkema SA
Biomerieux SA
Bollore SE
Bouygues SA
Bureau Veritas SA
Capgemini SE
Carrefour SA
Christian Dior SE
Compagnie de Saint Gobain SA
Michelin SCA
Covivio SA
Danone SA
Dassault Aviation SA
Dassault Systemes SE
Edenred SE
Eiffage SA
Electricite de France SA
Elis SA
Engie SA
EssilorLuxottica SA
Eurazeo SE
Faurecia SE
Gaztransport et Technigaz SA
Gecina SA
Getlink SE
Hermes International SCA
Ipsen SA
Kering SA
Klepierre SA
Air Liquide SA
L'Oreal SA
La Francaise des Jeux SA
Legrand SA
LVMH Moet Hennessy Louis Vuitton SE
Nexans SA
Orange SA
Pernod Ricard SA
Publicis Groupe SA
Remy Cointreau SA
Renault SA
Rexel SA
Rubis SCA
Safran SA
Sartorius Stedim Biotech SA
Schneider Electric SE
SEB SA
Sodexo SA
Soitec SA
Sopra Steria Group SA
Spie SA
Teleperformance SE
Thales SA
Ubisoft Entertainment SA
Unibail-Rodamco-Westfield SE
Valeo SE
Veolia Environnement SA
Verallia SA
Vinci SA
Vivendi SE
Wendel SE
Worldline SA
Adidas AG
Aixtron SE
Aurubis AG
BASF SE
Bayer AG
Bayerische Motoren Werke AG
Bechtle AG
Beiersdorf AG
Brenntag SE
Carl Zeiss Meditec AG
Continental AG
Covestro AG
Cts Eventim AG & Co KgaA
Delivery Hero SE
Deutsche Boerse AG
Deutsche Lufthansa AG
Deutsche Post AG
Deutsche Telekom AG
E ON SE
Encavis AG
Evonik Industries AG
Evotec SE
freenet AG
Fresenius Medical Care AG & Co KGaA
Fresenius SE & Co KGaA
Fuchs Petrolub SE
GEA Group AG
HeidelbergCement AG
Hellofresh SE
Henkel AG & Co KGaA
Hugo Boss AG
Infineon Technologies AG
K&S AG
Kion Group AG
Knorr Bremse AG
Lanxess AG
LEG Immobilien SE
Mercedes Benz Group AG
Merck KGaA
MTU Aero Engines AG
Nemetschek SE
Porsche Automobil Holding SE
Puma SE
Rational AG
Rheinmetall AG
RWE AG
SAP SE
Sartorius AG
Scout24 SE
Siemens AG
Siemens Energy AG
Siemens Healthineers AG
Symrise AG
Telefonica Deutschland Holding AG
thyssenkrupp AG
TUI AG
United Internet AG
Vantage Towers AG
Volkswagen AG
Vonovia SE

Wacker Chemie AG
Zalando SE
CRH PLC
DCC PLC
Experian PLC
Flutter Entertainment PLC
Glanbia PLC
Grafton Group PLC
Kerry Group PLC
Kingspan Group PLC
Ryanair Holdings PLC
Smurfit Kappa Group PLC
Entain PLC
A2A SpA
Amplifon SpA
Brunello Cucinelli SpA
Davide Campari Milano NV
DiaSorin SpA
Enel SpA
Eni SpA
Ferrari NV
Hera SpA
Infrastrutture Wireless Italiane SpA
Interpump Group SpA
Italgas SpA
Leonardo SpA
Moncler SpA
Prysmian SpA
Recordati Industria Chimica e Farmaceutica SpA
Reply SpA
Snam SpA
Telecom Italia SpA
Terna Rete Elettrica Nazionale SpA
Allegro.eu SA
ArcelorMittal SA
Aroundtown SA
B&M European Value Retail SA
Eurofins Scientific SE
Millicom International Cellular SA
SES SA
Tenaris SA
Kindred Group PLC
Aalberts NV
Adyen NV
Airbus SE
Akzo Nobel NV
Arcadis NV
argenx SE
ASM International NV
ASML Holding NV
BE Semiconductor Industries NV
Euronext NV
Heineken Holding NV
Heineken NV
IMCD NV
JDE Peets NV
Just Eat Takeaway.com NV
Koninklijke Ahold Delhaize NV
Koninklijke DSM NV
Koninklijke KPN NV
Koninklijke Philips NV
OCI NV
Prosus NV
Qiagen NV
Randstad NV
Signify NV
Stellantis NV
Universal Music Group NV
Wolters Kluwer NV
Aker BP ASA
Equinor ASA
Kongsberg Gruppen ASA
Nel ASA
Nordic Semiconductor ASA
Norsk Hydro ASA
Orkla ASA
SalMar ASA
Telenor ASA
Tomra Systems ASA
Yara International ASA
Dino Polska SA
KGHM Polska Miedz SA
LPP SA
Polski Koncern Naftowy Orlen SA
EDP Energias de Portugal SA
Galp Energia SGPS SA
Jeronimo Martins SGPS SA
Acciona SA
ACS Actividades de Construccion y Servicios SA
Aena SME SA
Amadeus IT Group SA
Cellnex Telecom SA
Corporacion Acciona Energias Renovables SA
EDP Renovaveis SA
Enagas SA
Endesa SA
Ferrovial SA
Grifols SA
Iberdrola SA
Industria de Diseno Textil SA
Inmobiliaria Colonial SOCIMI SA
MERLIN Properties SOCIMI SA
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Red Electrica Corporacion SA
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AAK AB (publ)
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EQT AB
Essity AB (publ)
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Getinge AB
H & M Hennes & Mauritz AB
Hexagon AB
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Hexpol AB
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Kinnevik AB
L E Lundbergforetagen AB (publ)
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Tele2 AB
Telefonaktiebolaget LM Ericsson
Telia Company AB
Thule Group AB
Trelleborg AB
Volvo AB
Wallenstam AB
Wihlborgs Fastigheter AB
Abb Ltd
Adecco Group AG
Alcon AG
Allreal Holding AG
Bachem Holding AG
Barry Callebaut AG
Belimo Holding AG
BKW AG
Bucher Industries AG
Chocoladefabriken Lindt & Spruengli AG
Clariant AG
Coca Cola HBC AG
Compagnie Financiere Richemont SA
DKSH Holding AG
Dufry AG
Ems Chemie Holding AG
Flughafen Zuerich AG

Galenica AG
Geberit AG
Georg Fischer AG
Givaudan SA
Glencore PLC
Holcim AG
Kuehne und Nagel International AG
Logitech International SA
Lonza Group AG
Nestle SA
Novartis AG
Partners Group Holding AG
PSP Swiss Property AG
Roche Holding AG
Schindler Holding AG
SGS SA
Siegfried Holding AG
SIG Group AG
Sika AG
Sonova Holding AG
Straumann Holding AG
Swatch Group AG
Swiss Prime Site AG
Swisscom AG
Tecan Group AG
Temenos AG
VAT Group AG
3i Group PLC
Allfunds Group PLC
Anglo American PLC
Antofagasta PLC
Ashtead Group PLC
Associated British Foods PLC
AstraZeneca PLC
Auto Trader Group PLC
BAE Systems PLC
Balfour Beatty PLC
Barratt Developments P L C
Bellway PLC
Berkeley Group Holdings PLC
Big Yellow Group PLC
BP PLC
British American Tobacco PLC
British Land Company PLC
Britvic PLC
BT Group PLC
Bunzl plc
Burberry Group PLC
Centrica PLC
CNH Industrial NV
Compass Group PLC
Computacenter PLC
ConvaTec Group PLC
Croda International PLC
Dechra Pharmaceuticals PLC
Derwent London PLC
Diageo PLC
Diploma PLC
Drax Group PLC
DS Smith PLC
Energean PLC
Future PLC
Games Workshop Group PLC
Genus PLC
Greggs PLC
GSK plc
Halma PLC
Harbour Energy PLC
Hargreaves Lansdown PLC
Hays PLC
Hikma Pharmaceuticals PLC
Howden Joinery Group PLC
IG Group Holdings PLC
IMI PLC
Imperial Brands PLC
Inchcape PLC
Indivior PLC
Informa PLC
InterContinental Hotels Group PLC
Intermediate Capital Group PLC
International Consolidated Airlines Group SA
International Distributions Services PLC
Intertek Group PLC
ITV PLC
J Sainsbury PLC
JD Sports Fashion PLC
Johnson Matthey PLC
Kingfisher PLC
Land Securities Group PLC
London Stock Exchange Group PLC
Londonmetric Property PLC
LXI REIT PLC
Marks and Spencer Group PLC
Melrose Industries PLC
Mondi PLC
National Grid PLC
Next PLC
Ocado Group PLC
Pearson PLC
Pennon Group PLC
Persimmon PLC
QinetiQ Group PLC
Reckitt Benckiser Group PLC
Relx PLC
Rentokil Initial PLC
Rightmove PLC
Rio Tinto PLC
Rolls-Royce Holdings PLC
Rotork PLC
RS Group PLC
Safestore Holdings PLC
Sage Group PLC
SEGRO PLC
Serco Group PLC
Severn Trent PLC
Shell PLC
Smith & Nephew PLC
Smiths Group PLC
Softcat PLC
Spectris PLC
Spirax-Sarco Engineering PLC
SSE PLC
Subsea 7 SA
Tate & Lyle PLC
Taylor Wimpey PLC
Tesco PLC
Travis Perkins PLC
Tritax Big Box Reit PLC
Unilever PLC
Unite Group PLC
United Utilities Group PLC
Vistry Group PLC
Vodafone Group PLC
Watches of Switzerland Group PLC
Weir Group PLC
Whitbread PLC
Wise PLC
WPP PLC

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