Exploring the Impact of ESG on Factor Models

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Abstract

Given the increasing interest in Environmental, Social and Governance (ESG) topics, mainly driven by both rising regulation for corporations and investors appeal to long-term sustainability, it has become necessary and useful to test the relevance of the ESG factor, namely a strategy that involves going long on stocks with low ESG performance and shorting those with high ESG score, on asset pricing. This thesis investigates the integration of ESG factor in traditional factor models and its explanatory power, in particular in FF 3-factor and 5-factor models, recognizing their central role in contemporary markets.

The review of the ESG topic starts with a discussion of the overall performance of ESG stocks, their evolution over time, compared to non-ESG stocks. The analysis of ESG factor is divided in two parts: first, it analyzes the factor given by the combined ESG score; second, the three pillars (Environmental, Social and Governance) are examined individually, as three factors. By outlining these "subfactors", the aim is to capture the blended dynamics within each ESG dimension and explore their respective impacts on investment performance and risk. Further breakdown is made by analyzing the impact of factors at industry-level and within different exchanges.

The analysis highlights how firms with low ESG scores experienced higher returns in the period considered than ESG leaders, implying the possibility of a particular risk borne by the former. Moreover, significant results are found when the ESG factor is added to asset pricing models in all its specifications and with varying degrees of relevance.

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Resumo

Dado o crescente interesse em temas Ambientais, Sociais e de Governação (ESG), impulsionado pela crescente regulamentação para as empresas e pelo apelo dos investidores à sustentabilidade a longo-prazo, tornou-se necessário e útil testar a relevância do fator ESG, uma estratégia que envolve a compra de ações com baixo desempenho ESG e a venda daquelas com alta pontuação ESG, na precificação de títulos. Esta tese investiga a integração do fator ESG nos modelos tradicionais de factores e o seu poder explicativo, em particular nos modelos FF de 3 e 5 factores.

A análise do tema ESG começa com uma discussão sobre o desempenho das acções ESG em comparação com as acções não ESG. A análise do fator ESG divide-se em duas partes: primeiro, analisa-se o fator dado pela pontuação ESG combinada; segundo, os três pilares (Ambiental, Social e Governança) são examinados individualmente, como três fatores. Ao delinear estes "subfactores", o objetivo é captar a dinâmica combinada dentro de cada dimensão ESG e explorar os respectivos impactos no desempenho e no risco do investimento. A análise do impacto dos factores a nível do sector e das diferentes bolsas de valores é mais pormenorizada.

A análise destaca o facto de as empresas com baixas pontuações ESG terem registado retornos mais elevados no período considerado do que as líderes ESG, o que implica a possibilidade de um risco particular suportado pelas primeiras. Ademais, são encontrados resultados significativos quando o fator ESG é adicionado aos modelos de avaliação de activos em todas as suas especificações.

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Título: Explorar o impacto do ESG nos modelos de fatores

Palavras-chave: Determinação do preço dos títulos, ESG, risco ESG, modelos de factores

Table of Contents

1. Introduction

The evolution of ESG (Environmental, Social, and Governance) topics from a corporate buzzword to a critical aspect of company operations, with a pivotal role regarding management and investment policies, has been remarkable in recent years, prompted by green concerns, such as environmental disasters, pollution and climate change, and corporate events (e.g., Microsoft's carbon negative commitment[1], Starbucks' enhancement of employee benefits and racial equity[2], Volkswagen's strengthening of compliance and governance following Dieselgate[3]). The concept of ESG (Environmental, Social and Governance) was first coined in 2004 in the report "Who Cares Wins" for the United Nations Environment Programme Finance Initiative[4]. Started out with uncertainty about "where it would end up"[5], the contemporary financial markets has integrated Environmental, Social and Governance perspectives and this has emerged as a significant change, redefining the scenario of portfolio management and investment strategies.

1.1 Background

Unlike the past, when investors were more interested in investing in companies or projects that were attractive only from an economic point of view, today we are seeing a new generation of *socially conscious investors* who want to invest in organizations with the same principles and moral values that they believe in. The interest toward these topics has grown substantially: according to GSIA Report[6], in 2022 global sustainable investment amounted to $30.3 trillion, accounting for 24.4% of total assets under management, and are expected to be over $53 trillion in 2025[7]. The importance of sustainability has grown as markets have recognized the link between financial performance and broader environmental, social, and governance considerations (Rahman, et al., 2023; Orlitzky, et al., 2003), in addition to the personal interest of some investors in these issues. This recognition stems from the growing awareness of the underlying risks posed by climate change, social inequality, and corporate misconduct that affects the company's business, along with

[1] https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/
[2] https://stories.starbucks.com/press/2020/starbucks-role-and-responsibility-in-advancing-racial-and-social-equity/
[3] https://www.forbes.com/sites/georgkell/2022/12/05/from-emissions-cheater-to-climate-leader-vws-journey-from-dieselgate-to-embracing-e-mobility/?sh=1437e9ff68a5
[4] https://www.unepfi.org/fileadmin/events/2004/stocks/who_cares_wins_global_compact_2004.pdf
[5] Paul Clement-Hunts, co-author of "Who cares wins" and of Principles for Responsible Investment (PRI 2006)
[6] https://www.gsi-alliance.org/wp-content/uploads/2023/12/GSIA-Report-2022.pdf
[7] https://www.bloomberg.com/professional/insights/markets/esg-assets-may-hit-53-trillion-by-2025-a-third-of-global-aum/

the shift in investor preferences in favor of sustainability and responsible investing. In addition, companies' commitment to shift towards sustainable practices and disclosing reliable ESG data is also driven by international agreements, as the United Nations Sustainable Development Goals (SDGs) and Paris Climate Agreement, and by the more and more stringent regulation adopted, mainly in Europe[8] and US[9].

To better understand the basis of the thesis topic, it is important to outline what ESG really means and how it is formed. The term ESG refers to three pillars, or dimensions, concerning environmental commitment, adherence to corporate values, and the extent to which a company acts with accuracy and transparency. In details, the three dimensions can be summarized as following[10]:

- Environmental pillar examines how a company manages risks and opportunities related to environmental challenges. These considerations include carbon emissions, waste, energy use and overall consequences for living beings.
- Social criteria focus on how a company treats its key stakeholders, particularly employees. Criteria include human capital management; opportunities for diversity, equity and inclusion; health and productivity in the work environment; and rules on unfair practices in selling products to customers.
- Governance dimension reviews how the company is governed, who makes decisions, and who is in charge. Evaluation metrics consider executive compensation, fiscal practices and strategies, diversity, and board structure.

Although they span a broad range of matters that traditionally have not been part of financial analysis, many of the elements addressed by ESG framework have a substantial financial relevance: for example, energy-efficient practices and a proactive management of carbon emissions and pollution can reduce costs and may avoid fines and regulatory penalties; moreover, the adoption of ethical principles in the production of goods and services and in the treatment of workers can reinforce customer loyalty, resulting in increased sales.

Finally, it is necessary to give a brief description of factor investing, in order to cluster everything presented before and go into detail about the goal of the thesis. Factor investing is an

[8] Regulation 2019/2088; Corporate Sustainability Reporting Directive 2023
[9] The Enhancement and Standardization of Climate-Related Disclosures for Investors, SEC 2024
[10] https://www.janushenderson.com/en-au/investor/article/what-is-esg-and-why-do-we-care/

investment strategy that involves the identification and analysis of specific drivers of return across various asset classes. This approach can assist investors in improving the performance of their portfolios and enhancing their diversification strategies. Two main types of factors can be identified: macroeconomic factors, such as real growth, inflation and real rates, that capture broad risks across asset classes; value, momentum and size, labeled as style factors, which help to explain returns and risk within asset classes. The thesis concept of including ESG characteristics in the creation of a portfolio falls into the last category. In particular, investment choices based on ESG, and sustainability in general, can assume different forms. CFA Institute, with the Global Sustainable Investment Alliance (GSIA), and the Principles for Responsible Investment (PRI) defined responsible investment definitions[11]: screening, a process for determining which investments are or are not permitted, according to ESG criteria; impact investing, where investments are made with the intention to generate positive, measurable social and/or environmental impact alongside a financial return; stewardship, that is the use of influence by institutional investors to maximize long-term value, including social and environmental assets; ESG integration, the one pertinent to the purpose of the thesis, where there is an ongoing consideration of ESG factors within an investment analysis and decision-making process with the aim to improve risk-adjusted returns. A 2020 CFA Institute analysis[12] found that 85% of investment professionals considered ESG factors when making their investment, remarking the importance that these elements are assuming in recent years.

1.2 Research questions

The main research question of the thesis is to test if the ESG factor is relevant for understanding returns, namely, to understand whether some of the variance in returns can be explained by the use of this new factor. This hypothesis is described as:

H1) The inclusion of an ESG factor will increase the explanatory power of the models.

This hypothesis is tested running several linear regressions, including and excluding the ESG factor. To accept or reject the hypothesis, we will look at the results of the different regressions, particularly the coefficient relating to the ESG factor and the adjusted R-squared.

[11] https://rpc.cfainstitute.org/-/media/documents/article/industry-research/definitions-for-responsible-investment-approaches.pdf
[12] https://rpc.cfainstitute.org/-/media/documents/survey/future-of-sustainability.pdf

To investigate the ESG topic further, two additional hypotheses are formulated to study the value of ESG criteria for portfolio management. These are:

H2) The low ESG portfolio shows higher returns than the high ESG portfolio.

H3) A strategy based on ESG outperforms the market.

These two additional hypotheses are used to test whether a portfolio built purely on ESG criteria is historically profitable, independently of the validity of the ESG factor in asset pricing models, as tested in H1.

1.3 Structure

The thesis is organized as follows. Chapter 2 will give an overview of the literature review on pricing models and integration of ESG. The subsequent Chapter 3 goes into detail of the data used. Chapter 4 describes the construction of the factors and the methodology adopted. In Chapter 5, the results of the ESG-factor testing are explained. Some possible limitations and improvements of the research question are presented in Chapter 6. Lastly, Chapter 7 draws a conclusion.

2. Literature Review

This chapter reviews the relevant literature to date. It is divided in two sections: first, I discuss the existing literature about portfolio theories and fundamental asset pricing models; in the second section it is analyzed the relationship between ESG and stock returns.

2.1 Portfolio Theory

The Efficient Market Hypothesis (EMH) is a cornerstone of financial economics, and many contemporary financial theories rely heavily on it as a fundamental principle, so it is appropriate to start here. The idea that financial markets incorporate all relevant information and can't be predicted stems from Eugene Fama (1970) with his review of the theoretical and empirical research: any information should be already incorporated into the stock price, otherwise there would be opportunities for arbitrage. The EMH is divided into three categories: weak-form, all past prices of a stock are reflected in today stock price; semi-strong form, publicly available information are already incorporated; strong-form, all public and private information are accounted in stock price. This is also related to the Random Walk Theory (Fama, 1965), according to which "successive price changes in individual securities are independent".

At the root of the main theoretical framework for portfolio management there is also the Modern Portfolio Theory (MPT), published by Harry Markowitz (1952). The MPT, or mean-variance analysis, states that a rational investor, assumed to be risk-averse, constructs a portfolio by maximizing the expected return given a certain level of risk (standard deviation of return), holding a portfolio on the efficient frontier. This theory relies on the core idea of diversification, that minimize idiosyncratic risk by holding assets that are not perfectly positively correlated: the evaluation of an asset's risk and return should be based on its contribution to the overall risk and return of a portfolio, rather than assessing it in isolation.

The Modern Portfolio Theory has given rise to numerous pricing models. One major type of model is the factor based one. These models associate the return of a security to single or multiple risk factors. The most popular single factor model is the Capital Asset Pricing Model (CAPM), introduced by several researchers independently (Treynor, 1961 and 1962; Sharpe, 1964; Lintner, 1965; Mossin 1966). This model incorporates the asset's sensitivity to non-diversifiable risk (or systematic risk), typically represented by the beta (β) parameter. Furthermore, it factors in both the projected market return and the expected return associated with a theoretical risk-free asset. Under

the main assumptions of the model (Berk & DeMarzo, 2016), investors will invest in the tangency portfolio, that is the portfolio that lies at the point where the efficient frontier is tangent to the highest possible capital market line (CML) in the risk-return space. CAPM today plays a central role in portfolio choices and is widely used by practitioners. Despite strong criticism (Roll, 1977; Dayala, 2012; Lai and Stohs, 2015), many extensions have been proposed (Black, 1972; Lucas, 1978; Breeden, 1979; Black and Litterman, 1992), confirming the strong influence of Sharpe and Treynor's work. Moving to multiple factor models, and at the same time to two of the CAPM's greatest critics, the three factors model proposed by Fama and French (1993) incorporates two additional factors that help to explain what the CAPM ignores. The new factors proposed by Fama and French are: SMB, (Small Minus Big), accounting for the size premium; HML (High Minus Low), measuring the value premium. The idea originates from the conjecture that small firms are more volatile and have higher returns compared to larger firms, while value stocks (with a high book-to-market ratio) outperform growth stocks (low book-to-market ratio). In many empirical studies, it is shown that the Fama-French Three-Factor Model has a higher explanatory power (Piela, 2013) and a better ability to forecast stocks' returns with respect to CAPM (Choi, 2017). This model was extended further with a new factor, creating the Carhart Four Factor Model (Carhart, 1997). This addition became necessary after the discovery of "momentum anomaly" (Jegadeesh and Titman, 1993; Asness, 1994), about the tendency of stocks to exhibit sustained periods of either positive or negative performance over multiple months: Fama and French (1996) stated that their model "cannot explain the continuation of short-term returns". As result, Carhart added a momentum factor (or WML, Winners Minus Losers), that increased the explanatory ability of the model (Jev, 2022). Finally, coming to the second model used in the thesis, Fama and French (2013) proposed a new approach composed by 5 factors, of which two are new and three comes from the 1993 model. The two new ones are about investment (Conservative Minus Aggressive, or CMA) and operating profitability (Robust Minus Weak, or RMW).

2.2 ESG and Stock Performance

Formally proposed in 2004, the ESG principles are developing very fast and more firms around the world are promoting them in their company strategies (Li, et al., 2021). The literature on the relationship between ESG and stocks performance is quite extensive and has been expanding greatly in recent years, in correlation with the increased interest in ESG topics. It can be divided in three groups: the first claims that stocks that are more compliant with ESG principles outperforms

than those who place these principles on the back burner, while the second group argue the opposite. The third group is placed in the middle, according to which there are no statistically significant evidences. Therefore, there isn't a clear answer on ESG impact on stocks.

It is shown empirically that equities displaying the poorest ESG exposures exhibit higher volatility levels and betas, up to 15% and 3% respectively, compared to stocks characterized by superior ESG exposures (Dunn, Fitzgibbons and Pomorski, 2018). Moreover, it is found that firms with superior ESG ratings exhibited lower leverage and credit risk compared to those with lower ESG score (Asimakopoulos, et al., 2023; Bannier, et al., 2022), resulting in a lower idiosyncratic risk (Godfrey et al., 2009). As a consequence, firms that perform poorly in ESG present a higher risk that may reflect higher returns: for example, Bolton and Kacperczyk (2020) found that stocks of firms with higher total carbon dioxide emissions, which results in increased environmental regulation risk (Ilhan, et al., 2020), earn significant high returns, and this "carbon premium" is not explained by known risk factors; Bannier, Bofinger and Rock (2019) showed that a portfolio composed by a long position in high ESG stocks and a short position in those with the lowest scores yields a significantly negative abnormal return, caused by the strong positive return of firms that perform poorly in ESG activity. The fundamental economic rationale behind these findings may be that certain investors are reluctant to retain stocks associated with inadequate ESG exposures. This diminished demand for shares is anticipated to lead to lower current prices, potentially resulting in higher returns in the future (Dunn, Fitzgibbons and Pomorski, 2018). The lower price may also be reflected by the higher cost of capital that firms with low value of Corporate Social Responsibility (CSR) faces (El Ghoul, et al., 2011). However, this result is in contrast with other studies that suggest that a portfolio composed by long position on stocks with low carbon intensity and short on stocks with high intensity generate an abnormal return of 3.5–5.4% per year (In, et al., 2017; Garvey, et al., 2018). Moreover, a side of literature shows that firms with poor Governance (computed through a "Governance Index") realize lower average returns (Gompers, Ishii and Metrick, 2003). To support the not conclusive answer of literature about effects of ESG, the work of Borgers et al. (2015) underscores that mutual funds with greater involvement in sin stocks (companies involved in activities that are considered unethical) experience slightly higher returns, however, the return difference is not statistically significant.

3. Data and Sample

This section will present the data and the research methods used to answer the research question of the thesis. In the last paragraph, the main descriptive statistics of the sample are shown.

3.1 Data and Sample Selection

The data for the analysis is comprised of accounting and market data of all US stocks and the period considered is 11 years, from January 2013 to December 2023: the reasons for the choice of this timeframe are: (i) Refinitiv Eikon started providing ESG data from 2002, excluding any possibility of a period starting from an earlier date; (ii) before 2013 only a low share of stocks of the sample have ESG data, making the analysis less reliable. Several databases are explored to gather all the information needed: monthly Fama-French factors from Kenneth French finance data library; stocks information are extracted from the Center for Research in Security Prices (CRSP), selecting only US-listed stocks that satisfy some filtering requirements, later descripted; firm accounting data are imported by Compustat, provided by S&P Global Market Intelligence; Refinitiv Eikon to get the ESG scores, both overall and at pillar-level. In the sample there are some cases of missing data, especially regarding ESG scores. Since the methodology used to build the factors requires yearly readjustment of stocks, in case of missing data it is enough to remove the observation of only that period and not to completely remove the stock from the sample. In the following sections more details about each type of data used are presented.

Data Type	**Source**	**Frequency**	**Observations**
Stocks Data	CRSP	Monthly	499.963
Accounting Data	Compustat	Yearly	126.577
ESG Score	Refinitiv Eikon	Yearly	21.767
U.S. Treasury Bill Rate (1-month)	Kenneth French Data Library	Monthly	132

Table 1: Data Sources and Data Series Characteristics.

3.1.1 Stocks Information

CRSP is one of the main databases for US stock, providing coverage for the US stocks starting from 1925. For the considered sample, data are filtered according to some filters: US stocks (i) from January 2013 to December 2023, (ii) identified as no-special share type, (iii) security type equity, (iv) security sub type common stock, (v) issuers that are a corporation, (vi) for months within permno-specific start dates and end dates. This selection results in a sample of 12,592 different firms, with a total of 499.963 observations. In particular, the data retrieved from CRSP

are security identifiers (permno, cusip, ticker), information (shares outstanding, primary exchange, industry), closing prices and monthly returns.

3.1.2 Firm Accounting Data

Specific accounting inputs are needed to the construction of the factors. The values are extracted from Compustat, choosing the standard format and filtering for desired time window. The variables vary from stockholders' equity and total assets to revenue and costs. Refer to Table 2 for more details. After that, data from CRSP and Compustat are merged using the CRSP-Compustat Merged table, provided by CRSP.

CRSP	Compustat	Refinitiv Eikon	K. French Library
Permno	Cusip	ESG score	FF3 factors
Cusip	Stockholders' equity	E pillar score	FF5 factors
Ticker	Total assets	S pillar score	Treasury bill 1-month
Shares outstanding	Total liabilities	G pillar score	
Closing Price	Capital investment		
Return	Operating cash flow		
Exchange	Revenue		
SICCD	Costs and expenses		
	Interest expenses		

Table 2: Detailed list of variables.

3.1.3 ESG Score

The ESG Score for all the stocks are retrieved from Refinitv Eikon dataset, that covers over 90% of global market cap and includes more than 630 ESG metrics, which come from corporate public reporting. The LSEG offering is one of the most comprehensive ESG databases in the industry, with history dating back to 2002[13] and spanning 10 main themes across the three dimensions. Refinitiv ESG rating system is based on 10 main topics, divided among the three dimensions, that are shown in Table 3. The score given is between 0 (worst) and 100 (best), computed with 186 comparable measures and with a comparative approach, in order to eliminate hidden layers of calculations and to make the data easily readable. Refinitiv ESG Dataset provides ESG scores at pillar-level (E, S, G), computed with an average of individual specific metrics score, each with a specific relative weight. Then, the overall score is obtained through a weighted average

[13] https://www.lseg.com/content/dam/data-analytics/en_us/documents/methodology/lseg-esg-scores-methodology.pdf?esg=Super+Retail+Group+Ltd

of the three pillar scores. Finally, the data are merged with the rest of the dataset through the stocks' cusip and permno (unique permanent identification numbers).

Environmental	Social	Governance
Resource Use	Workforce	Management
Emissions	Human Rights	Shareholders
Innovation	Community	CSR Strategy
	Product Responsability	

Table 3: Refinitiv Eikon ESG dimensions and main topics.

3.2 Sample Description

The resulting sample is quite diverse, including firms of different size, profitability, investment, and ESG focus. Table 4 reports some descriptive statistics of the sample. It is composed of firms with a market capitalization ranging from a few million dollars to billions and also profitability and BM ratio vary significantly. In contrast, the ESG score varies less markedly, with more than 50% of firms in the range between a score of 20 and 52. This result is influenced by the fact that at the beginning of the period only part of the sample has ESG data (Chart 1) and, as expected, they are not so detailed to receive a high score. In addition, still today many firms disclose little information, which affects the score negatively: Refinitiv Eikon ESG rating system penalizes the lack of disclosure by assigning a score of 0 to the missing metrics. If this seems to be too penalizing, it is also the only proper method to render sustainable the comparative methodology used to assign the scores.

Factor	1st Qu.	Median	Mean	3rd Qu.
Market Cap	79	359	4,872	1,736
Book-to-Market	0.298	0.553	0.790	0.916
Operating Profitability	-0.05	0.14	-0.66	0.26
ESG Score	23.77	35.05	38.63	51.23

Table 4: Sample statistics. The excess returns are monthly; the market capitalization is in $M.

However, this methodology may create some bias in the analyses performed, because firms that do not report ESG data may tend to have lower ESG scores. Although it may be consistent with the idea of public information actually available in the market, this remains an issue to be highlighted and will also be addressed later in one of the robustness checks.

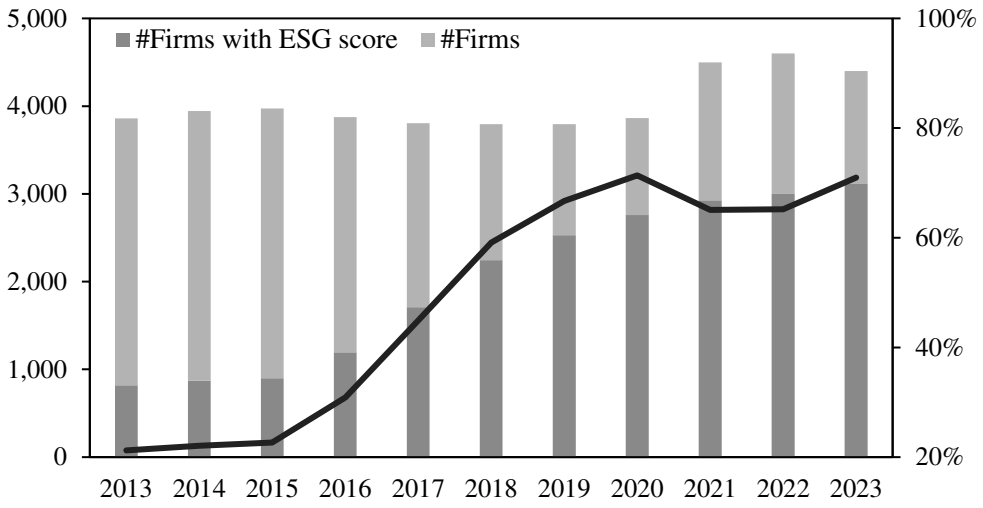

Chart 1: Number of the firms by year (left); share of firms with ESG data (right).

The descriptive statistics for all factors are shown in Table 5. The market return factor has a mean slightly above 1%, with a standard deviation of 4.6%. By contrast, the size (SMB), value (HML) and investment (CMA) factors have a negative average, contrasting with the classic positive returns that underlie the creation of these factors originally. This might be caused by several factors, such as some economic conditions during the period considered.

Factor	Mean	Std. Dev.	Min	Max
Rm-Rf	1.01%	4.63%	-13.39%	13.65%
SMB	-0.07%	2.73%	-6.29%	7.66%
HLM	-0.09%	3.43%	-12.81%	12.71%
RMW	0.38%	2.25%	-4.90%	8.06%
CMA	-0.08%	2.35%	-7.07%	7.74%

Table 5: Factors descriptive statistics.

4. Methodology

The methodology used to answer the research question is based on Fama & French (1993, 2015), both in the factor constructions and in its analysis. The following sections review the different parts of the methodology used. First, the asset pricing models used in the thesis. Second, the methodology of the factors construction. Third, model estimation and inference.

4.1 Asset Pricing Models

The methodology of the thesis builds on the need to test the integration of the ESG factor on a well-known and established model, such that the results are more reliable. The two asset pricing models used are the Fama-French 3 Factor model (Equation 1) and the Fama-French 5 Factor model (Equation 2). The new ESG factor is added to these two models, becoming 4 and 6 factor models, respectively. The models with the ESG factor are represented as follows:

$$r_i - r_f = \alpha_i + \beta_{i,m} \cdot (r_m - r_f) + \beta_{i,SMB} \cdot SMB + \beta_{i,HML} \cdot HML + \beta_{i,ESG} \cdot ESG + \varepsilon_i \quad (1)$$

$$r_i - r_f = \alpha_i + \beta_{i,m} \cdot (r_m - r_f) + \beta_{i,SMB} \cdot SMB + \beta_{i,HML} \cdot HML + \beta_{i,RMW} \cdot RMW + \beta_{i,CMA} \cdot CMA + \beta_{i,ESG} \cdot ESG + \varepsilon_i \quad (2)$$

The two models are used to test the differences in explanatory power with and without the ESG factor, which will make it possible to assess the influence on the model caused by the inclusion of the ESG factor. It is relevant to state that the choice of these two models is quite arbitrary, since other factor models could have been used. The decision to rely on the two models of Fama and French is partially driven by the idea of considering the model that is probably the most widely used both in literature and practical application (FF3 Factor) and a more recent version of it (FF5 Factor), consistent with the importance of ESG that has grown only the last decade.

4.2 Factor Construction

All the factors used in the models are created according to Fama and French (1993, 2015) methodology. Using the sample of all US stocks, different portfolios are formed and factors constructed, obtained with the following formulas:

$$SMB = \frac{r_{SV} + r_{SN} + r_{SG}}{2} - \frac{r_{BV} + r_{BN} + r_{BG}}{2} \quad (3)$$

$$HML = \frac{r_{SV} + r_{BV}}{2} - \frac{r_{SG} + r_{BG}}{2} \quad (4)$$

$$RMW = \frac{r_{SR} + r_{BR}}{2} - \frac{r_{SW} + r_{BW}}{2} \quad (5)$$

$$CMA = \frac{r_{SC} + r_{BC}}{2} - \frac{r_{SA} + r_{BA}}{2} \quad (6)$$

To check the quality of the replicated factors, they are tested against the factors provided by the Kenneth Frech Data Library. The obtained factors are good if the results of the regressions presents a non-significant intercept (rejecting the notion of systematic error), the coefficients close to 1 (indicating a high correlation), and the adjusted R-squared close to 1 (indicating a high proportion of explained variance). In Appendix 9.2 it is confirmed that the constructed factors are of high quality.

The ESG factor is the one that requires a new specific formulation. Following the approach for the construction of the previous factors, and in line with the majority of literature on this topic, companies were categorized into rated groups according to their ESG score. To 2 cut-off points are created to form three groups, that are, in decreasing order of ESG quality, Leader (top 30%), Neutral and Laggard (bottom 30%), according to the definitions used by Refinitiv Eikon database. Then I construct 6 portfolios based on size (Small and Big) and ESG scores, in which each firm is weighted based on their market capitalization. Finally, the factor is calculated as the average return on the two low ESG (defined as Bad, B) portfolios minus the average return on the two high ESG (defined as Good, G) portfolios. The decision to follow such an approach stems from the fact that stocks with a lower ESG score have a higher riskiness than ESG-leading firms, as shown both in the literature in Chapter 2.2 and later in Chapter 5 on findings. The factor is constructed as follows:

$$ESG = \frac{r_{SB} + r_{BB}}{2} - \frac{r_{SG} + r_{BG}}{2} \quad (7)$$

The factor is constructed using only stocks in the dataset that have an ESG score. As a result, the number of stocks used will be significantly different from that used to construct the other factors, given the greater presence of observations. However, this does not create problems because there are still enough stocks present to create a reliable ESG factor. Moreover, this issue is addressed again later and analyzed in one of the robustness checks. Since this is a new factor, it is relevant to provide some statistics on it. As shown in Table 6, the ESG factor has a positive average excess return and a standard deviation in line with that of the other factors (Table 5).

Factor	Mean	Std. Dev.	Min	Max
ESG	0.12%	2.18%	-7.04%	6.71%

Table 6: ESG Factor descriptive statistics.

When the cumulative returns of the factors are compared in Chart 2, we note how the ESG factor, along with the CMA factor, reports a positive return at the end of the time period considered. In particular, the initial trend of the factor was quite stable, with little fluctuation. However, after a decline in performance in 2020, at the beginning of COVID-19, the ESG factor shows a pronounced increase, with cumulative returns rising significantly until the end of 2023.

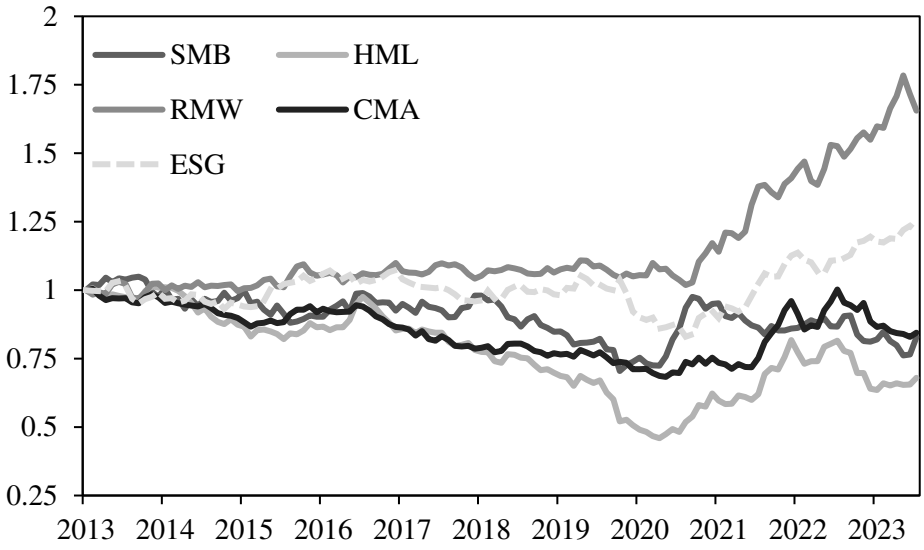

Chart 2: Cumulative returns of the factors

To analyze the relationships among the different factors, we show in Table 7 the correlations between the Fama-French factors and the new ESG factor. This analysis allows to understand how each factor interacts with the others, providing information on the unique contributions of each factor, in particular of the ESG one. I find a positive correlation only with the size factor, an expected result since many small firms have low ESG scores; this highly relevant aspect is further explored at the beginning of Chapter 5 and in Chapter 6 on the limitations of the thesis research question. Regarding the negative correlation with CMA and RMW factors, it may be explained by the fact that firms that are more conservative, namely more inclined to adopt sustainable practices as part of their long-term risk management, and that have higher profitability, which may translate in higher investment in sustainable practices as they can afford to do so, have also a high ESG score.

	SMB	*HML*	*RMW*	*CMA*	*ESG*
SMB	1				
HML	0.373	1			
RMW	-0.402	0.159	1		
CMA	0.093	0.738	0.170	1	
ESG	0.435	-0.169	-0.595	-0.332	1

Table 7: Correlations between factors for the period 2013-2023

Lastly, the ESG factor has a negative and relatively low correlation with HML factor, and this is a quite surprising result, since one would expect a firm with a high ESG score to be priced high by the market, thus be considered growth.

An identical approach is used to derive the factors for the three individual ESG pillars. The procedure described above is now computed for each ESG pillar. In this way three new factors are constructed, each given by the difference between the average return of the two portfolios with a low score in a specific ESG dimension and the average return of the two portfolios with a high score. The factors are derived as:

$$E = \frac{r_{SB,E} + r_{BB,E}}{2} - \frac{r_{SG,E} + r_{BG,E}}{2} \quad (8)$$

$$S = \frac{r_{SB,S} + r_{BB,S}}{2} - \frac{r_{SG,S} + r_{BG,S}}{2} \quad (9)$$

$$G = \frac{r_{SB,G} + r_{BB,G}}{2} - \frac{r_{SG,G} + r_{BG,G}}{2} \quad (10)$$

4.3 Model Estimation

The methodology used to assess the research question of the thesis is the time-series regression, using Ordinary Least Squares (OLS). This approach comes from Black, Jensen, and Scholes (1972) and is the most used in asset pricing theory (Fama and French, 1993, 1996; Carhart, 1997; Asness et al., 2013), thanks to its simplicity and ease of use: linear regression establishes the linear relationship between the dependent variable (Y) and the independent variables (X_i) based on a line of best fit, that minimize the sum of squared residuals (SSE) between observed observations and predicted values. The general equation for a multiple linear regression is:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon_{it} \quad (11)$$

The specific version used in this thesis is as follows,

$$r_{it} - r_{ft} = \alpha_i + \sum_{k=1}^{K} \beta_{i,k} \cdot F_{t,k} + \beta_{i,ESG} \cdot ESG_t + \varepsilon_{it} \quad (12)$$

where the dependent variable is the excess market returns, $r_{it} - r_{ft}$, $\sum_{k=1}^{K} \beta_{i,k} \cdot F_{t,k}$ represents different combination of the K factors presented in the previous section and $\beta_{i,ESG} \cdot ESG_t$ is the term associated to the ESG factor. For the aim of the thesis, the relevant parameters are the coefficients obtained from regression. In particular, the most important one is the coefficient of the ESG factor, $\beta_{i,ESG}$. To validate the hypothesis of the thesis, the coefficient must be significant, that is, have a t-stat above a certain threshold (i.e., 1.645 for a 90% confidence level, 1.96 for a 95% and 2.56 for a 99%). Another relevant regression result is the adjusted R-squared, specifically focusing on the difference in value between a regression with and without the inclusion of ESG factor as regressor. This difference allows to understand if the integration of environmental, social and governance concerns helps to improve the efficiency of a model.

5. Findings and Results

This section presents the empirical outcomes of the analyses that allows to accept or reject the hypothesis of the thesis. As delineated with the research questions (Section 1.2), the thesis explores whether a factor based on ESG scores increases the explanatory power of well-known asset pricing models, namely the Fama & French Three-factor model and the Fama & French Five-Factor model. In addition, the results of some portfolios built on ESG are reported and compared, to verify the existence of a valid investment strategy. The latter analysis is presented in the first paragraph. In the second paragraph, results based on the overall ESG scores are shown. In the third paragraph, outcomes by industry and exchange are presented. Finally, in the fourth paragraph, an analysis on ESG at pillar-level is made and their results are reported.

5.1 ESG Portfolios

Before testing the secondary hypothesis, it is interesting to investigate more deeply the relationship between size and ESG score of a firm. In order to do this, 12 portfolios were constructed by dividing stocks by size and ESG score, adopting a bivariate sorting approach and selecting 4 cut-off points for size variable (one for each quartile), while 3 cut-off points for ESG (following the division adopted in Section 4.2). In Table 8 are shown some statistics of the 12 portfolios.

	ESG					
Size	Laggard	Neutral	Leader	Laggard	Neutral	Leader
	Firm size			Firm ESG score		
Small	47.3	55.4	59.2	20.1	40.1	63.3
2	196.2	209.2	219.6	22.4	41.0	64.6
3	557.0	592.4	649.4	23.2	43.0	66.5
Big	3236.7	3295.1	7961.5	23.4	45.6	70.6
	Number of firms			BM ratio		
Small	445.6	179.7	15.0	0.85	0.89	0.92
2	199.5	198.1	38.3	0.55	0.60	0.70
3	124.6	196.5	75.7	0.45	0.48	0.47
Big	43.1	124.8	229.8	0.34	0.38	0.41

Table 8: Portfolios constructed on Size and ESG. The values are monthly average.

From these results, it is possible to note four points: (i) given the same group for the size, as the firm's ESG score increases, the average size increases; (ii) in the same ESG cluster, as the size increases, the ESG score also increases on average; (iii) the largest portfolio is composed of small firms with low scores, and the number of firms initially decreases as the size and score increase, then it reaches the second largest portfolio composed of large stocks with good ESG score; (iv) there appears to be no strong link between a firm's B/M and its ESG score, except for a slight increase as score increases. To summarize, there seems to be a link between size and ESG, specifically a positive correlation between the two variables, as also shown in Table 7. This finding is quite interesting, since it may alter the results of subsequent analysis, as part of the ESG factor returns may actually be explained in part by the size factor.

Turning to secondary hypothesis testing, we analyze two portfolios, based on their ESG scores: the top 30% is assigned to the "High ESG" (or, Leader) portfolio, and the bottom 30% to the "Low ESG" (or, Laggard) portfolio. In each portfolio the stocks are value-weighted.

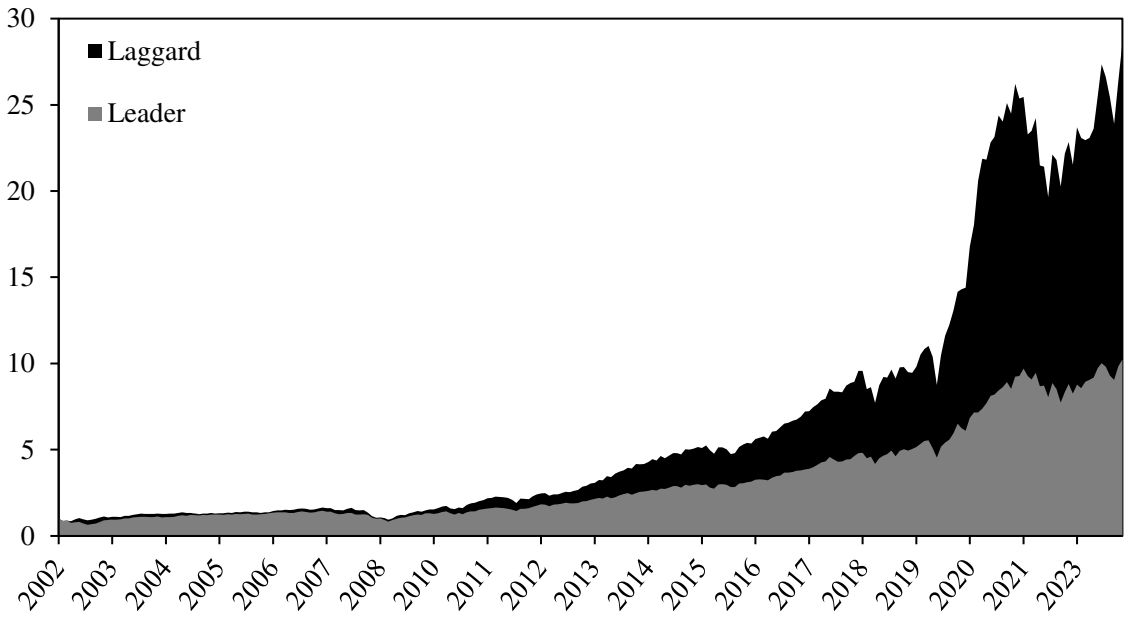

Chart 3: Cumulative Returns

From the Chart 3, it is possible to see how a portfolio consisting only of low score firms produces higher returns over time than a portfolio consisting of high scores. In particular, the gap begins to widen from 2010 onward, consistent with the time frame in which ESG considerations began to matter in society and markets. From 2020, the difference between the results of the two

portfolios will widen further, in line with the increasingly "ESG-friendly" trend that is spreading, and the consequent allocation of a risk premium to stocks with a low ESG score. Table 9 presents some statistics for the three ESG portfolios and the market, using different periods, to distinguish well the patterns previously described.

	2002-2023			2010-2023			2020-2023		
	Avg	Vol	S.R.	Avg	Vol	S.R.	Avg	Vol	S.R.
Leader	0.010	0.046	0.221	0.013	0.043	0.309	0.015	0.058	0.253
Neutral	0.012	0.048	0.261	0.016	0.048	0.327	0.017	0.063	0.263
Laggard	0.014	0.051	0.281	0.019	0.052	0.361	0.023	0.073	0.316
Market	0.013	0.045	0.284	0.015	0.045	0.342	0.017	0.059	0.271

Table 9: Statistics for three portfolios constructed on ESG and market portfolio.

Considering the whole period, there is no portfolio built on ESG that manages to do better in terms of Sharpe Ratio than the market. However, considering shorter periods, 2010-2023 and 2020-2023, betting on a portfolio composed of stocks with a low ESG score is the best choice. This results from higher average excess returns, which compensate for a larger standard deviation. In fact, the "Laggard" portfolio has, in all three periods considered, the highest volatility, showing a greater risk. This risk can arise from several sources, for example, a high environmental risk for the non-compliance with ESG parameters, or large presence of firms from some highly volatile industries; part of it could derive from the size factor, which as shown above is correlated with ESG score, however the portfolios considered contain firms of all sizes and are value-weighted, which should mitigate the impact of size on returns. The presence of this risk therefore justifies the idea of creating a factor to be included in asset pricing models.

In light of the results shown, conclusions can be drawn regarding hypotheses H2 and H3. About the first one, that is about the comparison in performance of portfolios built on ESG, it is possible to state that an investment strategy based on a long position in stocks with a low ESG score produces higher returns and Sharpe Ratio than a similar strategy with high ESG stocks, validating the hypothesis. Regarding the comparison between the market and the low ESG portfolio, represented by the H3 hypothesis, the answer is not so clear: depending on the period considered, the outcome varies, going either for or against the hypothesis. However, considering the nature of the ESG topic, it seems more appropriate to use a more recent period, consistent with the recent

integration of these issues in the society's interest. In this case, once again, the results over the last two periods considered (2010-2023 and 2020-2023) confirm the hypothesis.

5.2 Overall ESG

When referring to ESG, one refers primarily to the overall score and not to individual pillars. So, it is appropriate to talk first and foremost about the results obtained by integrating a factor built on the overall ESG score. Table 10 shows the results of the four regressions of the excess returns of a portfolio, composed by all the stocks of the sample, against the factors of the model considered (Fama-French Three-factor model in Panel A and Five-factor model in Panel B) and the ESG factor.

	Market	SMB	HML	ESG	RMW	CMA	Constant	Obs.	Adj. R2
Panel A									
FF3	0.981***	0.993***	0.146***				-0.002	132	0.947
	(0.029)	(0.047)	(0.036)				(0.001)		
FF3 + ESG	0.989***	0.901***	0.178***	0.211***			-0.002	132	0.950
	(0.028)	(0.054)	(0.036)	(0.066)			(0.001)		
Panel B									
FF5	0.990***	0.836***	0.056		-0.271***	-0.069	-0.001	132	0.957
	(0.028)	(0.052)	(0.055)		(0.059)	(0.074)	(0.001)		
FF5 + ESG	0.993***	0.805***	0.055	0.138**	-0.214***	-0.030	-0.001	132	0.958
	(0.027)	(0.053)	(0.055)	(0.068)	(0.064)	(0.075)	(0.001)		
Note:								*p<0.1; **p<0.05; ***p<0.01	

Table 10: Results for regressions with Fama-French 3 factor (Panel A) and 5 factor (Panel B) models

For the FF3 model, all the coefficients are statistically significant at 1% and the constant are slightly negative but non-significant. The ESG factor is also significant at 1% and, most importantly, when adding this factor the adjusted R-squared of the model (slightly) increases, with respect to the value of the model excluding ESG. The increase, only 0.3 percent, does not have great magnitude however, considering that the basic model of Fama and French already explains most of the variation in returns (94.7 percent), the gain assumes greater importance. In Panel B are reported the results for the FF5 model. Here the results for the coefficients in the baseline model are not the same as in the previous one: the value (HML) and investment (CMA) factors are not statistically significant, while the others all are, with a 99% confidence level. Conversely, the ESG factor continues to maintain its relevance, though with one degree less confidence (significant at 5%). Importantly, the inclusion of the ESG factor does not significantly change any other exposure, suggesting an additional source of information, additional to the other factors. Overall, it can be

stated that the ESG factor contributes positively to the explanation of the variance of a portfolio's returns, using the two Fama and French models.

5.2.1 Robustness check

To assess the robustness of these results, I perform the same analysis considering a "ESG subsample". For each month, I consider only stocks that have an ESG score: to be precise, I remove firms that do not have a score or that have a score below 10, to eliminate extreme cases due mainly to a lack of sufficient data for proper score calculation. By focusing only on firms that actually have a proper match for the ESG database, we can better evaluate the effect of this factor on the stock's returns by spanning the whole cross section with the factor, reducing the noise in the data. The results obtained (in Table 11) are similar to those of the analysis presented earlier. The ESG factor coefficients remain significant, although the values decreased by 15% for the FF3 model and increased by 20% for the FF5 model. However, while the adjusted R2 are lower than the analysis on the full sample, the integration of the ESG factor causes the value to increase more significantly in both models, especially for the 5-factor model.

	Market	SMB	HML	ESG	RMW	CMA	Constant	Obs.	Adj. R2
Panel A									
FF3	1.051***	0.745***	0.187***				-0.0002	132	0.937
	(0.031)	(0.052)	(0.035)				(0.001)		
FF3 + ESG	1.071***	0.661***	0.206***	0.181***			0.0003	132	0.941
	(0.031)	(0.056)	(0.034)	(0.056)			(0.001)		
Panel B									
FF5	1.053***	0.698***	0.011		-0.163***	0.056	0.0004	132	0.943
	(0.030)	(0.056)	(0.050)		(0.058)	(0.060)	(0.001)		
FF5 + ESG	1.071***	0.640***	0.031	0.166***	-0.111*	0.088	0.001	132	0.947
	(0.030)	(0.058)	(0.049)	(0.058)	(0.060)	(0.059)	(0.001)		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 11: Results for regressions with Fama-French 3 factor (Panel A) and 5 factor (Panel B) models using the ESG subsample

Another robustness check performed is the restriction of the time period to only the last 5 years, from January 2019 to December 2023, to account the fact that ESG concerns are gaining more relevance only in the last period, although it is a topic since more than 20 years. Also this check (results in Table 12) further reinforces previous analyses, confirming the predictive power of the

ESG factor. Here, the coefficients relative to ESG are even higher, validating the importance of the environmental, social and governance in the financial markets.

	Market	SMB	HML	ESG	RMW	CMA	Constant	Obs.	Adj. R2
Panel A									
FF3	1.053***	0.195***	0.884***				-0.001	60	0.940
	(0.047)	(0.049)	(0.080)				(0.002)		
FF3 +	1.097***	0.225***	0.739***	0.275***			0.002	60	0.948
ESG	(0.046)	(0.047)	(0.088)	(0.088)			(0.002)		
Panel B									
FF5	1.056***	-0.031	0.817***		-0.225**	0.059	0.001	60	0.950
	(0.043)	(0.073)	(0.089)		(0.085)	(0.083)	(0.002)		
FF5 +	1.092***	-0.001	0.720***	0.236***	-0.164*	0.102	0.002	60	0.955
ESG	(0.043)	(0.070)	(0.092)	(0.086)	(0.083)	(0.080)	(0.002)		
Note:									*p<0.1; **p<0.05; ***p<0.01

Table 12: Results for regressions with Fama-French 3 factor (Panel A) and 5 factor (Panel B) models for the period 2019-2023

5.3 Industry Results

Despite the fact that the ESG topic is becoming increasingly relevant in the general market, it is important to point out that some industries are more impacted, involved or concerned than others. Therefore, it is also considered necessary to conduct an analysis at the level of individual industries, which also serves as a form of robustness check. Eleven portfolios, each containing only companies in a specific industry, defined by their SIC Code, are constructed and tested with the two asset pricing models used in this thesis. The Table 13 presents the results of the regressions for the 11 industries portfolio against the Fama and French 5-factors model. The outcomes for the same analysis with the FF 3-factors model are shown in Appendix 9.3. For 8 out of 11 industries the coefficient corresponding to the ESG factor is statistically significant, however, the confidence level varies among sectors. An increase in adjusted R-squared is observed for the same industries, with gains ranging from 0.2% to 1.9%, while for two there is no change, and for one there is a small decrease of 0.1%. In addition, it is interesting to note how the sign of the ESG factors coefficient varies among industries. For three industries, Utilities, Finance and Agriculture, we find three coefficients that are negative, indicating that firms with high ESG scores outperform low ESG stocks in these industries. In these cases, it is unlikely that these higher returns will result from bearing more risk. The Agriculture sector is highly exposed to ESG issues, especially on the Environment; firms in the Utilities industry may be pushed by regulation to be more sensitive to

	Utilities	Finance	Manufactu ring	Wholesale	Retail	Transporta tion	Services	Mining	Constructi on	Agriculture	Public
Market	0.705***	0.758***	1.025***	1.031***	1.082***	1.057***	1.070***	1.537***	1.213***	0.907***	0.969***
	(0.056)	(0.034)	(0.030)	(0.039)	(0.069)	(0.050)	(0.034)	(0.167)	(0.074)	(0.086)	(0.048)
SMB	-0.003	0.714***	0.844***	0.872***	0.949***	0.718***	-0.026	1.229***	0.254*	0.137	-0.276***
	(0.109)	(0.067)	(0.058)	(0.077)	(0.135)	(0.097)	(0.069)	(0.334)	(0.148)	(0.172)	(0.097)
HML	0.158	0.570***	-0.082	0.021	-0.034	0.068	0.663***	0.537	0.914***	0.945***	1.016***
	(0.111)	(0.068)	(0.060)	(0.079)	(0.138)	(0.100)	(0.067)	(0.327)	(0.145)	(0.169)	(0.095)
ESG	-0.286**	-0.262***	0.082	0.098	0.635***	0.032	0.168*	0.899**	0.346*	-0.526**	0.305**
	(0.139)	(0.085)	(0.074)	(0.098)	(0.172)	(0.124)	(0.086)	(0.417)	(0.185)	(0.215)	(0.121)
RMW	-0.221*	-0.157*	-0.039	0.320***	0.711***	-0.102	-0.294***	-0.059	0.576***	-0.112	-0.658***
	(0.131)	(0.080)	(0.070)	(0.093)	(0.163)	(0.117)	(0.081)	(0.394)	(0.175)	(0.203)	(0.114)
CMA	0.168	-0.506***	0.126	0.322***	0.435**	0.149	-0.041	0.521	-0.257	-0.332	-0.011
	(0.153)	(0.094)	(0.082)	(0.108)	(0.190)	(0.137)	(0.095)	(0.460)	(0.204)	(0.238)	(0.133)
Constant	0.001	0.002	-0.001	-0.001	-0.003	-0.001	0.00005	-0.009	0.001	-0.003	-0.002
	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.001)	(0.007)	(0.003)	(0.004)	(0.002)
Observations	132	132	132	132	132	132	132	132	132	132	132
Adjusted R2	0.604	0.914	0.949	0.916	0.809	0.868	0.936	0.608	0.813	0.662	0.903
ΔAdj. R2	0.01	0.005	0	0	0.019	-0.001	0.002	0.011	0.004	0.013	0.004
Note:											*p<0.1; **p<0.05; ***p<0.01

Table 13: Results for regressions with Fama-French 5 factor model using industries portfolio. The ΔAdj. R2 indicates the difference between the adjusted R-squared of the ESG model and the baseline model (FF5).

ESG topics, while those in Finance by issues of trust and reputation toward a growing number of investors interested in sustainable finance. So, these results are more likely to result from a sudden increase in cash flows, namely the numerator in the pricing formula. On the other hand, we would expect some significant results on Construction and Transportation industries as well, that are high carbon-intensive, but from the results of the analyses conducted, these are not the cases.

The industries for which the effects of ESG factor integration are most visible, in terms of increase in adjusted R-squared, are mining, retail and agriculture. About the first one, mining operations typically have a significant environmental impact, while social factors such as human rights and labor practices are critical considerations in this sector, therefore if a mining firm shows a real commitment to these topics, it may be rewarded by the market. The retail industry is mainly affected by the perspective of consumers, who have an increasing interest in sustainability issues, with 24% of 'GenZ' and 'Millennials' checking sustainability claims made by brands and 21% having stopped buying a product if the brand does not make enough effort to help the environment[14]. Lastly, the agriculture sector is the one where the link to ESG is very straight forward, with a high weight on the environmental pillar and social concerns.

5.4 Exchange Results

Given the size of the U.S. stock market, and the presence of many markets, a specific analysis of the major exchanges can provide additional insights into how their different characteristics fit with investors' concerns about ESG. Below, in Table 14, the results of the regressions of the portfolios constructed based on the exchange against the factors of the Fama and French models and the new ESG factor are presented. For the NASDAQ and AMEX, the ESG factor coefficients are significant for both FF3 and FF5, at 99% and 95% confidence level, respectively. The adjusted R-squared also increases compared to the model excluding the ESG factor: the rise is more pronounced for the AMEX than for the NASDAQ, presenting values above 1%. In contrast, neither significant coefficients nor R-squared increases are found for the NYSE. This difference in the significance of the ESG factor among the stock exchanges may be attributed to the characteristics of their component firms: NASDAQ and AMEX tend to have higher concentrations of technology and growth-oriented companies, sectors that often have a stronger focus on environmental and

[14] https://www.ey.com/en_gl/insights/consumer-products/sustainable-flexible-plastic-packaging-strategy

	NASDAQ		AMEX		NYSE	
	FF3	**FF5**	**FF3**	**FF5**	**FF3**	**FF5**
Market	0.930***	0.940***	0.845***	0.890***	1.115***	1.101***
	(0.034)	(0.033)	(0.096)	(0.097)	(0.020)	(0.020)
SMB	1.026***	0.900***	0.939***	0.759***	0.666***	0.641***
	(0.066)	(0.064)	(0.184)	(0.191)	(0.039)	(0.039)
HML	0.048	-0.075	0.318***	0.140	0.403***	0.272***
	(0.043)	(0.065)	(0.121)	(0.195)	(0.026)	(0.040)
ESG	0.281***	0.169**	0.636***	0.560**	0.033	0.039
	(0.080)	(0.082)	(0.223)	(0.243)	(0.047)	(0.050)
RMW		-0.337***		-0.412*		0.045
		(0.077)		(0.230)		(0.047)
CMA		-0.040		0.277		-0.027
		(0.090)		(0.269)		(0.055)
Constant	-0.002	-0.001	-0.001	-0.0002	-0.002	-0.002*
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)
Observations	132	132	132	132	132	132
Adjusted R2	0.930	0.941	0.618	0.640	0.975	0.978
ΔAdj. R2	0.007	0.001	0.021	0.012	0	0
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 14: Results for regressions with Fama-French 3 factor and 5 factor models by exchange. The ΔAdj. R2 indicates the difference between the adjusted R-squared of the ESG model and the baseline model (without ESG factor).

social issues, which may lead to a more significant impact of the ESG factor on stock returns. However, sectors with little exposure to the ESG transition are also present in these exchanges, while the AMEX market is very small and poorly capitalized, so the results may not represent a completely correct view of the ESG effect but may be influenced by some noise. Furthermore, NYSE is one of the largest (Chart 4) and most consolidated stock exchanges, exhibiting a high market efficiency so information regarding ESG performance may already be fully reflected in stock prices. Lastly, the NYSE tends to have a higher proportion of large-cap companies with respect to NASDAQ and AMEX; these big firms may already have established ESG practices and reporting frameworks, reducing the incremental impact of the ESG factor on stock returns. However, it is important to note that the NASDAQ is very active in promoting sustainable

activities among its component stocks, for example the launch of the Green Equity Principles[15], unlike the NYSE which is much more neutral and has a low level of intervention[16].

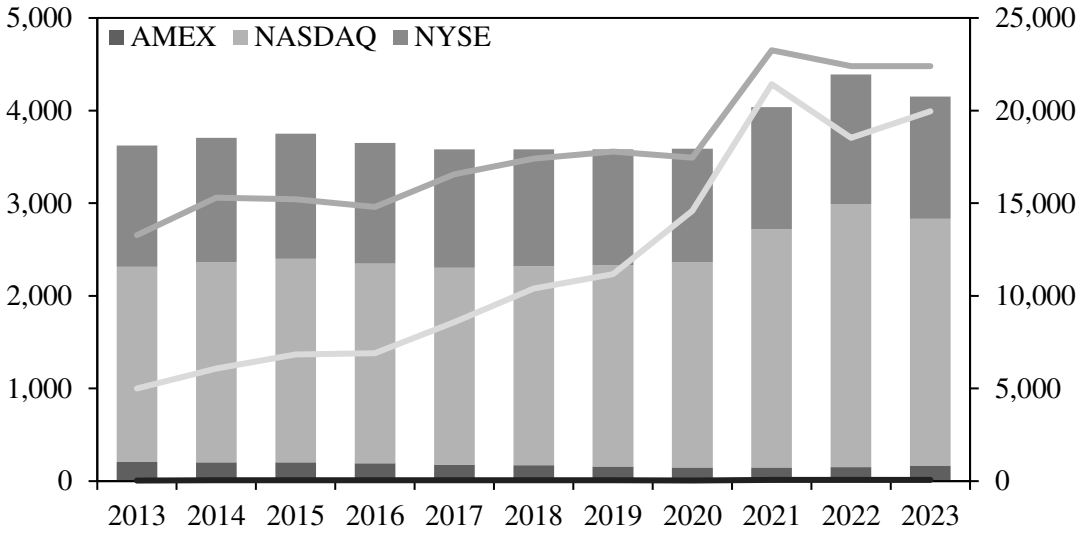

Chart 4: Numbers of firms per exchange (left); Market Capitalization in $M (right)

5.5 Pillars Results

Dividing ESG into 3 distinct factors - Environmental, Social and Governance - has diverse benefits. It allows for a deeper analysis, checking the contribution of every dimension individually on financial performance and risk. In addition, this split increases the specificity and relevance of the studies. Environmental considerations might have different financial impacts with respect to social concerns or governance issues. Breaking down ESG in this way gives investors a clearer understanding of the various effects on investment choices and the possibility to evaluate and compare companies based on their performance in each ESG dimension.

Before investigating the analysis of the three factors separately in detail, it is important to specify that the period considered here begins in January 2014, one year after the period used for the main analysis. The reason for this is the lack of sufficient data for each pillar to construct the factors, since in some observations the score for certain pillar is either missing or 0 (a fictitious value, not the result of the Refinitiv ESG methodology).

In the rest of the section the results obtained of the analysis of the three individual factors (whose formulas are presented in Section 4.2) are presented and described. Table 15 presents the

[15] https://www.nasdaq.com/articles/WFE-launches-green-equity-principles
[16] https://aces.kenaninstitute.unc.edu/wp-content/uploads/2020/12/ESG-Stock-Report-Carlyann-Edwards.pdf

analysis of the factors using the Fama French 3-factor model. Among the three pillars, only the one related to the Environment pillar seems to be relevant. For this dimension, the relative coefficient is significant at 5% when considering the model with the integration of only this factor, while it is at 1% in the model with all three factors. Regarding the adjusted R-2 squared, the increase is small and the same for both models, 0.2%. By contrast, the Social and the Governance ones turn out to be unimportant, individually, in explaining returns.

	FF3	**FF3 + E**	**FF3 + S**	**FF3 + G**	**FF3 + ESG**
Market	0.978***	0.984***	0.977***	0.975***	0.975***
	(0.030)	(0.030)	(0.031)	(0.031)	(0.031)
SMB	0.994***	0.932***	0.995***	0.995***	0.924***
	(0.049)	(0.056)	(0.051)	(0.049)	(0.056)
HML	0.141***	0.151***	0.142***	0.139***	0.155***
	(0.037)	(0.036)	(0.037)	(0.037)	(0.037)
E		0.115**			0.161***
		(0.052)			(0.060)
S			-0.005		-0.068
			(0.059)		(0.066)
G				-0.025	-0.067
				(0.065)	(0.069)
Constant	-0.001	-0.001	-0.001	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	120	120	120	120	120
Adjusted R2	0.947	0.949	0.947	0.947	0.949
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 15: Results for regressions with Fama-French 3 factor model with pillar factors. The ΔAdj. R2 indicates the difference between the adjusted R-squared of the ESG model and the baseline model (FF3 model).

These findings show that among the three pillars, only the one related to the environmental factor appears to be pertinent to investors. However, when I perform the same analysis using the 5-factor model of Fama and French (Table 16), the results are not completely confirmed. Now the Environmental factor becomes non-significant when considered individually, although a small increase in the adjusted R2-squared persists (0.1%). When we consider the model with all three factors, the E factor remains the only one that is significant, but the confidence level decreases. This shows how individual scores actually fail to provide new integration in factor models. This

was not totally unexpected, because although environment is the most important and considered among the three dimensions (Benuzzi, et al., 2024), it is also true that generally stock screening is done using the overall ESG score, without differentiating among the pillars. This is also due to the fact that many rating agencies only release an overall score, while those that release individual scores suffer in quality, given a great lack of such specific data and appropriate methodologies, making these values less reliable and usable.

	FF5	**FF5 + E**	**FF5 + S**	**FF5 + G**	**FF5 + ESG**
Market	0.987***	0.993***	0.985***	0.983***	0.986***
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
SMB	0.840***	0.817***	0.845***	0.838***	0.817***
	(0.054)	(0.055)	(0.055)	(0.054)	(0.055)
HML	0.050	0.036	0.052	0.050	0.036
	(0.057)	(0.057)	(0.057)	(0.057)	(0.057)
RMW	-0.265***	-0.232***	-0.269***	-0.274***	-0.234***
	(0.061)	(0.064)	(0.061)	(0.062)	(0.064)
CMA	-0.071	-0.030	-0.072	-0.073	-0.017
	(0.076)	(0.080)	(0.077)	(0.076)	(0.080)
E		0.079			0.117**
		(0.048)			(0.053)
S			-0.032		-0.080
			(0.056)		(0.062)
G				-0.047	-0.052
				(0.060)	(0.062)
Constant	-0.001	-0.0003	-0.001	-0.001	-0.0005
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	120	120	120	120	120
Adjusted R2	0.957	0.958	0.957	0.957	0.958
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 16: Results for regressions with Fama-French 5 factor model with pillar factors. The ΔAdj. R2 indicates the difference between the adjusted R-squared of the ESG model and the baseline model (FF5 model).

6. Limitations and Further Research

The integration of an ESG factor in asset pricing marks a step forward in the consideration of ethical and social topics in market performance, which have so far been sidelined by better-known models. In fact, it is now highly topical and a fundamental point of responsible investing. This thesis helps to understand that environmental, social and governance dimensions can play an important role in choosing an investment portfolio, taking into account both financial return and social impact. However, although the research is interesting and promising, it is fair to point out some possible limitations that could skew the results.

First of all, data availability poses great challenges for this research. Not all companies disclose their ESG results, making it difficult to select a suitable sample for analysis. While it is now a must to release annual, or even more frequent, ESG reports for large companies, it is at the same time a rarity for small companies. This happens either because they have less capital available to choose sustainable investments or to collect and report all the needed data, or because they do not find it useful at that stage of development. Beyond that, even if data is available, it is not necessarily that the data is qualitatively good and reliable. Some companies release a lot of information regarding their energy consumption and waste, employee management, and governance, and thus most likely receive a very good ESG score; on the other hand, there are those who publish limited essential information, receiving a lower score, but this does not necessarily imply that the former are more ESG compliant than the latter. This can create bias in the formation of high ESG and low ESG portfolios, which may not actually reflect the firm's commitment. Beyond that, even if data is available, it is not necessarily that the data is qualitatively good and reliable. Some companies release a lot of information regarding their energy consumption and waste, employee management, and governance, and thus most likely receive a very good ESG score; on the other hand, there are those who publish limited essential information, receiving a lower score, but this does not necessarily imply that the former are more ESG compliant than the latter. This can create bias in the formation of high ESG and low ESG portfolios, which may not actually reflect the firms' commitment. Another problem is the choice of rating agency from which to obtain the necessary ESG data. There are numerous rating players in the industry, and among them there is divergence in the method used to calculate the score, the weights given to each dimension, and the metrics considered, obviously resulting in different ESG overall scores (Chatterji, et al., 2016). Refinitiv

Eikon, the database used in this thesis, is regarded as one of the leaders in the rating sector[17], offering results on a large number of firms and using numerous metrics. However, it is important to note that using data from different agencies, results may vary; in fact, the correlations between ESG ratings from different rating agencies range from 0.38 to 0.71 (Berg et al., 2022), not so high values indicating that the different scoring methodologies used lead to quite different scores, with some cases where firms have high scores for some agencies and low scores for others.

After explaining the limitations, ideas for future research can arise from these. Analysis similar to that done in this thesis may involve different samples, expanding geography to Europe, more regulated in terms of reporting requirements, or focusing only on specific industries; it may be adopted the use of different rating agencies to obtain ESG results of firms, comparing the results with the ones obtained here with Refinitv Eikon; the study periods can be enlarged to before 2013, although there is a lack of proper data: this problem can be mitigated by the use of a few proxies, one for each ESG dimension, so that data are available even before the actual introduction of the ESG concept.

[17] https://issanet.org/content/uploads/2022/08/McKinsey-ratings_extract.pdf

7. Conclusion

This thesis aims to analyze the effectiveness of an ESG-related factor in explaining the variance of returns. The factor, constructed based on the absolute ESG score assigned by the rating agencies, was included in Fama and French's three- and five-factor models. Through time-series regressions with different portfolio and model settings shown earlier, conclusions can be summarized thanks to the results obtained.

First of all, we can say that a portfolio consisting of stocks with a poor commitment toward ESG, namely a low ESG score, outperforms both the portfolio of high ESG stocks and the market, in terms of cumulative returns and Sharpe Ratio over the period of analysis (201-2023). This result is true despite higher volatility of returns, a manifestation of the factor's inherent risk. In fact, low ESG-compliant stocks incorporate exposure to environmental and social risks, while high ESG firms are less affected by them. Therefore, investors get a premium for holding stocks subject to these risks. This difference is especially noticeable in the last 10 years, when themes about the environment, community and governance have begun to gain prominence in the corporate side.

Moving on to the main objective of the thesis, it is shown that the addition of an ESG factor increases the ability of the model to explain the returns of a portfolio. This is demonstrated both for the entire sample considered and for some particular subperiods and specifications. In addition, the further analysis performed allows these conclusions to be expanded, partially, to certain portfolios at the exchange and industry level. As might be expected, only certain sectors are exposed to ESG issues and with different magnitudes, both negative and positive. The same is true for exchanges, where the specific characteristics of these leave room or not for the integration of ESG themes within the different markets, although the reality on this aspect is much more complex and it is difficult to capture the real effect of the ESG factor.

Finally, it is interesting to analyze the impact of individual ESG pillars through the integration of one factor for each dimension. As a result, there seems to be significance only with the factor related to environment, both individually and with the other two pillars. Although it may be reasonable and plausible in some regards, it is important to note that this result should be taken with caution. In fact, the availability of data at such a granular level is very low, making the analysis less reliable. Moreover, although interesting at the conceptual level, it seems difficult to find on the practical level such specific portfolio choices.

In conclusion, this thesis joins the group in the literature that argues for the existence of overperformance of stocks with low ESG scores, due to the bearing of higher risk related to some of the specific pillars. It further contributes detailed analysis on the impact of ESG in different industries and markets, providing significant results. It endorses the importance of sustainable finance, with the hope that it will not only be relevant to achieve financial results, but also, and more importantly, to support a better future in the environment, society and governance.

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9. Appendix

9.1 SIC Divisions

The Standard Industrial Classification (SIC) is a system for classifying industries by a four-digit code as a method of standardizing industry classification. It has been replaced by the North American Industry Classification System (NAICS code), released in 1997; the main difference between the two systems is that NAICS allows for a more detailed division of sub-industries, but for the purposes of the analysis conducted in this thesis, where the focus is on the main industry, the use of both schemes is totally valid. WRDS and CRSP continue to provide SIC codes for all the firms, along with the NAICS codes as well. SIC Code is an integer between 100 and 9999 and each industry is represented by a range, described as follows[18]:

Range of SIC Codes	Industry	Range of SIC Codes	Industry
0100 – 0999	Agriculture	5000 – 5199	Wholesale
1000 – 1499	Mining	5200 – 5999	Retail
1500 – 1799	Construction	6000 – 6799	Finance
1800 – 1999	Not Used	7000 – 8999	Services
2000 – 3999	Manufacturing	9100 – 9729	Public Administration
4000 – 4999	Transportation	9900 - 9999	Not classifiable

Table 17: SIC Code – Industry conversion

9.2 Factors Description

The factors created and employed in the analysis must be in line with those presented by Fama and French, to assess the validity of the methodology used. To make sure this is the case, several regressions are run with the replicated factors as dependent variables and the real factors obtained from the Kenneth French data library as explanatory variables. The outcomes reflect the parameters listed in Section 4.2, that are statistically significant coefficients, nonsignificant constant, and a high R2. These results showed below in the Table 18 prove the good quality of the factors and, consequently, of the methodology used to construct them.

[18] https://en.wikipedia.org/wiki/Standard_Industrial_Classification

	FF3		FF5			
SMB	0.975***		0.940***			
	(0.008)		(0.008)			
HML		1.014***		0.993***		
		(0.013)		(0.019)		
RMW					0.922***	
					(0.017)	
CMA						0.947***
						(0.012)
Constant	0.00003	-0.00003	0.00005	0.0003	0.0003	0.0003
	(0.0002)	(0.0004)	(0.0002)	-0.001	(0.0004)	(0.0002)
R2	0.983	0.957	0.983	0.918	0.922	0.959
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 18: Results of the regressions of replicated factors.

9.3 Industry results with FF3 model

In the following tables results of the analysis at industry level, using the 3-Factor Fama French model are presented. With respect to the regressions made with 5FF model, presented in Section 5.3, here the integration of the ESG factor is not so relevant for the majority of industries, with statistically significant results only for 4 industries out of 11.

	Utilities	Finance	Manufacturing	Wholesale	Retail	Transportation
Market	0.673***	0.798***	1.028***	1.045***	1.104***	1.050***
	(0.054)	(0.034)	(0.030)	(0.041)	(0.072)	(0.048)
SMB	0.070	0.788***	0.858***	0.792***	0.858***	0.761***
	(0.104)	(0.065)	(0.058)	(0.078)	(0.138)	(0.092)
HML	0.208***	0.527***	0.159***	0.401***	0.352***	0.293***
	(0.069)	(0.043)	(0.038)	(0.051)	(0.091)	(0.061)
ESG	-0.193	-0.054	0.071	-0.060	0.186	0.053
	(0.126)	(0.079)	(0.070)	(0.094)	(0.168)	(0.112)
Constant	0.0003	0.001	-0.001	0.0004	-0.001	-0.001
	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
Observations	132	132	132	132	132	132
Adjusted R2	0.586	0.907	0.943	0.902	0.771	0.865
ΔAdj. R2	0.004	-0.001	0.000	0.000	0.001	-0.001
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 19: Results for regressions with Fama-French 3 factor model using industries portfolio. The ΔAdj. R2 indicates the difference between the adjusted R-squared of the ESG model and the baseline model (FF3).

	Services	Mining	Construction	Agriculture	Public
Market	1.058***	1.491***	1.287***	0.942***	0.936***
	(0.035)	(0.166)	(0.074)	(0.083)	(0.053)
SMB	0.780***	0.714**	0.826***	0.967***	1.218***
	(0.067)	(0.317)	(0.142)	(0.159)	(0.101)
HML	0.036	1.463***	0.388***	0.207*	-0.166**
	(0.044)	(0.209)	(0.094)	(0.105)	(0.066)
ESG	0.263***	0.851**	0.108	-0.377*	0.526***
	(0.081)	(0.384)	(0.172)	(0.193)	(0.122)
Constant	-0.001	-0.009	0.002	-0.003	-0.003
	(0.001)	(0.007)	(0.003)	(0.004)	(0.002)
Observations	132	132	132	132	132
Adjusted R2	0.928	0.579	0.796	0.656	0.875
ΔAdj. R2	0.006	0.013	-0.001	0.008	0.017
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 19 (continue)