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Master Thesis [Financial Economics]

The Cross-Sectional Returns of Green Stocks: A Win-Win Situation?

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Abstract

In this research the excess returns of green stocks compared to traditional stocks is examined. By using a cross-sectional analysis of Fama & French, the sensitivity towards anomalies of green stocks compared to traditional stocks is found. Green stocks are defined as firms allocated in the top 33% of the ESG scores and are matched by size, value, and momentum to weight the excess returns. By using a matching procedure, I allocate for fundamental differences in the stocks. The results show that green stocks show a significantly higher beta in the value effect compared to traditional stocks, while showing lower (insignificant) betas towards the size-, and the momentum effect. This would indicate that green stocks show higher excess returns in the value effect, and thus, are more sensitive to the value effect compared to traditional stocks.

Table of Contents

1 Introduction

1.1 Background

Recent numbers show a new striking positive trend in green investing, and it is here to stay (CNBC, 2020). The increasing awareness of climate change and behavioral and policy changes, such as lowering the cost of green technologies, have made green stocks more attractive. Investors have made more green investments over the past years and plan to further increase their green allocation in the coming years. Green investing is an investment strategy in stocks in environmentally friendly companies. There are several reasons for investors to invest green. An investor can invest purely for financial reasons, but also for non-financial reasons, and altruism (Yang et al. 2021). The preference for socially responsible investing has a strong positive relation with the altruistic values of the investor (Brodback et al. 2019). When investors believe they can make an impact with their investments or when they feel morally obliged to invest ethically, the relationship is stronger. This incentive is reduced when the responsible investment relates to higher earnings. Therefore, egoistic values are negatively associated with responsible investments, unless the individuals associate the responsible investment with higher returns. Deloitte (2020) states that globally, the percentage of environmental, social, and governance (ESG) investing has increased from 48 to 75 percent in just two years, both for retail and institutional investors that apply ESG to at least a quarter of their portfolio. And the peak has not been reached yet. According to Deloitte, the full potential of ESG investments will happen when ESG will be routinely considered in investment decisions. In line with this statement is a paper of Norman and Toms (2022) regarding the ESG trend in 2022. The paper postulates that the rise of ESG in the past few years will most likely continue in 2022, since ESG shall remain a business focus. S&P Global (2022) investigated multiple factors of ESG growth, including the recent increase in cases of greenwashing, and also concluded investing in ESG will continue to grow.

The fact that green investing is more than a trend is underpinned by the Sustainable Development Goals (SDGs) that have been globally set in 2015.[1] As a consequence of these goals, firms must help create a more sustainable environment. This change in sustainability can improve the long-term success of the business, by reducing costs. Therefore, investing in green stocks can

[1] https://www.rijksoverheid.nl/onderwerpen/ontwikkelingssamenwerking/internationale-afspraken-ontwikkelingssamenwerking/global-goals-werelddoelen-voor-duurzame-ontwikkeling

lower the risk associated with the enterprise. Moreover, the performance of investments in energy-intensive industries are more sensitive to climate and policy changes. For the stock market, this can result in challenges as well as new opportunities.

The lower risk of green stocks is visible in the recent COVID-19 pandemic and lock-down of countries. The US Dow Jones stock market has fluctuated less since the great recession in 2008.[2] Even though the stock market decreased by almost 35% in March 2020, right after the beginning of the COVID-19 pandemic, the stock market was at an all-time high in early 2022. In the first year of COVID-19, 19 out of 26 investigated ESG stocks outperformed the S&P500, with a performance between 27.3% and 55% (S&P Global, 2021). Stevens (2020) predicts that the amount of sustainable investments will increase even more after the pandemic and COVID-19 will have a long-term effect on the stock market. He states that responsible investing shows a fundamental shift in investing. Data from morningstar support this view by showing a record of inflows in sustainable funds and outperformance of the broader market in the year 2020.

However, there are some concerns about ESG investing, namely the transparency and the quality (Bloomberg, 2019). A first step for reducing the concerns would be providing consistent definitions of ESG. This will increase the effectiveness of investor engagement, since there will be less misleading information. A second step would be to increase depth and transparency regarding the environmental impact from public firms.

The trend of increased ESG investments cannot be avoided; it is here, and it will stay. The increased awareness engenders more academic research into the performance of green stocks. Several studies have found a positive abnormal return [Berton, 2000; Boulatoff & Boyer, 2009; Tripathi & Bhandari, 2015]. This indicates that stocks can be both profitable and sustainable. To be profitable is important, since investors will always chase the highest performing stocks. However, little research has been done on the cross-section and time-series return of green investing compared to traditional investing. Understanding the market anomalies of the Efficient Market Hypothesis (EMH) might help individuals and institutions choose a better portfolio for investment. The shift in ESG investing and the lack of research in ESG have led to the following research question:

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[2] https://www.macrotrends.net/1358/dow-jones-industrial-average-last-10-years

Have green stocks been more sensitive to market anomalies such as the small-firm effect, the book value effect, and the momentum effect compared to traditional stocks between 2003-2019 in the US?

Past literature has been investigating the ESG factor in cross-sectional returns. Loui (2018) found an ESG anomaly when it is evaluated as a characteristic. To obtain the ESG premium, an investor should invest in two ESG portfolios, by going short and long in non-responsible and responsible stocks. The premium cannot be obtained when the investor ignores the ESG factor. The return of the ESG factor is larger for small stocks, although it is present for large stocks as well. This could be an indication that the small-firm effect holds for both green- and traditional stocks, while green stocks show a larger excess return. If green stocks are more sensitive to the size effect, it might be that green stocks also act differently towards the other market anomalies.

1.2 Relevance

An important theory regarding stock returns is the EMH (Fama, 1970). One of the most important conclusions of this theory is that it is impossible to consistently realize profits above average, except by pure luck. In the past years, considerable research has discussed this theory and market anomalies have been found. These return predictabilities do not disprove the EMH and can be classified in cross-sectional and time-series anomalies. Even though a lot of research has been done on stock market anomalies and the current status of the EMH, limited research has been done on the effect of market anomalies on green investments. This study examines whether green stocks are more sensitive to market anomalies.

Previous research found that green stocks have positive abnormal returns compared to traditional stocks [Derwall et al., 2005; Ng & Zheng, 2018; Albuquerque et al., 2018]. Ng and Zheng (2018) found that both green stocks and non-green stocks show higher returns and outperform their benchmark portfolio of the S&P 500 Energy index. However, green stocks have a higher outperformance compared to their non-green counterparts. Bénabou and Tirole (2010) explain that the outperformance of green stocks is a result of a strategic market position that attracts socially responsible investors who are willing to invest for moral value. This is in line with McLachlan & Gardner (2004), which found a significant difference in characteristics between responsible investors and conventional investors. Responsible investors had more morality compared to their counterparts. This research builds upon those findings, by examining additional factors, such as the risk associated with ESG investing and the increase in demand, which could potentially influence the abnormal returns.

Looking at the risk factor associated with ESG investing, the risk of green stocks lies mainly in their nature, making them endogenous (Chakrabarti & Sen, 2021). US and European green stocks have a significantly higher local market volatility and are also more integrated with the global market. With aforementioned market risks, a potential negative switch in investment optimism is feasible. For investors, this requires more caution prior to investing in green stocks. Glossner (2017) found that firms with ESG risks realized negative stock returns in the long run. After controlling for various factors, such as risk, industry, and firm characteristics, they found a negative four-factor alpha of -3.5% per year for a value-weighted portfolio of firms with high ESG risks. Glossner gives two explanations for this negative alpha. Firstly, investors underestimate the tenacity of weak CSR. Secondly, firms with higher ESG risks have lower operating performances, more negative earnings announcement returns, and negative earnings surprises compared to peers. The ESG risk is defined as ESG incidents, such as human rights violation, fraud, or environmental pollution. High-risk ESG stocks are also known as sin stocks. This study will build on this research by investigating whether low environmental risk results in a positive return.

Looking at the market anomalies, Chakrabarti and Sen (2020) examined time-series momentum trading in green stocks. They found that the global green portfolios significantly outperformed their counterparts, although the number of profitable momentum strategies is higher for diversified portfolios in the long run. They used the global Green Indexes for 2003 until 2019. In this study, the S&P 500 and Thomson Reuters ESG scores will be used instead. Additionally, not only the time-series momentum will be investigated, but also different anomalies.

The recent development of green investment and the scarcity of academic literature on green investment means this study will be relevant for investors in the stock market. This study can help investors to select a better investment portfolio mix and understand the returns of green stocks. The potential abnormal return of green investments helps to attract investors, specifically speculators, to invest in green portfolios. Besides, a better valuation of sustainable stocks could drive firms to reduce their carbon footprints, which in turn will be better for the environment. Therefore, sustainable stocks could provide a win-win situation for the investor and the climate.

1.3 Thesis Overview

The stock performance will be measured by the abnormal return, which is the difference between the actual returns and the expected returns. The research question *"Have green stocks been more sensitive to market anomalies such as the small-firm effect, the book value effect, and the momentum effect compared to traditional stocks in the time period 2003-2019 in the US?"* will be answered by testing a few hypotheses. The first hypothesis is related to the effect of size for green stocks, the third hypothesis covers the value effect for green stocks, and the last hypothesis will analyze the momentum effect for green stocks. After combining these hypotheses, an answer to the central research question can be drawn.

This thesis is structured as follows. Chapter 2 concerns literature about the EMH and traditional stocks and provides an explanation for a potential difference in excess returns of green stocks. Chapter 3 describes the data used for this research. In Chapter 4, the analytical framework will be presented. This will include a description of the research question and the hypotheses. Chapter 5 describes the methodology, which will include the descriptive statistics and the regression analysis. In Chapter 6, the results will be examined and interpreted. In Chapter 7 robustness checks will be made. Finally, a conclusion, the limitations, and further research are discussed in Chapter 8.

2 Literature Review

This chapter will elaborate on the theoretical framework of the EMH and the anomalies. In order to predict the direction of the mispricing in the research question, academic literature will be discussed. The Capital Asset Pricing Model (CAPM) and the EMH will be explained first. Secondly, the size, value, and momentum anomaly will be discussed. Lastly, this chapter will discuss why the sensitivity of green stocks regarding anomalies might be different.

2.1 The Efficient Market Theory

The CAPM explains the relationship between systematic risk and the expected return of assets (Sharpe, 1964; Lintner, 1965). The aim of the CAPM is to value a stock at its fair value, controlling for its risk and the time value of money. The CAPM and the EMH are integrated with each other. According to the EMH, the market is efficient, and it is impossible to earn above-market returns without taking additional risk (Fama. 1970). Stock prices should reflect all information and stocks should trade at their fair value. This makes it impossible for investors to buy undervalued stocks or sell overvalued stocks. Therefore, outperformance of the market through market timing or expert stock selection is not possible. In theory, only inside information can result in outsized risk-adjusted returns. The primary assumptions are that information is universally shared and the prices follow a random walk. The latter means prices are determined by today's news rather than yesterday's trends. This theory also has various forms; the strong form states that prices reflect public and private information. The semi-strong form states that prices incorporate all public information. Lastly, the weak form states that prices reflect all past public information.

In line with this theory is Morningstar Inc. (2019). In this study, active managers' returns were compared against index funds and exchange-traded funds (ETFs). In total, 23% of active managers outperformed their passive peers consistently over time. In bond funds and foreign equity funds, a higher success rate was achieved. However, other investors, such as Warren Buffett, have also beaten the market.[3] Buffett made billions of dollars by focusing on undervalued stocks. The EMH states that this is either the result of pure luck or as a trade-off for taking more risk. Pure luck as a cause has been questioned, since certain investors continuously beat the market. This would indicate that human capital and stock expertise do predict stock returns. According to the EMH however, it is not possible to buy undervalued stocks or sell overvalued stocks. A higher return can only be earned when the investor takes on greater risk.

In support of market efficiency is high-frequency trading (HFTs), indicating that markets were inefficient before (Brogaard et al., 2014). HFTs improve price efficiency on average and on days with the highest stock-price volatility, by trading towards constant price changes and trading in the opposite direction of short-term volatility. By doing so, HFTs reduce the noise and risk, resulting in more efficient prices. There has been a broad discussion of the EMH, some showing evidence in support, but also a lot of research disagrees [Malkiel, 2003; Lee et al., 2010; Ball, 2009]. In conclusion, the EMH is only partly correct, but is still used because it is the best theory currently available (Sewell, 2011).

So, how is sustainable investing related to the EMH? The EMH is used to describe the non-linear relationship between the risk-adjusted returns of stocks and ESG factors. Cao et al. (2019) discussed that the ESG factor affects the future stock return depending on the direction of the

[3] https://www.forbes.com/profile/warren-buffett/?sh=784150234639

mispricing of the stock. The mispricing is more predictable for socially responsible investments. ESG investing has also been examined in three different markets: the ESG-unaware, ESG-aware, and ESG-motivated market (Pedersen et al., 2020). In the ESG-unaware market, prices are not affected by ESG-motivated investors, since ESG is not incorporated in the stock price. When investors are ESG-aware, the market shows a correlation between good ESG and higher profits. The degree of profits would be lower in the end since the future excess returns are lower. However, when the market represents ESG-motivated investors, stock prices will rise, leading to higher profitability due to the higher demand, resulting in a decrease of future returns. In this case (the lower return of "good" ESG stocks), the assumption of homogeneous expectations among investors should be replaced by a factor that includes this ESG recognition. Therefore, the EMH will no longer hold.

2.2 Market Anomalies

Research has shown that certain anomalies can result in outperformance of the market without taking additional risk (Dimson, 1988; Avramov & Chordia, 2006). There are three main anomalies: (1) the size effect, (2) the valuation effect, and (3) the momentum effect. The four primary explanations for market anomalies are (1) mispricing, (2) unmeasured risk, (3) limits to arbitrage, and (4) selection bias (McLean & Pontiff, 2016). In this paragraph, these anomalies will be explained in the same order.

2.2.1 Size effect

The first research that documented the size anomaly was of Banz (1981). The size effect implies that companies with a smaller market capitalization outperform companies with a larger market capitalization. In the research of Banz, stocks of small firms had 19.8% annualized higher risk-adjusted returns on average compared to stocks of large firms, for the time period 1936-1975. Banz showed little difference in returns of average and large sized firms, which illustrates a non-linear relation. The analysis also showed significant differences in the coefficient of the size factor through time. However, Banz specifies it is uncertain whether the size itself is accountable for the difference in return, or whether size is a proxy for (multiple) unknown factors that are correlated with size. Banz concludes that the size effect provides evidence that the CAPM does not hold.

Fama and French (1993) also examined the size effect, and showed that the lowest 30 percentile in size outperformed the largest 30 percentile by an average of 4.5% per year since 1926. The smaller stocks showed an average annualized return of 15.4%, while the larger stocks showed an average annual return of 10.8%. In the study of Fama and French, the outperformance of small stocks was very volatile. They did outperform the larger stocks over the entirety of the duration, but only in 49% of the individual months.

After Banz's work, the size effect almost disappeared, with low annualized differences. The absence of the size effect is a result of the quality of the stock and when examining the size effect, one should control for this junk (Asness et al., 2015). When controlled for illiquidity, volatility, idiosyncratic risk, asset turnover, and leverage, the size premium becomes evident. The theory behind this effect is that small firm stocks are riskier and therefore, the expected return is also higher. Inefficient production and cash flow problems are more common with small firms, with a drop in share price following. Small firms are more levered and thus riskier. Returns, measured by the bid-ask spread, are also affected by systematic risk and the illiquidity of the stock, affecting smaller firms more. The higher return of small stocks can also be the result of the greater amount of growth opportunities for small firms, which result in more volatile returns.

Looking at more recent research, the size anomaly still holds after controlling for various variables, such as the beta [Degustis & Novickyte, 2014; Hirschleifer, 2001; Huang, 2006; Schwert, 2003]. The economic motivation behind the size effect is unknown (Amel-Zadeh, 2010). There are mainly two paradoxical views. The first view supports a rational asset pricing explanation of the size effect and explains that the CAPM is incorrectly stated, missing factors, while the market is efficient in pricing assets. In this point of view, the differences in average returns can be explained by differences in risk. The other theory is based on behavioral finance. Smaller firms are more sensitive to asymmetric information and limited information, which could explain the size effect in stock returns. Another argument is the price of idiosyncratic risk, which is reflected in the firm size because of under-diversified investors. Amel-Zadeh has shown the size effect cannot be explained by differences in market-wide risk, which is in line with the critique on size-related anomalies (Berk, 1995). Berk implies the size effect is a consequence of characteristic components, such as the idiosyncratic risk. The effect captrues differences in profitability, bid-ask spread, trading volume, and book-to-market, resulting in differences in excess return. The effect of firm size also depends on the company's past performance.

2.2.2 Value effect

The second anomaly is the value effect, which explains that companies with low price-to-book (P/B) ratios outperform companies with high P/B ratios over three to five years (Fairfield & Harris, 1993; Block, 2019). A portfolio, after controlling for beta, risk, and size, with the lowest 30% P/B ratio had an average return of 18%, while the higher P/B ratio stocks had a return of 12%. However, this outperformance is not uniform over time. This means that the prices differ more from their intrinsic value in some years compared to other years. A hedging strategy based on this anomaly should have the highest return in the years where the pricing deviations are the greatest.

There are different value variables that show the value effect, such as the price-to-earnings (PE) and the book-to-market (B/M) ratios (Rosenberg et al., 1984). All of the value variables provide the same evidence (however, to a different degree) for the value effect. There are two conflicting explanations for this anomaly. According to Fama and French (1992), the return based on B/M compensates for the additional risk, which is in line with efficient market arguments. The other explanation is based on systematic mispricing of excessive B/M securities. This raises the question why professional arbitrageurs do not exploit this systematic bias and correct the mispricing. However, arbitrage is costly and if these costs exceed the benefits from the arbitrage, the systematic mispricing will not be resolved (Schleifer and Vishny, 1997). Additionally, the risk of the volatility of arbitrage returns discourages investors from exploiting this mispricing and reduces arbitrage activity. The B/M effect should be larger for stocks with higher expected volatility if mispricing explains this effect. It's important to note that short-term trading strategies have transaction costs that are equal to or exceed the mispricing, while with long-term trading strategies, the transaction costs are correlated to arbitrage risk and continue to grow over time. Behavioral finance has also played a role in explaining the value effect. This is manifested in the market's overreaction to both outperforming and underperforming companies (Lakonishok et al., 1994). Outperformance is too generously rewarded, with prices exceeding the intrinsic value of the stock. Similarly, underperformance is penalized too harshly, driving prices below the intrinsic value of the stock. The price paid depends on the risk of the firm and the expected growth. The lower price can be justified by a lower growth potential. Such stocks are also called value stocks. The overvalued glamor stocks can be justified by a high growth potential.

Ali et al. (2003) proved that the B/M effect is larger for stocks with higher transaction costs, higher idiosyncratic return volatility, and lower investor sophistication. This is in line with the market mispricing motive for the value anomaly. Ali et al. found that the B/M effect was larger for volatile stocks than for less volatile stocks in 20 of the 22 sample years, which corroborates the aforementioned study. Volatility much better explains the cross-sectional returns than transaction costs and investor sophistication.

2.2.3 Momentum Effect

According to the third effect, the momentum effect, companies that have performed the best over the past six to twelve months continue to outperform and companies that have performed the worst over the same period continue to underperform (Jegadeesh & Titman, 1993; Zaremba, 2017). This consistency of expected returns contradicts the assumptions of the EMH. The first study that examined the momentum effect, showed a strategy of going long in extreme winners and short in extreme losers, generalizing annual returns of 8%-18% over 3- to 12-month holding periods (Jegadeesh & Titman, 1993). According to the study, the profitability of this strategy is robust across different market capitalizations and CAPM betas. Lastly, they described that the momentum effect is driven by the firm-specific factor of an individual asset's return. They concluded the evidence conforms to deferred price reactions to firm-specific information. According to Schwert (2003), the small-firm effect and the value effect have disappeared over time, but the momentum effect still holds.

Agarwel and Taffler (2008) found significant evidence for an explanation of financial distress. This explanation is based on the theory that a positive risk premium exists when the risk of distress is correlated with the B/M, but the market overreacts to this risk or it is missed by the market factor. A negative premium is a result of an underreaction of the investors or lower systematic risk. Related to the momentum factors, an underreaction of the market to bankruptcy risk results in low prior-year returns for distressed firms. These low returns will remain in the future, creating a negative financial distress risk premium and a momentum factor. Other authors argue momentum returns can be explained by volume, trading costs, industry returns, skewness, macroeconomic factors, and market states (Ansari & Khan, 2012). The explanation for these factors are either risk-based or behavioral-based. However, the risk-based models' weakness is that it fails to account for the momentum effect.

The momentum effect can be explained by several behavioral biases, such as underreaction, herding, and the confirmation bias (Dittmar et al, 2017). Herding is the tendency of following the crowd instead of the investors' own analysis. Green stocks could be less sensitive towards these biases. Unlike the other anomalies, several studies argue that momentum cannot be explained by risk (Fama, 1998; Barberis & Thaler, 2003). Which is a result of the relation between risk and the momentum strategy, which is explained by the cross-sectional variation in expected returns. Stocks with on average high or low returns will be the stocks with on average relatively high or low expected returns. Therefore, a momentum strategy should realize positive returns on average.

Dittmar et al. (2007) concludes that momentum is not an anomaly. They did not find evidence of continuity in idiosyncratic risk, although they did find evidence of differences in expected returns and risks explained by cross-sectional differences. In line with this conclusion is the study of Blitz et al. (2020), which shows that the idiosyncratic momentum, after controlling for asset pricing factors, is priced in the cross-section of stock returns. Here again, crash risk, overreaction, and investors' overconfidence linked to market states did not explain the momentum profits. The authors found that momentum generates robust returns across emerging and developed markets. Moskowitz and Grinblatt (2002) examined whether industries could explain momentum. Significant evidence was found for industry momentum investment strategies. After controlling for size, B/M, microstructure influences, and cross-section in mean returns, buying stocks from previously winning industries and selling stocks from losing industries resulted in a winning strategy and thus, higher excess returns.

2.3 The Difference for Green Stocks

The following question is asked: why would the market react differently towards anomalies in green stocks? Boulatoff and Boyer (2009) argue that it is mainly due to differences in characteristics such as the higher risk, volatility, and costs. Green investments take longer to be profitable after the research or concept stage of the investment. They also have higher initial costs and are more dependent on government subsidies. This results in higher risk and less profitability for investors. Table 1 shows the results of a study by Boulatoff & Boyer (2009), who examined differences in characteristics between green stocks and regular stocks. The authors observed 310 green firms worldwide. These characteristics are correlated to fund performance. True market efficiency would mean that the stock prices would respond to these stock characteristics. However, an inefficient market could mean that stock characteristics do not fully explain stock prices. The differences in these characteristics could lead to different price outcomes. Negative characteristics could result in lower price predictions for green stocks. For example, the lower free cash flow of green firms would indicate that environmental firms are more often in a growth stage. Higher expected growth rates can explain larger momentum returns (Johnson, 2002). This would mean that the EMH predicts prices even worse for green stocks than their similar synthetic conventional stock.

Table 1. Differences in stock characteristics for green stocks examined by Boulatoff & Boyer (2009)

Characteristic	Green stocks
R&D	Larger
Capital Expenditures	Larger
Corporate Governance	Better
Size	Smaller
Risk of bankruptcy	Lower
Dividend yield	Same
Liquidity	More
Leverage	Less
Debt	Less
Debt to Equity	Lower
Free Cash Flow	Lower
PE ratio	Higher
Transaction costs	Larger
Trading Volume	Lower
WACC	Higher

If the ESG factor is priced properly, it must be included in a multi-factor asset-pricing model (Cornell, 2020). The higher returns of ESG firms are a result of the mispricing of ESG risk. Cornell discusses that direct risks could be associated with ESG characteristics, which in turn affect the expected return. He explained that fossil fuel manufacturers face risks associated with climate or regulatory shocks. The question is whether this is a priced risk factor or a proxy. For it to be a risk factor and not a proxy, the factor needs to be systematic and a risk premium must exist. Lioui (2018) hedges against the risks of climate shocks. The expectation is that ESG stocks should perform better in bad ESG-related times, relative to traditional stocks, and worse in good times. The risk factor is evident and the premium is negatively correlated with the ESG score. This means that stocks with high ESG scores have lower expected returns.

An additional primary factor affecting the stock return of ESG companies is investor preference. This preference can lower the cost of capital, although the expected return for investors is also lower. The preference for ESG investing could also be more prone to human error, resulting in lower return. Investors that have a strong ESG preference are willing to accept lower returns for stocks with higher ESG scores. Pedersen et al. (2020) provided evidence that carbon intensity and overall ESG scores correlate positively with higher valuations and investor demand. Investors with strong ESG preferences may refuse to hold certain stocks, such as sin stocks. This limitation can result in biases and more human errors, since ESG-prefererring investors choose not to invest even when the stock is undervalued. A fully rational investor is not necessarily morally driven but mainly profit and value driven, and would invest in an undervalued stock, even if the firm is not moral. If the value of ESG is not fully priced in the market but does predict the firms' future profits positively, then ESG is a positive return predictor. If investors look at the ESG score but do not necessarily have a preference for ESG, the predictor turns neutral. Lastly, if the investors have strong ESG preferences, the predictor turns negative. Pedersen concludes that the ESG measures are related to higher firm profits, which the market fails to predict. This would mean that the EMH fails to predict the prices of ESG stocks even more compared to traditional stocks. In line with this study is the higher mispricing of socially responsible stocks (Cao et al., 2019). Their evidence shows abnormal returns associated with mispricing to be greater for socially responsible stocks. The mispricing emerged since the rise of ESG investing and is only significant when there were arbitrage-related constraints. The lesser reaction to mispricing signals would indicate that the EMH would hold even less for green stocks.

Interestingly, while positive risk-adjusted stock returns on ESG stocks could be caused by mispricing, negative risk-adjusted stock returns are associated with a compensation for low non-sustainable risk (Manescu, 2011). The study found certain ESG factors to be value relevant, but not efficiently incorporated into stock prices. Existing literature indicates that green stocks are mispriced more often, meaning they might be more sensitive to market anomalies. The remainder of this thesis will explain this mispricing and greater sensitiveness towards market anomalies.

3 Data

This chapter will elaborate on the data used for the quantitative analysis. In the first section, the data collection will be discussed. In the second section, the variables will be explained.

3.1 Data Collection

The data used for this study has been obtained from Wharton Research Data Services (WRDS) and Thomson Reuters. WRDS provides historical data for academic research.[4] It is the leading business intelligence and research platform to institutions, globally. Multiple datasets of WRDS have been used. For the US stock market, the database Center for Research in Security Prices (CRSP) has been used. The CRSP is the most comprehensive dataset for the NYSE, AMEX, and NASDAQ. The CRSP covers the American stock market, and the dataset which is merged with Compustat has been obtained. Compustat holds data of the fundamentals of global companies. Data for the factor model has been derived from the Kenneth French's Data Library, which holds portfolios with the following factors: 1) size; 2) market; 3) Value; 4) Profitability, and 5) investment. The CRSP/Compustat database does not provide ESG scores for the companies. Therefore, the database Asset4 of Thomson Reuters has been used. Asset4 is the world's largest database of ESG information and provides ESG data of over 7,000 public companies worldwide (Thomson Reuters, 2019). The ratings are based on 226 Key Performance Indicators (KPI's). These KPI's are derived from over 400 data points to achieve transparent and accurate ESG scores. Asset4 contains ESG rating data from 2002 onwards. Thus, for both data sets, all data outside the period of 2002-2019 have been excluded from this research. The total observations of stocks in the US with a green score at least one year during this time is 8,694. To account for survivorship bias, joiners and leavers have been extrapolated. This resulted in a total of 7,823 observations. The data has been further adjusted according to previous literature on the cross-section of stock returns. To begin with, financial firms have been excluded since they are by default higher in leverage, which makes comparison with non-financial firms undesirable. Next, penny stocks have been excluded because it could lead to biases due to illiquidity reasons. Penny stocks are stocks with a price of less than $5 in any month in the specific year. Finally, micro-cap stocks on the NYSE (the

[4] https://wrds-www.wharton.upenn.edu/pages/about/

bottom 20% of market capitalization) have been dropped since they can lead to a bias when designing long-short portfolios, again due to illiquidity reasons.

To compare the difference between green investing and an otherwise similar synthetic conventional stock, a matching method has been used to compare the yield spread. The S&P500 of Reuters has been used as a benchmark index for the stocks in the USA. The beta of 0.96 and the annualized alpha of 2.93% indicate that the S&P500 is the best fit. The S&P500 is based on 500 leading companies with common stock listed on the NYSE or NASDAQ and is a good proxy for traditional stocks. However, the companies listed in the S&P500 in 2019 are different than in 2002. A double-sorting technique has been used with the estimated beta and the corresponding value of the anomaly. The beta has been estimated for each stock over the minimum period t – 2 and the maximum t – 5 to t. The portfolios have been held for a year and the monthly equally weighted returns have been calculated. For each year, the portfolios have been re-estimated and new portfolios have been formed.

3.2 Variables

3.2.1 ESG variable

In this study, green stocks have been identified based on their Thomson Reuters ESG score. Thomson Reuters determines companies' ESG level (Thomson Reuters, 2019). Each company in the database has several ESG scores, which are grouped in 10 categories. A company has a combined ESG score and separate scores in Environmental, Governance, and Social. This study specifically examined the environmental score, since it concerns green investments. The score range with its corresponding grade is provided in Table 2. A sustainable company is defined as being in the top 33% of the total database, corresponding to a score of above 0.4653. A company has been determined to be unsustainable if it's in the bottom 33%, corresponding to a score lower than 0.3804.

Table 2. Thomson Reuters environmental scores with corresponding grade

Score Range	Grade
0.0 <= score <= 0.083333	D -
0.083333 < score <= 0.166666	D
0.166666 < score <= 0.250000	D +
0.250000 < score <= 0.333333	C -
0.333333 < score <= 0.416666	C
0.416666 < score <= 0.500000	C +
0.500000 < score <= 0.583333	B -
0.583333 < score <= 0.666666	B
0.666666 < score <= 0.750000	B +
0.750000 < score <= 0.833333	A -
0.833333 < score <= 0.916666	A
0.916666 < score <= 1	A +

An important factor in the ESG ratings are the industries. ESG ratings and industries are most likely heterogenous. Utility companies will likely have higher levels of CO^2 emissions than, for example, the financial industry, such as banks. To examine this relationship, Figure 1 shows the average environmental ratings per industry. The over 170 industries in the database have been grouped into 10 classifications: (1) cyclical consumer goods & services, (2) energy, (3) financials, (4) health care, (5) industrials, (6) materials, (7) non-cyclical consumer goods & services, (8) real estate, (9) technology, (10) telecom, and (11) utilities. The figure shows the heterogeneity across industries and their environmental scores. In Figure 2, the heterogeneity between years and ESG scores is shown. The increasing awareness of and demand for environmental sustainability could have led to higher scores in later years. The heterogeneity shows that investors should account for the industry and year when integrating environmentally sustainable information. Decisions should be made relative to peers in the same industry and the same years.

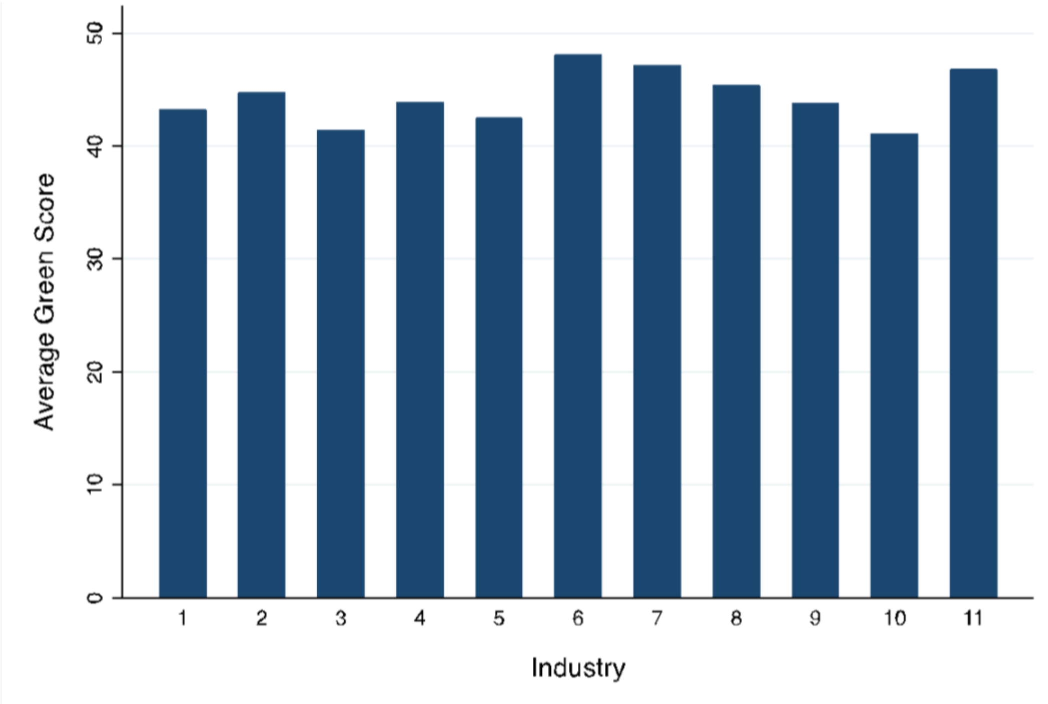

Figure 1. Heterogeneity average green score and industry, classified in: (1) Cyclical Consumer Goods & Services, (2) Energy, (3) Financials, (4) Health Care, (5) Industrials, (6) Materials, (7) non-Cyclical Consumer Goods & Services, (8) Real Estate, (9) Technology, (10) Telecom, and (11) Utilities.

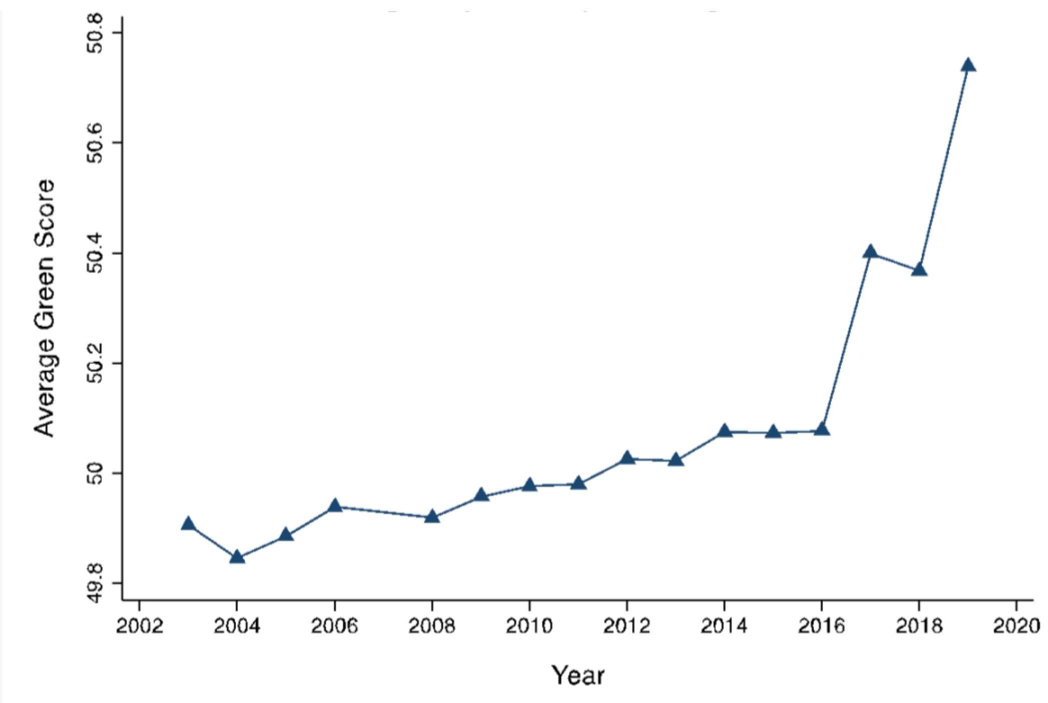

Figure 2. Heterogeneity average green score and year.

3.2.2 Financial variables

The stock performance has been measured by different variables (Table 3). Ten portfolios have been selected: from small firms to big firms, from low value to high-value firms, and for the momentum factor from low to high 12-month cumulative raw return. For the value and the growth factor, the percentile scores have been calculated. Fama and French (1993) found that value firms have more leverage on average and perform better compared to growth firms. A value premium is paid, which compensates for the risk of leverage. Therefore, the returns of the portfolios should be value- and equally weighted. To do so, the average green score has been calculated for each firm *i* in year *t*. The growth score has been subtracted from the value score to find the smallest and the largest stocks. Stocks with a positive score have been categorized as a growth stock and stocks with a negative score as a value stock. The financial data has been collected on a quarterly and annual basis and has been merged with the monthly stock return data for the corresponding anomaly. To ensure accurate results, duplicates and firms with a negative BE have been excluded from the database. Additionally, transaction costs have been excluded, since they cancel each other out.

Table 3. Measurements of the stock performance categorized per anomaly

Anomaly	Measurement stock performance
Size	(1) Book-to-value growth; (2) Sales growth; (3) Cash-flow growth; (4) Historical earnings growth
Value	(1) Book-to-market ratio; (2) Price-to-earnings ratio; (3) Price-to-book ratio; (4) Price-to-cashflow ratio
Momentum	Sorted by the 12-month cumulative raw return. The last month is not incorporated, since the short-term 1-month reversal effect.

4 Analytical Framework

In this chapter, the analytical framework will be discussed. The research question will be elaborated on in paragraph 4.1 and the hypotheses will be presented in paragraph 4.2

4.1 Research Question

Investors want to generate the highest risk-adjusted return on investments. To achieve this, investors need to understand the fundamentals of stock performance. The recent increase in sustainability creates awareness concerning sustainable investments. However, sustainable investments can have different stock performances due to differences in risk, competitive advantage, and stock characteristics. To provide a better understanding of this, the following research question has been asked:

Have green stocks been more sensitive to market anomalies such as the small-firm effect, the book value effect, and the momentum effect compared to traditional stocks in the time period 2003-2019 in the US?

Various literature has discussed the effect of ESG investing and stock performance, with ambiguous results. To examine ESG and the relation to stock performance, differences in firm characteristics between green and traditional firms and the correlation with stock performance must be examined first. To test whether green stocks show (higher) mispricing, the market anomalies will be investigated with their corresponding hypothesis.

4.2 Hypotheses

The research question has been answered by answering the following questions:

1. Is the size effect more strongly present for green stocks compared to traditional stocks?
2. Are green stocks more sensitive to the value effect?
3. Are green stocks more correlated to performances in the past?

The quantitative data from Thomson Reuters and WRDS provides a good outline of the stock performance and the sensitivity of green stocks. The following subsections will discuss the different questions and their hypotheses.

4.2.1 Size Effect

To determine whether the size effect is more present for green investing, it is important to keep in mind that on average, the size of green firms is most likely smaller than traditional firms. Larger firms might show better ESG performance, since they have more cash to invest in sustainable innovations and because they are more sensitive to public expectations (Borovkova & Wu, 2020). Therefore, this study has taken the correlation between size and ESG score into account, by using a matching procedure for size. When the green and traditional stocks are similar in size, the excess returns between large and small stocks can be examined (the size effect). The size effect in stock returns can be explained by the higher illiquidity and volatility of stocks. The growth opportunities for smaller firms can result in more volatile returns and explain the higher expected returns. Looking at responsible investing, green stocks are more often in the growth stage, with lower cash flows as a result and thus, higher illiquidity. This illiquidity and growth prospect leads to greater sensitivity for green stocks towards the size effect. Lastly, the risk associated with green investing can enhance the size effect. ESG stocks have less long-term risks, since they are less affected by climate change, but require more investments, face higher costs, and are less profitable. These factors can increase the ESG short-term risk and thus the size effect. Considering the higher growth opportunities, the illiquidity of green stocks, and increase of short-term risk, the size effect is likely to be larger for green stocks. This leads to the following hypothesis:

Hypothesis 1
H_a: The size effect is more present in green stocks compared to traditional stocks.

4.2.2 Value Effect

To answer the second question, whether green stocks are more sensitive to the value effect, the differences in volatility, transaction costs, and market-reaction have been investigated. Borovkova and Wu (2020) found a negative correlation between ESG score and the volatility of returns. The explanation for this can be found in the lower volatility and more consistent financial performance of sustainable companies. For example, sustainable companies obtained less losses during the COVID-19 pandemic compared to other companies, especially within the healthcare and utilities industry. In line with this study is Kumar et al. (2016), which shows a lower volatility in stock performance for ESG firms. This leads to lower risk, resulting in higher long-term returns compared to their riskier counterparts. The value effect holds when low-risk stocks systematically beat high-risk stocks. Therefore, it is most likely that green stocks are more sensitive to the value effect. Transaction costs affect the value effect as well and are expected to be higher for green stocks (Boulatoff & Boyer, 2009). When the transaction costs are higher, the chance of exceeding the mispricing is even larger. In that case, short-term trading is less frequent and the mispricing is not corrected. Finally, ESG-firms are more sensitive to public under- and overreaction. The value effect can be explained by an overreaction of the market, since investors overreact to the growth aspect of stocks (He & Wei, 2003). This reaction can result in either lower or higher stock prices (depending on the kind of reaction). An over- or underreaction depends on the risk and the expected growth. A lower risk and higher growth, which is the case for green stocks, could result in an overreaction and thus a stronger value effect. Taking all in consideration, it is most likely that the value effect is stronger for green stocks. Therefore, the following hypothesis has been examined:

Hypothesis 2
H_a: The value effect is more present in green stocks compared to traditional stocks

4.2.3 Momentum Effect

According to the theory of the momentum effect, higher average returns can be a result of an underreaction of the market, the higher risk to firm specific information and the expected growth rates. The underreaction is a result of investors not fully absorbing the information and anchoring their beliefs. Investors might under- or overreact more towards green stocks due to their ESG preference. The expectation of green stocks having better growth prospects could also indicate a greater momentum effect. At the same time, the increase in ESG attention by private as well as institutional investors would result in a momentum effect. ESG stocks that performed well in the prior months will continue to perform well since more investors want to invest in ESG stocks. Due to this increasing demand, the prices are driven up.

However, Asness et al. (2013) discusses that there is a negative relation between the momentum effect and the value effect. This would mean that the ESG criteria are restrictive to either the value effect or the momentum effect. Thus, if a significant positive value effect exists, there should be no significant positive momentum effect. Chakrabarti and Sen (2020) found no excess returns for green investing in momentum trading for local markets, but did find positive outperformance on the global market. The amount of profitable momentum strategies is significantly higher for diversified portfolios in the long run. The stable market, the increasing demand, and as a result the higher valuation of green stocks, result in even more green technologies. The continuous investment in green stocks will lead to a significant change for the environment, since a higher stock valuation would push firms to reduce their carbon footprint, with higher long-term returns as a consequence. Healthier companies have more additional funds to put towards ESG projects, which result again in outperformance. This vicious cycle results in good performing green stocks of the past months to perform well again in the following months and bad performing green stocks to perform less. In the long run, there is potential for investors to invest green since it is less affected by environmental damages, thus reducing the environmental risk. After the COVID-19 pandemic, the demand in sustainable stocks has increased even more. This has led to the third hypothesis:

Hypothesis 3
H_a: The momentum effect is more present in green stocks compared to traditional stocks

5 Methodology

This chapter will elaborate on the methodology used. In paragraph 5.1, the descriptive statistics of the data obtained from WRDS, CRSP, and Kenneth French will be discussed. Secondly, the inferential statistics, such as the tests, are examined. In the last paragraph, the portfolio calculation and the regression analysis of the anomalies will be explained.

5.1 Descriptive Statistics

To examine the differences between the characteristics of green stocks and traditional stocks, the descriptive statistics will be analyzed. The dependent variables have been winsorized at 1%- and 99% to exclude extreme outliers. The variables related to firm size and book-to-market ratio have been adjusted by their logarithm. Consequently, the variable follows a more normal distribution. Next, a potential correlation between the anomalies and the stocks has been examined. A correlation would influence the effect of variables on the dependent variables and if existent, an incorrect relationship could be found. A correlogram has been made, using the following formula:

$$corr(Y,Z) = \frac{cov\ (Y,Z)}{\sqrt{var(Y)var(Z)}} \tag{1}$$

To estimate the difference between green stocks and traditional stocks, a matching procedure for each effect, being firm size, value, and momentum has been used. Matching will result in two groups with similar characteristics, except for the green factor in this case. Next, the average treatment effect (ATE) has been calculated, which measures the difference in averages between the treated group (green stocks) and the control group (traditional stocks). The ATE can be used to weigh the dependent variable to determine the weighted stock performance in the regression analysis.

5.2 Portfolio construction

Each portfolio has been constructed by the average return, equally and value weighted. The portfolios have been rebalanced on a monthly basis and assigned to one of the ten portfolios. Annual and quarterly accounting data will remain constant. Since the S&P500 has been used, this research includes the 500 leading companies in the US. Therefore, small sized companies are relatively small within this database, but still large compared to enterprises overall.

The definitions of the high-minus-low (HML) portfolios are different for each anomaly. For the size effect, SMB means the top 10 percentile minus the bottom 10 percentile in terms of firm size. For the value effect, the HML holds the top 10 percentile highest B/M (or other corresponding value definition) minus the bottom 10 percentile. For the volatility however, the opposite applies. The low-minus-high portfolio is used to rank the bottom 10 percentile as highest volatility and the top 10 percentile as the lowest volatility (RMW). For the momentum effect the lagged market capitalization has been taken into account. The latest month is excluded to ensure the public holds all information issued.

This study has first determined whether an anomaly is present in both green stocks and traditional stocks. A binary variable has been determined, which amounts to 1 if the stock is a green portfolio and 0 if it’s a traditional stock. The anomalies have been tested separately by adding the binary variable to the regression analysis. To answer the hypotheses, the green component has been implemented as an interaction term. After the portfolio construction, the cross-sectional variation of the anomalies has been tested in the CAPM, 3-factor model, and 5-factor model of Fama and French. If the alpha turns out to be significant, the return can be allocated to unpriced or unsystematic risk, when controlled for systematic factors.

5.3 Regression Analysis

5.3.1 Risk Factor

As discussed in the literature review, sustainable companies most likely differ in risk compared to traditional companies. This difference may influence the excess return. To examine this relation, a risk factor has been added to the regression analysis. To calculate the risk factor, the idiosyncratic risk for each firm *i* in year *t* has been determined. This calculation has been performed using the FF four-factor by estimating the standard deviation of the daily residuals and annualizing them. The following regression has been used to determine the presence of a market anomaly for the stocks in the green group and the traditional group:

$$ER_{i,t} = R_{f,t} + \beta_1(R_{m,t} - R_{f,t}) + \varepsilon_{i,t} \quad (2)$$

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1(R_{m,t} - R_{f,t}) + \beta_2 SMB_t + \beta_3 HML_t + \varepsilon_{i,t} \quad (3)$$

Here, $(R_{i,t} - R_{f,t})$ represents the excess return of firm *i* in year *t* and $(R_{m,t} - R_{f,t})$ represents the market excess return. SMB is the return spread of small minus large stocks, which holds the size effect, and HML is the return spread of cheap minus expensive stocks, which holds the value effect. RMW is the return spread of the most profitable firms minus the least profitable in the past 12 months, which holds the momentum effect. The term $\sum_{i,t}$ holds the residuals. To estimate the idiosyncratic risk, the standard deviation of the returns has been used.

To account for firm-specific risk and incorporate the differences between green stocks and traditional stocks, the following regression has been performed:

$$std(\varepsilon) = \alpha + \beta_1 Rating + \beta_2 Leverage + \beta_3 Volatility + \beta_4 Dividend + \ldots \quad (4)$$

To examine whether green stocks are more sensitive to market anomalies, the interaction term with the green score has been investigated to account for the joint effect. Each anomaly, including the interaction term, has been tested against the CAPM, 3-factor, and 5-factor model.

$$ER_{i,t} = R_{f,t} + \beta_1 ESG\#\#(R_{m,t} - R_{f,t}) + \varepsilon_{i,t} \quad (5)$$

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1 ESG\#\#(R_{m,t} - R_{f,t}) + \beta_2 ESG\#\#SMB_t + \beta_3 ESG\#\#HML_t + \varepsilon_{i,t} \quad (6)$$

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1 ESG\#\#(R_{m,t} - R_{f,t}) + \beta_2 ESG\#\#SMB_t + \beta_3 ESG\#\#HML_t + \beta_4 ESG\#\#MOM_t + \beta_5 CMA + \varepsilon_{i,t} \quad (7)$$

Lastly, since the ESG score is related to the industry, the stock returns and the ESG scores across industries have been examined. The industries have been classified in 12 categories. Thus, it could be determined whether the ESG premium is more present in specific industries. The CAPM and FF4-factor model have been tested to examine the alphas.

6 Empirical Results

This chapter will elaborate on the results of the empirical analysis. Paragraph 6.1 highlights the descriptive statistics. Paragraph 6.2 concerns the results of the inferential statistics. This chapter ends with a discussion of the results of the regression analysis.

6.1 Descriptive Statistics

This first paragraph examines the summary statistics of the firm characteristics and the asset pricing factors (Table 4). The final sample includes 8,695 firms. The sample has an average ESG score of 0.437 and a median of 0.42. This indicates more high scores are present in the data compared to low scores. Looking at panel A2, the beta of ESG is relatively low compared to the market beta. The beta of the market is close to one, which is in line with the expectations based on the literature. The average logarithm of size is 3.7 and the B/M ratio is close to 0.5. The average

MOM has a coefficient of 1.4, which is in line with previous cross-sectional literature. Panel A3 shows a summary of the asset pricing factors. The variables are the F&F 3- and 5- factor variables of the size and value effect. In the 5-factor model, the factors return spread and momentum are included. The results show a small difference in the SMB coefficients between the 3 and 5 factor model. The HML also shows data coefficients consistent for each model.

The correlation between the variables is presented in Table 5. Size has a significant positive correlation with the beta of ESG and the beta of the market. Both coefficients are small and close to zero. Variables with a high correlation need to be adjusted or replaced by an instrumental variable. However, this dataset does not show a significant correlation between the variables, meaning the coefficients do not imply an incorrect relationship with the dependent. The low correlation is in line with the academic literature. Therefore, there is no concern that the expected returns are driven by the correlations instead of the factors. The ESG factor can thus be added to the regression analysis. In line with Kaiser (2020) is the stronger correlation between ESG performance and the MOM compared to the other factors. This can be a result of the stark demand for sustainable firms and the increasing inclusion of such firms in investor portfolios.

After matching the stocks on size, value, and momentum, the propensity score has been estimated (Table 6). The results show no significant difference between the two groups in the conditioning variables. The matched models show a bias percentage lower than ten, the variance ratio falls within the interval, and the beta is lower than 0.25 for all matching procedures. The t-test is insignificant, resulting in a rejection of the null hypothesis of no significant differences in the mean of the treated and the untreated group. Therefore, the matched model should be used for the regression analysis.

Table 4. Descriptive statistics of explanatory variables and asset pricing factors

The table shows the descriptive statistics of the variables used. ESG score is the environmental score of the firm as obtained from the Asset4 database of Thomson Reuters. The βMKT has been estimated by using a rolling regression over a 60-month time period, with a minimum of 24 months (Fama & French, 1992). Size is the logarithm of the firm size to follow a more normal distribution. For the same reason, B/M is the logarithm of the book-to-market ratio. MOM holds the momentum effect, which has been estimated following Jegadeesh and Titman (1993). The sample period is July 1926 till December 2019.

	Mean	Std dev	Median	Min	Max
Panel A1: Green score					
Green Score	0.426	0.11	0.42	0.17	0.84
Panel A2: Firm characteristics					
βESG	0.281	0.08	0.30	-0.02	5.19
βMKT	1.113	0.83	1.15	-0.10	12.46
SIZE	3.764	0.36	3.79	2.09	4.51
B/M	0.498	0.15	0.23	-4.15	7.03
MOM	1.413	0.52	0.87	-2.41	6.51
Panel A3: Asset pricing factors					
MKTRF	0.688	5.34	1.06	-29.13	38.85
SMB3	0.203	3.18	0.10	-17.29	36.56
HML3	0.335	3.54	0.12	-14.02	35.61
SMB5	0.236	3.04	0.12	-15.39	18.38
HML5	0.271	2.90	0.23	-14.02	12.48
RMW5	0.257	2.20	0.24	-18.76	13.38
CMA5	0.263	2.00	0.10	-6.78	9.06

Table 5. Correlogram of the stock characteristics

This table shows the Pearson correlations of the stock characteristics. The ESG is the reported environmental score of the companies. The βMKT is estimated by using a rolling regression over a 60-month period, with a minimum of 24 months (Fama & French, 1992). Size is the logarithm of the firm size to follow a more normal distribution. For the same reason, B/M is the logarithm of the book-to-market ratio. MOM holds the momentum effect, which has been estimated following Jegadeesh and Titman (1993). The asterisk (*) shows a significant correlation.

	ESG	βMKT	SIZE	B/M	MOM
ESG	1.000				
βMKT	0.032	1.000			
SIZE	0.026*	0.072*	1.000		
B/M	0.028	-0.109*	-0.293	1.000	
MOM	0.113*	0.084	0.073*	-0.182	1.000

Table 6. Propensity score Test

The propensity score test measures whether the matched sample results in a better fit than the unmatched sample. The dependent variable is the excess return. With a logistic regression for propensity score, a matching method has been applied. The logarithmic values of the variables size and value are used.

Variable	Unmatched Matched	Mean Treated	Control	%Bias	t-test	Variance ratio	β
Size	U	3.248	4.179	-28.6	-3.98	0.59*	8.6**
	M	3.248	3.251	-0.2	-0.01	1.11	0.2
Value	U	3.216	3.786	-11.3	-3.27	0.53*	7.2**
	M	3.216	3.221	-0.5	-0.02	0.97	0.2
Momentum	U	1.402	2.238	-25.2	-3.46	0.68*	3.2**
	M	1.402	1.413	-0.1	-0.01	0.73	0.1

* if variance ratio outside [0.69; 1.46] for U and [0.68; 1.47] for M
** if β >25%, R outside [0.5; 2]

6.2 Portfolio Analysis

This paragraph elaborates on the portfolio analysis. Table 7 shows the monthly excess returns for each decile portfolio. The excess return is higher for green stocks in the low portfolio than for traditional stocks. However, the high portfolio shows stronger excess returns for traditional stocks than for green stocks. For green stocks, the excess returns are U-shaped, while for traditional stocks, the excess returns increase as the portfolio deciles increase as well. The excess return on the long/short strategy is slightly negative for green stocks but very positive for traditional stocks. This implies that executing a long/short strategy would result in an average monthly excess return of -0.57% for green stocks and +2.25% for traditional stocks. However, the differences in the H-L portfolio are not statistically significant. Furthermore, the standard deviations within portfolios between the groups are comparable, especially for the lowest portfolio decile. As for the ESG score, the green stocks show a significantly lower and higher ESG score in the lowest and highest portfolio compared to traditional stocks. The long/short portfolio strategy has a difference of 66% for green stocks, and only 18% for traditional stocks. The beta and the Sharpe ratio for both stocks are equivalent, and the H-L strategy shows a significant result for both. The number of stocks is slightly lower in the green portfolio, since the matching procedure was based on 1:m stocks.

Table 7. Portfolio characteristics and CAPM regression

This table presents the portfolio characteristics for the ESG-integrated and the traditional portfolios for the US. It shows the average return in each of the 10 decile portfolios and the long/short portfolio strategy (H-L), which has been estimated using the CAPM:

$$ER_{i,t} = R_{f,t} + \beta_1 (R_{m,t} - R_{f,t}) + \varepsilon_{i,t}$$

	Portfolios											
	Low	2	3	4	5	6	7	8	9	High	H-L	(stat)
Panel A1: Excess return												
Green	10.02	9.68	9.24	8.36	8.88	9.05	9.14	9.62	9.31	9.45	-0.57	(-0.31)
Traditional	8.42	8.53	8.96	9.52	10.01	10.63	11.34	11.71	11.25	10.67	2.25	(0.52)
Panel A2: Std Dev												
Green	16.31	17.04	17.84	18.00	17.65	17.12	16.85	15.24	14.72	13.48	-2.83	(0.33)
Traditional	16.73	16.28	15.33	14.72	15.11	14.88	14.61	14.00	14.73	15.02	-1.71	(0.54)
Panel A3: Green score												
Green	22	25	26	34	38	51	54	62	76	88	66	(40.83)
Traditional	46	49	53	56	57	59	62	62	63	64	18	(6.68)
Panel A5: Beta												
Green	0.91	0.92	1.04	1.09	1.14	1.01	1.12	1.18	1.21	1.23	0.32	(0.05)
Traditional	0.99	1.01	1.08	1.16	1.20	1.15	1.19	1.16	1.14	1.11	0.12	(0.04)
Panel A6: Sharpe ratio												
Green	0.22	0.21	0.19	0.14	0.17	0.19	0.18	0.16	0.20	0.24	-0.02	(-0.03)
Traditional	0.18	0.20	0.17	0.19	0.15	0.12	0.14	0.17	0.19	0.20	-0.02	(-0.02)
Panel A7: Number of stocks												
Green	128	128	128	128	128	128	128	128	128	128		
Traditional	184	184	184	184	184	184	184	184	184	184		

6.3 Regression Analysis

In this chapter, the performed regression analysis will be discussed. First, the cross-sectional regression for green stocks and traditional stocks will be examined (Table 8). In the size portfolios, the green stocks start with a higher intercept and have similar MKT coefficients. However, the SMB and MOM have a more negative impact and the HML a less negative. This would indicate that for the size portfolio, green stocks are less sensitive to the size anomaly. In the value portfolios, a higher intercept is again visible for green stocks. However, all coefficients have a lower value for green stocks than for traditional stocks. In the last panel, the momentum portfolios have been investigated. In this panel, the MKT and SMB coefficients of green stocks are significantly higher than for the traditional stocks. The HML is significantly lower. The MOM and SMB show less significant results. All things considered; three main observations can be made. Firstly, the systematic risk (βMKT) is lower after environmental integration. Secondly, the green stocks are less impacted by the size effect. Thirdly, the green stocks have a reduced exposure to the momentum effect.

Next, the interaction effect of the environmental score with the Fama & French model has been examined (Table 9). For the lowest decile, the interaction effect has an insignificant positive correlation. This indicates that when a firm has a high environmental score and the size of the firm increases, the excess return could increase relatively even more. However, the insignificance means evidence is too thin for a conclusion. The interaction effect of the environmental score on the value effect is significant and positive in two of the models, meaning an additional effect on the excess returns exists for the lowest and highest decile when incorporating a higher environmental score. For the momentum effect, a significant interaction term is only examined for the lowest percentile, with a negative correlation. This implies that the MOM effect will decrease when a company has a higher environmental score and performed better in the previous year.

Table 8. ESG portfolio and Fama cross-sectional regressions

This table presents the portfolio characteristics for the portfolios and ESG-integrated portfolios for the US using the following model:

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1(R_{m,t} - R_{f,t}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t}$$

Each portfolio has been regressed on the factors excess return (MKT-RF), size premium (SMB), value premium (HML), and the momentum factor (MOM). The excess return has been weighted by the ETA of the matching procedures. The portfolios are equally weighted vs the FF4 model. The intercept is in annual percentages. Statistical significance follows: *p < 0.1; **p < 0.05; and ***p < 0.01

	Intercept	MKT	SMB	HML	MOM	R2
Panel A. Size portfolios						
Green	0.85	1.06***	-0.03	-0.51***	-0.06	0.93
Traditional	0.69	1.10***	0.35***	-0.78***	-0.11	0.79
Panel B. Value portfolios						
Green	6.32***	0.84***	-0.01	0.43***	-0.22**	0.93
Traditional	4.54***	0.79***	0.14	0.62***	0.24**	0.99
Panel C. Momentum portfolios						
Green	1.59	1.19***	0.56***	-0.65***	-0.08	0.96
Traditional	1.31	1.05***	0.21*	-0.58***	0.04	0.75

Table 9. ESG portfolio interacted with the Fama cross-sectional regressions

Table presents the portfolio characteristics for the portfolios and the interaction term of the ESG-integrated portfolios for the US, using the CAPM, FF3, and FF5 model. The excess return has been weighted by the ETA of the matching procedures. The portfolios are equally weighted vs the corresponding model. Statistical significance is provided as follows: *p < 0.1; **p < 0.05; and ***p < 0.01

	(1)	(2)	(3)
	1	10	H-L
Panel A. CAPM model			
Intercept	0.48***	0.55***	0.07
ESG	3.78**	6.63**	2.85
MKT	1.27***	1.14***	-0.13***
ESG##MKT	1.21	1.15**	-0.06
R2	0.75	0.69	0.09
Panel B. FF3 factor model			
Intercept	0.62***	0.63***	0.01
ESG	4.22***	6.97*	2.75
MKT	1.19***	1.00***	-0.19***
ESG##MKT	1.16	1.08***	-0.08
SMB	0.43***	0.36***	-0.07
ESG##SMB	0.38	0.22	-0.16
HML	-0.10	-0.08***	-0.23***
ESG##HML	-0.04**	0.02***	0.06**
R2	0.88	0.92	0.12
Panel C. FF5 factor model			
Intercept	0.73***	0.79***	0.06
ESG	5.01***	7.48***	2.47
MKT	1.14***	0.99***	-0.15***
ESG##MKT	1.18	1.00***	-0.18
SMB	0.39***	0.37	-0.02
ESG##SMB	0.41	0.14	-0.27
HML	-0.09***	-0.06	0.03
ESG##HML	0.03***	0.03***	0.00***
MOM	-0.11***	-0.15	-0.04

ESG##MOM	-0.15***	-0.12	0.03
CMA	-0.30***	-0.31***	-0.01***
R2	0.93	0.95	0.18

6.4 Industry Analysis

Finally, the ESG premium has been investigated within industries, since the ESG score is correlated with industry. Table 10 shows the results of the performed CAPM and FF4-model. The results show no rejection of the null-hypothesis, and thus, no significant difference in the risk premium, providing no evidence of an industry premium. The portfolios also do not show a clear pattern in excess returns. Therefore, no conclusion can be drawn from the industry analysis, and the results do not indicate a particular industry paying an ESG premium.

Table 10. ESG portfolio for 11 different industries

This table represents the division of stocks in 11 different industries, established from the SIC code. The stocks are divided into 10 decile portfolios and are following the CAPM model in panel A.

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1(R_{m,t} - R_{f,t}) + \varepsilon_{i,t}$$

Panel A2 follows the FF4-factor model

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1(R_{m,t} - R_{f,t}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t}$$

	Portfolios											
	Low	2	3	4	5	6	7	8	9	High	H-L	(stat)
Panel A: Industry												
Panel A1: CAPM alphas												
Cyclical CGS	0.49	0.33	0.28	0.35	0.28	0.28	0.31	0.32	0.32	0.35	-0.14	(-0.33)
Energy	0.31	0.27	0.22	0.39	0.45	0.31	0.23	0.18	0.30	0.47	0.16	(0.46)
Financials	0.58	0.43	0.32	0.30	0.25	0.22	0.29	0.31	0.35	0.41	-0.17	(-0.79)
Health Care	0.81	0.83	0.88	0.89	0.91	0.77	0.72	0.76	0.89	0.90	0.09	(0.51)
Industrials	0.28	0.29	0.31	0.26	0.27	0.28	0.29	0.30	0.30	0.32	0.04	(0.05)
Materials	0.15	0.39	0.24	0.28	0.36	0.42	0.51	0.49	0.46	0.42	0.27	(0.67)
Non-cyc CGS	0.48	0.44	0.39	0.35	0.33	0.34	0.36	0.37	0.40	0.42	-0.06	(-0.17)
Real Estate	0.37	0.18	0.23	0.31	0.37	0.39	0.40	0.35	0.32	0.30	-0.07	(-0.11)
Technology	0.62	0.58	0.48	0.45	0.39	0.41	0.46	0.49	0.51	0.54	-0.08	(-0.56)
Telecom	0.38	0.27	0.11	0.24	0.31	0.34	0.41	0.53	0.61	0.74	0.37	(0.86)
Utilities	0.33	0.30	0.26	0.35	0.44	0.49	0.51	0.46	0.40	0.38	0.05	(0.07)

Panel A2: FF4 alphas												
Cyclical CGS	0.41	0.32	0.18	0.27	0.34	0.29	0.21	0.36	0.49	0.53	0.12	(0.37)
Energy	0.31	0.25	0.22	0.36	0.43	0.40	0.35	0.39	0.44	0.49	0.28	(0.88)
Financials	0.48	0.41	0.36	0.24	0.19	0.28	0.31	0.29	0.30	0.44	-0.04	(-0.22)
Health Care	0.84	0.92	0.87	0.81	0.95	0.99	1.03	0.96	0.87	0.81	0.03	(0.01)
Industrials	0.26	0.24	0.21	0.31	0.22	0.36	0.39	0.27	0.30	0.33	0.04	(0.11)
Materials	0.09	0.18	0.19	0.23	0.28	0.34	0.41	0.44	0.39	0.37	0.28	(0.73)
Non-cyc CGS	0.33	0.29	0.35	0.39	0.31	0.37	0.26	0.32	0.25	0.21	-0.12	(-0.29)
Real Estate	0.31	0.22	0.17	0.26	0.33	0.35	0.31	0.38	0.29	0.25	-0.06	(-0.09)
Technology	0.48	0.43	0.36	0.32	0.42	0.49	0.52	0.44	0.38	0.39	-0.09	(-0.65)
Telecom	0.35	0.28	0.16	0.11	0.20	0.22	0.35	0.45	0.51	0.65	0.40	(0.92)
Utilities	0.24	0.19	0.20	0.27	0.34	0.41	0.48	0.53	0.40	0.32	0.08	(0.11)

7 Robustness Checks

To test the value measurement on robustness, a univariate sort has been performed for the B/M ratio and the PE ratio. A relation between higher ESG ratings and risk-adjusted returns has been found while having a lower value premium compared to the multivariate Morningstar approach. For the momentum portfolio, the past 7- to 12-month returns and the past 2- to 6-month returns have been examined (Novy-Marx, 2012). For robustness, no significant difference has been found (Appendix, Table 1). Finally, a value-weighted, rather than equally weighted, portfolio has been constructed and regressed (Appendix, Table 2 and 3). The results between strategies remain unchanged and are therefore robust.

8 Conclusion

This study investigated whether green stocks are more sensitive to market anomalies than traditional stocks. To do so, the cross-sectional returns in the CAPM, FF3, and FF5 model have been examined. Regarding the first hypothesis, ‘The size effect is more present in green stocks compared to traditional stocks’, a lower effect of environmental ratings on size portfolios has been found. However, the interaction effect of ESG and size show insignificant results. In light of the second hypothesis, ‘The value effect is more present in green stocks compared to traditional stocks’, green portfolios show an improved risk-adjusted return, which supports the risk mitigation hypothesis. Companies with a higher environmental score have higher value characteristics on average. When the interaction term has been added to the regression, the excess portfolio return increased even more. As for the third hypothesis, ‘The momentum effect is more present in green stocks compared to traditional stocks’, the same conclusion can be drawn as for the first hypothesis. Thus, environmentally friendly stocks that performed better in the previous year show lower excess returns compared to traditional stocks that performed better in the previous year. Looking at the interaction effect, the ESG interacted term shows significant lower returns for the lowest portfolio decile, but the highest decile shows insignificant results. In conclusion, green stocks are more sensitive to the value effect, but they are less sensitive to the size effect and the momentum effect. Furthermore, there has not been found an ESG industry premium, which contradicts previous literature (Kaiser, 2020).

The lower sensitivity of green stocks towards the size effect can be explained by more transparency of the firm due to governmental regulators. This would mean that there is less asymmetric information for green firms, leading to lower excess returns and less sensitiveness towards the size effect. The lower sensitivity of green stocks towards the momentum effect can be explained by the relation found by Asness et al. (2013), stating that when the value effect is present, the momentum effect is negatively affected. The factor liquidity risk results in this correlation. Companies that have performed worse over the past month show higher liquidity risk, resulting in higher volatility and vice versa. The higher volatility would mean the value effect would be more present. So if the momentum effect is negatively affected for green stocks, the value effect should be positively affected, which can be found in the results.

Several limitations to this study can be identified, such as the total number of observations and the limited time frame. Since ESG stocks are quite young, and their presence has significantly increased in the last few decades, the data can be noisy and potentially biased. For example, awareness of climate change has increased significantly over the last ten years. This could lead to the environmental stock premium only being visible in recent years. This can potentially be researched by adding a time-regression on the ESG performance. The number of observations is mostly a problem for the first years in the examined time frame, since ESG was less prevalent during that time. The database is less complete the further back in time one goes. Another potential issue is that the EMH is not the correct way to estimate the sensitivity of green stocks. The EMH has been proved incorrect various times and one could incorporate the social behaviors in the analysis as well, by using the Adaptive Market Hypothesis (‘AMH’; Lo, 2004). The thought behind this hypothesis is that opportunities in the market, resulting in an inefficient market, are exploitable by arbitrageurs. Arbitrageurs restore the efficiency of the market and can thus lead to a market with efficiency and inefficiency patterns in the return. This study has been further examined and proven to be true by Urquhart and Hudson (2013) for the major stock markets around the world.

In conclusion of this thesis, sustainable investing is progressing, and after the COVID-19 pandemic, demand for green stocks has increased even more. Investors will always try to obtain excess returns and potential new drivers of market inefficiency will always be investigated. The rise of sustainable investing is relatively young, but it shows potential for a win-win situation: higher excess returns for value stocks whilst being good for the environment.

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Appendix

Table 1. ESG Equal Weighted Portfolio characteristics

This table presents the robustness tests performed. The first panel shows the univariate sort. In the second and third panel, the results of the past 7- to 12-monthly returns and the past 2- 6-monthly returns are shown. The model performed is the FF4:

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1(R_{m,t} - R_{f,t}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t}$$

The excess return has been weighted by the ETA of the matching procedures. The portfolios are equally weighted.

	Portfolios											
	Low	2	3	4	5	6	7	8	9	High	H-L	(stat)
Panel A: Stocks sorted by univariate ratio												
Panel A1: Excess Return												
Green	9.43	9.21	8.61	8.77	8.82	9.01	9.32	9.46	9.37	9.49	0.06	(0.18)
Traditional	8.78	8.88	9.12	9.46	10.52	10.63	11.78	12.03	11.43	10.85	2.07	(0.44)
Panel A2: Std Dev												
Green	15.11	15.78	15.88	16.32	16.37	16.02	15.98	15.15	14.63	13.78	-1.33	(0.21)
Traditional	16.22	15.68	14.34	13.97	14.69	14.25	14.01	13.77	13.56	13.21	-3.01	(0.38)
Panel A3: Alpha												
Green	0.66	0.78	0.82	0.89	0.91	1.03	1.08	0.99	0.93	1.07	0.41	(0.04)
Traditional	0.79	0.81	0.84	0.86	0.91	0.95	0.99	0.95	0.89	0.86	0.07	(0.02)
Panel B: Stocks sorted by 7-to 12-month return												
Panel B1: Excess Return												
Green	8.88	8.43	8.15	8.55	8.64	8.78	8.99	9.12	8.93	9.09	0.21	(0.43)
Traditional	8.14	8.21	8.37	8.54	8.77	8.91	9.03	9.27	9.31	9.22	1.08	(0.36)
Panel B2: Std Dev												
Green	13.62	13.82	14.11	14.29	14.53	14.87	15.22	14.61	14.28	13.31	-0.31	(0.13)
Traditional	14.01	14.43	13.94	13.21	13.73	14.22	13.81	13.54	13.72	13.39	-0.62	(0.22)
Panel B4: Alpha												
Green	0.81	0.83	0.87	0.99	0.92	1.04	1.12	1.14	1.17	1.19	0.38	(0.09)
Traditional	0.93	0.97	1.08	1.12	1.14	1.13	1.17	1.15	1.12	1.09	0.16	(0.05)
Panel C: Stocks sorted by 2-to 6-month return												
Panel C1: Excess Return												
Green	9.01	9.11	8.83	9.05	8.77	8.83	9.04	9.22	9.18	9.15	0.14	(0.15)
Traditional	8.63	8.84	9.02	9.31	9.49	9.51	9.70	9.81	10.00	9.74	0.99	(0.38)
Panel C2: Std Dev												
Green	14.22	14.73	15.02	15.31	15.49	14.71	14.28	13.49	13.31	12.82	-1.40	(0.33)
Traditional	15.18	14.98	14.22	14.01	13.75	14.10	13.83	13.42	13.35	13.19	-1.99	(0.41)
Panel C4: Alpha												
Green	0.73	0.75	0.82	0.87	0.91	0.93	0.94	0.96	0.99	1.01	0.28	(0.07)
Traditional	0.84	0.88	0.92	0.96	1.04	1.06	1.05	1.01	0.97	0.95	0.11	(0.04)

Table 2. ESG Value Weighted Portfolio and Fama cross-sectional regression

Table presents the portfolio characteristics for the value weighted portfolios and ESG-integrated portfolios for the US using the following FF4 model:

$$R_{i,t} - R_{f,t} = \alpha_{i,t} + \beta_1(R_{m,t} - R_{f,t}) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t}$$

Each portfolio is regressed on the factors: excess return (MKT-RF), size premium (SMB), value premium (HML), and the momentum factor (MOM). The excess return has been weighted by the ETA of the matching procedures. The portfolios are value weighted vs the FF4 model. The intercept is in annual percentages. Statistical significance follows: *$p < 0.1$; **$p < 0.05$; and ***$p < 0.01$

	Intercept	MKT	SMB	HML	MOM	R2
Panel A. Size portfolios						
Green	0.73	1.12***	-0.08	-0.69***	-0.11	0.89
Traditional	0.65	1.20***	0.27**	-0.83***	-0.05	0.75
Panel B. Value portfolios						
Green	7.01***	0.77***	-0.21	0.83**	-0.08**	0.88
Traditional	5.13***	0.93***	0.12	0.99***	0.21**	0.94
Panel C. Momentum portfolios						
Green	1.49	1.03**	0.32**	-0.59***	-0.12	0.91
Traditional	1.14	1.00***	0.08*	-0.42***	-0.04	0.83

Table 3. ESG portfolio interacted with the Fama cross-sectional regressions

Table presents the portfolio characteristics for the portfolios and the interaction term of the ESG-integrated portfolios for the US, using the CAPM, FF3, and FF5 model. The excess return has been weighted by the ETA of the matching procedures. The portfolios are value weighted vs the corresponding model. Statistical significance is provided as follows: *$p < 0.1$; **$p < 0.05$; and ***$p < 0.01$

	(1)	(2)	(3)
	1	10	H-L
Panel A. CAPM model			
Intercept	0.54***	0.69***	0.15*
ESG	4.06***	7.13***	3.07
MKT	1.41***	1.13***	-0.28**
ESG##MKT	1.31	1.08**	-0.23
R2	0.81	0.74	0.11
Panel B. FF3 factor model			
Intercept	0.45***	0.52***	0.07
ESG	3.87***	7.03**	3.16
MKT	1.22***	1.14***	-0.08**

ESG##MKT	1.24	1.05**	-0.19
SMB	0.39**	0.28***	-0.09
ESG##SMB	0.23	0.11	-0.12
HML	-0.07	-0.02***	-0.05***
ESG##HML	-0.08**	0.01***	0.09**
R2	0.85	0.93	0.14
Panel C. FF5 factor model			
Intercept	0.61***	0.73***	0.12
ESG	4.78***	7.16***	2.38
MKT	1.19***	1.02***	-0.17***
ESG##MKT	1.22	0.96	-0.26
SMB	0.43***	0.38**	-0.05
ESG##SMB	0.40	0.27	-0.13
HML	-0.12***	-0.02	0.10
ESG##HML	0.04***	0.06***	0.02***
MOM	-0.18**	-0.24	-0.06
ESG##MOM	-0.11**	-0.07	0.04
CMA	-0.23***	-0.24***	-0.01
R2	0.91	0.94	0.17