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Climate Change Coverage and the Performance of Green and Brown Equities

Evidence from Europe

by

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Abstract

Climate change has emerged as one of the world's most pressing issues, a development that has prompted investors to shift their focus accordingly, catalysing a significant increase in green investments. This study is set against this backdrop, focusing on the performance of portfolios of European firms classified as low or high emission intensity – green or brown respectively – during an eight-year period, from January 2010 to June 2018. Furthermore, we aim to explain the difference in performance using media coverage of climate change. We also conduct a panel data analysis to investigate the difference in individual firms reaction to climate change reporting, emissions intensity and the interaction between these terms. We find a significant discrepancy in the performance of green and brown portfolios, and can show that the green portfolio has a significant positive alpha as well as a positive relationship to an increase in climate change concerns. On a firm-level, we also find that firms with higher emissions intensity outperforms when there's no news reporting about climate change and that firms with higher emissions intensity react worse than their low counterpart when there's an increase in climate change news reporting.

Keywords: *Climate Change, Green Investments, Equities, Sustainability, News*

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1 Introduction

The aim of this study is to investigate the performance of portfolios containing green and brown companies on the European stock market, by examining whether there is a difference in returns and if it can be explained by news regarding climate change concerns. By conducting this research, it is postulated that valuable insights to the relationship between environmental concerns and stock market performance may be concluded.

With departure in the stated research purpose, the role of non-financial metrics is increasingly vital in today's market. Various stakeholders, including governments, investors, consumers, and businesses, are prioritising social responsibility and environmental factors in their decision-making processes. This shift in preferences has sparked interest in the academic world, and resulting in extensive research being made on the effects of environmental factors in various fields. Climate change is considered one of the most pressing challenges of our time, however, there is disagreement on the underlying causes of the problem and how it should be addressed (European Environment Agency, 2021; Simon-Kucher & Partners, 2021). Despite this, investors' preferences have largely shifted towards assets that promote sustainability and mitigate climate change. This rapid growth in sustainable investments, commonly known as green investments, has also led to divestment campaigns targeting brown companies with higher levels of carbon emissions (Global Sustainable Investment Alliance, 2020; Halcoussis & Lowenberg, 2019). This suggests that investors are increasingly more aware of the impact that their investments have on the environment and society as a whole, hence affecting their investments decisions.

Henceforth, sustainable investing has steadily gained prominence in the investment industry in recent decades, particularly with respect to *environmental, social, and governance* (ESG) issues. OECD (2022) highlights this in their report "Global Outlook on Financing for Sustainable Development 2023", as it emphasise the rapid growth rate of sustainable finance. As a result of this market trend, asset managers are increasingly focusing on ESG factors, where climate change is the most important issue when it comes to investments. The US SIF Foundation (2022) report further indicates that climate change is guiding investment decisions relating to over $3.4 trillion worth of assets. The reported large weight of assets having been placed, guided by climate change, reflects a rising public awareness and concern about environmental issues. This suggests an existing potential impact of climate change on the financial performance of firms (US SIF Foundation, 2022).

As a result of this, an increase of ESG funds have been further observed, growing at a faster pace than the broader fund market overall, as highlighted in Morningstar's Global Sustainable Fund Flows Q4 2022 and Q1 2023 reports (Morningstar, 2022, 2023). Europe has emerged as the frontrunner in this domain, having captured the majority of inflows and accounting for the lion's share - $2.1 trillion, or 83% - of global sustainable fund assets at the end of 2022 (Morningstar, 2022, 2023). To summarize, the financial landscape has undergone a transformation due to the direct impact of climate change on the valuation of financial assets, thereby driving the expansion of green investing. Thus, it is presumed that with growing public attention being paid to the issue of climate change, the financial performance of green firms may be positively affected.

Meanwhile, in recent years, many companies worldwide have started to green their operations, encompassing aspects ranging from product development to management of the entire product life cycle (Al Khidir & Zailani, 2009; Kleiner, 1991). While some of this has been driven by government regulations, many companies also green their operations to increase and diversify their market share, as well as reduce their costs (Saha & Darnton, 2005). Significant incentives within this includes the signing of the Paris Agreement (2015a) and the 2030 Agenda for Sustainable Development of the United Nations (United Nations, 2015b). Moreover, several central banks and governments have developed regulatory changes in the financial markets to channel the funds needed to transform the economy toward a climate-neutral one (Gonzalez, 2021a,b). Henceforth, by greening the supply chain, companies can potentially enhance their competitiveness and improve their overall economic performance.

The financial markets, as well as the firms operating within it, have thus been found to shift their incentives towards sustainability. Therefore, given the context of climate change and its impact, we find it particularly relevant to investigate the relationship between climate change and stock prices, specifically in the context of news coverage surrounding climate change. As investors increasingly shift their focus towards green firms, understanding this dynamic becomes crucial in assessing the implications for stock market behaviour. Additionally, the significance of the environmental crisis as a societal challenge further emphasizes the need to explore the interplay between climate change and stock prices (Tjernström & Tietenberg, 2008; Ziegler, 2017).

In our study, the results points towards the green portfolio outperforming the brown portfolio, and that news about climate change plays a part in explaining the excess returns of the portfolios. Furthermore, we find that news about climate change is positively related to firm's excess returns, and that firms with higher *greenhouse gas* (GHG) intensity perform worse than firms with low GHG intensity when there is an increased reporting about climate change. We also find that when there's no reporting, firm's with high GHG intensity tend to have a positive excess return, potentially indicating market mispricings. The findings of this study may be of interest to a variety of stakeholders, including policymakers, portfolio managers and most importantly firms. We broaden the financial literature by investigating the characteristics of firms and portfolios as well as their relation to media reporting about climate change with a European perspective. The findings of this study supports further research in the area and encourages continued exploration and investigation into the dynamics of green and brown firms, their performance, and the impact of climate change news. This study also highlights the need for more comprehensive and nuanced approaches to understanding and integrating environmental considerations into investment decision-making processes.

Previous studies have examined the performance disparity between green and brown portfolios, as well as the impact of news on firm performance. Additionally, similar research has been conducted in the American market, exploring similar themes to our study. However, there is a significant gap in research when it comes to investigating differences between green and brown portfolios in relation to news about climate change on the European market. Therefore, our study aims to fill this gap.

The remainder of the paper is structured as follows. In Section 2, we provide a comprehensive review of the existing literature on the topic. Section 3 introduce the conceptual framework that establishes the theoretical and conceptual foundation for our analysis. The data and variables used in the study are presented in Section 4. Section 5 will then present our methodology, followed by Section 6 that presents and discusses the empirical results derived from our analysis. Finally, in Section 7, we conclude the study by summarising the key findings and their implications.

2 Literature Review

To gain a deeper understanding of previous achievements and results in the field, the following part reviews literature of interest for this study, thus aiding the study in further formulating research hypotheses. The existing research in this field has produced varying findings regarding the relationship between the performance of green and brown firms, which will be examined in the first part of this literature review. Following this, previous research on climate change in relation to the performance of financial markets is presented. Last, the relationship between news about climate change and financial performance is shed light on by presenting findings from prior research within this field.

Beginning with stock returns, Levi & Newton (2016) find that green firms outperform the firms with highest pollution by 3.7% per year on a risk-adjusted basis, when looking at media attention and firm returns between 2009 and 2010. Moreover, Kempf & Osthoff (2007) claims that portfolios that include companies with higher social responsibility ratings have generated positive returns. Furthermore, Gimeno & González (2022) constructed a green factor for European and U.S. stocks between the years of 2002 and 2020 which revealed that investors are giving significant consideration to the importance of climate change in their portfolio choices. Specifically, there is a clear inclination towards companies with a lower carbon footprint, as opposed to those with a higher. Moreover, Yadav, Han, & Rho (2016) established a relationship between pollution and financial valuation, where companies with better environmental performance tend to have higher market valuations.

As stated above, it has been established that there is a difference in performance of green and brown firms in the financial markets. This leads us to further examine previous research on the relationship between climate change and financial markets. A number of research papers indicate that the risks associated with climate change are reflected in the prices of financial assets. However, these results are somewhat divergent. According to Chava (2014), firms that are exposed to climate change have significantly higher equity and debt costs. Moreover, Matsumura, Prakash, & Vera-Munoz (2014), find that the financial market punishes all firms for their carbon emissions and that the market reacts positively to carbon emissions disclosure. In contrast, Bolton & Kacperczyk (2021) find that returns are higher for companies with high emissions, implying that investors are already demanding compensation for their exposure and risk associated with carbon emission. The differentiating findings on the topic may however be explained by the sample periods and the individual characteristics of firms in the selected samples. For instance, Choi, Gao, & Jiang (2020) find that stocks of firms with large carbon emissions underperform their counterparts in abnormally warm weather conditions. Additionally, Monasterolo & De Angelis (2020) find that, as a result of the Paris Agreement, systemic risk is reduced for low-carbon firms and that there is an increase in the weight on optimal portfolios for low carbon emissions companies. Moreover, Nguyen, Truong, & Zhang (2020) find that firms with higher carbon footprints experience a significant increase in debt and equity costs following the ratification of the Kyoto Protocol, when looking at the Australian market.

The preceding research on the topic discussed in the previous paragraph contribute to the understanding of climate change in relation to the financial market, and suggests that green firms in many cases outperform brown firms. With departure in this, the objective of our research is to further evaluate the relationship between green and brown firms and their performance, with focus on the European stock market. In contrast to the papers mentioned above, which focus on various aspects of sustainability and the performance of green and brown firms, this research paper seeks to highlight the significance of climate change-related news as an explanatory variable for portfolio returns. This decision is rooted in the premise of existing previous research that has explored the relationship between climate news and financial markets which is presented below.

Moving on to the impact of climate-related news, Engle, Giglio, Kelly, & Stroebel (2020), construct a climate change news index through a textual analysis of newspapers which shows that U.S. stocks react strongly to the climate change news index. Moreover, Campos-Martins & Hendry (2020) find strong evidence that climate change news drives volatility surprises for brown holdings, such as gas and oil assets. Similarly, the market tends to react more to bad news than to good news. This is also the case for ESG news, as highlighted in the study by Capelle-Blancard & Petit (2019). Companies that receive negative announcements tend to experience a decline in their market value, whereas positive events have no impact on the firms' value. Moreover, Arkko (2019) finds that investors punish firms when news about irresponsible social activities regarding ESG is published, while they do not reward companies when news about positive socially responsible activities is published. On the other hand, Anderson-Weir (2010) states that the stock market does not seem to take into account news about environmentally friendly behaviour when valuing firms, and may even perceive it as negatively impacting a firm's value. In line with this, Borgers, Derwall, Koedijk, & Ter Horst (2013) and Halbritter & Dorfleitner (2015) show that portfolios that include firms with higher ESG ratings have generated exceptional returns are no longer statistically significant, despite being so in the past.

Another contribution to the area of investigation is the paper by Pástor, Stambaugh, & Taylor (2021), that models sustainable investing while taking into account ESG criteria. The paper indicates that green assets have low expected returns but outperform when positive shocks hit the ESG factor, which captures shifts in customers' tastes for green products and investors' tastes for green holdings. However, Pástor, Stambaugh, & Taylor (2022) later find that the factors that have contributed to the recent high returns for green investments does not correspond to high predicted returns but rather to the sharp growth in environmental concerns. Their study investigate this by creating a "green factor", a return spread between green and brown firms, and discover that its outperformance vanish in the absence of shocks related to climate change (Pástor, Stambaugh, & Taylor, 2021).

The prediction made by Pástor, Stambaugh, & Taylor (2021), that green firms outperform brown firms during unanticipated spikes in climate change concerns, was later tested by Ardia, Bluteau, Boudt, & Inghelbrecht (2022). By using articles from significant U.S. newspapers, they create an index of *media climate change concern* (MCCC), and discover a link between index exposure and companies' greenhouse gas emissions. The findings demonstrate that when concerns about climate change unexpectedly rise, the stock prices of green companies rise and those of brown companies fall (Ardia et al., 2022). Our study further investigate these findings.

In light of the above examined literature review, it is evident that sustainable investing is becoming increasingly important in response to the challenges posed by climate change. It is further established that the findings on climate changes' impact on financial markets are split, which makes this a subject worthy of further exploration. With departure in the pioneering studies of Pástor, Stambaugh, & Taylor (2021) and Ardia et al. (2022), using news about climate change as a variable for investigating, this research further examines the relation between stock market excess return and climate concerns. Thereby, the papers provide insights and serve as a springboard for developing the research question for this case study. While inspiration is found in these studies, we have decided to, as described above, explore the relationship between firm performance and climate concern in the European market between January 2010 and June 2018, aiming to contribute with an extended view to the field of investigation. Henceforth, the following two hypotheses have been formulated:

Hypothesis 1: Green and brown portfolios have different levels of performance, with the green portfolio expected to outperform the brown portfolio in Europe during the period January 2010 to June 2018.

Hypothesis 2: The performance difference between the green and brown portfolios can be explained by climate change concerns, where increase in concerning news about climate change is expected to be positively (negatively) related to the performance of green (brown) equities during the sample period.

By testing these hypotheses, we aim to provide an increased understanding of how climate change concerns affect the performance of green and brown portfolios and assets. The broader objective of this research is to provide valuable insight for investors, policy makers, and other stakeholders dealing with the complexities of today's financial markets.

3 Conceptual Framework

The following section aims to provide the basis of theories and concepts utilised in this study. The section is divided into four parts, whereby three describe the selected theories and the last section shed light on the concept of emissions and sustainability.

3.1 Stakeholder Theory

According to Freeman (1984) and his stakeholder theory, a company's stakeholders are those groups without whose support it would not be able to exist. Several groups are included in the stakeholder theory, ranging from customers and suppliers to society, media and the government. According to the framework, in order to run a company successfully over the long term, all of these stakeholders must be properly considered and satisfied, rather than solely focusing on maximising profits for shareholders. (Freeman & McVea, 2005).

According to this theory, organisations are not only responsible for their shareholders, but also for their employees, customers, suppliers, communities, and the environment they operate in. Moreover, organisations are advised to adopt a stakeholder management approach to their business operations. A key component of this process involves identifying and understanding the needs and concerns of all stakeholders, as well as incorporating them into the decision-making process. As opposed to a purely exploitative relationship, this approach is intended to create a mutually beneficial relationship between the organisation and its stakeholders (Freeman, 1984).

The stakeholder theory also shows that there is a relationship between corporate social performance and financial performance where "bad social performance hurts a company financially" (Wood & Jones, 1995). In the context of environmental sustainability, stakeholder theory emphasises the need for organisations to consider the impact of their activities on the environment. In addition, firms are responsible for addressing the concerns of stakeholders and in order to achieve this, environmentally friendly practices may need to be implemented, such as reducing greenhouse gas emissions, minimising waste, and utilising renewable resources. According to Kumar & Pankaj (2021) measures of the stakeholder's theory are direct determinants of ESG and that ESG performance is a measure of stakeholders theory.

Lipton, Emmerich, Schwartz, Niles, & D'Ginto (2022) states that each of the practices, actions and policies adopted within the ESG components represent risk that must be considered and managed by the firm and its management. The failure to oversee and tackle such risks could expose firms to the destruction of shareholder value. According to stakeholder theory, organisations that prioritise the interests of all stakeholders, including the environment, are more likely to achieve long-term sustainability and profitability. It is important to maintain a positive relationship with stakeholders in order to increase customer loyalty, improve employee satisfaction, improve supplier relationships, and prevent regulatory and reputational risks (Lipton et al., 2022).

In our study, stakeholder theory provides a framework for understanding the relationship between climate concerns and stock returns. Specifically, it suggests that investors may value companies higher, that prioritise environmental sustainability and engage with stakeholders' environmental concerns. With this said, we expect that firms with lower greenhouse gas emissions may outperform those with higher emissions and lower sustainability ratings.

3.2 Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) was introduced by Eugene Fama in his 1970 article "Efficient Capital Markets: A Review of Theory and Empirical Work" (Fama, 1970). Financial markets are assumed to be efficient in this hypothesis, in the sense that all available information is reflected in asset prices, and this information is incorporated quickly and accurately. As a result, achieving returns greater than what the market offers is not possible without taking on additional risk (Fama, 1970).

All investors in a financial market have access to the same information and act rationally according to the EMH. This means they will make decisions according to their best interests. In this way, investors adjust their buying and selling decisions based on any new information they receive about a security. Due to this, securities' prices include all available information, and new information is generally reflected in new prices almost immediately. Since securities prices change only when new information becomes available, historical information cannot predict future returns in an efficient market (Fama, 1970). Hence, when news about the value of a security hits the market, its price should react immediately to that news. Therefore, the price of a security should neither underreact nor overreact to the announcement and a security's price should be equal to its fundamental value (Fama, 1970).

Market efficiency is categorised by Fama (1970) according to the quality of information available. The three types of EMH are weak, semi-strong, and strong. Each of these three forms assumes that future stock price changes are independent of past stock price changes. In other words, stocks follow a random walk. According to the weak form of the theory, all historical information is included in securities prices. In other words, securities prices consider, for example, information about previous stock price developments and trading volumes (Fama, 1970). The semi-strong market assumes that all publicly available information is reflected in securities' prices. When markets are semi-strong, investors cannot outperform the market by using fundamental analysis. When strong market conditions apply, assets' prices reflect all available information. In the strong market case, all historical information, public information, and insider information are considered. However, the strong form is not expected to reflect the exact description of market conditions, and reality lies somewhere in-between (Fama, 1970).

In finance, EMH has been widely studied and debated since Eugene Fama (1970) introduced it. Many variations of the EMH have been developed since then, both supporting and questioning the hypothesis. While there have been criticisms of the EMH, it remains a fundamental concept in finance, as well as a model for establishing investment theory and practice. It has been determined that the theory of market efficiency is not always accurate, and that in the real world, the perfect market assumptions underpinning the efficient market hypothesis do not hold and markets are not fully efficient. For example, Bromiley, Govekar, & Marcus (1988) point out that short-term price changes, unlike what the EMH assumes under full market efficiency, may not be a good indicator of a firm's long-term success. Furthermore, McGoun (1990) notes that markets are neither perfectly efficient nor perfectly inefficient, but rather have diverse levels of efficiency-related characteristics like the speed at which prices adjust and the volume it takes for a price adjustment to take place.

In Liesen's (2015) paper "Climate Change and Financial Market Efficiency", she demonstrated that the stock market fails to accurately account for the systematic risk posed by climate change on European companies. To conduct her research, Liesen employed the Fama-French (1993) model along with Carhart's (1997) momentum factor, studying a sample of 433 European companies from 2005 to 2009. The study find abnormal returns, indicating that information related to climate change is relevant to firm value. Additionally, Liesen's (2015) findings revealed that the market does not adequately price the positive effects of firm performance in addressing climate change. These results align with the conclusions drawn by other researchers (see e.g., Derwall et al., 2005; Herremans, Akathaporn, & McInnes, 1993) who suggest that risk-adjusted returns of companies with good *Corporate Social Performance* (CSP) are consistently higher than those of companies with poor CSP only when the financial market inaccurately incorporates CSP information. Generally, the stock market achieves efficiency when participants perceive it to be inefficient and exploit arbitrage opportunities until prices adjust to reflect available information (Grossman & Stiglitz, 1980). Lastly, Liesen (2015) highlights that opponents of the EMH often interpret any abnormal risk-adjusted returns as evidence of market inefficiencies. On the other hand, advocates of the EMH contend that when abnormal returns consistently occur in various markets and over extended periods, it indicates shortcomings in the underlying asset pricing model's capacity to precisely evaluate the related risks.

Considering climate concerns and stock returns, the EMH may be useful as if it holds true, any new information about climate change risks should already be incorporated into prices. This suggests that there may not be a significant relationship between climate concerns and stock returns. However, if the EMH is not fully efficient, we may observe deviations from market efficiency that might be driven by climate concerns. This allows for a potential observable relationship between climate concerns and stock returns.

3.3 Behavioural Finance: News and Stock Prices

According to traditional financial theory, investors make investment decisions rationally, with no room for emotions or psychology (Markowitz, 1952). Additionally, the EMH includes the law of one price meaning that assets only have one price at any given time. While these concepts seem reasonable, the question of whether or not the law of one price really exists is often debated within the field of behaviour finance, which demonstrates that while investors make financial decisions based on knowledge and thoughts, they also use emotions and values to base their decisions on. Since its early years, behavioural finance has attempted to explain a great deal of bias and inefficiency in financial markets, arguing that people's characteristics influence their decisions. According to behavioural finance theories, investors are irrational as they don't always make investments based on statistics and risk-return relationships (Matloff & Chaillou, 2013).

According to psychological research, humans give more weight to negative events than positive events (Rozin & Royzman, 2001; Ito et al., 1998). Furthermore, Kahneman & Tversky (2013), show that investors value losses and gains differently because losses cause greater emotional impact on an individual than does an equivalent amount of gain. Moreover, the research of Galil & Soffer (2011) about credit default swaps shows that the market reacts stronger to bad news than they react to positive news. Similarly, Norden (2008) finds there is significant reaction in the financial market to bad news but not good news. Norden (2008) shows that bad news, in this case credit rating downgrades, face stronger media coverage than good news, credit rating upgrades. Galil & Soffer (2011) further investigated the findings of Norden (2008) and concluded that there is a positive correlation between media coverage and stock market reaction.

Behavioural finance theory may provide insight into the relationship between returns on the stock market and climate concerns. Because investors' emotions, values, and biases influence their investment decisions, market inefficiencies and mispricings can occur. Furthermore, Galil & Soffer (2011) and Norden (2008)'s research on the effect of negative news on stock returns, highlights the importance of analysing the effect of negative climate news on investor sentiment and market reactions. Therefore, wider understanding of market dynamics can be obtained by applying behavioural finance theories on our research.

3.4 Emissions and Sustainability

We present two justifications for using GHG emissions as a suitable proxy for environmental impact. First, using GHG emissions as a proxy is an established notion in the academic literature (see e.g., Drempetic, Klein, & Zwergel, 2020; Pástor, Stambaugh, & Taylor, 2022; Qian & Schaltegger, 2017; Sun & Wang, 2022). If larger firms are assumed to be more sustainable than smaller firms, then they should exhibit lower GHG emissions when scaled by revenue, also known as GHG intensity. This is based on the understanding that greenhouse gas emissions, particularly carbon dioxide (CO_2), contribute immensely to global warming and climate change (IPCC, 2014).

Second, the political and practical efforts directed towards achieving the sustainable development goals, specifically focusing on climate mitigation, place emphasis on reducing GHG emissions as part of these movements (European Commission, 2018a,b). Moreover, in accordance with international agreements such as the *United Nations Framework Convention on Climate Chang*e (UNFCCC), the Kyoto Protocol, and the Paris Agreement, countries and organisations have recognized that greenhouse gas emissions are a primary factor that determines the environmental impact of their country or organisation (United Nations, 1992, 1997, 2015a). Numerous studies have explored the correlation between emissions and environmental impact. For example, Solomon, Plattner, Knutti, & Friedlingstein (2009) in their paper "Irreversible climate change due to carbon dioxide emissions" and, Weber & Matthews (2007) article "Embodied environmental emissions in U.S. international trade", where both papers emphasised the significance of carbon emissions in overall environmental impact.

In our study, emissions intensity serves as a proxy for assessing a firm's environmental impact. A company with relative low emission intensity is considered to have a low environmental footprint and therefore is classified as a "green" firm and the opposite for the classification of "brown" firms. These classifications align with the prevailing understanding in environmental economics and sustainability literature that emissions, particularly CO_2 emissions, are a fundamental factor in environmental degradation (Fankhauser, 1994; Stern, 2007). When mentioning "green" and "brown" firms, we refer to the same classification of firms as Pástor, Stambaugh, & Taylor (2021), where green firms create positive externalities for society, and the opposite case for brown firms. It is obvious that there are other factors having an environmental impact, for example water and land use, and waste generation. Nevertheless, emissions intensity serve as a pragmatic and significant proxy for a firm's overall relative environmental impact.

4 Data and Variables

This chapter describes the purpose and construction of data and variables used in the analysis. Furthermore, it describes the software used to retrieve data and the data collection process.

4.1 STOXX Europe 600

STOXX Europe 600 Index has been selected to be the index of examination for this study, hence serving as the data providing means for the examination. STOXX Europe 600 Index tracks performance of 600 companies across 17 European countries, including large, mid, and small-cap companies. It provides broad exposure to the European equity market as well as exposure to a wide range of industries. STOXX 600 is broadly used in literature as a proxy for the European stock market. In addition, the index serves as the basis for numerous investment products, including mutual funds and exchange-traded funds. Furthermore, the STOXX 600 index is one of the largest European equity indices by market capitalization, accounting for roughly 90% of all listed companies in Europe (STOXX Ltd., 2023). This reflects the index's ability to capture the performance of a sizable portion of the European equity market, making it an appropriate choice in this research.

4.2 Fama-French and Momentum Variables

As previously stated, this study examines the impact of climate change concerns on stock returns, using the Fama & French (2015) five-factor model and the Carhart (1997) momentum variable to account for the influence of factors not related to our main study objective. The factors in the Fama & French (2015) five-factor model are: Market risk premium ($R_m - R_f$), which refers to the excess return on the market, Size premium, Small Minus Big (SMB), which represents the average return on small stock portfolios subtracted from the average return on big stock portfolios. Another factor in the model is the value premium, High Minus Low (HML), which denotes the average return on value portfolios minus the average return on growth portfolios. Furthermore, there is the profitability premium, Robust Minus Weak (RMW), which represents the average return on robust operating profitability portfolios minus the average return on weak operating profitability portfolios. Finally, there is the investment premium, Conservative Minus Aggressive (CMA), which indicates the average return on conservative investment portfolios minus the average return on aggressive investment portfolios. To estimate the risk-adjusted returns of portfolios, the Fama & French (2015) five-factor model has been widely used in finance research.

Carhart (1997) added momentum (MOM) to the Fama & French (1993) three factor model which we also include to control for momentum in addition to the Fama & French (2015) five-factor model factor. In the short term, momentum is the tendency for past well-performers to continue performing well and past bad-performance to continue performing bad. Carhart (1997) has shown that adding momentum to the model enhances its explanatory power and captures a broader range of anomalies in the stock market. The momentum factor is constructed by subtracting the equal weighted average of lowest performing firms from its highest performing counterpart, lagged by one month.

4.3 Greenhouse Gas Variable

In order to conduct our analyses, we identify green and brown firms. As mentioned earlier, we define green firms as firms that create economic value while minimising damages to the environment. The same goes for brown companies, but in the opposite direction. Using this approach allows us to sort firms that create economic value in the way of generating revenue with least effect on the climate. Depending on where a firm falls within the distribution of its total CO_2-equivalent GHG emissions, a firm may be classified as green or brown. This scaled GHG variable in this study is referred to as GHG emissions intensity, or GHG intensity.

After further examining the environmental impact measures used in previous studies, we find that multiple authors employ an industry-adjusted emissions- or environmental measure. After investigating further we find that leading suppliers usually employ this approach and use industry adjustment in their composite ESG ratings. This approach is not flawless, as a company that produces high emissions cannot be deemed green solely because it produces less emissions than other companies in the same sector when measuring between sectors. To avoid this, we employ an unadjusted environmental measure using GHG intensity from Refinitiv.

GHG emissions intensity is calculated by taking the total scope 1 and scope 2 emissions for a firm and scaling them by revenues. This creates a measure for the amount of GHG emissions per revenue generated. Greenhouse gas emissions are divided into three scopes. Scope 1 emissions are direct emissions from sources owned or controlled by the company whereas Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the firm's value chain. They are expressed in tonnes of CO_2-equivalents. The total GHG emissions from Scope 1 and Scope 2 are scaled by the firm's revenue in order to account for the economic value generated by the GHG emissions (Refinitiv, 2023).

4.4 Media Climate Change Concerns

The Media Climate Change Concerns (MCCC) index was initially created by Ardia et al. (2022), and it's being selected to be used as a proxy for media reporting about climate change. MCCC is constructed using data from eight major U.S newspapers and the index covers the time period from January 2003 through June 2018. The index covers the number of climate news stories each day as well as their focus on risk and their sentiment Ardia et al. (2022). While searching for a proxy for news coverage related to climate change, our initial aim was to find a European equivalent of the MCCC index, which covers U.S. news. However, no such index is found, implying a potential limitation for this research project. Despite this, we acknowledge that the climate crisis has global implications, and therefore deem it reasonable to believe the observable effect spreads overseas to also affect European equities. As such, we consider the MCCC index to be a relevant and suitable proxy for media climate change concern news in this paper.

The MCCC index is computed through each news article about climate change being measured based on two quantities, first, the proportion of words relating to risk and second, the scaled difference between negative and positive words. A measure of concern from stories over a newspaper day is aggregated by the authors using the total concern value over the stories for a newspaper day. Once heterogeneity among newspapers is adjusted for, it is aggregated to the day level by averaging across newspapers. To assess the extent of climate concern, we utilise the decaying-memory measures of climate concern as proxies following the works of Sun & Wang (2022); Pástor, Stambaugh, & Taylor (2022). We construct this index by employing a distributed-lag model that accounts for the gradual decrease in individuals' recollection of climate news stories over time. Specifically, we compute the level of climate concerns at the end of month t using the following equation:

$$Concerns_t = \sum_{\tau=0}^{T} \rho^{\tau} MCCC_{t-\tau} \tag{4.1}$$

The parameter ρ, $0 < \rho < 1$, reflects the duration of climate news persistence in investors' memories and is set to 0.94, implying a half-life of one year for news stories. We observe similar $Concerns$ patterns for similar ρ values, and we select $T = 36$ months because the effects of further lags of the relatively short-lived MCCC index are minimal. To ensure stationarity, we take the first difference of the $Concerns$ variable before applying it in the regressions.

4.5 Portfolio Construction

In order to investigate returns for green and brown assets we initially create two portfolios, based on GHG intensity. We gather monthly data on constituents from the STOXX 600 index, covering the period from January 2010 to June 2018, following the time period employed by Ardia et al. (2022) and allowing us to examine a broad sample of reporting firms. Additionally, we collect data on GHG intensity, market capitalization in Euro, monthly total return, and GICS Industry for each firm in each period. Any rows with missing data are excluded from the analysis. Each month, we sort the firms based on their GHG intensity and filter out the top and bottom 10% of companies, following the methodology employed in previous studies (Ballinari & Mahmoud, 2021; Faccini, Matin, & Skiadopoulos, 2022). The top firms constitute the green portfolio, while the bottom firms form the brown portfolio. We assign weights to each firm within the portfolios based on their market capitalization for that particular period. The monthly return of each portfolio is then calculated by multiplying the weight of each asset by its corresponding return for the month.

To assess the relative performance, we compute the excess return of both the green and brown portfolios, using the risk-free returns provided by the Fama-French (2015) factors. The portfolios are re-balanced monthly to maintain their respective weights. Furthermore, we construct a third portfolio known as the green-minus-brown (GMB) portfolio. The GMB portfolio represents the spread or difference in performance between the green and brown portfolios. This portfolio serves as a valuable basis for drawing conclusions in subsequent analyses.

4.6 Data Collection

Data is obtained from the Refinitiv database, covering the time period from January 2010 to June 2018, with a monthly frequency. We use the Refinitiv API with Python 3.9.15 and Jupyter Notebook 6.4.12 to extract firm-specific data and conduct analysis. Furthermore, we use the *Linearmodels* package to perform analysis, *Pandas* package to handle data and *Seaborn* to perform visualisations. The data is cleaned by removing observations with missing data, and merged with the Fama-French and the MCCC dataset. MCCC data is downloaded from the Sentometrics Research website[1] and monthly aggregated observations are used.

Finally, we want to emphasise that it's important to consider potential biases during the data collection process. As mentioned earlier, we need to keep the limitations of the carbon intensity metrics that we use to construct our portfolios in mind. These metrics provide a useful approximation of a company's carbon performance, but they do not fully capture the extent of a firm's environmental impact. Moreover, there may be variations in the reporting and disclosure of emissions data across companies, which can introduce measurement errors and biases. We address these issues by conducting robustness tests of our results as well as investigating different time periods. Finally, we provide a detailed discussion of the limitations and implications of our findings.

[1] Available at https://www.sentometrics-research.com/

4.7 Summary Statistics

Table 4.1 presents the descriptive statistics for the main variables that constitute the full sample that are used in our analysis. The data sample spans between January 2010 and June 2018 with a total of 37,278 firm observations. Each variable is reported in terms of its mean and standard deviation. The descriptive statistics shown are displayed in a balanced panel data table and provide an overview of the data's characteristics.

Variable	Obs.	Mean	Std.	Min	25%	50%	75%	Max
GHG Intensity	37,278	207.99	607.35	0.00	8.21	28.34	106.55	8,708
Market Cap	37,278	18,730	27,364	244	3,977	8,431	21,514	253,368
Return	37,278	1.22	7.29	-41.42	-2.99	1.19	5.37	79.27
MCCC	37,278	1.15	0.31	0.63	0.90	1.10	1.36	2.10
Mkt-RF	37,278	0.69	4.66	-12.32	-2.28	0.59	4.27	11.88
SMB	37,278	0.29	1.58	-4.35	-0.82	0.21	1.47	4.68
HML	37,278	-0.12	2.28	-4.30	-1.82	-0.26	1.38	6.36
RMW	37,278	0.36	1.63	-3.85	-0.74	0.38	1.60	3.52
CMA	37,278	0.02	1.13	-3.00	-0.74	-0.06	0.83	2.96
RF	37,278	0.02	0.03	0.00	0.00	0.01	0.02	0.14
MOM	37,278	0.98	2.71	-8.99	-0.62	0.96	2.49	8.94

Table 4.1: Summary statistics for the sample period.

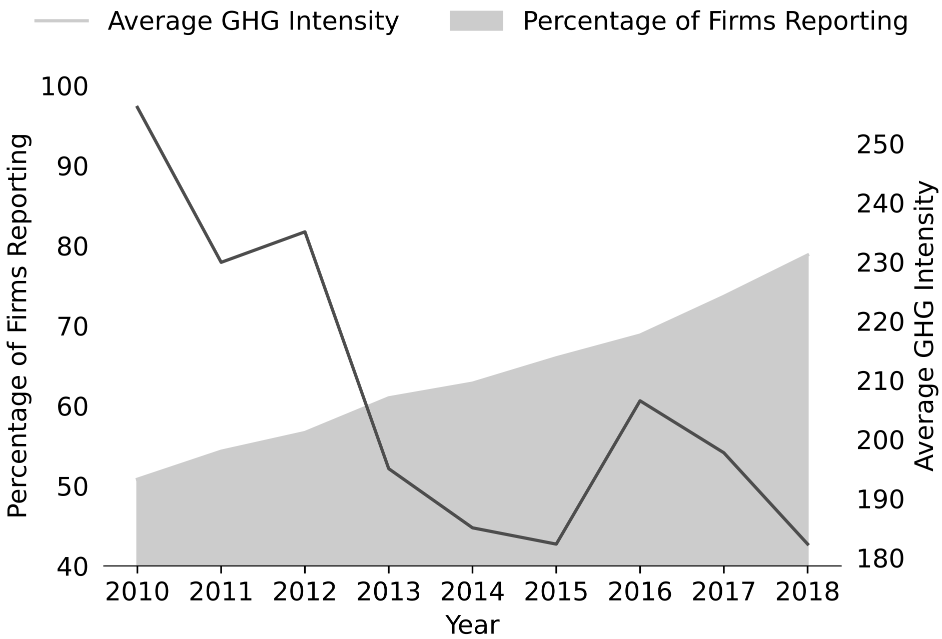

Figure 4.1: Illustration of the percentage of STOXX 600 firms reporting GHG emissions and their average GHG intensity in the sample.

Figure 4.1 illustrates the percentages of firms reporting GHG emissions and their average intensity over the time period spanning January 2010 to June 2018. As illustrated in the graph, it is evident that there is an inverse relationship between the percentage of firms that report and the average emission intensity for each firm. There's been a noticeable increase in the percentage of firms reporting emissions, which has increased every since the start of the sample period. In the same years, there's been an overall decline in the average GHG intensity.

5 Methodology

The following section provides a detailed description of the model specifications, the regression analysis and robustness. It starts off with a description of the models and provides background to the interpretation of variables in the empirical analysis.

5.1 Multivariate Portfolio Analysis

The primary analytical tool utilised for this research paper is multivariate linear regression analysis, allowing us to explore the influence of multiple independent variables on the portfolios' returns. Portfolio regressions use MacKinnon & White (1985) robust standard errors to account for heteroskedasticity, as returns volatility are expected to change over time. We use control variables in the form of Fama & French (2015) five-factor model, including market risk, size, value, profitability, and investment factors as well as Carhart (1997) momentum factor, adding up to six control variables, well-anchored in the financial literature. By including the momentum variable in our regressions, we try to further isolate the relationship between climate concerns and stock returns in order to ascertain whether any observed relationship is truly caused by climate concerns or if there's underlying dynamics unexplained by our model. Furthermore, because the five-factor model and the momentum factor are well-explored significant drivers of stock returns, controlling for them can improve the accuracy of our regression results (Carhart, 1997; Fama & French, 2015). Following the works of Alekseev, Giglio, Maingi, Selgrad, & Stroebel (2022); Ballinari & Mahmoud (2021); Campos-Martins & Hendry (2020); Pástor, Stambaugh, & Taylor (2022) we incorporate the MCCC-related factor *Concerns* to address climate change concerns, giving us the following model specification for the portfolio regressions:

$$R_{i,t} - R_{f,t} = \alpha_i + \beta_1 R_{m,t} + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + \beta_6 MOM_t + \beta_7 \Delta Concerns_t + \epsilon_{i,t} \quad (5.1)$$

In the regression model specified in equation 5.1, $R_{i,t}$-$R_{f,t}$ is the dependent variable and excess return of the green, brown and GMB portfolio i at time t, which is calculated by subtracting the risk-free rate, $R_{f,t}$, from the portfolio return $R_{i,t}$. The risk-free rate is the return on a risk-free investment, such as a government bond, at time t. The excess market return is denoted by $R_{m,t}$, which is the return on the market portfolio above the risk-free rate at time t. The sensitivity of portfolio i to market risk is represented by the coefficient β_1. SMB_t is the small minus big factor at time t, which measures the excess returns of small-cap stocks over large-cap stocks. The sensitivity of portfolio i to the SMB factor is represented by coefficient β_2. HML_t is the high minus low factor at time t, which measures the excess returns of value stocks (high book-to-market ratio) over growth stocks (low book-to-market ratio). The sensitivity of portfolio i to the HML factor is represented by the coefficient β_3. RMW_t is the profitability factor at time t, which measures the difference between the returns of firms with robust (high) and weak (low) profitability. The sensitivity of portfolio i to the RMW factor is represented by the coefficient β_4. CMA_t is the investment factor at time t, which measures the difference between the returns of firms that invest conservatively and those that invest aggressively. The sensitivity of portfolio i to the CMA factor is represented by the coefficient β_5. MOM_t is the momentum factor at time t, which measures the difference in returns between stocks that have performed well in the past and those that have performed poorly. The sensitivity of portfolio i to the momentum factor is represented by the coefficient β_6. $\Delta Concerns_t$ is the change in the media climate concerns variable at time t. The sensitivity of portfolio i to this change is represented by coefficient β_7. Finally, $\epsilon_{i,t}$ is the error term, which captures the portion of portfolio i's return at time t that cannot be explained by the factors included in the model.

Through the regression analysis, we examine whether different portfolios' excess returns are affected differently by news related to climate changes by including the variable

Concerns. In the green portfolio regression, we expect a significant positive coefficient for the concerns variable, implying that the excess returns of the green portfolio are positively affected by environmental news. In addition, we expect a significant negative coefficient for the media climate concern index in the brown portfolio.

In order to avoid multicollinearity and ensure model validation, we examine correlation in the explanatory variables and explore different time periods. As mentioned previously we also explore different lags for the *Concerns* variable, as well as plotting the residuals from our estimation results. These examinations yield similar findings as the main results discussed in this study and are therefore not presented. We don't find any concerning correlation in the explanatory variables ($\rho > 0.8$) and the results from the residual plots are discussed further in chapter 6.

5.2 Stock Returns Panel Data Analysis

Furthermore, we conduct regression analysis on each individual stock's monthly excess return, utilising a panel data approach in order to detect any differences at the firm level that might be present. The aim is to identify if the impact of environmental performance on returns depends on climate change concerns. Through this analysis, we can also identify potential factors that may drive the differences in environmental performance between the green and brown portfolios. For this model, we use the same control variables as presented in the previous section; the Fama & French (2015) five-factor model and Carhart (1997) momentum variable. In addition, we also include the GHG intensity of a specific firm, the climate concerns variable *Concerns* as well as their interaction variable. We estimate the following panel data regression model:

$$\begin{aligned} R_{i,t} - R_{f,t} = \alpha_i &+ \beta_1 R_{m,t} + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t \\ &+ \beta_5 CMA_t + \beta_6 MOM_t + \beta_7 \Delta Concerns_t + \beta_8 lGHG_{i,t} \\ &+ \beta_9 lGHG_{i,t} \times \Delta Concerns_t + \epsilon_{i,t} \end{aligned} \tag{5.2}$$

In the panel data regression presented in equation 5.2, $R_{i,t} - R_{f,t}$ is the excess return of firm i at time t, calculated by subtracting the risk-free rate, $R_{f,t}$, from the firm's return. Control variables and the previously discussed $Concerns$ variable are independent of firms and follows the definition provided in Section 5.1. Firm-specific variables are $lGHG_{i,t}$, defined as the log of the GHG intensity of firm i at time t. The sensitivity of firm i to the GHG intensity is represented by the coefficient β_8. $lGHG_{i,t} \times \Delta Concerns_t$ is the interaction between the log of the GHG intensity and the climate concerns variable. The sensitivity of firm i to this interaction is represented by coefficient β_9. Finally, $\epsilon_{i,t}$ is the error term, which captures the portion of firm i's return at time t that cannot be explained by the factors included in the model.

We opt for using the fixed effects estimator as our primary means of analytic tool for the panel data, in order to isolate the time-varying component of the variables. Errors are clustered on a firm level, to examine changes across firms and avoid time-invariant omitted variable bias (Best & Wolf, 2013). To ensure robustness of the results for the choice of estimation approach and potential time varying confounding factors we also apply and report the random effects estimator as well as the fixed effects estimator with time effects.

As the effect of changes in the MCCC index is dependent on a firm's relative level of emission intensity in comparison to other firms we expect a negative sign for the coefficient of the interaction term. This would indicate that the higher (lower) a firm's level of GHG intensity the more negative (positive) the firm's exposure is to increases in climate change concerns. The main reason for including the panel data regression in our research is to identify the firm-specific characteristics related to environmental performance, stock returns and media reporting on climate change. Overall, this panel data regression analysis provides a broader understanding of how climate change concerns may affect individual firms within the green and brown portfolios.

6 Empirical Analysis

The following section presents the results of the empirical analysis of this study. It starts off by presenting the portfolio analysis, followed by the findings of the panel data regression analysis.

6.1 Portfolio Analysis

	Green Portfolio	Brown Portfolio	GMB Portfolio
Intercept	1.0246**	0.2036	0.8210**
	(0.402)	(0.349)	(0.285)
Mkt-RF	0.5209***	0.5758***	-0.0548
	(0.073)	(0.070)	(0.057)
SMB	-0.6499***	-0.5122**	-0.1377
	(0.236)	(0.197)	(0.173)
HML	0.4820*	0.6476**	-0.1657
	(0.292)	(0.251)	(0.212)
RMW	-0.7060*	0.5979	-1.3039***
	(0.403)	(0.394)	(0.332)
CMA	-0.7426*	0.0177	-0.7604*
	(0.419)	(0.377)	(0.434)
MOM	-0.0089	-0.0548	0.0459
	(0.170)	(0.152)	(0.116)
ΔConcerns	1.8107*	0.0460	1.7647**
	(1.093)	(1.017)	(0.870)
Observations	101	101	101
R^2	0.713	0.659	0.292
Adj. R^2	0.692	0.634	0.238

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6.1: Green, Brown, and GMB portfolio regression results.

The estimation results presented in table 6.1 depict the relationship between the excess return of the green, brown and GMB portfolio, control variables and the climate change concerns variable. The model explains a large part of the variation in excess returns with an R^2 of 0.713. For the green portfolio, we make primarily two interesting observations in line with our hypothesis. First, the climate change concern variable is positive and significant on the 10% level. Specifically, our results show that a one-unit increase in climate concern news implies an additional 1.8% increase in excess returns for the green portfolio, showing that there exists a positive significant relationship for green European stocks and news about climate change concerns on an aggregate level. We achieve these results despite the potential limitation of the news source utilised stemming from the U.S. This result is in line with previous findings from Ardia et al. (2022), which conducted similar research on the constituents of the S&P 500, indicating the global nature of climate-related news. Similar results have also been shown for emerging markets when looking at firm returns, further strengthening the theory about the widespread effect of news on green firms (Robinson, Glean, & Moore, 2018).

Second, the constant in our results for the green portfolio implies there's an alpha of 1.02% originating from the characteristics of the green assets, significant on a 5% level. This result imply that an investor can expect the green portfolio to outperform, holding everything else constant. This implies that green equities outperform, when idiosyncratic risk is mitigated through diversification. However, the alpha shown in table 6.1 are not to be interpreted as investment advice, as it is purely backwards looking and might be heavily influenced by the performance of certain assets. When looking closer at the portfolio, we notice that it is heavily weighted towards financial and insurance firms.[1] We believe the explanation for this is that these companies generate a majority of their revenue from interest and investments, an activity with minimal emissions, when purely looking at the revenue generating process and excluding emissions from holdings. Since these banks and financial institutions primarily generate revenue through investments, these fall into Scope 3 emissions and are therefore exempt in our analysis. Scope 3 emissions often make up a majority of emissions from these companies but the reporting difficulties and differences makes it hard to compare Scope 3 emissions between companies, hence it is often excluded (Jones, Templeman, & Fitzpatrick, 2021; World Resources Institute, 2011). In order to ensure robustness in our findings, we therefore decided to also test the green portfolio after excluding financials from GICS Industry in the portfolio creation process. This procedure showed an even better performance and alpha, and we could therefore

[1]Portfolio weights are not reported but available upon request.

conclude that the results were robust and not related to a specific sector outperforming. Results from this operation is not reported, as we consider it cherry picking of results, deviating from the main objective of this paper.

Looking at the control variables, we notice that all of the Fama-French factors are significant at the 10% level at lowest, as expected. Only the momentum factor is insignificant in the regression results from the green portfolio. The portfolio is positively related to MKT and HML, and negatively related to SMB, RMW and CMA. As anticipated, the portfolio is expected to perform well when the market does, as seen from the positive coefficient (0.5209) from the MKT variable. We can also show that the green portfolio behaves more like a portfolio of value stocks than of growth stocks, and thus suggests that it performs well when value stocks outperform growth stocks, from the HML coefficient (0.4820). This result is in contrast with previous findings from the U.S. by Ardia et al. (2022) and we believe this difference is relatable to index characteristics of the S&P 500 and STOXX 600. A paper by Lehmann (2021) highlights this difference, where the S&P 500 had 15.7% of its constituents from the technology sector, a sector generally characterised as growth, compared to only 1.7% of STOXX 600 in the beginning of 2010. The negative relationship between excess return, SMB, RMW and CMA suggests that companies with smaller market capitalization, lower profitability, and a more conservative investment approach tend to have lower excess returns in the green portfolio and follows earlier results from the U.S (Ardia et al., 2022).

When comparing the different portfolios, we notice that the green portfolio has the highest excess return among the portfolios, significant on a 5%-level. This result is in line with the literature, and has previously been proved by multiple authors, including Ardia et al. (2022); Choi, Gao, & Jiang (2020); Engle et al. (2020); Pástor, Stambaugh, & Taylor (2021). However, it is important to note that this result could be explored further, and that markets might have started to price in this discrepancy, as suggested by the efficient market hypothesis. Additionally, these findings emphasise the market's inability to fully reflect the overperformance of the green portfolio which raises questions about the efficiency of the market in incorporating and pricing this discrepancy. This observation challenges the assumptions of the efficient market hypothesis and suggests potential deviations from market efficiency during the analysed sample period (Fama, 1970).

From the estimation results for the brown portfolio we can see that the model explains 65.9% of the variation in the excess return of the brown portfolio. Furthermore, the brown portfolio is lacking positive alpha and does not seem to be affected by climate change concerns. We still acknowledge the lower coefficient for this variable, however we cannot draw any conclusions from the effect due to the lack of significance.

Significant Fama & French (2015) factors, MKT, SMB and HML carry the same sign as in the green portfolio regression, indicating similar characteristics. What is more interesting about the estimation results is the lack of significance for both the alpha and the climate change concerns variable. These results further strengthen the hypothesis that green assets outperform its brown counterpart, in line with the findings of Levi & Newton (2016). However, the effect from climate change concerns news seems to lack evidence. Thus, we are unsure about the underlying reasons but believe the reason could be related to energy stocks making up a large portion of this portfolio, which strongly correlate with the oil price development (Bernanke, 2016). Thru the lens of the stakeholder theory, the lack of a significant effect of climate concerns on the excess return of the brown portfolio may be attributed to the attitudes and priorities of the stakeholders of brown firms. As stakeholders in companies classified as brown, may not place significant importance on environmental issues or perceive them as imminent threats. Consequently, the market response to climate concerns within the brown portfolio may be limited. This suggests that stakeholders, primarily investor, may not view climate-related changes as a primary driver of value or risk in their investment decisions. However, this contradicts the statement of (Lipton et al., 2022) that all ESG factors constitutes risk that firm and their management must consider as it otherwise would negatively impact shareholder value. However, it's important to note that this interpretation is speculative and would require further empirical evidence to validate its accuracy.

When analysing the results from the GMB regression we notice that our control variables and climate change concern variable can explain 29.2% of the variation in spread between the green and brown portfolio. From this model, we can further confirm our hypothesis, that there is a discrepancy in returns between the green and brown portfolio. We draw this conclusion from the constant coefficient being positive and highly significant on a 1%

level, showing a 0.8% expected outperformance for the green portfolio on a monthly basis, when compared with the brown portfolio. This constant might also capture the average effect on any omitted factors from the previous regressions and can therefore not be fully explained by the explanatory factors discussed in this paper.

From the estimation results we can also see that the RMW is negatively related to the GMB spread with a coefficient of -1.3039 and significant on the 0.1% level. This indicates that the return spread between the portfolios broadens when less profitable companies outperform highly profitable companies. For the portfolio composition, these results might suggest that the brown portfolio tends to include more profitable firms compared to the green portfolio. The negative coefficient for the CMA factor is significant at the 10% level, and indicates that the return spread between the green and brown portfolios widens when firms that invest aggressively outperform those that invest conservatively. This suggests that a 1% increase in the CMA factor (implying that conservative investment firms are outperforming) is associated with a decrease of 0.76% in the green-minus-brown return spread, holding all else constant. This could suggest that brown portfolios have a higher proportion of companies that invest more conservatively compared to the green portfolios. Residual plots for these estimations are not reported, but indicate normally distributed and generally well-behaved model residuals with some outliers, as expected by the volatile nature of financial markets.

6.2 Panel Data Regression Analysis

In table 6.2 the results from the panel data estimation is presented. We conduct panel data regressions for 262 common firms identified during the entire sample period with three different specifications. It is important to note that this sample may have some induced bias, as firms with lower reported emissions are more likely to participate, potentially skewing the results. However, we believe that these firms still provide a reasonable representation of the European stock market. We denote the different model specification as 1, 2 and 3, where 1 is the fixed effects estimator and our primary analytic tool, 2 is the random effects estimator and 3 is the fixed effects estimator with time effects.

	Spec. 1	Spec. 2	Spec. 3
Intercept	0.4333	1.4148***	0.5523
	(0.4384)	(0.0970)	(0.4308)
Mkt-RF	-0.0210**	-0.0207*	
	(0.0088)	(0.0118)	
SMB	-0.0838***	-0.0835***	
	(0.0295)	(0.0289)	
HML	-0.2450***	-0.2440***	
	(0.0399)	(0.0424)	
RMW	-0.1086**	-0.1076**	
	(0.0489)	(0.0530)	
CMA	0.7175***	0.7173***	
	(0.0470)	(0.0521)	
MOM	-0.2425***	-0.2419***	
	(0.0151)	(0.0194)	
ΔConcerns	1.5156***	1.4954***	
	(0.3421)	(0.3603)	
lGHG	0.2616**	-0.0074	0.1668
	(0.1209)	(0.0224)	(0.1180)
lGHG$\times\Delta$Concerns	-0.3880***	-0.3902***	-0.4113***
	(0.1010)	(0.0866)	(0.1011)
Observations	262	262	262
R^2 (Within)	0.0153	0.0150	0.0012
R^2 (Overall)	0.0095	0.0150	-0.0030
Fixed Effects	YES	NO	YES
Random Effects	NO	YES	NO
Time Effects	NO	NO	YES

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6.2: Panel data regression results for firms' excess returns with different model specifications.

The results are generally in line with our expectations for all three specifications, which indicates that the interaction variable is highly significant and negative across all three model specifications. We see similar results from the fixed and random effects estimations for our variables of interest, and explain the difference in the intercept with firm-specific unobserved factors, related to firm's idiosyncratic characteristics. This gives us further evidence that model specification 1 is indeed correct. Hence, the following analysis solely focus on the results derived by the fixed effects specification.

In terms of the Fama-French (2015) factors, the majority of the variables show expected results and are not particularly noteworthy, with exception of the market factor which is close to zero, and negative. We attribute this result to firm-specific idiosyncratic risk factors and do not consider it a significant finding. Regarding the climate-related variables, we find significant results for all additional factors. Notably, our analysis reveals a statistically significant and positive relationship between the factor of climate concerns and excess returns. This finding suggests that, on average, firms experience a 1.5% increase in excess returns for each incremental rise in climate concerns. This particular result is unexpected, prompting us to conduct further investigations. To delve deeper into these results, we replicate the regression analysis using a modified version of the MCCC index, incorporating a lagged and first-differenced approach, however we are not able to recreate the results using this approach. This discrepancy may suggest the presence of omitted variables in our regression analysis but most likely is the reason related to underlying idiosyncratic firm characteristics.

Furthermore, the GHG intensity variable shows a significant positive coefficient, which aligns with previous research by Ardia et al. (2022). This implies that investors are willing to pay a premium for exposure to greener firms, accepting lower expected returns but implying stronger long-term return prospects, holding everything else zero. These results, consistent with the research conducted by Zhang (2022), suggest that firms with a higher emission intensity (potentially sacrificing low emissions and prioritize profits) perform better when media reporting on climate change concerns is absent. This finding suggests possible market mispricing, as discussed by Matloff & Chaillou (2013), indicating that investors may not always make rational decisions and can be influenced by irrational factors such as news reporting. Another explanation is presented by Bolton & Kacperczyk

(2021) which finds that returns are higher for firms with higher emissions, as investors demand compensation for their exposure for climate risk. This effect remains even when *Concerns* and the interaction variable are excluded from the analysis.

When looking at Specification 1, we can observe the interaction term between $lGHG$ and *Concerns* reveals a significant negative coefficient. This suggests that climate concerns increase the firm's negative reaction if it's characterised by higher GHG intensity. This result can be understood within the context of stakeholder theory, which suggests that a company's negative social performance can harm its financial performance (Wood & Jones, 1995). While this relationship may not be directly observed when examining only the results related to GHG intensity, an increase in the reporting of climate change news appears to have this impact, as seen by evaluating the interaction variable. This result challenges the efficient market hypothesis, which assumes that all relevant information is quickly and accurately reflected in stock prices. These findings might indicate that investors place additional value on firms with lower GHG intensity and are more cautious about firms with higher GHG emissions, considering them to be exposed to greater environmental risks. In relation to the EMH, this might suggest information asymmetry or market inefficiency regarding the pricing of climate-related risks in certain firms. These observations are in line with the research conducted by Liesen (2015), which provides evidence that the financial market does not adequately incorporate the systemic risk associated with climate change when analysing European firms. However, Liesen (2015) also points out that advocates of the EMH argue that if there are inconsistencies in the financial markets over extended periods, it could be interpreted as shortcomings in the underlying asset pricing model's capacity to precisely evaluate the related risks.

7 Conclusion

This study investigates the performance of green and brown equities in the European market, covering the time period from January 2010 to June 2018. The research starts off by categorising assets into green and brown portfolios, based on their emissions intensity. Excess returns for portfolios are calculated and a third, green-minus-brown portfolio is created, denoted as the difference in performance between the green and the brown portfolio. Portfolio excess returns are regressed on the Fama & French (2015) five-factor model and Carhart (1997) momentum factor, as well as a climate change news variable. Furthermore, a panel data approach is applied to the cross section of firms' excess returns, in which we investigate the potential effects of GHG intensity and its interaction term with media climate change concerns.

From these regressions, we find that the green portfolio significantly outperforms the brown portfolio, indicating that green assets have a positive alpha for the period from January 2010 to June 2018, when idiosyncratic risk is effectively diversified. We also find that news about climate change plays a part in explaining the difference in excess returns, and that there's a positive relationship for the factor and the green portfolio's excess returns. On a firm-level, we find that news about climate change is positively related to firm's excess returns in Europe, but the overall explanatory power is low. Furthermore, we find that firms with higher GHG intensity perform worse than its low GHG intensity counterpart when there's an increased reporting in news about climate change, however when everything else is held zero, firms with higher intensity tend to have higher excess return.

To conclude, this paper contributes to the existing body of research on the outperformance of green firms by offering unique insights from a European perspective. Our findings broaden the literature by demonstrating that climate change developments in the

U.S. have a significant impact on European stocks, aligning with expected patterns at an aggregate level. Moreover, our analysis reveals that firms with higher GHG intensity experience more pronounced effects when confronted with an increase in reported climate change news. Additionally, our study confirms that green firms exhibit superior performance, and importantly, we unveil that the disparity in performance between green and brown portfolios can be partially attributed to the influence of news reporting. These discoveries shed light on the intricate relationship between environmental factors, stock performance, and the significance of news dynamics in shaping investment outcomes.

For future research, we suggest further development of a European version of the MCCC index, to deepen the understanding of news rooted in Europe. However, even though we did not go through this process, we found evidence of an effect from the U.S. and believe a similar approach on European news could further strengthen the case for green stocks outperformance. We also suggest experimenting further with different environmental measures, such as implementing E-score and testing Scope 1 and Scope 2 emissions separately as well as a way to implement Scope 3 emissions to further investigate financial institutions' holdings. Furthermore, we suggest future research to also look into any changes in the pricing dynamics of green and brown firms in relation to important policy changes (e.g., the Paris Agreement and the Kyoto Protocol). This would allow for a deepened understanding of how investors price climate change risk and how the market's reaction has changed. Moreover, we suggest any author taking inspiration from this study to further implement firm-specific control variables to control for idiosyncratic risk, in order to isolate the effect of climate change concerns.

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