Universidade do Minho
Escola de Economia e Gestão

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The financial performance of low-carbon mutual funds versus their high-carbon counterparts: Evidence from France

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DIREITOS DE AUTOR E CONDIÇÕES DE UTILIZAÇÃO DO TRABALHO POR TERCEIROS

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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O desempenho financeiro de fundos de investimento de baixas emissões carbónicas versus altas emissões carbónicas: Evidência para França

RESUMO

O objetivo desta dissertação é avaliar o impacto financeiro de escolher fundos de investimento com uma baixa pegada carbónica. Para isso foram selecionados fundos da *Autorité des marchés financiers (AMF)*, tendo sido identificados os fundos com elevadas emissões e fundos com emissões mais reduzidas de combustíveis fósseis. Por sua vez, os fundos foram agrupados consoante o seu foco geográfico, nomeadamente Global ou Europeu, tendo-se formado carteiras igualmente ponderadas e ponderadas pelo valor em cada categoria. Assim a carteira de fundos com elevadas emissões que investem globalmente é composta por 65 fundos, a carteira de fundos com emissões mais reduzidas que investem globalmente por 31, a carteira de fundos com elevadas emissões que investem na Europa 56 e, por fim, a carteira de fundos com emissões mais reduzidas que investem na Europa por 91, prefazendo assim um total de 243 fundos. De modo a dar resposta ao objetivo inicial, a performance financeira das carteiras com elevadas emissões foi comparada com a carteira de fundos com emissões mais reduzidas através dos modelos de quatro fatores de Carhart (1997) e o modelo de cinco fatores de Fama e French (2015), tendo sido cada um destes aplicado na sua forma não condicional e condicional.

Os resultados obtidos revelam que, na maioria dos casos o desempenho dos fundos com baixa pegada carbónica não é estatisticamente diferente do desempenho dos fundos com elevada pegada carbónica. Adicionalmente, não se observam diferenças significativas de desempenho dos fundos ao longo do tempo. No entanto, os resultados documentam diferenças dos dois tipos de fundos em termos do seu estilo, com os fundos de baixa pegada carbónica mais expostos a empresas de elevada capitalização e de valor.

Palavras-chave: Avaliação do Desempenho, Fundos de investimento, Fundos franceses, Investimentos de baixo carbono, Investimentos Socialmente Responsáveis.

The financial performance of low-carbon mutual funds versus their high-carbon counterparts: Evidence from France

ABSTRACT

The aim of this dissertation is to assess the financial impact of investing in mutual funds with low carbon footprint. For this purpose, funds from the *Autorité des marchés financiers (AMF)* were selected and their level of carbon emissions was used to classify them into low-carbon or high-carbon funds. In turn, they were grouped according to their geographic focus, namely Global and European. Equal and value weighted portfolios of funds were formed for each category. The portfolio of high-carbon funds investing globally is composed of 65 funds, the portfolio of low-carbon funds investing globally is composed of 31, the portfolio of high-carbon funds investing in Europe is composed of 56, and the portfolio of low-carbon funds investing in Europe is composed of 91 funds, giving a total of 243 funds. In order to address the initial objective, the financial performance of the low-carbon portfolios was compared to the portfolios of high-carbon funds using Carhart's (1997) four-factor model and Fama and French's (2015) five-factor model, each of these being employed in their unconditional and conditional forms.

The results obtained indicate that in most cases low-carbon funds do not perform differently from high-carbon funds. The results also show that portfolio performance is similar over time. Nevertheless, style differences between low-carbon and high-carbon funds are documented, with the former being more exposed to large cap and value stocks.

Keywords: Performance Evaluation, Mutual funds, French mutual funds, Low-carbon investments, Socially Responsible Investments.

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CHAPTER ONE

Introduction

1. INTRODUCTION

The scientific community has for some time been calling attention to the fact that the recurrent use of fossil fuels is tapering life on planet earth, having even declared a climate emergency that can lead to serious consequences (Ripple et al., 2020). Nevertheless, a general societal awareness on global warming and the urgency to undertake actions to mitigate climate change appears to have been achieved only around the mid-2000 (Baiardi & Morana, 2021) after the first impacts began to be observed. These consequences are known as externalities, which refer to environmental, health and climate costs that are not reflected in the market prices, such as extreme weather, ocean acidification, air pollution among many others (Bertrand, 2021).

The groundbreaking legal agreement on climate change - the Paris Agreement (UNFCCC, 2021) - was signed by 196 countries in the Paris climate conference in December of 2015 standing for "the highest level of worldwide consensus ever achieved since the Rio Earth Summit in 1992, in relation to the existence of climate change, its human-made origin, and the urgent need to implement mitigation and adaptation policies" (Baiardi & Morana, 2021, p. 1). The growing concerns on the effects of climate change has motivated activists to put pressure on investors to divest holdings of oil, coal, and other fossil fuel industry stocks. In all, the awareness of social, environmental, ethical, and corporate governance issues is being reflected in an explosive growth of socially responsible investments (Renneboog et al., 2008; Halcoussis & Lowenberg, 2019), with an increasing number of investors wishing to incorporate environmental concerns in their investment decisions. This trend can be seen as a form of protest against the use of production processes based on fossil fuels, which are one of the main drivers of greenhouse gas emissions. Socially responsible investments were originally linked to religious concerns, with emphasis on ethical issues, but nowadays this approach has evolved to embrace a more social and environmental agenda (Renneboog et al., 2008).

In recent years, there has been a significant surge in the number mutual funds that integrate environment, social and governance (ESG) criteria in the investment process, with worldwide investment in sustainable funds in 2021 increasing more than 200 per cent from 2019 (UNCTAD, 2022). A subset of these funds places great emphasis on addressing climate degradation resulting from the use of fossil fuel energy sources and greenhouse gas emissions. The so called low-carbon or fossil fuel free mutual funds represent a simple way for investors to divest from fossil fuels and direct their savings to companies with a low carbon footprint, thereby contributing to a transition to a more sustainable economy. Given the emergence of these funds, and investors' preferences for these investment vehicles (Ceccarelli et al., 2023) it is important to assess whether engaging in a low-carbon investment strategy also contributes towards the financial objectives of a positive risk-adjusted return or whether, in contrast, it penalizes financial performance. As such, this dissertation aims to evaluate the performance of French low-carbon mutual funds compared to a set of high-carbon mutual funds. The French market was selected for being an early adopter of socially responsible investments and for its status as one of the most dynamic markets for this type of investments (Crifo et al., 2019).

The debate surrounding performance of funds with different levels of "greenness" primarily revolves around two key issues: diversification considerations and the influence of climate risks on stock returns. Several empirical studies address this issue, namely Ibikunle and Steffen (2017), who focus on green versus black funds and Marti-Ballester (2019a,b), who focus on renewable energy versus black funds. Additionally, Soler-Domínguez et al. (2021) investigate whether fund performance is related to their 'Low carbon designation' label. Closer to our research topic, Guo et al. (2022) investigate the performance of fossil-fuel and non-fossil fuel funds in the Eurozone. In general, these studies show positive results in the sense that greener and more environmentally friendly funds end up being also financially advantageous.

This research contributes to shed light on the issue of the financial performance of low-carbon mutual funds. The dataset consists of low-carbon mutual funds and high-carbon mutual funds of the *Autorité des marchés financiers (AMF)*, based on the ratings provided by Refinitiv Eikon's platform. To assess the financial performance of these mutual funds and their respective portfolios, the four-factor model of Carhart (1997) and the Fama and French (2015) five-factor model will be used in their original specification and also allowing for time-varying alphas and betas (Christopherson et al., 1998).

This dissertation is organized as follows: Chapter 2 concerns the literature review that briefly presents and discusses relevant studies related to the research topic. Chapter 3 provides a detailed description of the methodology used to carry out the analysis, while chapter 4 describes the data used. In chapter 5 the empirical results are presented and discussed. The final part of the empirical analysis presents the results pertaining to the analysis of portfolio performance across subperiods. Chapter 6 concludes the dissertation by summarizing the results and relating them with the literature.

CHAPTER TWO

Literature Review

2. LITERATURE REVIEW

There are several arguments concerning the financial impact of removing fossil companies from mutual funds. In light of portfolio theory (Markowitz, 1952), since fossil fuel free mutual funds are associated with screening out entire industries, this may lead to a low diversification of the portfolio that consequently leads to a poorer performance. Another argument supporting underperformance is related to the abnormal returns of controversial stocks, whose price is pushed down by an increasing number of investors excluding them (Hong & Kacperczyk, 2009). Currently, the discussion regarding the performance of portfolios consisting of green assets compared to those without a green focus is primarily centered on theoretical models that explore the impact of investor tastes for greenness on asset prices. Pástor et al. (2021) introduced a model that suggests green assets have lower expected returns than brown assets not only because of their higher demand but also because they hedge against climate risk.

In contrast, an argument in favour of a better performance of low-carbon mutual funds is that these portfolios betters integrate climate risks (Bassen et al., 2021), in opposition to high-carbon portfolios, which encompass significant transition risks (Stroebel & Wurgler, 2021), namely the risk of fossil fuels becoming stranded assets (Plantinga & Scholtens, 2021). Furthermore, fossil fuel companies also bear technological risks, as conventional technologies becoming obsolete due to the development of greener and more efficient sources of energy. It is also worth noting that Pástor et al. (2021) acknowledge that green assets could potentially outperform brown assets in times where there is an unexpected shift in investors' preferences towards environmentally-friendly investments.

There is a vast empirical literature on the performance of funds that integrate sustainability issues, with most studies finding that, in general, there are no statistical differences between the performance of socially responsible funds and their conventional peers[1]. There is also a subset of studies that focus on the performance of green funds. Climent and Soriano (2011) identify lower returns for green funds when compared to conventional funds, possibly explained by a loss of diversification. Furthermore, Ibikunle and Steffen (2017) compare the financial performance of green, black, and conventional European mutual funds and find that for the period under evaluation green mutual funds underperformed conventional ones, with the difference being explained by the exposure of green funds to small cap and growth stocks. However, no significant distinction was

[1] For a review of the literature on socially responsible fund performance, see Friede et al. (2015), Revelli and Viviani (2015) and Kim (2019)

observed between the performance of green and black mutual funds. The authors also note that over time the return of green mutual funds improved, reaching a stage where there were no differences in their performance and that of conventional mutual funds, and with green funds even ending up with better financial performance than their black counterparts.

Regarding the financial performance outcomes of low-carbon portfolios and mutual funds, the results are consistent, suggesting that divestment from fossil fuels can result in a better performance, and reinforcing the idea that socially responsible investment carries no costs in terms of performance (Guo et al., 2022; Halcoussis & Lowenberg, 2019; Henriques & Sadorsky, 2018; Soler-Domínguez et al., 2021). To the best of our knowledge, there are two studies addressing the performance of actively managed funds with low carbon footprint, namely Soler-Dominguéz et al. (2021) and Guo et al. (2022). Soler-Dominguéz et al. (2021) examine the performance of mutual funds that present low carbon risk and fossil fuel exposure, based on the Low Carbon Designation (LCD) developed by Morningstar. Their results show that low-carbon funds outperformed those with high-carbon emissions. In turn, when studying fossil fuel funds (FFF) and non-fossil fuel funds (NFF) from the Eurozone from January 2010 to December 2020, Guo et al. (2022) conclude that there are no differences in their performance either when using Sharpe ratio or Jensen's Alpha. These findings lead to the conclusion that there are no benefits in investing in high emission companies and that a transition from high to low emission companies eventually leads to a better financial performance, in line with the arguments for divestment in fossil fuel portfolios.

Closely related to this topic Martí-Ballester (2019a) assess the performance of investments focused on renewable energy funds as an alternative to fossil fuels funds, and finds that they underperform both the market benchmark and fossil fuel funds. These results are consistent with those from another study where the performance of energy funds is evaluated with a specialized market benchmark (Marti-Ballester, 2019b). However, when evaluating the financial performance of investments focused on renewable energy using conditional models, the results are shown to be different, with performance being similar to that of the market (Marti-Ballester, 2019a). In turn, Reboredo et al. (2017) pointed out that renewable energy mutual funds have lower performance than other social and responsible mutual funds, reinforcing the argument that investors typically pay a premium for becoming responsible through the investment in this type of mutual funds (Reboredo et al., 2017).

In terms of methodology, studies that evaluate the performance of environmentally friendly funds (renewable energy, fossil fuel free, green, low-carbon), typically focus on a comparison that enables answering the central issue of differences in performance resulting from the consideration of ethical and social concerns. Therefore, the authors usually start by comparing a portfolio of funds with the desired characteristics with a portfolio of conventional funds, but there are also some who choose to include a portfolio of funds with completely opposite features, such as fossil fuel, black and high emission funds (Bello, 2005; Climent & Soriano, 2011; Reboredo et al., 2017; Henriques & Sadorsky, 2018; Halcoussis & Lowenberg, 2019; Marti-Ballester, 2019; Martí-Ballester, 2019; Soler-Domínguez et al., 2021; Guo et al., 2022). Regarding the models used to assess mutual fund' performance, the most commonly ones are multifactor models, with emphasis on the four-factor of Carhart (1997) and the five-factor model of Fama and French (2015) (e.g., Climent & Soriano, 2011; Reboredo et al., 2017; Marti-Ballester, 2019; Martí-Ballester, 2019; Soler-Domínguez et al., 2021; Guo et al., 2022).

CHAPTER THREE
Methodology

3. METHODOLOGY

This chapter presents and explains the models used, along with all the risk factors involved. To address our research question, several portfolios are formed, namely high-carbon mutual funds investing globally, low-carbon mutual funds investing globally, high-carbon investing globally and low-carbon mutual funds investing in Europe. Additionally, to better assess the performance differentials between low-carbon and high-carbon funds, a differences portfolio is formed, both for global and European funds. In addition, for each category of mutual funds, equally and value weighted portfolios were created. The financial performance of these portfolios is assessed using two types of models: unconditional models, followed by their conditional counterparts. Financial performance evaluation will be conducted at the aggregate level by evaluating portfolios of mutual funds, and also at the individual level. Furthermore, the analysis will be performed for the whole period under analysis and for sub-periods.

3.1. Unconditional models

Considering that multi-factor models are well-established in the performance evaluation literature, the models that will be used include multiple variables that have been shown to be useful in explaining the cross-section of returns (Fama & French, 1996). Hence, financial performance will be evaluated using the Carhart (1997) four-factor model and the Fama and French (2015) five-factor model. These models were adopted to provide a more thorough analysis of fund performance that goes beyond a simple comparison of raw returns.

The development of multi-factor models was prompted by development the Arbitrage Pricing Theory (APT), that can be expressed as:

$$E(r_p) = r_f + \beta_1\lambda_1 + \beta_2\lambda_2 + \cdots + \beta_k\lambda_k \quad (1)$$

(..) which explains the expected rate of return of an asset [$E(r_p)$], or set of assets (portfolio), considering the risk associated (β) with various factors (λ). To empirically implement APT, we will use the four-factor model of Carhart (1997), that incorporates the momentum factor (MOM) into the three-factor model proposed by Fama and French (1993). The three-factor model takes into account not only the beta of the market factor but also a size factor (SMB), based on the fact that smaller firms tend to generate higher returns, and also a book-to-market factor (HML), since higher returns were observed in firms with high book-to-market values. The three-factor model is expressed as follows:

$$R_{p,t} = \alpha_p + b_{p1}(R_{m,t}) + b_{p2}SMB_t + b_{p3}HML_t + \varepsilon_{p,t} \quad (2)$$

(…) where $R_{p,t}$ represents the excess return of fund *p* over period *t*, $R_{m,t}$ the excess return of the market over period *t*, the SMB factor represents the difference in returns between a portfolio of small stocks and a portfolio of large stocks, and the HML factor shows the difference in returns between a portfolio of high book-to-market stocks and a portfolio with low book-to-market stocks.

The momentum factor (MOM) was subsequently proposed by Carhart (1997), based on Jegadeesh and Titman's (1993) observation of momentum in stock returns. The four-factor model of Carhart (1997) is given by:

$$R_{p,t} = \alpha_p + b_{p1}(R_{m,t}) + b_{p2}SMB_t + b_{p3}HML_t + b_{p4}MOM_t + \varepsilon_{p,t} \quad (3)$$

(…) where the MOM factor measures the difference in returns of a portfolio of past winners and a portfolio of past losers.

Finally, the addition of one factor referring to profitability and one relating to investment to the three-factor model resulted in the development of the five factor model of Fama and French (2015), as follows:

$$R_{p,t} = \alpha_p + b_{p1}(R_{m,t}) + b_{p2}SMB_t + b_{p3}HML_t + b_{p4}RMW_t + b_{p5}CMA_t + \varepsilon_{p,t} \quad (4)$$

(…) where the profitability factor (RMW) represents the difference in returns observed in diversified portfolios of high and low profitability stocks whilst the investment factor (CMA) represents the difference in returns observed between portfolios of stocks of companies with high levels of investment and those with low levels of investment. It is worth noting that the five-factor model is also used by Plantinga and Scholtens (2021). Their research shows that fossil fuel stocks exhibit greater exposure to factors such as size, profitability, and investment, in comparison to non-fossil fuel stocks. This finding motivates the use the five-factor model in the context of portfolios associated with fossil fuel investments.

3.2. Conditional models

Despite the generalization of the multi-factor models of Carhart (1997) and Fama and French (2015), it should be noted that these models are unconditional, as they assume that the expected return and risk remain unchanged over time regardless of market conditions. As such, this approach overlooks publicly available information about the state of the economy, which could result in biased estimates (Ferson & Schadt, 1996). Thus, it is relevant to use a model in which risk exposure and market premiums are allowed to vary over time according to the state of the economy. For this purpose, Ferson and Schadt (1996) developed a conditional models of performance evaluation with time-varying risk according to market conditions, as measured by predetermined public information variables (PIV). The model of Ferson and Schadt (1996) is expressed in the following formula:

$$R_{p,t} = \alpha_p + \beta_{0p}(R_{m,t}) + \beta'_p(z_{t-1}R_{m,t}) + \varepsilon_{p,t} \tag{5}$$

(...) where α_{0p} is an average alpha, $\beta_{0p}$is an average beta that represents the (unconditional) mean of the conditional betas, β'_p a vector that measures the response of the conditional beta of a portfolio p to the PIV, and finally z_{t-1} a vector of deviations of the PIV Z_{t-1} from the (unconditional) average values.

With the aim of addressing potential biases that might arise when forcing alphas to be constant over time (Ferson et al., 2008), financial performance will also be evaluated through the conditional multi-factor model of Christopherson et al. (1998) which takes into account time-varying betas as in the previously mentioned model. However, the model goes beyond that by incorporating time-varying alphas, as follows:

$$R_{p,t} = \alpha_{0p} + A'_p z_{t-1} + \beta_{0p}R_{m,t} + \beta'_p(z_{t-1}R_{m,t}) + \varepsilon_{p,t} \tag{6}$$

(...) where A'_p represents a vector that measures the response of the conditional alpha to the information variables.

As PIV, the short-term rate (STR) and the dividend yield (DY) will be used, as in Cortez et al. (2012) and Ferson and Warther (1996). The extension of conditional models to a multi-factor context is straightforward. In the case of the conditional model of Christopherson et al. (1998) with four and five risk factors, the corresponding conditional four-factor and conditional five-factor model with the two selected PIV are, respectively:

$$
\begin{aligned}
R_{p,t} = {} & \alpha_0 + \alpha_1 STR_{t-1} + \alpha_2 DY_{t-1} + \beta_{0p} R_{m,t} + \beta_{1p} R_{m,t} STR_{t-1} + \beta_{2p} R_{m,t} DY_{t-1} \\
& + \beta_{3p} SMB_t + \beta_{4p} SMB_t STR_{t-1} + \beta_{5p} SMB_t DY_{t-1} + \beta_{6p} HML_t \\
& + \beta_{7p} HML_t STR_{t-1} + \beta_{8p} HML_t DY_{t-1} + \beta_{9p} MOM_t \\
& + \beta_{10p} MOM_t STR_{t-1} + \beta_{11p} MOM_t DY_{t-1}
\end{aligned} \tag{7}
$$

$$
\begin{aligned}
R_{p,t} = {} & \alpha_0 + \alpha_1 STR_{t-1} + \alpha_2 DY_{t-1} + \beta_{0p} R_{m,t} + \beta_{1p} R_{m,t} STR_{t-1} + \beta_{2p} R_{m,t} DY_{t-1} \\
& + \beta_{3p} SMB_t + \beta_{4p} SMB_t STR_{t-1} + \beta_{5p} SMB_t DY_{t-1} + \beta_{6p} HML_t \\
& + \beta_{7p} HML_t STR_{t-1} + \beta_{8p} HML_t DY_{t-1} + \beta_{9p} MOM_t \\
& + \beta_{10p} MOM_t STR_{t-1} + \beta_{11p} MOM_t DY_{t-1} + \beta_{12p} RMW_t \\
& + \beta_{13p} RMW_t STR_{t-1} + \beta_{14p} RMW_t DY_{t-1} + \beta_{15p} CMA_t \\
& + \beta_{16p} CMA_t STR_{t-1} + \beta_{17p} CMA_t DY_{t-1}
\end{aligned} \tag{8}
$$

CHAPTER FOUR

Data

4. DATA

This chapter focuses on the data collection process, providing a detailed description of the data and the sources used to collect it.

4.1. Mutual fund data

First of all, it is relevant to mention that this study was performed taking into account a US investor's perspective, i.e., a US investor that is interested in French funds. The funds were selected through Refinitiv Eikon's platform. Several screens were applied on this platform to select the funds. In particular, only the primary share class of each fund was considered. Concerning the classification schemes, funds from the Autorité des marches financiers (AMF) list were selected. Finally, regarding the asset attributes, equity funds with a geographical focus as Global or Europe were filtered. This process yielded a total of 1245 mutual funds. Next, data regarding the emission scores of the funds was retrieved, as well as the date this score was last updated. After this procedure, all funds that did not have an assigned score were removed, resulting in a set of 255 mutual funds. In the Refinitive Eikon database, funds are assigned an emission score ranging from 0 to 100. A score close to zero indicates poor performance in terms of emissions and transparency, while a score close to one hundred indicates an excellent performance and optimal transparency of information. The funds' monthly total return indexes (TRI) and the total net assets (TNA) were retrieved from Refinitiv DataStream, in US Dollars, from October 2012 to October 2022. Returns were computed in a discrete way. Upon a closer analysis of the funds return series, some of them were excluded for failing to meet the minimum requirement of 24 observations as in Silva and Cortez (2016). As a result, the final sample consists of 243 mutual funds. The following step consisted in forming different portfolios out of the total number of mutual funds. The criteria to identify low-carbon funds and high-carbon funds was to use the median of the funds' emission scores. Therefore, considering the median value of the funds' emission scores at 81.13, the categorization of funds into low-carbon (high-carbon) was established for those with an emission score above (below) the median. Accordingly, low-carbon funds show a smaller carbon footprint, demonstrate a stronger commitment to reducing greenhouse gas emissions, whilst high-carbon mutual funds have a large carbon footprint and contribute significantly to greenhouse gas emissions.

Due to the difference in geographical focus between the funds under consideration, it was deemed necessary to partition each class into distinct categories, namely Global and European funds. Out of the the total sample of 243 funds, 147 had a focus on European investments while the remaining 96 had a global investment strategy. Furthermore, 122 funds were identified as low-carbon, while the remaining 121 were found to have high-carbon investments.

Based on these categorizations, four portfolios were formed: high-carbon mutual funds that invest globally (65 mutual funds), low-carbon mutual funds that invest globally (31 mutual funds), high-carbon mutual funds that invest in Europe and low-carbon mutual funds that invest in Europe (56 and 91 mutual funds, respectively). It is also important to mention that the dataset is comprised of monthly observations and goes from October 2012 until October 2022. Table 1 summarizes the composition of the portfolios. The complete list of the funds comprising each portfolio is presented in appendices 1 to 4.

Table 1 - Composition of the portfolios

	Geographical area of investment		**Total**
	Europe	**Global**	
Low-carbon funds	91	31	122
High-carbon funds	56	65	121
Total	147	96	**243**

This table shows the allocation among the funds into portfolios according to the geographical focus and the emission score.

4.2. Risk factors and public information variables (PIV)

In this empirical work, the aim is to evaluate and compare the financial performance of the portfolios formed based on the emissions ratings provided. To evaluate performance with the models presented in the previous chapter, it was necessary to collect the data, namely the return of each fund, the risk-free rate return, the return of the market, the difference in returns between a small stock portfolio and a portfolio of large stocks (SMB), the difference in returns between a portfolio with high book-to-market and a low book-to-market (HML), the momentum factor (MOM), the difference between the returns on diversified portfolios of stocks with high and low profitability (RMW) and the difference between the returns on diversified portfolios of stocks of high and low investment firms (CMA). For that purpose, all the data on the risk factors was retrieved from Professor Kenneth French's website[2]. Considering the different geographical focus of mutual funds,

[2] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/

it was necessary to collect the risk factors based on the corresponding geographical areas. Therefore, in order to ensure an accurate evaluation of financial performance, data pertaining to these factors was drawn from both the global and European markets.

The estimation of the conditional models requires the inclusion of the public information variables which, as previously mentioned, are the short-term rate (STR) and dividend yield (DY). For the short-term rate, the yield on a 3-month US Treasury Bill was used, whereas for the dividend yield it was based on the WORLD-DS Market Index. This data was being collected through Refinitiv DataStream. Considering the potential issues of auto-correlation could lead to biases from spurious regressions, the approach of Ferson et al. (2003) was followed. Specifically, a stochastic detrending of the variables was performed by subtracting their 12-month moving average. Further, the variables were used in terms of mean-zero.

4.3. Heteroskedasticity and autocorrelation in the dataset

In order to understand which is the most appropriate method to use for estimating the regressions that drive the performance evaluation of the different portfolios, as well as of the individual funds, it is first necessary to assess whether the sample has any statistical problems, namely heteroskedasticity and autocorrelation, which will be reviewed in this subsection.

Heteroskedasticity is a statistical phenomenon that occurs when the variance of the residuals in a regression model varies across the range of values of the independent variables (Stock & Watson, 2015). This is an important consideration in empirical research, as it can affect the accuracy of parameter estimates and statistical inference. Therefore, it is important to test and account for heteroskedasticity in the data to ensure the validity and reliability of the results, which was done through the Breusch-Pagan test in Stata. The test is based on the null hypothesis that the errors in the model have constant variance, meaning that the variance of the error term is the same for all values of the independent variables and there is no evidence of heteroskedasticity.

From the regressions computed across the portfolios for the different models, 33.3% of them showed a statistically significant chi square test result at the 5% level, leading to the rejection of the null hypothesis, and indicating that there is a significant evidence of heteroskedasticity. More detailed background information can be consulted in Appendix 5.

Autocorrelation, also known as serial correlation, refers to the correlation between the values of a time series variable at different time points. In time series analysis, autocorrelation can indicate the presence of a pattern or trend in the data, while in regression analysis, autocorrelation can lead to biased and inefficient estimates of the regression coefficients. Bearing this in mind, it is also necessary to correct for this problem, by using the Durbin-Watson test in Stata. The Durbin-Watson test provides a useful tool for identifying the presence of autocorrelation in the residuals of a regression analysis. Typically, a Durbin-Watson test statistic value of 2 is taken to indicate the absence of autocorrelation, while values below or above 2 suggest the presence of positive or negative autocorrelation, respectively.

The results for the regressions of the different portfolios for the various models indicated that 58,3% of them exhibited autocorrelation problems, the majority of which proved to be negative. Further detailed information is displayed in Appendix 6.

That being said, since heteroskedasticity and autocorrelation is found in the sample, even though it is not observed in all of the computed regressions, this requires a way to correct for both in order to reach more reliable results and interpretation, which was accomplished by using the Newey–West (1987) variance estimator, that is used to calculate heteroskedasticity and autocorrelation consistent standard errors (HAC standard errors) for linear regression models. To specify the number of lags to be used in the study, the rule of tumb was followed, in which the period is defined as the fourth root of the number of observations, resulting in a lag(3) (Baum, 2009).

4.4. Descriptive statistics of the equally and value weighted portfolios

Table 2 displays the descriptive statistics of the French portfolios investing globally. Overall, the average returns and standard deviations of the portfolios were positive and similar. By taking the equally weighted high-carbon portfolio as an example, it is shown to have an average return of 0.78% approximately. This average return has an associated standard deviation of 3.79%, that measures the volatility or risk of the portfolio's returns.

The minimum value across the global portfolios belongs to the equally weighted low-carbon portfolio (-0,13539) whereas the maximum is part of the equally weighted high-carbon portfolio (0,14039) . Regarding skewness, it can be observed that three out of these four portfolios exhibit a negative coefficient for this indicator, which reveals that the returns are skewed to the left, indicating that the majority of returns are concentrated on the right side of the distribution, with a few large negative returns on the left. Finally, with respect to excess kurtosis, all values are positive, which infers that the portfolios have a higher probability of experiencing both large gains and losses, relative to a normal distribution. These last two topics are important to take into account as an investor when taking an investment decision, since it can provide insights into the potential risks and rewards associated with the portfolio. However, fat tails should be used in conjunction with other risk measures to get a more complete picture of a portfolio's risk profile.

Looking now at the descriptive statistics of the portfolios investing in Europe, as shown in Table 3, it is possible to observe that, as in the case of global portfolios, the values of mean return and standard deviation are similar across portfolios. The average returns vary between 0.51% and 0.56%, while the standard deviation ranges from 3.90% to 4.15%. The minimum observed value among all these four portfolios is -0.16736 associated to the equally weighted high-carbon portfolio. In the other spectrum, the maximum value is 0.13941, which corresponds to the equally weighted low-carbon portfolio. All portfolios exhibit a negative skewness and a positive excess kurtosis, which implies that the returns are skewed to the left and the portfolios are likely to experiencing both large gains and losses.

Table 2 - Descriptive statistics of the portfolios investing globally

		Number of observations	***Average Returns (%)***	***Standard Deviation (%)***	***Minimum***	***Maximum***	***Skewness***	***Excess Kurtosis***
Eq. Weighted	**High-carbon**	120	0,77883	3,79316	-0,131896	0,14039	0,04123	2,67486
	Low-carbon	120	0,7209	3,71386	-0,13539	0,11585	-0,5095	1,96332
Value Weighted	**High-carbon**	120	0,71869	3,65448	-0,12934	0,12106	-0,5347	2,28236
	Low-carbon	120	0,72712	3,74866	-0,12906	0,1074	-0,47936	1,32883

This table presents the descriptive statistics for the monthly returns of the high-carbon and low-carbon equally (EW) and value (VW) weighted portfolios of funds that invest globally. The number of observations, average returns, standard deviation, minimum, maximum, skewness, and excess kurtosis that are presented in this corresponds to the period frame between October 2012 and October 2022.

Table 3 - Descriptive statistics of the portfolios investing in Europe

		Number of observations	***Average Returns (%)***	***Standard Deviation (%)***	***Minimum***	***Maximum***	***Skewness***	***Excess Kurtosis***
Eq. Weighted	**High-carbon**	120	0,54033	4,15151	-0,16736	0,13061	-0,72156	2,35281
	Low-carbon	120	0,50737	3,95703	-0,15755	0,13941	-0,51995	2,33017
Value Weighted	**High-carbon**	120	0,51237	3,90481	0,15177	0,09957	-0,71939	1,63659
	Low-carbon	120	0,56387	3,89721	-0,13775	0,13104	-0,40521	1,34683

This table presents the descriptive statistics for the monthly returns of the high-carbon and low-carbon equally (EW) and value (VW) weighted portfolios of the funds that invest in Europe. The number of observations, average returns, standard deviation, minimum, maximum, skewness, and excess kurtosis that are presented in this corresponds to the period frame between October 2012 and October 2022.

CHAPTER FIVE
Results

5. RESULTS

In this section, the results obtained through the application of each performance evaluation model to the constructed portfolios, as well as to individual funds, are presented. First the results of the multi-factor models in their original version will be analyzed, followed by the results of the conditional models. Each model is associated with two tables, one concerning portfolios and funds that invest globally and another with concerning those investing in Europe.

As previously mentioned, funds were categorized across two dimensions: 1) low-carbon and high-carbon, and 2) geographical focus, which resulted in the formation of four portfolios. In turn, portfolios were formed with two alternative weighting schemes by: a) giving the same weight and allocation to each fund (equally weighted portfolios) and b) weighting each fund according to its market value (value weighted portfolios). Finally, differences portfolios between the returns of the two portfolios (high-carbon and low-carbon) were also formed, with the purpose of better assessing the differences between high-carbon and low-carbon portfolios. Furthermore, it should be pointed that each table shows the estimates of the equally and value weighted portfolios' regressions, and summarizes those of the individual fund regressions.

5.1. Unconditional Models

5.1.1. Performance based on the Charhart (1997) four-factor model

Table 4 displays the Carhart (1997) four-factor model results for funds investing globally during the ten-year period from October 2012 to October 2022.

Table 4 - Carhart (1997) four-factor model – Global funds

Portfolios	α	β_{Rm}	β_{SMB}	β_{HML}	β_{MOM}	Adj. R^2 (%)
			High-carbon			
Eq. Weighted	0.00223	0.700***	0.0665	-0.157*	-0.0490	60.88
Val. Weighted	0.00085	0.776***	-0.0166	-0.191**	-0.0400	80.39
N+	45[4]	64[58]	27[1]	13[4]	18[0]	
N-	20[0]	1[0]	38[11]	52[23]	47[5]	
			Low-carbon			
Eq. Weighted	0.00076	0.796***	-0.202*	-0.0347	-0.0836	80.30
Val. Weighted	0.00055	0.802***	-0.284**	-0.0652	-0.0692	79.15
N+	22[3]	31[31]	3[0]	12[2]	3[0]	
N-	9[0]	0	28[16]	19[10]	28[3]	
			Difference Portfolio (Low-carbon – High-carbon)			
Eq. Weighted	-0.00147	0.0960	-0.269**	0.123**	-0.0346	7.86
Val. Weighted	-0.00030	0.0261	-0.267***	0.126***	-0.0291	21.95

This table displays the regression estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest globally for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML) and momentum (MOM). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented.

As the main objective of this study is to assess the financial performance of low-carbon portfolios and compare them against their high-carbon counterparts, it is therefore important to first focus the attention on α_p, the constant term, as it represents the expected return of the portfolio or fund, when all four factors (market risk premium, size, value, and momentum) are equal to zero. All portfolios exhibit non-statistically significant alphas, indicating that the portfolios' performance is neutral relative to the benchmark. The results on the differences portfolio, although negative, are insignificant, indicating that there are no statistically significant differences between the performance of high-carbon and low-carbon funds. On an individual perspective, most funds also exhibit neutral performance, with a small number of funds showing positive and satistically significant alphas.

Regarding the market factor, all portfolios exhibit positive and statistically significant (at the 1% level) market betas. Focusing on the size factor (SMB), it can be observed that the low-carbon fund portfolios display a negative and statistically significant coefficient (at the 10% and 5% level for equally and value weighted portfolios, respectively). This indicates that, in general, low-carbon funds tend to be exposed towards large-cap stocks. In terms of the differences between the portfolios, the results indicate that low-carbon funds are more exposed to large companies than their high-carbon counterparts.

The book-to-market ratio (HML) is negative and statistically significant for high-carbon portfolios, indicating a higher exposure to growth stocks. The positive and statistically significant HML coefficient of the differences portfolios further indicates that high-carbon portfolios are more oriented towards growth stocks than low-carbon portfolios.

When looking at the momentum factor (MOM) the first thing that stands out is the absence of significance regarding the impact of this indicator on portfolios, however, individually, a few coefficients, namely negative ones, are statistically significant at 5%.

To evaluate the explanatory power of these models, it is important to focus on the adjusted R squared (Shieh, 2008), which is shown to be overall slightly higher for the low-carbon portfolio. However, the portfolio that shows the highest coefficient is the value weighted high-carbon portfolio, where the independent variables are able to explain 80.39% of the variation in portfolio returns.

Table 5 presents the estimates of the Carhart (1997) four factor model regressions for funds and portfolios that invest in Europe. It is possible to observe that, as in the case of global funds, the alphas of the portfolios are insignificant, showing neutral performance relative to the benchmark. However, the results of the value-weighted difference portfolio show a positive and statistically significant alpha (at the 5% level), indicating that the value-weighted portfolio of low-carbon funds performs better than its high-carbon counterpart. The number of individual low-carbon funds showing statistically significant alphas is consistent with this finding. Also, the results are consistent with these good performing funds being larger funds.

Regarding the exposure to the market factor, all portfolios show positive and statistically significant coefficients at a 1 % level. In what concerns the differences portfolio, the results show that the equally-weighted portfolio of low-carbon funds has lower systematic risk than its high-carbon counterpart. Regarding the size factor, the low-carbon portfolios show a negative and statistically significant coefficient, although only at the 10% level, indicating a slight tendency to be exposed to large firms. As in the case of global portfolios, the size coefficients of the differences portfolios are negative and statistically significant at a 1% level, indicating that low-carbon funds are more exposed to large firms than high-carbon funds.

For the HML all portfolios, except the low-carbon equally-weighted one, show negative and statistically significant coefficients, indicating that they are exposed to growth firms. The results of the differences portfolio shows that the high-carbon portfolios are more exposed to growth firms than low-carbon portfolios.

With respect to the explanatory strength of the models, one can observe that the high-carbon and low-carbon portfolios show similar values, meaning that, generally speaking, the models are able to account for most of the variations observed in the returns of the portfolios.

Table 5 - Carhart (1997) four-factor model – European funds

Portfolios	α	β_{Rm}	β_{SMB}	β_{HML}	β_{MOM}	Adj. R² (%)
			High-carbon			
Eq. Weighted	0.00197	0.807***	0.0422	-0.264**	-0.132**	81.13
Val. Weighted	0.00157	0.775***	-0.0974	-0.304***	-0.0739	78.73
N+	51[8]	56[56]	31[8]	4[1]	4[0]	
N-	5[0]	0	25[5]	52[32]	52[20]	
			Low-carbon			
Eq. Weighted	0.00236	0.771***	-0.289*	-0.122	-0.129**	80.68
Val. Weighted	0.00311	0.759***	-0.332*	-0.236**	-0.146**	78.99
N+	84[21]	91[91]	9[0]	22[8]	10[0]	
N-	7[0]	0	82[44]	69[35]	81[38]	
			Difference Portfolio (Low-carbon – High-carbon)			
Eq. Weighted	0.00039	-0.0366**	-0.331***	0.142***	0.00355	77.98
Val. Weighted	0.00154**	-0.0154	-0.234***	0.0681**	-0.0719*	51.19

This table displays the regression estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest in europe for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML) and momentum (MOM). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented.

5.1.2. Performance based on the Fama and French (2015) five-factor model

In this section, the tables concerning the results of the five-factor model of Fama and French (2015) regressions for the different portfolios and individual funds over the period ranging from October 2012 to October 2022 are displayed.

Table 6 - Unconditional Fama and French (2015) five-factor model – Global funds

Portfolios	α	β_{Rm}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	Adj. R² (%)
			High-carbon				
Eq. Weighted	0.00132	0.701***	0.169	-0.0487	0.321	-0.0329	61.24
Val. Weighted	0.00047	0.765***	0.0271	-0.0446	0.185	-0.164	80.51
N+	43[6]	64[60]	30[7]	34[4]	48[13]	19[3]	
N-	22[0]	1[0]	35[4]	31[4]	17[3]	46[9]	
			Low-carbon				
Eq. Weighted	0.00019	0.795***	-0.162	0.155	0.180	-0.166	80.12
Val. Weighted	0.00029	0.793***	-0.277*	0.149	0.124	-0.235	79.08
N+	19[1]	31[31]	5[0]	22[7]	28[8]	4[0]	
N-	12[0]	0	26[8]	9[1]	3[0]	27[2]	
			Difference Portfolio (Low-carbon – High-carbon)				
Eq. Weighted	-0.00113	0.0937	-0.331**	0.204**	-0.141	-0.133	7.94
Val. Weighted	0.00046	0.0144	-0.214***	0.0769	-0.114	0.0812	35.02

This table displays the regression estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest globally for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), profitability (RMW), and investment (CMA). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented.

Table 6 presents the results concerning the set of global funds and the corresponding portfolios of high and low carbon funds. The results show that portfolios' abnormal returns are not statistically significant, indicating once again, neutral performance. Also, low-carbon and high-carbon funds perform similarly.

The exposure to the market factor is evident for all portfolios and funds. Concerning the other factors (SMB, HML, RMW and CMA), portfolios display insignificant coefficients, with the exception of the size factor in the value weighted low-carbon portfolio, which holds statistical significance at 10%. Regarding the difference portfolios, these results show that low-carbon funds are more exposed to large caps than high-carbon funds. The style of the portfolios does not differ with respect to the other risk factors.

Finally, through observation of the R^2 one may conclude that the model has a similar explanatory power compared to the ones observed for the same funds and portfolios in Carhart's (1997) four-factor model.

Table 7 reports the results of the same model for the group of funds investing in Europe. Once again, portfolio performance is neutral and does not differ between the two types of funds.

In line to what was previously observed, the market is still the most relevant factor in explaining portfolios' and funds' excess returns. Regarding the size factor (SMB), the results obtained are similar to the ones observed in the Carhart (1997) four-factor model for the European portfolios. The coefficients of the difference portfolios are negative and statistically significant at the 1% level, indicating that the low-carbon portfolios are more exposed to large firms than its high-carbon counterparts.

Regarding the remaining factors (HML, RMW and CMA) none of them shows significant coefficients for the high-carbon and low-carbon portfolios. As for the differences portfolio, HML is significant at a 1% level, presenting a positive coefficient for the equally weighted portfolio, revealing that the portfolio has a higher exposure to value stocks compared to growth stocks. Additionally, the investment factor is also statistically significant at a level of 1% for the same portfolio, indicating that the portfolio has a higher allocation to companies with strong profitability, which tend to have higher expected returns according to the profitability premium. Individually, it is noteworthy that few of these factors' coefficients have statistical significance.

Finally, one can see that this model has about the same explanatory power as the Carhart (1997) four-factor model for this group of funds, with the best result indicating that 80.86% of the variability in the excess returns of the equally weighted high-carbon portfolio is explained by the independent variables on the regression model.

Table 7 - Fama and French (2015) five-factor model – European funds

Portfolios	α	β_{Rm}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	Adj. R² (%)
				High-carbon			
Eq. Weighted	0.000148	0.805***	0.0315	-0.00307	0.252	-0.206	80.86
Val. Weighted	0.000391	0.774***	-0.0900	-0.133	0.224	-0.0665	78.59
N+	35[2]	56[56]	28[8]	26[3]	46[8]	7[0]	
N-	21[0]	0	28[4]	30[6]	10[1]	49[5]	
				Low-carbon			
Eq. Weighted	0.000610	0.780***	-0.281*	0.115	0.286	-0.0635	80.15
Val. Weighted	0.00130	0.774***	-0.327*	-0.00367	0.257	-0.0607	78.12
N+	65[2]	91[91]	12[0]	61[18]	83[13]	40[0]	
N-	26[0]	0	79[43]	30[1]	8[1]	51[3]	
				Difference Portfolio (Low-carbon – High-carbon)			
Eq. Weighted	0.000462	-0.0250*	-0.313***	0.118***	0.0344	0.143***	80.16
Val. Weighted	0.000913	-0.000486	-0.237***	0.129	0.0331	0.00587	44.61

This table displays the regression estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest in Europe for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), profitability (RMW), and investment (CMA). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented.

5.2. Conditional Models

This section reports the results achieved through the implementation of multi-factor models in their conditional form according to the model of Christopherson et al (1998). This model allows for performance and risk to vary over time according to variables that capture changes in the economic environment, the PIV, namely the short term rate (STR) and dividend yield (DY).

5.2.1. Carhart (1997) four-factor model

Table 8 - Conditional Carhart (1997) four-factor model – Global funds

	High-carbon				Low-carbon				Difference Portfolio (Low-carbon – High-carbon)	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**
α	0.00312	0.00067	47[8]	18[0]	0.00126	0.00088	24[4]	7[0]	-0.00186	-0.00034
α_{STR}	-0.00276	-0.00565	33[3]	32[4]	-0.00122	-0.00136	15[0]	16[0]	0.00154	-0.00024
α_{DY}	-0.00254	0.01030	23[0]	42[1]	-0.00190	-0.00333	9[2]	22[1]	0.00063	0.00187
β_{Rm}	0.604***	0.745***	64[59]	1[0]	0.754***	0.764***	31[31]	0	0.150*	0.0514
β_{RmSTR}	-0.222**	0.0333	10[1]	55[27]	-0.0950*	-0.0892	3[0]	28[5]	0.127	0.0188
β_{RmDY}	1.271**	0	61[39]	4[0]	0.719***	0.584**	31[15]	0	-0.552	-0.223
β_{SMB}	-0.0348	-0.0981	20[1]	45[16]	-0.260**	-0.363***	2[0]	29[19]	-0.225*	-0.256***
β_{SMBSTR}	0.0716	-0.524*	36[1]	29[1]	-0.0551	-0.130	8[2]	23[0]	-0.127	0.0724
β_{SMBDY}	-0.0764	0.506	25[2]	40[1]	-0.518	-0.484	10[0]	21[2]	-0.442	-0.377
β_{HML}	-0.158*	-0.191**	14[3]	51[34]	-0.0772	-0.0919	9[2]	22[12]	0.0812	0.127**
β_{HMLSTR}	-0.282	-0.182	9[0]	56[26]	-0.333**	-0.340**	0	31[20]	-0.0505	-0.0644
β_{HMLDY}	0.411	-0.353	49[3]	16[0]	0.375	0.254	27[2]	4[0]	-0.0361	0.108
β_{MOM}	0.000856	0.0363	34[0]	31[3]	-0.0254	-0.00556	8[1]	23[0]	-0.0262	-0.0277
β_{MOMSTR}	-0.0289	0.227	30[2]	35[1]	-0.0133	-0.0207	16[0]	15[0]	0.0156	-0.0317
β_{MOMDY}	0.793	-0.275	52[4]	13[0]	0.928*	0.620	29[4]	2[0]	0.135	-0.175
W_1	0.8502	0.0000			0.9192	0.8716			0.9503	0.9775
W_2	0.0511	0.0000			0.1284	0.2497			0.5516	0.5185
W_3	0.0469	0.0000			0.2232	0.4063			0.3673	0.4863
Adj. R² (%)	63.85	80.66			80.85	79.24			8.67	21.65

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest globally for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), momentum (MOM), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY,βMOM*STR, βMOM*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

Table 8 displays the results regarding the application of the conditional Carhart (1997) four-factor model to funds investing globally over the period ranging from October 2012 to October 2022.

Similar to previous findings in other models, none of the alpha coefficients are statistically significant. Portfolio performance is neutral and there are no statistically significant differences between the performance of low-carbon and high-carbon funds. The conditional alphas are also not statistically significant, indicating that they are not related to the short term rate or dividend yield.

With regard to the market factor, once again the coefficient is positive in all the high-carbon and low-carbon portfolios, with these coefficients being statistically significant at the 1% level. When it comes to the difference portfolios, only the coefficient of the equally weighted portfolio is positive and statistically significant, although only at the 10% level. Also, the conditional betas are statistically significant. The beta of the equally-weighted high-carbon and low-carbon portfolios associated with the STR is negative and statistically significant at a 5% and 10% level, respectively, which indicates that portfolio returns are negatively affected by increases in interest rates. Additionally, the beta associated with the DY is positive and statistically significant for the previously mentioned portfolios, as well as for the value weighted low-carbon portfolio, meaning that the portfolios are positively affected by increases in dividend yields since the coefficients are positive. These results are in line with the theoretical expectations, as one can expect a negative relationship between the short term interest rate and expected returns and a positive relationship between the dividend yield and expected returns.

Now looking to the outputs regarding the size factor, one can see that it presents negative and statistically significant coefficients for both the low-carbon and the difference portfolios, as in the case of unconditional models, thus pointing out that low-carbon funds are more exposed to big companies. Concerning the interaction of this factor with the public information variables, the coefficient of the value weighted high-carbon portfolio interacted with the STR shows a negative sign, with a significance level of 10%.

Regarding the HML factor, its coefficient is negative and statistically significant for both high-carbon portfolios and it is positive for the value weighted differences portfolio. Again these results are consistent with high-carbon firms being more exposed to growth firms. When looking at the interaction of this factor with the PIVs, one can see that when interacted with the STR this coefficient is negative and statistically significant at a 5% level for the low-carbon portfolios, revealing that the portfolios are negatively affected by increases in interest rates.

When it comes to MOM and its interaction with dividend yield, there is a positive and statistically significant coefficient at the 10% level in the case of the equally weighted low-carbon portfolio, showing a directly proportional relation with the portfolio's excess returns.

The Wald test results allow us to clearly reject the hypothesis of time-varying alphas being jointly equal to zero for the value weighted high-carbon portfolio. Regarding its equally weighted counterpart, the hypothesis of no time-varying αs and βs is rejected at a 5% level. As to low-carbon portfolios, the null hypothesis of no time varying αs, βs, and αs and βs cannot be rejected.

One final glance is that compared to the Carhart (1997) four-factor model in its unconditional form, these regressions exhibit a similar explanatory power regarding global investment funds.

Table 9 displays the results obtained by running the same model for funds investing in Europe. The results on the alpha coeffecients show, once again, a neutral performance relative to the benchmark, as well as a similar performance between low-carbon and high-carbon funds. It can be observed that, once again, the market factor is statistically significant at a 1% level for all the high-carbon and low-carbon portfolios. As for the difference portfolio, the equally weighted portfolio exhibits a negative and statistically significant coefficient at the 5% level, indicating that the equally-weighted low-carbon portfolio has a lower systematic risk than its high-carbon peers. When interacted with the DY, all coefficients of the market factor come out positive and statistically significant at a 5% level.

Turning now to the size factor, the low-carbon portfolios are clearly more exposed to large companies. When interacted with DY, the coefficient is shown to be negative and statistically significant at the 10% level for the equally weighted differences portfolio, which indicates that in times of high dividend yields, the low-carbon equally weighted portfolio is more exposed to big cap stocks, when compared to the high-carbon portfolio.

Regarding HML, all portfolios show a negative and statistically significant coefficient, at least at the 5% level, indicating that they are mainly exposed to growth firms. Furthermore, the results on the differences portfolios show that the high-carbon portfolios are more exposed to growth firms than low-carbon ones. Focusing now on this variable intertwined with STR, the two low-carbon portfolios show statistically significant coefficients at the 10% level, with an inverse relationship with the excess returns.

The MOM factor only reveals some relevance on the results when connected with the PIV DY for the value weighted differences portfolio, with this coefficient being positive and statistically significant at the 1% level. This indicates that in times of high dividend yields, the funds were more exposed to companies that recently experienced good performance.

For all portfolio classes displayed in the table, the joint hypotheses of no time-varying βs, and no time-varying αs and βs are rejected, thereby inferring that conditional variables are relevant when explaining variations in the returns.

Finally, looking at the R^2, it can be inferred that this model has a higher explanatory power than the four-factor Carhart (1997) model in its unconditional form. With the largest difference refering to value weighted differences portfolio (where the explanatory power increased by 10.62% upon adding the PIVs).

Table 9 - Conditional Carhart (1997) four-factor model – European funds

	High-carbon				**Low-carbon**				**Difference Portfolio (Low-carbon – High carbon)**	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**
α	0.00292	0.00268	54[13]	2[0]	0.00289	0.00350	86[35]	5[0]	-0.00003	0.00082
α_{STR}	0.00052	-0.00037	30[2]	26[0]	0.00036	0.00121	51[3]	40[0]	-0.00017	0.00158
α_{DY}	-0.02620	-0.02130	1[0]	55[10]	-0.02110	-0.02410	5[0]	86[8]	0.00520	-0.00277
β_{Rm}	0.775***	0.738***	56[56]	0	0.745***	0.734***	91[91]	0	-0.0291**	-0.00408
β_{RmSTR}	-0.0734	-0.0967	6[1]	50[7]	-0.0665	-0.0514	14[0]	77[8]	0.00686	0.0453
β_{RmDY}	1.041**	0.907**	56[37]	0	0.964**	0.930**	90[61]	1[0]	-0.0770	0.0230
β_{SMB}	-0.0965	-0.242*	20[7]	36[17]	-0.414***	-0.461***	5[0]	86[61]	-0.317***	-0.219***
β_{SMBSTR}	-0.127	-0.139	17[0]	39[8]	-0.184	-0.231	11[1]	80[13]	-0.0574	-0.0915
β_{SMBDY}	0.445	0.501	43[3]	13[0]	0.142	0.254	58[8]	33[2]	-0.302*	-0.247
β_{HML}	-0.316***	-0.358***	3[1]	53[41]	-0.174**	-0.280***	18[4]	73[49]	0.142***	0.0779**
β_{HMLSTR}	-0.244	-0.247	5[0]	51[15]	-0.275*	-0.272*	3[0]	88[39]	-0.0303	-0.0244
β_{HMLDY}	0.0785	0.154	29[1]	27[2]	0.206	0.112	62[6]	29[1]	0.127	-0.0412
β_{MOM}	-0.0455	-0.0167	13[0]	43[2]	-0.0384	-0.0446	28[1]	63[6]	0.00710	-0.0279
β_{MOMSTR}	0.190	0.202	45[3]	11[0]	0.133	0.102	66[8]	25[1]	-0.0575	-0.100
β_{MOMDY}	0.409	0.0607	39[2]	17[1]	0.639	0.728	79[9]	12[0]	0.230	0.667***
W_1	0.0906	0.1656			0.1982	0.1675			0.1802	0.6444
W_2	0.0009	0.0012			0.0055	0.0095			0.0046	0.0000
W_3	0.0029	0.0038			0.0152	0.0248			0.0107	0.0001
Adj. R^2 (%)	83.83	81.65			82.71	80.94			80.48	61.81

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest in Europe for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), momentum (MOM), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY,βMOM*STR, βMOM*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

5.2.2. Fama and French (2015) five-factor model

This section presents the results achieved by applying the Fama and French (2015) five-factor model in its conditional form for the ten-year time frame starting in October 2012 and ending in October 2022.

Table 10 - Conditional Fama and French (2015) five-factor model – Global funds

	High-carbon				Low-carbon				Difference Portfolio (Low-carbon – High-carbon)	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**
α	0.00240	0.00095	50[7]	15[0]	0.00066	0.00089	22[3]	9[0]	-0.00175	-0.00013
α_{STR}	-0.00205	0.00046	35[4]	30[4]	-0.00091	-0.00210	17[2]	14[0]	0.00114	0.00030
α_{DY}	0.00894	0.00063	38[4]	27[0]	0.00673	0.00503	17[1]	14[0]	-0.00221	0.00976
β_{Rm}	0.633***	0.726***	64[60]	1[0]	0.770***	0.762***	31[31]	0	0.137*	0.0362*
β_{RmSTR}	-0.247*	-0.0940	14[0]	51[12]	-0.0549	-0.0405	4[0]	27[0]	0.192	0.0230
β_{RmDY}	1.126**	0.546**	57[31]	8[0]	0.336	0.238	24[10]	7[0]	-0.790*	-0.240*
β_{SMB}	0.0896	-0.0751	20[6]	45[6]	-0.222	-0.360**	2[0]	29[9]	-0.311**	-0.186***
β_{SMBSTR}	0.464	0.00367	49[3]	16[0]	0.0549	-0.000913	11[0]	20[0]	-0.409	-0.275**
β_{SMBDY}	-1.469	-0.770	10[0]	55[4]	-1.147	-1.003	7[0]	24[2]	0.322	-0.169
β_{HML}	-0.326*	-0.283*	12[0]	53[15]	-0.00907	0.00224	12[0]	19[3]	0.317*	0.0289
β_{HMLSTR}	-0.778*	-0.643*	2[0]	63[29]	-0.573*	-0.590*	3[0]	28[12]	0.205	0.137
β_{HMLDY}	-0.441	-0.400	28[4]	37[5]	0.0189	0.372	15[1]	16[1]	0.460	-0.918***
β_{RMW}	0.115	0.0235	39[5]	26[3]	0.0949	0.0419	23[0]	8[0]	-0.0205	-0.133*
β_{RMWSTR}	0.474	0.185	41[0]	24[1]	0.112	0.0907	22[0]	9[0]	-0.362	0.243
β_{RMWDY}	-2.443*	-0.958	18[0]	47[5]	-0.858	-0.619	7[0]	24[0]	1.585	-0.756
β_{CMA}	0.370	0.133	43[8]	22[2]	0.0471	-0.0350	18[2]	13[1]	-0.323	0.130*
β_{CMASTR}	1.333**	1.028**	61[22]	4[0]	0.766	0.773	25[10]	6[0]	-0.567	-0.105
β_{CMADY}	-1.208	-0.647	17[1]	48[7]	-0.931	-1.419	10[0]	21[2]	0.278	0.563
W_1	0.9239	0.9846			0.9154	0.9190			0.9810	0.0324
W_2	0.0604	0.1038			0.5111	0.5159			0.4830	0.0000
W_3	0.0565	0.1482			0.6499	0.6782			0.3905	0.0000
Adj. R^2 (%)	64.27	81.43			79.69	78.57			8.64	52.9

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest globally for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), profitability (RMW), investment (CMA), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY, βRMW*STR, βRMW*DY, βCMA*STR, βCMA*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

Table 10 reports the results for global funds. The estimates on alpha, once again, indicate that portfolio performance is neutral relative to the benchmark, and that there are no statistically significant differences in the performance of low-carbon and high-carbon funds. As to the market factor, it is once again statistically significant at the 1% level for all high-carbon and low-carbon portfolios. Furthermore it is noticeable that all coefficients, including both portfolios and individual funds, have a positive coefficient, with the exception of one high-carbon fund, suggesting that in the majority of cases funds's and portfolio's returns are positively related to the overall performance of the market. Regarding the interactions that this factor presents with the PIVs, it can be observed that when interacted with the STR, only the equally weighted high-carbon portfolio shows a statistical significant coefficient at the 10% level, pointing out an inverse relationship with the portfolio's excess returns. As for the DY variable, the high-carbon portfolios show positive and statistically significant coefficients at the 5% level, suggesting that when the dividend yield of the market is high, the excess return of the market tends to be higher, and this has a positive impact on the returns of the portfolios.

Regarding the size factor (SMB), the value weighted low-carbon coefficient is negative and statistically significant at the 5% level, indicating that this portfolio tends to invest in large firms. Furthermore, the SMB coefficients of the differences portfolios are negative and statistically significant at least at the 5% level, suggesting that low-carbon funds are more exposed to large firms than high-carbon funds. Moreover, in the case of the value weighted portfolio of differences, this factor is negative and statistically significant at a 5% level when interacted with the STR.

As for the book-to-market variable (HML), the coefficients of the high-carbon portfolios (negative but only statistically significant at the 10% level) show a slight tendency for these funds to be exposed to growth firms. However, the results of the differences portfolios are not supportive of style differences between low-carbon and high-carbon funds in what this risk factor is concerned. The coefficients of this risk factor interacted with the STR are negative and statistically significant at the 10% level for both high-carbon and low-carbon portfolios. When it comes to the interaction with DY, only the value weighted portfolio of differences shows a negative and statistically significant coefficient at the 1% level, indicating that when compared to a high-carbon portfolio, the low-carbon portfolio is more exposed to growth stocks in times of high dividend yields.

As for the profitability factor (RMW), this factor does not seem to be relevant in explaining portfolios returns. The results for the difference of the value weighted portfolios shows a negative and statistically significant coefficient, although only at the 10% level, meaning that the low-carbon portfolio shows a slight tendency to be more exposed to companies with low profitability when compared to the high-carbon portfolio. When interacted with DY, this factor is statistically significant at the same level, but this time for the equally weighted high-carbon portfolio, indicating that high dividend yields tend to have a slightly more negative impact on the returns of firms with lower profitability compared to firms with higher profitability.

A positive and statistically significant coefficient concerning the investment factor (CMA) is observed in case of the value weighted differences portfolio, but even so only at the 10% level, indicating that the value-weighted low-carbon portfolio tends to be slightly more exposed to conservative companies. A positive CMA coefficient can also be observed when interacted with the STR for the high-carbon portfolios, suggesting that when short-term interest rates are high, firms with conservative investments tend to outperform those with riskier investments.

The results of the Wald test are not supportive of time-varying alphas, time-varying betas, or time-varying alphas and betas, particularly to what concerns the low-carbon portfolios.

Lastly, looking at the results shown for the R squared indicator, it appears that these are in line with the ones previously achieved for the same model but in its unconditional form, indicating that the inclusion of the public information variables does not significantly affect the explanatory power of the regressions.

Table 11 displays the results generated by the application of Fama and French's (2015) five-factor model in it's conditional form, for funds investing in Europe over the same time frame.

Beginning with the analysis of abnormal returns, one can see that the average alpha is neutral for all portfolios, and there are no statistical significant differences in performance between low-carbon and high-carbon portfolios. However, unlike previous findings, the differences portfolio shows a negative and satistically significant conditional alpha associated with the STR, suggesting that in times of high short-term rates the low-carbon portfolio presents a lower performance than the high-carbon portfolio. There is another statistically significant coefficient of the conditional alpha, although only at the 10% level, when the factor is interacted with DY, although this time with a positive coefficient.

Regarding the market factor, the results show that European low-carbon funds bear less market risk than their high-carbon counterparts. The interaction coefficient of this factor with the DY is statistically significant at the 1% level for all the high-carbon and low-carbon portfolios.

Referring now to the size factor (SMB), the results show that not only low-carbon funds are exposed to large firms, but they are more exposed to large firms than high-carbon funds.

In turn, low-carbon funds are more exposed to big companies that high-carbon funds. Also with respect to this factor, there is a positive and statistically significant coefficient (at a 10% level) for the equally weighted differences portfolio when interacted with the STR, which indicates that in times of high short-term rates, the low-carbon portfolio tends to be more exposed to high book-to-market firms (value firms) than high-carbon portfolios.

When it comes to the profitability factor (RMW), the coefficients of the differences portfolios are positive and statistically significant when this factor is linked with the STR, although only at the

10% level, suggesting a tendency for a directly proportional relationship with the excess returns of the portfolios. Furthermore, still regarding this factor, its coefficient intertwined with the DY, in the case of the value weighted portfolio of differences, is negative and statistically significant at the 5% level, which indicates that low-carbon mutual funds are more exposed to weak profitability campanies, in times of high dividend yields.

As to the last variable, the investment factor (CMA), it exhibits a positive and statistically significant value at the 5% level for the equally weighted portfolio of differences, indicating that the equally weighted portfolio of low-carbon funds is more exposed to conservative firms than their high-carbon counterparts.

For both high carbon and differences portfolios, the hypotheses of no time-varying βs, and αs and βs are rejected since they exhibit p-values below 0.05. Meanwhile, as regards low-carbon portfolios, only time-varying βs appear to be jointly statistically significant.

On a final note, it can be concluded that the explanatory power of these regressions increased with the inclusion of the PIVs, indicating that the Fama and French (2015) five-factor model in its conditional form is more capable of explaining the variation in the excess returns of individual portfolios and funds.

Table 11 - Conditional Fama and French (2015) five-factor model – European funds

	High-carbon				Low-carbon				Difference Portfolio (Low-carbon – High-carbon)	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**	**N+**	**N-**	**Eq. Weighted**	**Val. Weighted**
α	0.00226	0.00256	54[14]	2[0]	0.00219	0.00294	82[19]	9[0]	-0.00007	0.00038
α_{STR}	0.00421	0.00266	35[10]	21[5]	0.00220	0.00248	66[4]	25[1]	-0.00201**	-0.00018
α_{DY}	-0.01830	-0.01640	9[0]	47[2]	-0.01090	-0.00840	20[0]	71[3]	0.00741*	0.00797
β_{Rm}	0.765***	0.733***	56[56]	0	0.742***	0.738***	91[91]	0	-0.0231**	0.00533
β_{RmSTR}	-0.135	-0.177	8[1]	48[4]	-0.156	-0.132	6[0]	85[14]	-0.0200	0.0452
β_{RmDY}	1.141**	1.154**	55[34]	1[0]	1.022**	1.064**	87[55]	4[0]	-0.119	-0.0898
β_{SMB}	-0.0796	-0.233	20[9]	36[13]	-0.380**	-0.409**	5[0]	86[53]	-0.300***	-0.176***
β_{SMBSTR}	-0.179	-0.279	16[1]	40[12]	-0.271	-0.349	13[0]	78[19]	-0.0918	-0.0703
β_{SMBDY}	0.955	1.084	49[9]	7[0]	0.641	0.746	78[11]	13[1]	-0.313	-0.338
β_{HML}	-0.167	-0.299*	10[2]	46[17]	-0.0246	-0.157	38[8]	53[14]	0.142***	0.142**
β_{HMLSTR}	-0.211	-0.140	8[0]	48[11]	-0.0653	-0.0465	25[0]	66[4]	0.145*	0.0935
β_{HMLDY}	-1.426	-1.238	11[0]	45[4]	-1.545	-2.128	10[1]	81[9]	-0.118	-0.890
β_{RMW}	-0.0114	-0.0615	24[3]	32[4]	0.0565	0.0202	53[4]	38[3]	0.0680	0.0817
β_{RMWSTR}	-0.310	-0.399	13[0]	43[10]	-0.151	-0.111	25[2]	66[4]	0.159*	0.288*
β_{RMWDY}	0.197	0.467	23[0]	33[1]	-0.302	-0.978	34[0]	57[0]	-0.499	-1.446**
β_{CMA}	-0.199	-0.0978	14[0]	42[6]	-0.0706	-0.0354	35[1]	56[4]	0.128**	0.0624
β_{CMASTR}	-0.263	-0.513	22[1]	34[4]	-0.443	-0.447	14[1]	77[5]	-0.180	0.0665
β_{CMADY}	2.769	3.061	48[3]	8[1]	2.550	2.931	85[8]	6[0]	-0.219	-0.130
W_1	0.5473	0.6481			0.8176	0.8605			0.0801	0.2697
W_2	0.0061	0.0035			0.0399	0.0345			0.0014	0.0000
W_3	0.0152	0.0093			0.0833	0.0730			0.0036	0.0002
Adj. R^2 (%)	83.05	81.31			81.47	79.67			83.14	56.63

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest in Europe for the time period between October 2012 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), profitability (RMW), investment (CMA), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY, βRMW*STR, βRMW*DY, βCMA*STR, βCMA*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

5.3. Subperiods analysis

Motivated by the increasing societal awareness regarding climate-related issues, particularly after the Paris Agreement, the next analysis explores the financial performance of low and high carbon portoflios in different subperiods. To determine whether there is any significant difference in the performance of the formed portfolios over time, these were evaluated using two different sub-periods: the first 5 years (November 2012 to October 2017) and the subsequent 5 years (November 2017 to October 2022), respectively. The analysis was performed resorting to the model that, for the preceding observations, reflected a higher explanatory power (R^2), Conditional Carhart (1997) four-factor model. Therefore, in the present section the tables that reflect the results obtained for both sub-periods are presented, first for the portfolios of firms that invest globally, followed by the ones that invest in Europe.[3]

Table 12 - Conditional Carhart (1997) four-factor model – Subperiod 1 – Global funds

	High-carbon		**Low-carbon**		**Difference Portfolio (Low-carbon – High-carbon)**	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**
α	0.00984	0.00128	0.00431	0.00447	-0.00529	0.00344
α_{STR}	0.0149	-0.0341	0.0150	0.0294	-0.00315	0.0599**
α_{DY}	-0.0583	-0.0136	-0.0338	-0.0498	0.0269	-0.0334
β_{Rm}	0.232	0.691***	0.676***	0.766***	0.460	0.0928
β_{RmSTR}	-2.558	-0.0583	-1.177	-1.448	1.632	-1.108
β_{RmDY}	3.659	0.765	1.725	2.108	-2.138	1.115
β_{SMB}	-0.413*	-0.349*	-0.597***	-0.738***	-0.286	-0.503***
β_{SMBSTR}	-3.830	-1.913	-2.259	-2.519	0.419	-1.898
β_{SMBDY}	3.520	1.037	-0.808	-0.892	-3.887	-1.434
β_{HML}	-0.187	-0.232	-0.144	-0.0609	0.0296	0.156
β_{HMLSTR}	3.249	2.713*	2.137	1.885	-0.781	-0.456
β_{HMLDY}	4.589	1.041	1.896	1.639	-3.367	-0.158
β_{MOM}	-0.0623	0.0464	-0.150	-0.127	-0.0389	-0.119
β_{MOMSTR}	-0.404	0.424	-2.661*	-3.924**	-1.140	-3.095**
β_{MOMDY}	0.850	0.651	2.487*	3.425**	0.691	1.714
W_1	0.5465	0.4248	0.6092	0.4139	0.8435	0.1162
W_2	0.5071	0.7931	0.5180	0.3875	0.7480	0.2629
W_3	0.5005	0.4928	0.3210	0.2288	0.8666	0.3923
Adj. R^2 (%)	17.14	55.38	60.24	62.81	-5.56	18.03

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest globally for the time period between November 2012 and October 2017 and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), momentum (MOM), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY,βMOM*STR, βMOM*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

[3] This analysis is focused on the funds' performance at the aggregate level (and not at the individual fund level).

By looking at table 12, which exhibits the results obtained from the financial performance evaluation of portfolios investing globally covering the period from November 2012 to October 2017, portfolio performance is neutral. However, it is possible to observe that the value weighted differences portfolio shows a positive and statistically significant coefficient conditional alpha associated with the short term rate (at the 5% level), which indicates that in times of high short term rates the low-carbon portfolio outperform the high-carbon one.

Unlike what was previously observed, the market factor only appears to be statistically significant for the low-carbon portfolios and the value-weighted high-carbon portfolio, both at the 1% level, demonstrating that these portfolios' returns are positively related to the overall performance of the market.

Looking now at the SMB factor, it is statistically significant for the low-carbon portfolios, as well as for the value-weighted portfolio of differences. All these coefficients are negative, which means that not only are low-carbon funds exposed to large firms, they are also more exposed when compared to high-carbon funds.

When it comes to the momentum indicator, its coefficient associated with the short-term rate is statistically significant at a 5% level, with relatively strong effect on the returns of the value weighted low-carbon and differences portfolios. This suggests that in times of high short term rates, low-carbon funds were more exposed to companies that recently experienced poor performance when compared with high-carbon funds. On the other hand, during times of high dividend yield, the value weighted low-carbon portfolio is more exposed to companies that performed well in the last few years.

It is safe to say that the conditional variables failed to add any significant contribution to the models, as none of the Wald tests show statistically significant values.

Overall, the explanatory powers are quite low when taking into account the ones obtained from the analysis of the portfolios and funds for the entire timeframe. Furthermore, it should be noted that the equally weighted difference portfolio has a R^2 so small that it turns out to be negative.

Table 13 - Conditional Carhart (1997) four-factor model – Subperiod 2 – Global funds

	High-carbon		Low-carbon		Difference Portfolio (Low-carbon – High-carbon)	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**
α	0.00107	0.00267	0.00177	0.00059	0.00069	-0.00208
α_{STR}	-0.00003	0.00251	0.00110	-0.00032	0.00114	-0.00283
α_{DY}	0.00164	-0.00490	0.00124	0.00140	-0.00040	0.00629
β_{Rm}	0.689***	0.721***	0.759***	0.727***	0.0698*	0.00635
β_{RmSTR}	-0.193**	-0.100	-0.0542	-0.0463	0.138**	0.0541
β_{RmDY}	0.963***	0.769**	0.543*	0.438*	-0.420	-0.331*
β_{SMB}	-0.0309	0.0622	-0.0797	-0.212	-0.0488	-0.274**
β_{SMBSTR}	0.0163	-0.0746	-0.0512	-0.219	-0.0675	-0.144
β_{SMBDY}	0.157	0.167	0.0738	0.0547	-0.0836	-0.112
β_{HML}	-0.0909	-0.204*	-0.0266	-0.0803	0.0643	0.124***
β_{HMLSTR}	-0.238	-0.198	-0.246*	-0.283*	-0.00781	-0.0855
β_{HMLDY}	0.149	0.222	0.328	0.245	0.179	0.0226
β_{MOM}	0.0721	-0.0626	-0.0773	-0.0787	-0.149	-0.0161
β_{MOMSTR}	-0.0989	-0.0374	-0.0346	-0.0167	0.0644	0.0207
β_{MOMDY}	0.739	0.724	0.730	0.460	-0.00981	-0.263
W_1	0.9897	0.8851	0.9381	0.9955	0.9383	0.6120
W_2	0.0049	0.0795	0.4519	0.3630	0.0515	0.2532
W_3	0.0018	0.0661	0.4487	0.4273	0.0071	0.2258
Adj. R^2 (%)	89.89	91.25	90.06	89.8	46.38	47.76

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest globally for the time period between November 2017 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), momentum (MOM), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY,βMOM*STR, βMOM*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

Looking now at table 13 where the results regarding the period between November 2017 and October 2022 are reported, it can be seen that, in line with what was noticed in the majority of the 10-year analysis, no significant alphas are observed, neither is there any significant difference between the two portfolios. Once again the market factor shows up to be statistically significant at a 1% level for both low-carbon and high-carbon portfolios reflecting a positive relation with the market. When interacted with STR, this factor is statistically significant at 5% for the equally weighted high-carbon and differences portfolios, being negative and positive, respectively. As for DY, the coefficients are positive and statistically significant for both high-carbon portfolios.

Regarding the remaining factors, SMB exhibits a negative and statistically significant value at a 5% level for the value weighted portfolio of differences, as in the first subperiod that was previously analyzed. Additionally, a positive and statistically significant coefficient (at the 1% level) is found for the book-to-market (HML) variable on the value weighted differences portfolio, suggesting that the high-carbon portfolios are more exposed to growth firms than low-carbon ones.

When it comes to the equally weighted high-carbon portfolio, the results of the Wald test suggest rejecting the hypotheses of no time-varying βs, and βs and αs jointly.

Lastly, when applying the same model to the portfolios over the second half of the time horizon, the explanatory power of the model increases considerably, suggesting that, for this case, the models are more capable of explaining the portfolios' returns.

Table 14 - Conditional Carhart (1997) four-factor model – Subperiod 1 – European funds

	High-carbon		Low-carbon		Difference Portfolio (Low-carbon – High-carbon)	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**
α	0.00582	0.00577	0.00612*	0.00636*	0.00031	0.00059
α_{STR}	0.01990	0.01820	0.01840	0.01500	-0.00147	-0.00318
α_{DY}	-0.06880*	-0.06630*	-0.06250*	-0.06750*	0.00628	-0.00119
β_{Rm}	0.655***	0.647***	0.626***	0.612***	-0.0285*	-0.0343
β_{RmSTR}	-0.500	-0.658	-0.674	-0.682	-0.174*	-0.0248
β_{RmDY}	1.880*	1.725*	1.663*	1.607*	-0.217	-0.118
β_{SMB}	-0.239	-0.403**	-0.529***	-0.564***	-0.290***	-0.162***
β_{SMBSTR}	0.0800	-0.234	-0.515	-0.431	-0.595**	-0.197
β_{SMBDY}	0.0769	-0.0964	-0.549	-0.468	-0.626	-0.372
β_{HML}	-0.346*	-0.384*	-0.220	-0.320*	0.125**	0.0644
β_{HMLSTR}	0.821	0.520	1.043	0.886	0.221	0.367*
β_{HMLDY}	-3.045*	-2.785	-2.343	-2.118	0.702	0.667*
β_{MOM}	-0.249*	-0.237*	-0.273**	-0.272**	-0.0236	-0.0355
β_{MOMSTR}	-3.815**	-3.539**	-3.746**	-3.601**	0.0692	-0.0627
β_{MOMDY}	0.772	0.649	1.180	1.323	0.407	0.674*
W_1	0.1532	0.1712	0.1826	0.1664	0.5963	0.8544
W_2	0.1674	0.2852	0.2359	0.3863	0.0237	0.4776
W_3	0.0899	0.1053	0.0757	0.1150	0.0266	0.5389
Adj. R^2 (%)	67.21	68.41	70.75	67.76	71.26	32.42

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest in Europe for the time period between November 2012 and October 2017, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), momentum (MOM), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY,βMOM*STR, βMOM*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

Based on the results of the financial performance evaluation of the funds investing in Europe for the first 5 years of the sample displayed in table 14, it can be seen that, similarly to what was observed before, there is no statistically significant alpha or any significant differences among the two sets of portfolios.

Regarding the market factor, once again this coefficient presents positive and statistically significant coefficients for both low and high-carbon portfolios.

The size factor (SMB) exhibits a negative and statistically significant coefficient at a 5% level for the value weighted high-carbon portfolio, which indicates that the portfolio tends to invest in large firms. For both low-carbon portfolios and both difference portfolios, the coefficients are negative statistically significant at the 1% level, from which one can conclude that low-carbon funds are more exposed to big companies than high-carbon funds. The conditional beta interacted with STR has a negative and statistically significant value at a 5% level for the equally weighted portfolio of differences.

With respect to the HML component, it shows a positive and statistically significant value at 5% for the equally weighted portfolio of differences, indicating that low-carbon portfolios are more exposed to growth stocks when compared to their high-carbon counterparts.

As for the momentum factor (MOM), this presents negative and statistically significant coefficients at a 5% level for both low-carbon portfolios, showing that these are exposed to companies that perform poorly in recent years. When interacted with the PIV STR, the conditional beta exhibits negative and statistically significant coefficients at the 5% level.

By looking at the Wald test it is possible to conclude that the hypotheses of no time-varying βs, and βs and αs are statistically significant to be included in the model since they show lower values than 0.05.

Considering the R^2, which provides the explanatory power of the independent variables over the dependent variable, one can conclude that, in general, the values are identical, with the exception of the value weighted portfolio of differences, that presents a much lower value. When comparing these results with those obtained within the same period of time but looking at the portfolios of funds that invest globally, a considerable difference can be seen, as the former portfolios exhibit higher values.

Table 15 - Conditional Carhart (1997) four-factor model – Subperiod 2 – European funds

	High-carbon		Low-carbon		Difference Portfolio (Low-carbon – High-carbon)	
Portfolios	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**	**Eq. Weighted**	**Val. Weighted**
α	0.00267	0.00263	0.00206	0.00308	-0.00042	0.00056
α_{STR}	0.00394	0.00311	0.00110	0.00186	-0.00119	-0.00073
α_{DY}	-0.01810	-0.01220	-0.01270	-0.01460	0.00552	-0.00170
β_{Rm}	0.790***	0.732***	0.767***	0.761***	-0.0124	0.0356
β_{RmSTR}	-0.0560	-0.0720	-0.0905	-0.0631	0.00285	0.0323
β_{RmDY}	0.691*	0.584	0.526	0.453	-0.153	-0.159
β_{SMB}	0.110	0.0144	-0.267*	-0.315**	-0.373***	-0.328***
β_{SMBSTR}	-0.0455	-0.0622	-0.0193	-0.0674	-0.0422	-0.0398
β_{SMBDY}	1.003	1.120*	0.815	0.978	-0.215	-0.143
β_{HML}	-0.289***	-0.354***	-0.118	-0.226**	0.179***	0.133***
β_{HMLSTR}	-0.181	-0.211	-0.221**	-0.207*	-0.0238	0.0252
β_{HMLDY}	0.288	0.465	0.153	0.0242	-0.0846	-0.462***
β_{MOM}	-0.111	-0.0811	-0.0499	-0.0525	0.0576*	0.0219
β_{MOMSTR}	0.153	0.160	0.153	0.150	-0.0221	0.00338
β_{MOMDY}	0.224	0.0226	0.107	0.0982	-0.0150	0.00924
W_1	0.4716	0.7278	0.6417	0.6138	0.4181	0.7224
W_2	0.0041	0.0047	0.0037	0.0053	0.0391	0.0001
W_3	0.0067	0.0066	0.0014	0.0020	0.0846	0.0001
Adj. R^2 (%)	92.46	90.17	91.01	89.61	86.66	77.65

This table displays the regression estimates estimates of the equally and value weighted portfolios of high-carbon and low-carbon funds, that invest in Europe for the time period between November 2017 and October 2022, and the differences between both. The table describes the abnormal return (α_p), the systematic risk (βp), the adjusted coefficient of determination (Adj. R^2) and the factors of the regressions namely, size (SMB), book-to-market (HML), momentum (MOM), the conditional α coefficients (αSTR, αDY) and β coefficients (βp*STR, βp*DY, βSMB*STR, βSMB*DY, βHML*STR, βHML*DY,βMOM*STR, βMOM*DY). Standard errors were corrected for heteroscedasticity and autocorrelation by following Newey and West (1987). To identify the statistical significance of the coefficients, asterisks were used to represent the level of significance of 1% (***), 5% (**) and 10% (*). N+ and N- indicate the number of individual funds that have positive and negative estimates, respectively, were within brackets, the number of funds whose estimates were statistically significant at a 5% significance level are presented. W_1, W_2 and W_3 are the p-values of the Wald tests for the significance of time-varying α, β, α and β, respectively.

Table 15 reports the results concerning the funds that invest in Europe for the second 5-year sub-period. As to performance, the results indicate that it is neutral. With regard to the market factor, this presents positive and statistically significant coefficients at a 1% level for both the low-carbon and high-carbon portfolios, revealing a direct proportional relationship with the market.

When it comes to the SMB indicator, it shows a negative and statistically significant coefficient at a 5% level for the value weighted low-carbon portfolio and negative and statistically significant coefficients at the 1% level for both difference portfolios, all these values are negative, suggesting that low carbon funds are more exposed to big companies.

Looking now at the book-to-market ratio it is possible to observe that it presents statistically significant values at the 1% level for both the high-carbon and differences portfolios, while for the value weighted low-carbon portfolio it presents a statistically significant coefficient at 5%. As for the difference portfolios, both coefficients are positive, meaning that the low-carbon funds are more exposed to value stocks compared with the high-carbon ones. In periods of high short term rates the equally weighted low-carbon portfolio shows to be negatively affected by increases in interest rates. As for the interaction with DY, it also presents a negative value, in the case of the value weighted portfolio of differences, which demonstrates that in periods of high dividend yields low-carbon funds are more exposed to growth stocks and the portfolio is expected to have higher returns when growth stocks outperform value stocks.

The Wald test results indicate that, for all the examined portfolios, the hypotheses of no time-varying βs, and αs and βs are rejected, apart from the joint hypothesis of αs and βs for the equally weighted portfolio of differences.

Lastly, it is worth emphasising how good this model is in explaining the differences in the returns of the present portfolios, given that all R^2 estimates are high.

CHAPTER SIX
Conclusions

6. CONCLUSIONS

This dissertation aims to analyse and compare the financial performance of French low-carbon funds for the time frame between October 2012 and October 2022, with the objective of understanding if environmentally friendly investors' who invest in these vehicles also meet the financial objectives of a positive risk-adjusted return or whether there is a cost of turning green. For this purpose, a dataset of funds from the Autorité des marchés financiers (AMF) were identified and classified into low-carbon and high-carbon funds based on the emission score index provided by Refinitiv Eikon's platform. Based on this dataset, four portfolios were formed: a portfolio of high-carbon funds investing globally, a portfolio of high-carbon funds investing in Europe, a portfolio of low-carbon funds investing globally and a portfolio of low-carbon funds investing in Europe. The differences portfolios were also computed, in order to assess whether any performance differentials between these two types of portfolios were significant. The performance evaluation considered two distinct portfolio building methods, namely equally weighted portfolio and value weighted portfolio. Portfolio performance was evaluated for the period October 2012 to October 2022 and also for two 5 year subperiods with the purpose of understanding if there was any notorious difference between those periods. The models employed to evaluate the financial performance were the Carhart (1997) four-factor model and the five-factor model of Fama and French (2015), both in their unconditional and conditional forms.

For the 10-year time frame under analysis, the results show that low-carbon funds perform similar to high-carbon funds. The only exception refers to the value-weighted portfolio of low-carbon funds investing in Europe, which outperform their high-carbon counterparts when using the Carhart (1997) four-factor model. As far as the results observed in the subperiod analysis are concerned, there are no observable differences in portfolio performance over time. Nevertheless, it is worth emphasizing that, in periods of high short term rates, according to the Carhart (1997) four-factor model in its conditional form, the performance of low-carbon funds that invest globally increases more than that of their high-carbon counterparts within the time span ranging from November 2012 to October 2017. Notably, the explanatory power of the models improves in the second period compared to the first one. This research also documents style differences between low and high carbon funds, with the former being more exposed to large cap firms and value stocks.

Accordingly, after interpreting the results of the financial performance evaluation of the selected sample, one can conclude that the low-carbon funds showed evidence of a neutral performance, giving that a large part of the evaluation resulted in alpha coefficients that do not show any statistical significance. These results go along with those achieved by Guo et al. (2022), indicating that it is neither worthwhile to invest in high-carbon mutual funds, nor is there a cost of turning green.

Some limitations of this dissertation are the low number of mutual funds that make up the sample mainly due to the dimension of the French market. Thus, one of the suggestions for future research is to apply the analysis to wider markets, with a larger sample of funds. Furthermore, it is expected that the coverage of french funds that are rated on the emissions score increases over time, providing a higher number of funds to classify as low- and high-carbon. Is is also important to mention that if funds that are currently rated with the emissions scores are those that are more compliant with environmental issues, then the criteria used to classify funds into the low- and high-carbon category might not be the best one. As such, a possible avenue for future research is to consider a more stringent criteria to classify funds into these categories, rather than the median. Alternatively, the classification of funds into high versus low carbon can be based on other labels, such as the Greenfin Label, instead of ratings from data vendors. Another limitation of this research is the fact that the historical time series of funds' emission scores are not available – only the latest values are available. Therefore, this research assumes that the funds with higher scores today also had higher scores in the past. The availability of funds' emission scores over time would enable a dynamic portfolio analysis that could shed more light on this issue.

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APPENDICES

Appendix 1 - High-carbon mutual funds that invest globally

Lipper RIC	Fund Name	Base Date	Emissions Score Date	Emissions Score Value
LP68200796	ABCM Global Allocation R	15/02/2013	31/08/2022	81,11308636
LP60038048	AGIPI Actions Monde EUR	22/05/1997	30/04/2020	66,33264022
LP60094420	AXA ACT Carbon Offset Equity QI C	06/07/2004	31/07/2022	80,47465258
LP60083472	AXA Or et Matieres Premieres C EUR	27/05/2003	31/03/2022	80,79073201
LP60042578	AXA Valeurs Ex Eurolande C	02/06/2000	30/04/2022	79,12464433
LP68509521	Amethyste Global AC	26/07/2018	30/06/2021	73,83142347
LP68402486	Amundi - KBI Aqua (C)	16/12/2016	31/08/2022	66,06745446
LP68317309	Amundi Actions Or P C	07/05/2015	31/12/2020	67,17346786
LP65080243	Amundi Actions Ressources Naturelles P (C)	26/07/2007	31/05/2020	73,58658029
LP60038170	Amundi Europe Monde D	31/01/1996	31/01/2020	81,11128562
LP60069675	Antarius Fonds Actions Plus	21/03/2002	31/05/2020	81,11924862
LP65144879	BNP Paribas Aqua Classic	12/12/2008	31/07/2022	69,44438282
LP68312555	BNP Paribas Multigestion ISR Actions Monde	01/04/2015	31/08/2022	76,0474471
LP68584015	BNP Paribas next tech - Classic	15/11/2019	31/08/2022	72,72677363
LP60039880	BSO Bio Sante C	27/12/1996	30/06/2022	71,92110849
LP68293639	CPR Global Silver Age - P (C-D)	22/12/2014	31/05/2020	66,14120966
LP60040175	Camgestion Active 100	06/01/1997	31/05/2020	81,07888031
LP65006322	Camgestion Avenir Investissement Classic	26/05/2005	31/12/2021	76,45810157
LP68352429	Cardif Countries Convictions Classic	13/04/2016	31/07/2022	73,77099592
LP60040948	Carmignac Investissement A EUR acc	26/01/1989	31/12/2021	75,09573785
LP60039728	Chaussier International C	27/12/1996	31/12/2020	62,89910321
LP68203007	Constance BE World A/EUR	08/03/2013	31/08/2022	75,98436749
LP60054909	DNCA Global New World R/C (EUR)	28/06/2004	31/01/2021	71,32740735
LP60039745	ECOFI CONVICTIONS MONDE D	27/02/1997	31/08/2022	80,85007761
LP68301641	Echiquier Robotics A	19/02/2015	31/03/2022	63,52770807
LP68583178	Echiquier World Next Leaders A	26/04/2013	31/03/2022	26,93288988
LP65012210	Ecofi Actions Croissance C	18/10/2005	31/01/2020	74,54103793
LP65124190	Ecofi Enjeux Futurs C	18/07/2008	31/03/2022	80,64954399
LP65018190	Etoile Multi Gestion Monde C	09/12/2005	31/05/2022	78,29611676
LP60043018	Federal Multi Or Et Matieres Premieres	05/01/1996	31/12/2021	76,31048351
LP68529584	Federal Transition Oxygene P	19/12/2018	31/08/2022	74,43292419
LP68323491	Fundquest Ethisworld Classic	12/06/2015	31/08/2022	74,96347136
LP60055725	GF GLOBAL MEGATRENDS	14/05/2001	31/07/2022	79,19246188
LP68339297	Groupama Horizon Actions Monde	28/09/2015	31/03/2022	80,48436737
LP60039548	Horizon Monde	03/01/1996	28/02/2022	76,97840817
LP68221342	Invest Latitude Croissance A	28/06/2013	31/12/2019	58,6762209
LP60038260	LBPAM ISR Actions Monde C	30/07/1996	31/07/2020	73,22696799
LP65136922	LBPAM Multi Actions Monde A	10/10/2008	31/03/2022	76,6483466

LP65136926	LBPAM Multi Actions Potentiel A	10/10/2008	31/03/2022	69,65001581
LP60039431	LCL Actions Or Monde	05/01/1996	31/08/2022	68,96258091
LP65071182	Lazard Multigestion Actions	01/01/2007	31/12/2021	72,23221074
LP68279121	Lazard World Innovation IC	10/09/2014	30/06/2022	78,68459373
LP68584469	M Climate Solutions C	15/11/2019	30/06/2022	64,16556475
LP60044979	ODDO BHF Best Thematics CR-EUR	06/11/2000	31/07/2022	74,89464464
LP65095914	OFI RS ACT4 Green Future OFI ACTIONS MONDE DURABLE	09/11/2007	31/03/2022	80,61512975
LP68295354	Prevoir Pangea R	12/12/2014	30/11/2021	68,57607168
LP68536532	R-Co Thematic Gold Mining C EUR	04/06/1996	31/05/2022	64,86633656
LP68622589	R-Co Thematic New Consumer Trends C EUR	04/09/2020	31/07/2022	79,03983807
LP60090044	R-co OPAL 4Change Sustainable Trends C EUR	12/08/2004	31/12/2021	72,59619911
LP60077593	SG Actions Luxe C	25/10/2002	30/09/2021	78,12554522
LP60037583	SG Actions Monde C	07/02/2006	28/02/2022	79,07019758
LP60038848	SG Actions Monde Selection C	05/04/2006	28/02/2022	80,50084881
LP60040194	SG Actions Or (C)	31/07/1996	31/08/2022	68,96258091
LP68528745	SG Amundi Actions Monde EAU - C	10/12/2018	31/05/2020	52,44429338
LP68156239	Sanso Essentiel A	11/06/2012	30/09/2021	75,41954248
LP60056285	Strategie Alimentation	25/05/2001	30/06/2022	80,27158514
LP60041470	Strategie Indice Or	05/01/1996	30/06/2021	75,85645215
LP60041173	Strategie Sante	25/10/1999	30/06/2022	80,99955035
LP60041481	Strategie Telecom	25/04/2000	30/06/2022	77,63982847
LP65032257	Thematics Global Alpha Consumer R (C) USD	30/12/2005	31/08/2020	76,68345192
LP65136920	Tocqueville Gold P	06/10/2008	31/03/2022	56,53707093
LP68401019	TrendSelection International	30/11/2016	31/07/2022	79,60210059
LP68084914	Trusteam Roc A	07/01/2011	30/04/2020	68,65955967
LP68628393	Uzes Sport R	17/09/2020	31/07/2021	58,48496077
LP68590157	Valeurs Feminines Global R	26/11/2019	31/07/2022	75,80645826

Appendix 2 - Low-carbon mutual funds that invest globally

Lipper RIC	Fund Name	Base Date	Emissions Score Date	Emissions Score Value
LP68476605	ALM Selection ISR RB	25/04/2018	30/09/2021	81,8166212
LP65088818	Agipi Monde Durable Classique Dis	21/09/2007	31/08/2022	84,39455484
LP68206083	Amplegest Pricing Power US AC	13/03/2013	30/09/2021	82,66070119
LP60070746	Amundi - KBI Actions Monde - (C)	24/05/2002	31/08/2022	81,23578255
LP60095406	BNP Paribas Actions Monde ISR Classic	28/09/2004	31/07/2022	81,83797639
LP60038101	Comgest Monde C	05/02/1998	31/03/2022	81,6042429
LP68137971	Echiquier Luxury A	20/11/2013	31/03/2022	85,49344557
LP68542989	Echiquier World Equity Growth A	19/04/2010	31/03/2022	87,34585249
LP68202461	Etikea PEA	26/02/2013	30/09/2021	83,78240731
LP68389213	Etoile Actions Internationales C/D	30/12/1999	28/02/2022	87,12521681
LP68400901	Etoile Matieres Premieres (C)	02/01/1992	31/10/2021	82,40131733
LP68582675	HSBC RIF SRI Global Equity AC	19/11/1999	31/03/2022	86,08562717
LP60042237	Hevea Dynamique C	17/04/1998	31/03/2020	83,04602662
LP60086118	LBPAM Actions ISR Euromonde MH	04/07/2003	31/03/2022	86,84170466
LP60041890	LBPAM ISR Actions Europe Monde D	15/06/2000	30/06/2021	85,94273407
LP68087111	LBPAM ISR Global Climate Change E	04/02/2011	29/02/2020	86,07905256
LP68259996	LCL Actions Monde (C)	02/01/1992	31/08/2022	81,30981007
LP60044909	LCL Actions Monde Hors Europe (D)	23/10/2000	30/09/2021	83,06915572
LP68603016	LCL Compensation Carbone Actions Monde P (C)	10/03/2020	31/08/2022	86,46503216
LP60081298	La Francaise Actions Monde	21/03/2003	30/06/2022	84,6556526
LP60051305	MAM Transition Durable Actions C	12/01/2001	31/07/2022	82,335882
LP68583738	MC Leaders Durables NC	13/11/2019	31/08/2022	87,62728159
LP60040112	SG Actions Energie C	05/01/1996	31/01/2022	82,35532255
LP60099727	Sogeactions Selection Monde C	20/01/2005	30/11/2021	84,78949319
LP60093653	Sogeretraite Actions C	18/05/2004	30/11/2021	84,44876843
LP60041482	Strategie Techno	25/04/2000	30/06/2022	83,61043222
LP65007377	Tocqueville Megatrends ISR C	04/07/2005	31/03/2022	83,77819185
LP60054086	Toni Actions ISR 100 R	22/03/2001	31/08/2022	86,84629944
LP65018198	Vivaccio ISR Actions Vivaccio	06/12/2005	29/02/2020	83,41115596
LP68586215	WISE World ISR	02/12/2019	31/08/2022	81,91841227
LP68507334	Yomoni Monde	07/08/2018	31/07/2022	82,35938316

Appendix 3 - High-carbon mutual funds that invest in Europe

Lipper RIC	Fund Name	Base Date	Emissions Score Date	Emissions Score Value
LP68281088	AFER Actions PME Classique Cap/Dis	23/09/2014	31/08/2022	69,02556827
LP68598555	AIS Venn Smart Alpha Europe P	17/10/2019	31/08/2022	76,98984838
LP60088187	Allianz Actions Euro PME-ETI RC EUR	30/06/2003	31/07/2022	57,30169236
LP60044870	Allianz Secteur Euro Immobilier C/D EUR	23/10/2000	31/05/2020	66,02116619
LP60040822	Amilton Premium Europe R	28/11/2008	30/04/2020	66,67085047
LP60038367	Amundi Actions Europe - P (C)	12/11/1999	31/10/2020	78,18878845
LP60054080	Amundi Actions Foncier - P (D)	22/03/2001	31/03/2022	74,67237679
LP60038269	Amundi Small Cap Euro P (C)	31/01/1996	31/10/2020	66,23974862
LP60038193	Amundi Strategies Actions Europe (C)	30/07/1996	31/03/2020	80,82857984
LP60081279	Amundi Valeurs Durables - P (C/D)	07/03/2003	28/02/2022	77,11711346
LP60040944	Carmignac Euro-Entrepreneurs A EUR acc	05/10/1998	28/02/2022	52,93416725
LP68532347	Echiquier Agenor SRI Mid Cap Europe A	27/02/2004	30/06/2021	65,94549462
LP68532722	Echiquier Agressor PEA A	07/09/2001	30/06/2020	77,72234229
LP68538604	Echiquier Entrepreneurs A	18/10/2013	30/06/2021	54,04563542
LP68575475	Echiquier Health A EUR C	23/09/2019	31/03/2022	66,10601738
LP68051408	Echiquier Positive Impact Europe A	30/04/2010	30/09/2021	78,5543967
LP60084453	Etoile Multi Gestion Europe C	02/05/2003	31/07/2022	80,95759353
LP65022368	Europe Entrepreneurs	13/01/2006	31/05/2021	79,10936247
LP60096101	Federal Multi Actions Europe	04/10/2004	31/07/2022	79,65412734
LP68459225	Flornoy Midcap Europe R	15/12/2017	31/03/2022	69,76451348
LP65007326	Gay-Lussac Green Impact A	09/06/2005	31/07/2022	71,21280572
LP60043508	Generali Audace Europe	12/01/1996	31/12/2021	79,77827635
LP60063321	Generali Europe Mid-Caps	21/11/2001	31/08/2022	68,4175741
LP60038436	Groupama Croissance I	23/08/1996	31/12/2019	80,21424389
LP60040918	HSBC Europe Small & Mid Cap AC	19/07/1999	31/12/2019	62,77254546
LP60075927	ICP Evolution	31/07/2002	29/02/2020	68,93067983
LP65136902	LBPAM ISR Multi Actions Euro A	10/10/2008	31/07/2020	77,89837295
LP60079124	LCL Actions Developpement Durable (C)	28/10/2002	31/07/2022	78,82520782
LP60039416	LCL Actions Euro Futur (C)	05/01/1996	31/12/2019	79,32393912
LP60055264	LCL Actions Europe (C)	25/04/2001	31/05/2020	80,03147246
LP68207255	Lazard Mid Caps Europe A	18/04/2013	30/06/2022	74,73805436
LP68190714	Luxe & Low Cost Leaders	04/01/2013	31/12/2019	66,76084585
LP60038302	MC Europe Internationale	02/11/2000	31/08/2020	79,99879951
LP68240043	ODDO BHF Active Small Cap CR-EUR	26/11/2013	31/08/2022	59,05050071
LP65088891	ODDO BHF Future of Finance CR-EUR	28/08/2007	31/08/2022	79,69268521
LP68392209	Oddo Cap Horizons PME ETI CI-EUR	06/10/2016	31/03/2022	57,75151501
LP68062190	Oddo Europe Valeurs Moyennes	01/07/2009	31/07/2022	78,82409087
LP68025769	Oudart Midcap Europe P	10/09/2009	30/06/2021	73,48706586
LP60039505	Palatine Europe Small Cap	05/01/1996	31/05/2020	59,18571044
LP60041106	Palatine Immobilier	05/01/1996	31/08/2020	76,82685046

LP60095411	Performance Environnement A	27/08/2004	30/04/2020	75,78654675
LP65010194	Performance Vitae A	12/09/2005	31/01/2020	51,73700112
LP68357911	QUADRIGE EUROPE Midcaps C	31/12/2015	30/06/2022	67,10291348
LP60040391	R-Co Thematic Family Businesses C EUR	02/01/1996	30/06/2022	69,54629842
LP60041624	Richelieu Pragma Europe R	12/05/2000	31/03/2022	80,94364819
LP60041638	SG AMUNDI Actions Europe Environnement P	19/05/2000	31/05/2020	75,87194794
LP65026246	SG Actions Euro Small Cap P	18/04/2006	31/12/2021	70,61932276
LP65035072	SG Actions Europe Multigestion (C)	07/08/2006	31/03/2020	80,11925252
LP65027897	SG Actions Europe Selection C	07/04/2006	31/05/2020	77,81438395
LP60038114	SG Actions Immobilier C	06/04/2006	31/08/2022	76,90124193
LP68331573	Sanofi Small Mid Cap Europe B	03/08/2015	31/03/2022	78,9273722
LP68121627	Sextant Tech A	22/07/2011	31/01/2022	57,56326434
LP60041471	Strategie Indice Pierre	05/01/1996	30/06/2022	74,46422527
LP60037775	Thematics AAA Consumer RC	26/07/1996	31/03/2021	79,07356903
LP60041778	Tocqueville Silver Age ISR R	14/09/2000	31/03/2020	75,90226732
LP60041777	Tocqueville Technology ISR R	14/09/2000	31/03/2020	64,19656176

Appendix 4 - Low-carbon mutual funds that invest in Europe

Lipper RIC	Fund Name	Base Date	Emissions Score Date	Emissions Score Value
LP60040506	AGIPI Actions Europe	29/04/2008	31/08/2022	88,19418223
LP60074321	ALM Actions Europe ISR IC	17/07/2002	31/03/2022	88,4050149
LP60041626	Allianz Secteur Europe Immobilier C EUR	04/06/1999	30/11/2021	88,05991817
LP60066664	Allianz Transition Actions Europe C	21/02/2002	31/12/2021	88,33754462
LP60081278	Amundi Actions Europe ISR P (C/D)	07/03/2003	30/09/2021	86,27799702
LP60040092	Amundi Actions Restructurations P (C)	28/02/1997	30/09/2021	85,93230946
LP68520997	Amundi European Sector Rotation Fund P-C/D	18/01/2019	31/08/2022	87,25581057
LP60086095	Antinea	29/11/2002	31/07/2022	86,25905488
LP65136932	BDL Convictions C	19/09/2008	31/07/2022	89,89251537
LP68555060	BFT Partners Via Equity Europe SRI P-C	29/05/2019	31/07/2022	85,35349012
LP60095409	BNP Paribas Actions Patrimoine ISR Classic C	26/07/1996	31/08/2022	90,20512349
LP60070427	BNP Paribas Developpement Humain Classic	19/08/2004	31/08/2022	86,10075505
LP60070256	BNP Paribas Energie & Industrie Europe ISR Classic	19/08/2004	31/08/2022	87,87815392
LP60087419	BNP Paribas Europe Dividende Responsable Classic C	23/09/2003	31/03/2020	90,76907513
LP60070232	BNP Paribas Finance Europe ISR Classic	19/08/2004	31/08/2022	87,73872038
LP60099255	BNP Paribas Immobilier ISR Classic C	20/01/2005	31/07/2022	83,45558911
LP68312552	BNP Paribas Multigestion ISR Actions Europe Clsc C	23/04/2015	31/12/2021	84,50308264
LP60070428	BNP Paribas Technologies Europe ISR Classic	19/08/2004	31/08/2022	85,14141095
LP65032332	BNP Paribas Telecoms Classic	27/06/2006	30/04/2021	92,49696635
LP65022426	BNP Paribas Utilities	15/03/2006	31/05/2020	93,73663849
LP68240557	Betamax Europe Smart for Climate P	06/12/2013	31/07/2022	86,77669131
LP60071222	CD Europe Expertise C	07/11/2003	30/06/2021	81,3851136
LP60038769	CPR Europe ESG - P (C/D)	17/05/1993	31/01/2022	83,75210937
LP68045712	CPR Silver Age - P (C-D)	06/04/2010	31/07/2022	86,65543346
LP60090040	Conservateur Unisic C	20/01/2004	30/11/2020	86,31846146
LP68239270	Constance Be Europe A	22/11/2013	31/07/2022	84,40113992
LP65137105	DNCA Actions Europeennes RC	28/10/2008	30/06/2022	85,73566866
LP65022354	DNCA Euro Dividend Grower R (C)	13/01/2006	30/06/2021	85,77947813
LP60092347	DNCA Value Europe C	25/08/2004	30/06/2022	83,66794504
LP68595282	Dividende Durable RC	17/12/2019	31/08/2022	81,90490617
LP68532611	Echiquier Agressor A	29/11/1991	31/03/2022	84,90214743
LP65043530	Epargne Europe Dynamique	17/02/2006	31/07/2022	87,8646752
LP60051936	Ethique et Partage - CCFD Part D	29/12/2000	31/07/2022	88,30260794
LP60041696	Etoile Banque Assurance Europe (C)	13/07/2000	31/08/2022	89,84901436
LP60088207	Etoile Consommation Europe (C)	23/09/2003	31/07/2022	88,66122339
LP60088208	Etoile Energie Europe (C)	23/09/2003	30/06/2022	90,52486538
LP60088209	Etoile Industrie Europe (C)	23/09/2003	31/07/2022	84,66632769
LP60088211	Etoile Sante Europe C	23/09/2003	31/01/2022	86,50129515
LP60041695	Etoile TMT Europe (C)	13/07/2000	31/08/2022	84,47929713
LP60097214	Etolie Rotation Sectorielle C	23/11/2004	31/07/2022	83,1800883

LP60065533	Fidelity Europe Action A	24/01/2002	31/07/2022	84,98770067
LP68546587	Flornoy Valeurs Familiales R EUR	16/03/2012	31/08/2022	85,50946515
LP65062678	FundQuest Europe Opportunities Classic	01/02/2007	31/03/2020	82,79995021
LP60042339	GF Europe	09/04/1999	31/08/2022	85,38032734
LP60040971	Gaipare Action C/D EUR	22/08/1997	28/02/2022	86,70434602
LP60080215	Galilee Innovation Europe RC	22/10/2002	30/06/2022	83,44740164
LP65007342	Groupama Actions Europeennes M	15/06/2005	30/06/2020	81,66527854
LP68281017	Groupama Europe Equities M	17/09/2014	31/03/2022	87,32937802
LP68339296	Groupama Horizon Actions Europe NC	28/09/2015	31/03/2022	83,48249302
LP60040425	HSBC Actions Europe AC	01/08/1997	31/03/2022	85,26197406
LP60090387	HSBC Europe Equity Income AC	13/01/2004	30/11/2021	88,01891266
LP68582666	HSBC RIF Europe Equity Green Transition AC	22/03/2002	31/03/2022	83,15448846
LP68221331	Impact ES Actions Europe	04/07/2013	31/08/2022	88,69930947
LP68417272	LBPAM Actions Dividendes Europe GP	03/04/2017	30/06/2021	84,76039125
LP65161591	LBPAM ISR Actions Environnement C	26/05/2009	30/06/2021	84,23310748
LP68419420	LBPAM ISR Actions Europe 50 GR	12/04/2017	31/03/2022	91,74635138
LP65012294	LBPAM ISR Actions Europe C	15/11/2005	29/02/2020	85,62747592
LP68419422	LBPAM ISR Actions Focus Europe R	12/04/2017	31/05/2020	89,75279597
LP68042636	LFIP Multi Trends	28/01/2010	31/03/2022	87,39495998
LP65004048	Larcouest Investissement	22/04/2005	31/03/2022	85,26170042
LP60038592	Lazard Alpha Europe A	02/01/1992	30/06/2022	86,94959548
LP68335656	Lazard Equity Expansion A	28/08/2015	30/06/2022	84,82220297
LP68470257	Lazard European Innovation IC	01/02/2018	30/06/2022	81,49953559
LP68407534	Lazard Patrimoine Actions SRI	30/01/2017	30/06/2022	87,82407372
LP65150390	MAIF Actions Climat P	13/02/2009	31/07/2022	89,85470742
LP60042234	MAM Europa Growth C	30/04/1998	31/07/2022	84,12640833
LP60039909	MAM Europa Select C	19/09/1997	31/07/2022	82,08494679
LP60042297	MAM Human Values C	03/07/1998	31/07/2022	88,07609109
LP65103413	Mandarine Valeur R	29/01/2008	30/06/2022	84,38858553
LP68233854	ODDO BHF Algo Min Var CR-EUR	04/10/2013	31/08/2022	82,22002049
LP60037965	ODDO BHF Generation CR-EUR	17/06/1996	31/08/2022	84,36113868
LP60080237	ODDO BHF Valeurs Rendement CR-EUR	13/12/2002	31/07/2022	90,12854281
LP68431843	OFI RS Equity Climate Change RC	07/07/2017	31/03/2022	86,39416578
LP60043016	Portzamparc Opportunites ISR C	04/01/1996	31/03/2022	86,24853054
LP68190704	Promepar Actions Rendement O	27/12/2012	31/07/2022	89,80498336
LP60076487	R-co OPAL 4Change Equity Europe	17/09/2002	31/08/2022	85,37475737
LP60038623	Renaissance Europe C	23/08/1996	31/03/2022	82,52612061
LP60063283	Richelieu Cityzen R	09/11/2001	31/03/2022	84,50424019
LP60091537	Roche-Brune Europe Actions P	16/01/2004	31/07/2022	83,6074589
LP60038185	SG Actions Euro (C)	08/02/2006	31/01/2020	84,57253411
LP60062150	Seeyond Actions Europeennes ESG R C	01/11/2001	31/08/2022	86,06816347
LP60038754	Seeyond Euro Sustainable Minvol R	22/08/1996	31/08/2022	81,95498513
LP68320436	Strategie Consommation - Luxe & Low Cost	02/06/2015	30/06/2022	88,89827799

LP68540534	THEAM Quant Europe Climate Carbon Offset Plan C	01/03/2019	31/08/2022	86,44334622
LP60041779	Tocqueville Actions Finance R	14/09/2000	31/03/2020	81,31055899
LP60064399	Tocqueville Dividende ISR C	24/12/2001	31/03/2022	86,83953297
LP60039242	Tocqueville Value Europe ISR P	05/01/1996	31/03/2022	88,06574383
LP60064371	Trusteam Roc Europe A	07/12/2001	31/07/2022	84,8923688
LP60037581	Unigestion	26/07/1996	30/09/2020	89,4165659
LP60038035	Vega Europe Convictions ISR RC	13/08/2008	31/12/2019	83,95192917
LP68507334	Yomoni Monde	07/08/2018	31/07/2022	82,35938316

Appendix 5 - Heteroskedasticity of the models regressions

		Chi²	p-value	Result	Sig. Evidence
EQUALLY WEIGHTED PORTFOLIO	**4HCG**	3.48	0.0621	Don't reject	No evidence
	4LCG	2.94	0.0865	Don't reject	No evidence
	4HCE	7.45	0.0064	Reject	Evidence
	4LCE	5.95	0.0147	Reject	Evidence
	4DifG	8.07	0.0045	Reject	Evidence
	4DifE	0.31	0.5786	Don't reject	No evidence
	5HCG	2.08	0.1496	Don't reject	No evidence
	5LCG	0.75	0.3854	Don't reject	No evidence
	5HCE	3.79	0.0514	Don't reject	No evidence
	5LCE	1.86	0.1728	Don't reject	No evidence
	5DifG	12.06	0.0005	Reject	Evidence
	5DifE	0.01	0.9402	Don't reject	No evidence
	C-4HCG	5.18	0.0228	Reject	Evidence
	C-4LCG	3.05	0.0805	Don't reject	No evidence
	C-4HCE	1.15	0.2832	Don't reject	No evidence
	C-4LCE	0.84	0.3583	Don't reject	No evidence
	C-4FDifG	17.03	0.0000	Reject	Evidence
	C-4DifE	0.06	0.8119	Don't reject	No evidence
	C-5HCG	3.75	0.0529	Don't reject	No evidence
	C-5LCG	2.68	0.1016	Don't reject	No evidence
	C-5HCE	0.42	0.5179	Don't reject	No evidence
	C-5LCE	0.16	0.6903	Don't reject	No evidence
	C-5DifG	26.39	0.0000	Reject	Evidence
	C-5DifE	0.00	0.9885	Don't reject	No evidence

		Chi²	p-value	Result	Sig. Evidence
VALUE WEIGHTED PORTFOLIO	4HCG	4.51	0.0336	Reject	Evidence
	4LCG	3.54	0.0601	Don't reject	No evidence
	4HCE	6.12	0.0133	Reject	Evidence
	4LCE	2.88	0.0897	Don't reject	No evidence
	4DifG	0.82	0.3644	Don't reject	No evidence
	4DifE	6.56	0.0104	Reject	Evidence
	5HCG	2.81	0.0935	Don't reject	No evidence
	5LCG	2.11	0.1462	Don't reject	No evidence
	5HCE	4.04	0.0445	Reject	Evidence
	5LCE	0.37	0.5411	Don't reject	No evidence
	5DifG	1.82	0.1774	Don't reject	No evidence
	5DifE	7.77	0.0053	Reject	Evidence
	C-4HCG	6.72	0.0095	Reject	Evidence
	C-4LCG	4.04	0.0445	Reject	Evidence
	C-4HCE	1.4	0.2369	Don't reject	No evidence
	C-4LCE	1.03	0.3101	Don't reject	No evidence
	C-4FDifG	0.31	0.5766	Don't reject	No evidence
	C-4DifE	0.00	0.9469	Don't reject	No evidence
	C-5HCG	7.51	0.0061	Reject	Evidence
	C-5LCG	5.63	0.0177	Reject	Evidence
	C-5HCE	0.62	0.4313	Don't reject	No evidence
	C-5LCE	0.26	0.6097	Don't reject	No evidence
	C-5DifG	0.28	0.5953	Don't reject	No evidence
	C-5DifE	2.02	0.1557	Don't reject	No evidence

This tables presents the results (Chi²) for the Breusch-Pagan test for all the computed regressions and their respective p-values, first for the equally-weighted portfolios followed by the value-weighted ones. Additionally, the third column refers to the decision carried out considering the previous values. In the last column the result, whether or not the linear model presents evidence of heteroskedasticity. “HC” refers to the high emission portfolios, “LC” to the lower emissions portfolios and "Dif" to the difference portfolio. “G” and “E” represent the geographic focus, namely Global and European. “4” and “5” indicate the four-factor model of Carhart (1997) and the five-factor model of Fama and French (2015), respectively. "C" stands for the model in its conditional form.

Appendix 6 - Autocorrelation of the models regressions

		d-statistic	Result
EQUALLY WEIGHTED PORTFOLIO	4HCG	1.931505	Positive
	4LCG	2.002684	NO
	4HCE	2.16911	Negative
	4LCE	2.099815	NO
	4DifG	1.989764	Positive
	4DifE	2.372955	Negative
	5HCG	1.896595	Positive
	5LCG	2.018728	NO
	5HCE	2.164245	Negative
	5LCE	2.128701	NO
	5DifG	1.966086	Positive
	5DifE	2.284581	Negative
	C-4HCG	1.859127	Positive
	C-4LCG	2.067823	NO
	C-4HCE	2.156263	NO
	C-4LCE	2.123759	NO
	C-4FDifG	1.965339	Positive
	C-4DifE	2.424477	Negative
	C-5HCG	1.770869	Positive
	C-5LCG	2.057418	NO
	C-5HCE	2.059504	NO
	C-5LCE	2.089516	NO
	C-5DifG	1.904341	Positive
	C-5DifE	2.3854	Negative

		d-statistic	Result
VALUE WEIGHTED PORTFOLIO	**4HCG**	1.927871	Positive
	4LCG	2.0651	NO
	4HCE	2.165193	Negative
	4LCE	2.068305	NO
	4DifG	2.162185	Negative
	4DifE	2.316705	Negative
	5HCG	1.904309	Positive
	5LCG	2.084909	NO
	5HCE	2.161019	Negative
	5LCE	2.097729	NO
	5DifG	2.364835	Negative
	5DifE	2.34401	Negative
	C-4HCG	1.879544	Positive
	C-4LCG	2.112739	NO
	C-4HCE	2.141094	NO
	C-4LCE	2.083733	NO
	C-4FDifG	2.205818	Negative
	C-4DifE	2.3874	Negative
	C-5HCG	1.844875	Positive
	C-5LCG	2.100269	NO
	C-5HCE	2.043442	NO
	C-5LCE	2.055354	NO
	C-5DifG	2.358146	Negative
	C-5DifE	2.346758	Negative

This table presents the results obtained using the Durbin-Watson test for the linear models used throughout the study, first for the equally-weighted portfolios followed by the value-weighted ones. The d-statistics refers to the result of the test, where 2 is taken to indicate the absence of autocorrelation, and a lower or higher value indicates the presence of positive or negative autocorrelation in the regressions, respectively. The last column presents the conclusion drawn from the test, where NO stands for the absence of autocorrelation and, positive and negative for the existence. “HC” refers to the high emission portfolios, “LC” to the lower emissions portfolios and "Dif" to the difference portfolio. “G” and “E” represent the geographic focus, namely Global and European. “4” and “5” indicate the four-factor model of Carhart (1997) and the five-factor model of Fama and French (2015), respectively. "C" stands for the model in its conditional form.