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EUROPEAN ENVIRONMENTAL POLICY AND CLIMATE BENCHMARKS: WHAT HAPPENS TO MY MONEY?

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Abstract. Climate change raised the interest in how the regulatory policy affects investor portfolios. The aim of this study is to analyze whether a new policy framework, that is the new European Climate Benchmark, negatively impacts the risk-return performance when investments are directed into stocks with specific emission-oriented criteria. By using a dataset of company Emission Score and recursive portfolio methodology, this article analyses the performance of High and Low Emission Stocks in European region. The study focuses on stocks listed on the Eurostoxx600 Benchmark, during the period 2006-2020. By implementing a variety of portfolio screens, our analysis provides the following insights. First, active selection of high-rated stocks does not provide inferior performance in comparison to low-rated stocks. Second, investors preferring stocks with low carbon footprints (good portfolio) and high carbon footprints (bad portfolio) still observe a performance similar to the broad market in terms of overall riskiness, while showing a U-shaped relationship between riskiness and Emission level. Moreover, investing in best Emission score stocks led investors to greater overall returns in the most turmoil periods, providing the insurance-like protection attribute associated with ethical investments. Therefore, there is no incompatibility between pursuing higher sustainable values as well as greater financial performances from investments.

Keywords: *Emission-based Portfolio, Investment Performance, Sustainability, Insurance-like effect.*

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1. Introduction

International climate finance should be used as a lever to incentivize climate-resilient and low-carbon investments, by attracting sources of financing which may be drawn from both the public and the private sectors. Climate finance is critical to addressing climate change because large-scale investments are required to adapt to the current and future impacts of a changing climate and to support significant reductions in greenhouse gas emissions.

According to Falconer and Stadelmann (2014)[1], Climate finance is defined as the financial resources that are paid to support climate change mitigation and to build resilience against current and future climate change impacts by covering the costs of the transition to a global low-carbon economy. The issue of the risk of climate transition, or the financial risk associated with the transition to a low-carbon economy (for example, the risk of regulation) has become clear to public opinion on May 26, 2021, when the

[1]https://arca.unive.it/retrieve/handle/10278/43732/31800/CPI%202014%20Brief-on-Climate-Finance-Definitions.pdf

Hague District Court ordered Royal Dutch Shell to cut Scope 1, 2, and 3 emissions by 45% by year-end 2030 relatively to the baseline year 2019. This landmark ruling originated from a lawsuit filed by an environmental protection organization, setting a precedent of its kind, determining that a high emission company is responsible for climate change, thereby exposing companies operating in specific industries to new carbon emissions legal risks (Hösli, 2021).

UN Environment's work on climate finance focuses on supporting private sector financial institutions including Banks and Investors to mitigate climate risks, seize the commercial opportunities from climate action, and ultimately take all necessary measures to fully align portfolios with the mitigation and adaptation objectives of the Paris Agreement[2]. Indeed, at the 2019 UN Climate Summit in New York City, banks making new commitments to disclose the carbon emissions of their investment and loan portfolios, while adhering to the new Principles for Responsible Banking. This includes phasing out financing for fossil fuel energy projects to the aim to align their entire portfolios with the Paris Agreement, also to meet the new Climate Benchmark. The idea was also supported by various initiatives, such as the Financial Stability Board's "Task Force on Climate-Related Financial Disclosures" or the "Network of Central Banks and Supervisors for Greening the Financial System". Moreover, under the Sustainable Stock Exchange Initiative of United Nations, there are 38 exchanges worldwide that include ESG (Environmental, Social and Governance) guidance. Green financial system is also crucial for achievement of Sustainable Development, and thus, the growing importance of Sustainable and responsible investments (SRI) recording an impressive growth over the last two decades, reaching an aggregate value of $30.7 trillion at the end of 2019, 34% up with respect to year-end 2018[3].

Under the Paris Agreement, countries committed to make finance flows consistent with a low-emission and climate-friendly economy and drive sustainable economic growth. In this context, the EU has launched an ambitious Action Plan on Financing Sustainable Growth.

The EU, its Member States (including the UK) and the European Investment Bank are together the biggest contributor of public climate finance to developing countries with the primary objective of Becoming climate-neutral by 2050. While large scale investment, up to totaling hundreds of billions of Euro per year, are needed for the adaptation to the adverse effects of climate change and for a climate-resilient, and resource-efficient economy, private investments will complement investments of public money at the European, national and local levels. Indeed, only when the huge amount of investment flows belonging to the private sector intervene, can we actually have a strong action in contrasting the effects of climate change.

Nonetheless in terms of private and institutional investors, the question arises as to whether the increase in stringent criteria in the field of Emission could affect the risk and return profile of portfolios, in particular with regard to the new climate benchmarks aiming to increase transparency on investors" alignment with the needs of ambitious climate scenarios

Two climate benchmarks aimed at reallocating capital towards a low-carbon and climate resilient economy. According to Hoepner et al. (2019), an "EU Climate Transition Benchmark" means a benchmark that is labelled as an EU Climate Transition Benchmark

[2] https://www.i4ce.org/wp-core/wp-content/uploads/2019/09/I4CE%E2%80%A2Framework_Alignment_Financial_Paris_Agreement_52p.pdf

[3] "Global Sustainable Investments Rise 34 Percent to $30.7 Trillion", Bloomberg Markets, April 1st, 2019.

where the underlying assets are selected, weighted or excluded in such a manner that the resulting benchmark portfolio is on a decarbonization trajectory and is also constructed in accordance with the minimum standards laid down in the delegated acts. An "EU Paris-aligned Benchmark" means a "benchmark that is labelled as an EU Paris-aligned Benchmark where the underlying assets are selected in such a manner that the resulting benchmark portfolio's GHG emissions are aligned with the long-term global warming target of the Paris Climate Agreement ". The two climate benchmarks pursue similar objectives but vary in their level of ambition while they both required a GHC reduction of at least 7% on average per annum: in line with or beyond the decarbonization trajectory from the IPCC"s 1.5°C scenario, the EU Climate Transition Benchmarks establishes a reduction of GHG intensity or absolute emissions of 30 % lower than investable universe and for the Paris-Aligned Benchmarks the GHG intensity reduction raise up to 50% lower than investable universe

As the Climate policy regulation is becoming more prominent, for investors (Bioy, 2019), questions which arises whether climate change affect portfolio performance? If so, are investment strategies that focus on climate-friendly stocks achieving increased returns and a lower riskiness level?

Our study builds on previous literature (see among others Bătae *et al*., 2021 and Bernardini *et al*., 2019) and it aims to examine the Impact of Carbon Emissions on Investment Performance. To conduct this analysis, we match emission data from the Thomson Reuter Refinitiv and stock prices from Eurostoxx600 Index. This provides us with a dataset of 600 stocks in the period 2006-2020. We divide the equities into mutually exclusive portfolios based on their carbon footprint, using equally-weighted construction methods.

Our results indicate that low-carbon portfolios slightly outperform high-carbon portfolios and that stocks with high carbon emissions underperform in the market. In terms of riskiness does emerge a U-shape relationship between volatility and emission score in line among others with Liesen et al. (2017)[4] and Bernardini et al. (2019)[5].

The topic of emissions that at this time in the context of Climate actions is the real "big issue", is scarcely hidden in the academic financial literature, although: i) there is growing awareness amongst investors that the changing climate impact the financial system stability (Carney, 2015); ii) investors pick stocks based on climate measures (Bătae *et al.,* 2021[6]; Choi *et al*., 2020) and their portfolios are exposed to transition risk (Clapp *et al*., 2017).

Our contribution to previous literature is threefold. Firstly, we analyze together with the financial performance also the riskiness of High and Low Emission portfolios. Secondly, we focus on the European countries that is currently the area of the world with a greater focus in terms of emission regulation policy. Lastly, in line with Lins et al, (2017) we posit that company 'investments in social and environmental capital provide an insurance-like protection to corporations when markets suffer a negative shock, and we provide empirical results supporting these hypotheses.

[4] Liesen et al. (2017) found that investors achieved abnormal returns of up to 13% annually by exploiting inefficiently pricing of stocks based on the disclosure of GHG emissions.
[5] Bernardini et al. (2019) found a positive correlation between investment returns and low-carbon stocks.
[6] Bătae et al., 2021 in a panel of 39 European banks, shows a positive relationship between emission reductions and financial performance.

The paper is structured as follows. Section 2 describes the background and develops the hypotheses. Section 3 presents the selection process and data features. Section 4 discusses the empirical results. Section 5 concludes the paper.

2. Literature review and hypothesis development

With spread of awareness of how people are contributing to environment pollution and carbon emission, Governments increase their attention to this global problem by making firms responsible for carbon emission reduction. That is the reason why international policies towards restrictions of carbon emissions create both opportunities and risks for firms (Trinks *et al*., 2020; Wang *et al*., 2021). To provide a rich understanding of relationship between carbon emission reduction and its effects on firm, literature considers the analyzes of two aspects: firm financial performance and firm risk.

The literature on the relationship between carbon emission efficiency and firm financial performance is widespread. Previous studies revealed positive association between environmental regulation and firm financial performance (Tang *et al*., 2018; Ma *et al.*, 2021), where the obvious benefits for the company are seen in efficient use of resources and cost minimization due to waste reduction (Xie *et al.*, 2019; Duque-Grisales *et al.* (2020). The effect of regulation is also important because carbon emission has a negative effect on financial performance (Griffin *et al.*, 2017; Fullerton & Heutel, 2007). According to Gallego-Álvarez et al. (2015) if emissions are reduced, it generates positive impact on financial performance, which also depends on whether companies tend to promote greater environmental behaviour. Delmas et al. (2015) and Zhou et al. (2018) found that firm with low carbon intensity demonstrated higher long-term market financial performance and higher market value. Research on positive association of carbon efficiency and financial performance also include studies on specific measures that quantify and rank firm's dependence on carbon in the production process (Trinks et al., 2020), moderation effect of resource efficiency (Wang *et al*., 2021), green innovations as drivers for resource efficiency (Farza *et al*., 2021).

Fewer studies analyzed the impact of CSR on the company cost of debt capital, where in general, they confirmed a positive association with carbon emissions dimension of CSR (Kumar *et al.*, 2018; Jung *et al*., 2018; Zhou *et al*., 2018; Caragnano *et al*., 2020). In particular, Kumar et al. (2018) found positive and significant relationship between carbon emissions and cost of debt financing. Jung et al. (2018) highlighted the importance of carbon risk assessment during controlling for the overall risk and proved the existence of mitigation effects of firm carbon risk on its cost of debt for companies with high carbon awareness. Zhou et al. (2018) revealed a U-shaped relation between carbon risk and the cost of debt financing and discussed possible factors that can moderate this relationship, such as media attention. Caragnano et al. (2020) found an evidence of positive effect of reduced carbon emissions on the cost of debt financing in both high and low emitting industries, however, high emitting firms pay a higher cost of debt financing than low emitting firms.

Literature indicates that diverse regulations of carbon emission footprint across countries bring different effects, in particular, strict carbon emission policies make firms experience stronger impact of carbon performance on financial performance (Zhang *et al.*, 2008; Wang *et al.*, 2012; Wang *et al.*, 2021), however, studying of how carbon performance affects financial performance in a particular area can help companies understand their potential financial benefits from increasing their environmental

responsibilities. According to Cucchiella et al. (2017), dramatic reduction of greenhouse emission is a moral obligation of developed countries, and indicated that activities with high-energy consumption in these countries led to return maximization and increase demand and productivity.

To improve their environmental performance firms, have to use eco-innovative products, thus, invest into new environmental technologies to reduce carbon emissions. Due to high cost of such emission reduction and expensive low-carbon technologies which might exceed the economic return, carbon intensity reduction can affect negatively the financial performance indicators, such as ROA, firm investment value, Tobin Q (Busch & Lewandowski, 2018; Olsthoorn *et al*., 2001), proving no significant relation between emission reduction and firm financial performance. Another risk comes from the fluctuation of carbon prices that affect the power generation cost of power companies and, as a result, the firm stock value (Palmer *et al*., 2018). This demonstrates a very strong connection between carbon prices and stock returns of power companies, that need to be understood from the side of policymakers to stabilize the mechanisms on the carbon market and from the side of investors to optimize their portfolios. Tian et al. (2016) investigated the relationship between the European Union Allowance market and stock returns of electricity companies and found that this relationship is driven by market shocks, where stock returns of carbon-intensive companies are negatively affected for high carbon-intensive producers, which is opposite for less-carbon intensity companies.

Very few studies address the emission restrictions directly, apart from CSR score, however, they are a very important part of environmental regulations. It is also essential to understand whether investors pay attention to the level of carbon emissions footprint when making their decisions and accessing creditworthiness of companies. Alsaifi (2020) underlined the importance of carbon emission disclosure for positive market reaction in carbon-intensive industries. Radu et al. (2020) underlines the importance of carbon emission for accessing the default and reputational risk. Karim et al. (2021) provides a measurement to capture the CO2 emission including scope 1 and scope 2, and ESG score, and found a positive relationship between capital expenditure and carbon emission disclosure. Ilhan et al. (2021) estimated the effects of carbon emissions on downside risk and found that high carbon emissions increase downside risk for firms in high-emission industries. All in all, the existing literature speaks about the crucial necessity in carbon awareness as business strategy for highly polluting companies and investor attention towards considering the level of carbon footprint emissions in their decisions.

A growing literature in support of risk mitigation hypothesis, draws attention to the concept of CSR resilience involving risk management capabilities of companies, including carbon efficiency impact on systematic risk exposure and total risk. Trinks et al. (2020) proved that carbon efficiency impacts the total risk (systemic and non-systemic risks) negatively and significantly in firms from carbon-intensive industries. Other studies conclude that carbon efficiency does affect systematic risk through its relation to the cost of equity capital (Dietz *et al*., 2018). Unlike previous papers documenting a negative association between CSR and firm risk and cost of equity (El Ghoul *et al*. 2012; Oikonomou *et al*., 2012), Albuquerque et al. (2019) revealed the channel through which CSR policies affect firm systematic risk and firm value, and offered a model predicting that CSR was actually decreasing systematic risk but increasing firm value. Wang et al. (2021) proved close relationship between carbon efficiency and resource efficiency and its effect on financial performance, in particular lowering the systematic risk.

With increasing concern on environmental pollution and global warming from greenhouse gases emission, many studies involve CSR approach as a resilience tool especially in times of financial turmoils, however the focus of this CSR is seen only from the side of environmental issues (Garel & Petit-Romec, 2021; Alsaifi 2020). Albuquerque et al. (2020) found that stocks with high CSR ratings demonstrated significantly higher returns and lower volatilities than other stocks during COVID period of 2020, that made the conclusion about especially well performance of firms with high CSR rating during financial crushes and highlighted the importance of CSR policies in making firms more resilient during crisis. Bae et al. (2021) see market crash of COVID-19 as an opportunity to test that CSR protects firm value during crisis periods. Therefore, for the reasons mentioned above, we posit the following:

H1: Low-Emission portfolios are not penalized both in terms of return and risk, then High-Emission

The way investors value CSR performance of companies during financial turmoil is reflected in a number of papers. They find that long-term investing is associated with higher demand for CSR and in general, better CSR performance is valued more by investors (Nguyen *et al*., 2020). Better stock price performance of high CSR score companies is expected during crisis period if the CSR activities are related to stakeholders' increased demand for CSR (Bae *et al*., 2021), however, pre-crisis CSR might not be effective to protect shareholder wealth from adverse effects of crisis (Bae *et al.*, 2021). Very few papers analyzed a specific CSR dimension during crisis time. According to Garel and Petit-Romec (2021), environmental score of CSR is significantly and positively related to stock returns during crisis. Lins et al. (2017) underlines the importance of social dimension, they found that high CSR firms have stronger relations to stakeholders, therefore, it is the social capital that provides insurance against event risk for this companies. They also proved that high CSR firms experienced higher profitability, growth, and sales than low CSR firms during the crisis. In the line of above we propose the following

H2: During financial turmoil, accordance with the insurance-like effect of the social capital, proxied by the Emission score, Low emission companies tend to achieve better performance, than High emission companies.

3. Data and methodology

Among a number of investment decision rules used in investment choices, our paper considers the one related to business activities and environmental impact in terms of harmful emissions. The aim of our research method is to highlight that investing in low emission firms is not penalizing the financial performance. One of the key elements at COP 21 on December 2015, the so-called Paris Agreement, is to "making finance flows consistent with a low GHG emissions and climate-resilient pathway".

To achieve this goal, multi-stakeholder interventions are necessary and require not only a public effort, but also an individual private effort. To this end, our investment strategy is built upon previous literature (see among others, Abdelsalam *et al*., 2014 and Matallín *et al*., 2019) accounting for the emission level of each companies listed on the Exx600 Benchmark.

To be specific, in this paper, we apply the recursive portfolio approach (Busse *et al.*, 2010; Fama & French, 2010) by ranking stocks year by year according to emission score, from lowest and highest, and consequently we create and compare a series of portfolios performance based on emission scores starting from the statistical distribution of scores. Basically, we identify the emission score as the discriminating factor of investment choices, as if investors were using only this score to distinguish which companies to invest in. To do this, the historical series of the portfolios are built on emission scores on the basis of two rules for the construction of portfolios.

As a first rule of portfolio allocation, we consider companies with an emission score in year t below the median (low scores) and companies with a value above the median (high scores). Following the portfolio allocation rule described above, we introduce a second rule that identifies five portfolios based on the quintile distribution of the emission score. The analysis of the quintiles allows to better understand the return as a function of the statistical distribution of the emission score, catching any non-linear relationships. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the above median group. The portfolios for the top quintile Q1 contain the stocks with the lowest emission scores (emission score of the 20% worst stocks), while in Q5 it includes the top 20% of the best-scoring stocks.

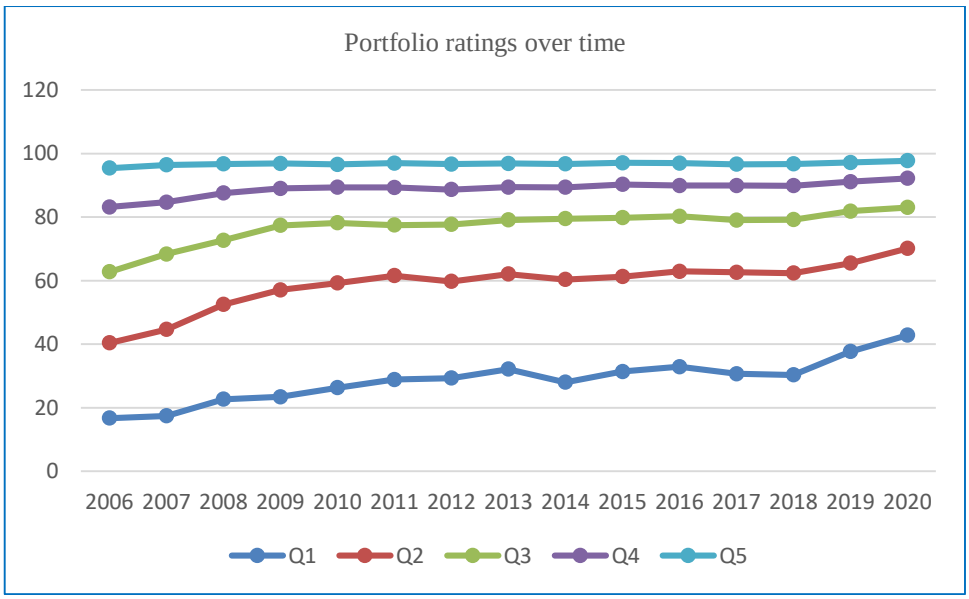

Fig. 1. Portfolio ratings over time

For each year in our sample period, this figure shows the Performance (Annual Return) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: above Median (High), below Median (Low), Lower two quintiles (Q1_Q2) and Upper tow Quintiles (Q4_Q5). Emission scores of Stocks listed in Eurostoxx600 Index come from Refinitiv. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed.

The empirical analyzes considers both risk and return profile of portfolios in order to verify whether investment choices oriented towards companies with low emissions could involve a kind of "second best" due constraint to the production process and

consequently to the company output. The results below do not confirm this "fear". Investors addressing to companies with low emissions are neither penalized in terms of return nor experiencing a higher level of overall riskiness. We build portfolios to catch the relationship between harmful emissions and financial performance, rather than to study a single stock. Companies considered in the analysis are those listed on EURO STOXX 600 index. We use monthly prices of this index for the period 2005-2020. To reveal the insurance-like benefits of social and environmental capital, we also deepen our results by considering the financial turmoil periods. To this end, we disentangle our empirical evidence by analyzing two recent crisis period, the Global Financial crisis, covering 2008-2010 years, and the recent COVID pandemic in 2020.

Our measure of Emission intensity is the Emission score drawn from EIKON Refinitiv Database, aiming to measures a company's commitment and effectiveness towards reducing environmental emission in the production and operational processes. Throughout the time, the quintile median value grows as well as the emission score due to both attention of policymakers and law enforcement on emissions reduction. These motivations push the quintile distribution to the top (Fig.1).

4. Empirical results

The results showed that portfolios built with a high environmental emissions score do not necessarily have a worse return than those with a lower score. In Table 1, When we compare High Emission Score vs Low Emission Score, and we find, on average, a positive difference, both with respect to the median and Quintiles criteria.

Table 1. Performance of Emission-based selection at a cut-off rate corresponding to Median and Quintiles

PANEL A - All Period

Year	Low Emission Score (Below Median)	High Emission Score (Above Median)	Diff	Low emission Score (Quintile 1 and 2)	HIgh emission Score (Quintile 4 and 5)	Diff
2006	10,04%	6,73%	-3,31%	18,98%	13,24%	-5,74%
2007	2,18%	2,52%	0,34%	4,90%	4,50%	-0,39%
2008	-24,30%	-24,12%	0,18%	-50,37%	-48,93%	1,44%
2009	23,33%	21,97%	-1,36%	45,36%	44,34%	-1,02%
2010	6,68%	7,79%	1,11%	14,75%	15,22%	0,47%
2011	-3,77%	-2,22%	1,55%	-7,06%	-5,15%	1,91%
2012	8,79%	9,44%	0,65%	17,75%	17,95%	0,21%
2013	8,94%	10,90%	1,96%	17,70%	20,77%	3,06%
2014	6,52%	5,74%	-0,78%	12,71%	12,02%	-0,69%
2015	5,13%	8,30%	3,17%	10,57%	18,74%	8,17%
2016	3,23%	2,40%	-0,83%	6,68%	5,07%	-1,60%
2017	11,21%	10,19%	-1,02%	21,68%	21,00%	-0,68%
2018	-4,24%	-3,09%	1,14%	-8,17%	-6,61%	1,56%
2019	11,47%	9,45%	-2,02%	22,74%	19,92%	-2,81%
2020	4,00%	5,46%	1,46%	7,22%	9,78%	2,57%
Mean Return	4,61%	4,76%	0,15%	9,03%	9,46%	0,43%

PANEL B - Crisis Period (Global Financial Crisis and Covid Pandemic)

Year	Low Emission Score (Below Median)	High Emission Score (Above Median)	Diff	Low emission Score (Quintile 1 and 2)	HIgh emission Score (Quintile 4 and 5)	Diff
2008	-24,30%	-24,12%	0,18%	-50,37%	-48,93%	1,44%
2009	23,33%	21,97%	-1,36%	45,36%	44,34%	-1,02%
2010	6,68%	7,79%	1,11%	14,75%	15,22%	0,47%
2020	4,00%	5,46%	1,46%	7,22%	9,78%	2,57%
Mean Return	2,43%	2,77%	0,35%	4,24%	5,10%	0,86%

For each year in our sample period, this Table shows the Performance (Annual Return) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: Panel A: above Median (High) and Panel B: below Median (Low) or Lower two quintiles (Q1_Q2) and Upper tow Quintiles (Q4_Q5). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. In Panel A, they are then clustered into above/below median group, where the above median group corresponding to those stocks with the best performance and below median group including the 50% of stocks with worst performance (corresponding to the Lowest Emission scores). In Panel B, they are then clustered into quantiles, the first quintile corresponding to those stocks with the worst performance and the fifth quintile including the 20% of stocks with better performance (corresponding to the highest Emission scores). Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the above median group. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed. Crisis period cover the Global Financial Crisis (2008-2010) and the Covid pandemic (2020).

As a matter of fact, results in Fig.2 and Fig.3 (the year-to-year comparison between companies with scores above and below the median and between two quintiles with the greatest value (Quintile 4 and Quintile 5) and two quintiles with the least value (Quintile 1 and Quintile 2), demonstrate no evidence that companies with low emission score underperform the ones with high emission score (confirming our H1). When considering the whole time period, the differentials of mean return are positive both from median and quintile analyses (respectively 0.15% and 0.43%). Therefore, investors making their sustainable decisions based on high emission score should not have low returns expectations. From this point of view, sustainability is not seen as a disadvantage to the remuneration of the investment.

If the investor's perspective is shifted by using a reinvestment allocation, the return on maturity from having invested in a portfolio of low-Emission shares is even higher (Fig. 4 and Fig.5). In such a way, if we reassess the portfolio at the beginning and until the end of each year, and cumulate the return of each portfolio, we can obtain a positive yield from high score portfolios. Furthermore, the yield to maturity of Quintiles 4 and 5 is greater than High Emission Score. This evidence suggests that among high score emission companies, the top 25% of stocks performed better (in the "portfolio return" graphs contained in fig.2, 187,18% vs 260,18%); that means a lower emission level is coupled to a higher return at maturity. This result is in line with Gallego-Alvarez et al. (2015), Trinks et al. (2020), and Wang et al. (2021) finding a positive correlation between lower carbon emissions and profitability.

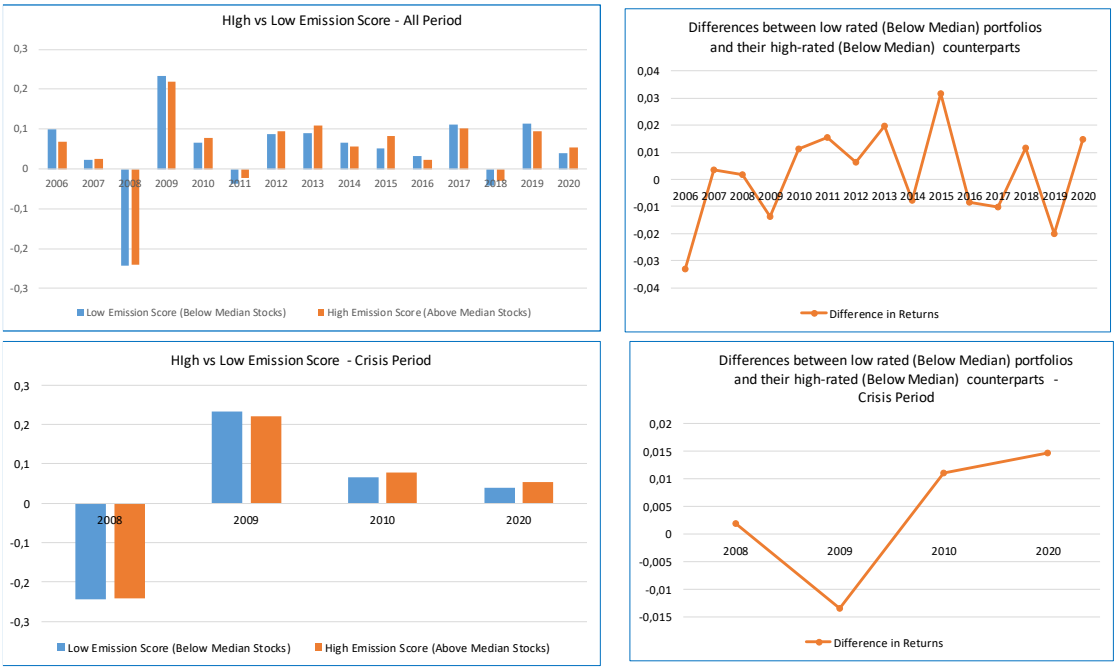

Fig. 2. Performance of Emission-based selection - High (Above Median) vs Low (Below Median)

For each year in our sample period, this figure shows the Performance (Annual Return) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: above Median (High) and below Median (Low). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. They are then clustered into above/below median group, where the above median group corresponding to those stocks with the best performance and below median group including the 50% of stocks with worst performance (corresponding to the Lowest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the above median group. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed. Crisis period cover the Global Financial Crisis (2008-2010) and the Covid pandemic (2020).

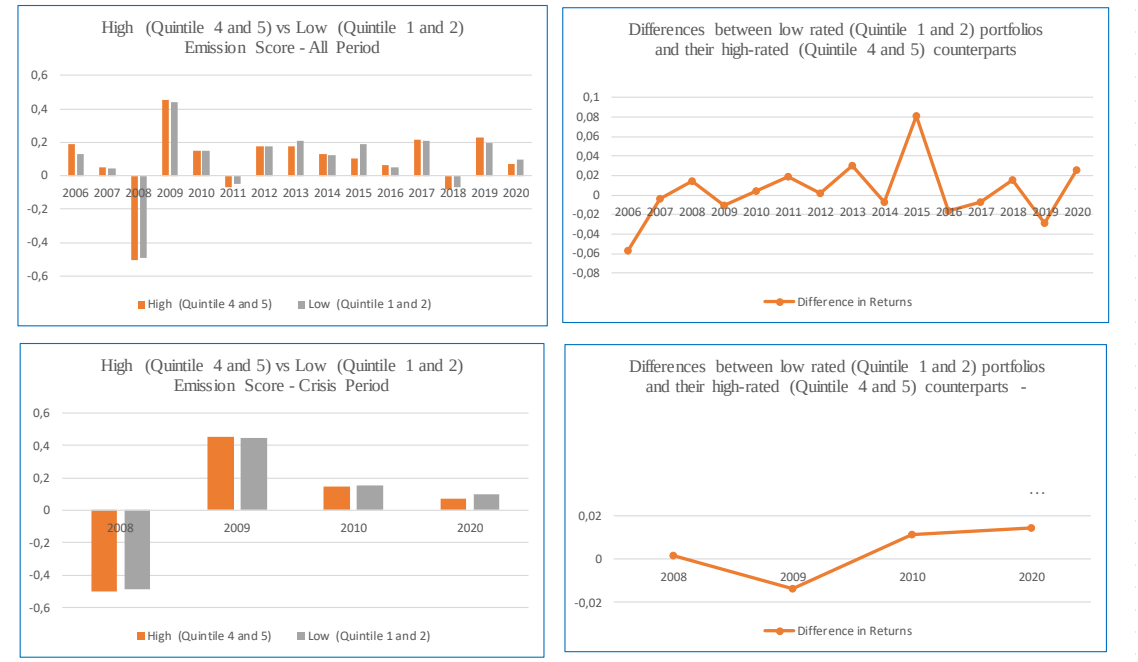

Fig. 3. Performance of Emission-based selection - High (Quintile 4 and 5) vs Low (Quintile 1 and 2)

For each year in our sample period, this figure shows the Performance (Annual Return) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: Lower two quintiles (Q1_Q2) and Upper tow Quintiles (Q4_Q5). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. They are then clustered into quantiles, the first quintile corresponding to those stocks with the worst performance and the fifth quintile including the 20% of stocks with better performance (corresponding to the highest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the first and second (quintile). In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed. Crisis period cover the Global Financial Crisis (2008-2010) and the Covid pandemic (2020).

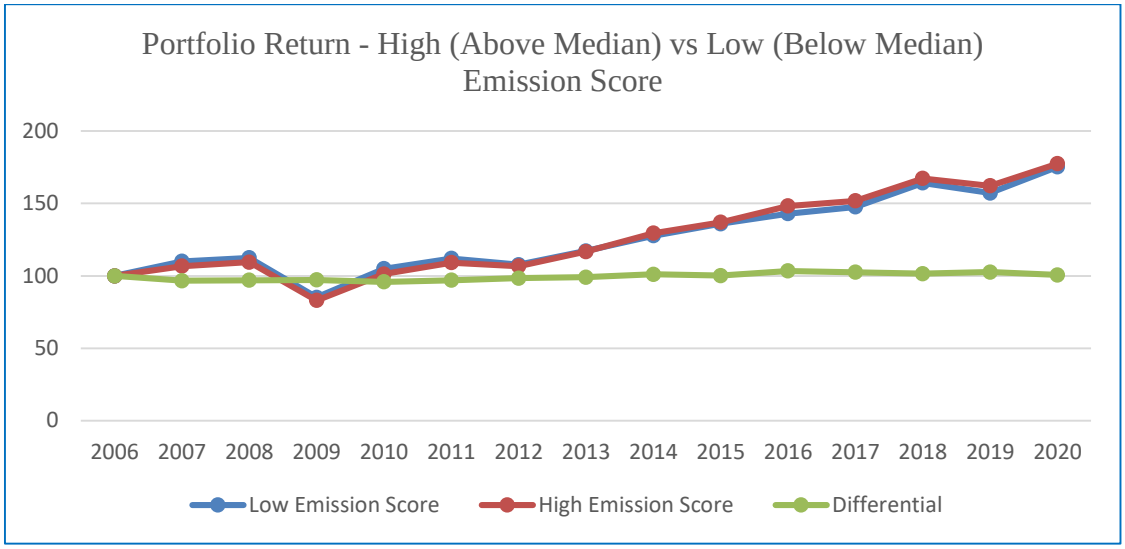

Fig. 4. Portfolio Return - High (Above Median) vs Low (Below Median) Emission Score

For each year in our sample period, this figure shows the Performance (Annual Return) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: above Median (High) and below Median (Low). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. They are then clustered into above/below median group, where the above median group corresponding to those stocks with the best performance and below median group including the 50% of stocks with worst performance (corresponding to the Lowest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the above median group. Each of these portfolios starts investing in the 2006, in such a way that the portfolio is reassessed at the beginning of each year and until the end of the sample period. With this information, we compute the cumulative return of each portfolio. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed.

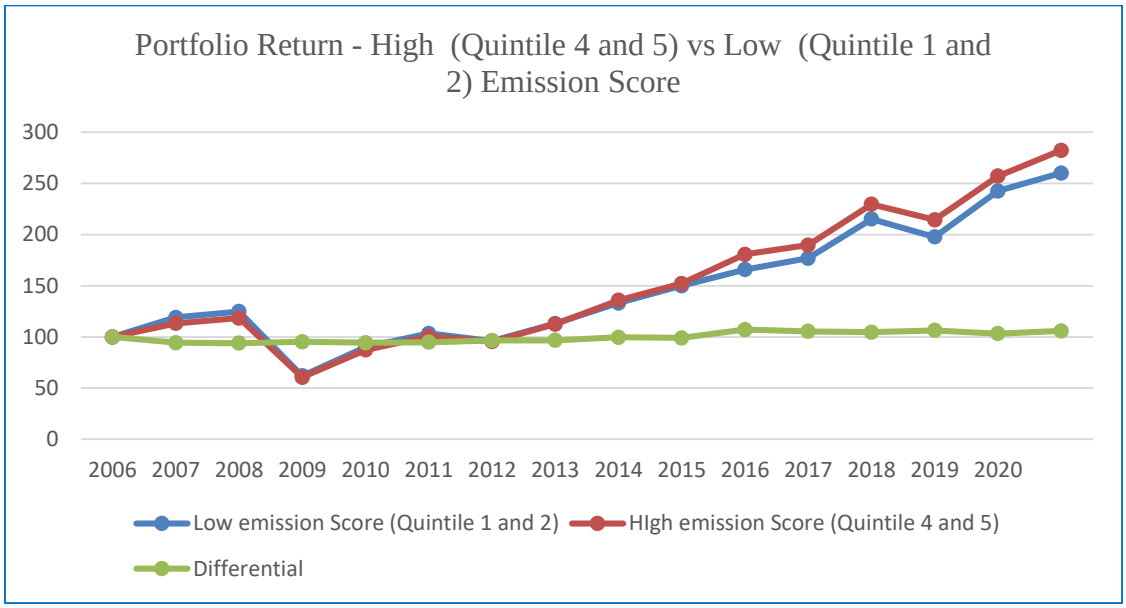

Fig.5. Portfolio Return - High (Quintile 4 and 5) vs Low (Quintile 1 and 2) Emission Score

For each year in our sample period, this figure shows the Performance (Annual Return) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: Lower two quintiles (Q1_Q2) and Upper tow Quintiles (Q4_Q5). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. They are then clustered into quantiles, the first quintile corresponding to those stocks with the worst performance and the fifth quintile including the 20% of stocks with better performance (corresponding to the highest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the first and second (quintile). Each of these portfolios starts investing in the 2006, in such a way that the portfolio is reassessed at the beginning of each year and until the end of the sample period. With this information, we compute the cumulative return of each portfolio. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed.

A better performance of high emission scoring portfolios seems to be present also in crisis periods (confirming our H2). Investing in high-score stocks allows investors to earn more when the markets experience a turmoil period, the symptom of increased resilience to financial crises and a possible solution to build portfolios with fewer concerns during crisis periods. If we consider the overall crises periods, the differentials of mean return are 0.35% and 0.86% for High vs Low score, respectively, and Q4-5 vs Q1-2. Moreover, even during the most acute phase of the COVID-19 in 2020, companies with high emission scores had a higher average return than those with low emission scores, where the differential of High Emission Score vs Low Emission Score was 1,46%, while for Quintile 4 and 5 vs Quintile 1 and 2 it was 2,57% for 2020 (Table 1, Crisis Period section).

Table 2. Risk of Emission-based selection Portfolio at a cut-off rate corresponding to Median and Quintiles

For each year in our sample period, this Table shows the Risk (Volatility proxied by Standard Deviation) of portfolios containing the best-rated (worst-rated) firms according to specific threshold in terms of emission Score, that is: Panel A: above Median (High) and Panel B: below Median (Low) or Lower two quintiles (Q1_Q2) and Upper tow Quintiles (Q4_Q5). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. In Panel A, they are then clustered into above/below median group, where the above median group corresponding to those stocks with the best performance and below median group including the 50% of stocks with worst performance (corresponding to the Lowest Emission scores). In Panel B, they are then clustered into quantiles, the first quintile corresponding to those stocks with the worst performance in terms of Riskiness and the fifth quintile including the 20% of stocks with better performance (corresponding to the highest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the above median group. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed. Crisis period cover the Global Financial Crisis (2008-2010) and the Covid pandemic (2020).

	All Period					
Year	Low Emission Score	High Emission Score	Diff	Low emission Score (Quintile 1 and 2)	HIgh emission Score (Quintile 4 and 5)	Diff
2006	19,32%	21,30%	1,98%	18,63%	21,52%	2,89%
2007	23,92%	24,95%	1,03%	24,44%	24,95%	0,51%
2008	42,73%	45,12%	2,39%	42,80%	47,71%	4,91%
2009	49,10%	45,81%	-3,30%	42,83%	45,62%	2,79%
2010	25,68%	28,35%	2,67%	26,28%	29,81%	3,53%
2011	23,56%	20,79%	-2,77%	22,55%	20,92%	-1,63%
2012	22,36%	24,28%	1,93%	21,45%	25,05%	3,59%
2013	21,96%	29,34%	7,38%	22,79%	27,22%	4,43%
2014	21,20%	20,42%	-0,78%	19,70%	20,94%	1,24%
2015	24,65%	27,68%	3,03%	25,11%	26,82%	1,71%
2016	27,87%	22,69%	-5,19%	29,51%	23,04%	-6,47%
2017	21,23%	23,09%	1,87%	19,82%	22,27%	2,46%
2018	22,11%	24,33%	2,22%	21,89%	23,80%	1,91%
2019	23,46%	22,07%	-1,39%	23,19%	22,10%	-1,10%
2020	22,35%	24,82%	2,47%	22,36%	23,31%	0,95%
Mean Volatility	26,10%	27,00%	0,90%	25,56%	27,01%	1,45%

Crisis Period (Global Financial Crisis and Covid Pandemic)

Year	Low Emission Score	High Emission Score	Diff	Low emission Score (Quintile 1 and 2)	HIgh emission Score (Quintile 4 and 5)	Diff
2008	42,73%	45,12%	2,39%	42,80%	47,71%	4,91%
2009	49,10%	45,81%	-3,30%	42,83%	45,62%	2,79%
2010	25,68%	28,35%	2,67%	26,28%	29,81%	3,53%
2020	22,35%	24,82%	2,47%	22,36%	23,31%	0,95%
Mean Volatility	34,97%	36,02%	1,06%	33,57%	36,61%	3,05%

Fig. 6. Risk of High (Above Median) vs Low (Below Median) Emission Score Portfolio

For each year in our sample period, this figure shows the Risk (Volatility proxied by Standard Deviation) of portfolios containing the best-rated (worst-rated) firms according to specific threshold, that is: above Median (High) and below Median (Low). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. They are then clustered into above/below median group, where the above median group corresponding to those stocks with the best performance and below median group including the 50% of stocks with worst performance (corresponding to the Lowest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the above median group. In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed. Crisis period cover the Global Financial Crisis (2008-2010) and the Covid pandemic (2020).

With regard to the riskiness analysis, portfolios built on shares with high emission scores and portfolios built on bad emission scores present similar risks over the years. In our results, in the middle of emission score distribution – where there are companies with neither high nor low emission scores – there are portfolios with the lowest risk. Table 2 summarizes the findings of riskiness analysis. The analyzes of mean standard deviation (not showed in Table), shows that values of Quintiles 1 and 5 (27,08% and 28,16%, respectively) are higher than the values of Quintiles from 2 to 4 (24,03%, 26,65% and 25,84% respectively).

Fig. 7. Risk of High (Quintile 4 and 5) vs Low (Quintile 1 and 2) Emission Score Portfolio

For each year in our sample period, this figure shows the Risk (Volatility proxied by Standard Deviation) of portfolios containing the best-rated (worst-rated) firms according to specific threshold: Lower two quintiles (Q1_Q2) and Upper tow Quintiles (Q4_Q5). Emission scores come from Refinitiv. Stocks are ranked according to their Emission performance, proxied by Emission scores from lowest to highest. They are then clustered into quantiles, the first quintile corresponding to those stocks with the worst performance and the fifth quintile including the 20% of stocks with better performance (corresponding to the highest Emission scores). Then we create portfolios that follow an investment strategy consisting of selecting stocks according to their quintile each year. Within all portfolios, stocks are weighted equally. Portfolio decompositions are adjusted at the end of every year provided that changes in the Emission score have occurred. The literature refers to this methodology as a recursive portfolio. For example, High portfolio invests proportionally and in an equally weighted fashion in stocks that were included in the first and second (quintile). In addition, the differences between low rated portfolios and their high-rated counterparts are analyzed. Crisis period cover the Global Financial Crisis (2008-2010) and the Covid pandemic (2020).

This outcome shows a non-linear connection between risk and the scoring of emissions, that in the research stream of Climate Finance is known as a U-form relationship between Corporate Social Performance and Financial Performance. This evidence also emerges when portfolios with high scores vs those with low scores are compared over the years, so we observe an erratic trend (Fig.6 and Fig.7) with a slightly

positive drift. Indeed, the differentials of mean standard deviation are positive in both groups: high vs low and Q4-5 vs Q2-1, suggesting more risks for high score portfolio (0,90% and 1,45%, respectively, in Table 2), even this figure slightly rises up to 1,06% and 3,05% respectively) during crisis period. This means that, less risky portfolios are those that are placed in the quintiles close to the median value. Therefore, the Latin phrase "in medio virtus stat" can be adapted to risk analysis associated with construction of portfolios with low/high scores.

5. Conclusion

Given the growing social awareness of investors and the increasing regulatory environment targeting the Emission reduction, the potential impact over financial investments has become a major topic of interest for both researchers and practitioners. Therefore, the efforts of policymakers must focus on improving the transparency, quality, and availability of data reported by the financial industry. The European Commission has launched in March 2018, for first in their action plan, new tools for financing sustainable growth and enhancing the ESG transparency of benchmark methodologies. Under this framework the European Commission promotes an initiative to put forward the standards for the methodology of low-carbon benchmarks in the EU, namely the Paris-aligned and the Climate transition Benchmarks. Therefore, obtaining information related to social responsibilities and financial characteristics of these investment tools plays an important role in improving investment decisions of all individuals participating in the market.

Both private and institutional investors might have a fear that the new policy framework will negatively affect investment performance, in particular, with regard to the emission reduction claims. The primary purpose of this paper is to investigate the effect of stocks' carbon emissions score on investment performance. We explicitly intend to answer the following research question: do low-carbon investments perform differently than high-carbon investments? Due to the inconsistent results reported in the existing literature, we think this is an interesting topic that needs further exploration.

The study focuses on stocks listed on the Eurostoxx600 Benchmark, during the period 2006- 2020. By using a new international dataset of Refinitiv Emission scores and implementing a variety of portfolio screens, we find that selecting high (low) Emission stocks does not appear to consistently increase or decrease investment performance relative to the benchmarks and to low (high) ESG stocks. In Europe, we find an evidence that investors pay a slightly price for being socially responsible in their stock selection, in terms of overall riskiness while observing a U-shaped relationship between riskiness and Emission level. Moreover, this study also highlights the importance of Low Emission stocks during turmoil periods, according to well-known insurance-like protection attribute associated with ethical investments. Therefore, our empirical evidence shows, all in all, that there are no significant performance differences between High and Low emission stocks. However, we observe a slight overperformance in terms of financial return of portfolio that selects Low Emission stocks.

These findings have several theoretical and practical implications. This is especially relevant for asset manager, aiming to promote mutual funds investing in sustainable assets to meet a higher socially-conscious objectives in their financial products. Indeed, by taking more care about the company's involvement in socially responsible programs, financial intermediaries can satisfy the ethical needs of their investors by Emission-based stock selection. Under this rationale, by implementing a variety of portfolio screens, we

provide insights for fund managers to optimize their financial and sustainable investment decisions and offer 'socially filtered' investment funds.

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