Does Environmental Investment Pay Off? – Portfolio Analyses of the E in ESG during the European Russia Ukraine War and Global Public Health Crises

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Abstract

This paper examines the contribution of environmental investment in the times of the European Russia Ukraine Conflict and Global Public Health Crises. The analysis employs a portfolio approach to investigate the impact of emission reductions and green technology innovations manifested in news and social media on investment alphas. The results indicate that engaging in environmental activities increases the cost of investment during the noncrisis time. In contrast, the evidence suggests that advocating for environmental protection creates value when companies face crises, especially after the breakout of the Russia Ukraine War. These findings partly support that environmental investment serves as a risk hedging vehicle for political, health, and economic crises. In addition, compared to corporate internal ESG disclosures, a firm-level study of external media environmental scores mitigates the endogeneity issue between a company's internal activities and its intrinsic characteristics.

Key words: Environmental Investment, ESG, Portfolio Analysis, European Russia Ukraine War, Global Public Health Crisis

1 | INTRODUCTION

There has been much hype around sustainable investing, especially for environmental criteria, such as emission, waste reductions, and green technologies. In October 2022, the OECD released a statement in its fifth roundtable to boost sustainable investment globally. However, whether environmental investment creates value for shareholders is still an important question to answer. The value creation school argues that strong environmental propositions increase a company's competitive advantage in risk management and improve its financial performance (Dowell et al., 2000), while the cost-concerned school argues that environmental investments represent increased costs – agency cost and negative cash flows, resulting in decreased earnings and lower market values (Hassel et al., 2005; Krüger, 2015). In this study, we construct US stocks' portfolios according to their emission reduction score and environmental score, and further test the environmentally sorted portfolios' performances when exposed to the European Russia Ukraine War and Global Health Crises.

Energy-related emissions and climate change impose negative consequences on human health, water resources, food supply, industrial development, etc. Thus, significant investments have been made in corporate social responsibility (CSR) and clean energy development to alleviate such environmental issues. Following the Paris Agreement in December 2015, with 190 countries plus the European Union agreeing to reduce their carbon emissions and limit the global temperature increase, recent studies have attempted to address the impact of climate risk, such as carbon risk, on asset prices (Agliardi et al., 2023; Delis et al., 2019; Ilhan et al., 2021). However, although it has been drawing considerable attention, the impact of environmental investment remains unclear, especially in times of crisis.

Political uncertainty generates a negative shock to economic conditions, which commands a risk premium by investors (L. Pástor & Veronesi, 2012; Ľ. Pástor & Veronesi, 2013). The outbreak of the Russia Ukraine War on February 24, 2022, has been developed to be the most prominent political conflict in Europe since the Second World War. This important European political issue has brought about impacts on climate change adaptation and vulnerability, as addressed in the IPCC (2022) report. A relevant question in financial economics is whether the environmental, social, and governmental (ESG) investment alleviates a portion of political risk drawn from the spread of the conflict, future sanctions, and policy uncertainties due to the Russia Ukraine geopolitical crisis. Deng, Leippold, Wagner, and Wang (2022) documented that in the US market, firms more exposed to climate transition risk are compensated with higher risk premia after the outbreak of the Russia Ukraine war. Basnet, Blomkvist, and Galariotis (2022) show that firms with ESG scores have a less negative stock market reaction during the Russia Ukraine War. In contrast, Kalhoro, Kumar, and Kyaw (2022) found that the Russia-Ukraine war is more pronounced in the western region. Their results indicated that ESG ETFs underperformed conventional ETFs in the US. Following the aforementioned literature on this current European geopolitical issue, we compare the portfolio performances according to the environmental emission and technology criteria using a US sample similar to some of these studies.

Another recent global crisis is the COVID pandemic, which is considered an unprecedented worldwide health and socioeconomic crisis. The aftermath of the COVID crisis calls to understand the financial behavior of companies and individuals as a response to public health shock, especially whether the relevant environmental, social, and governmental (ESG) practices mitigate parts of public health risks during global pandemics. Zhou and Zhou (2021) posited that ESG performance plays a role in managing risks during global health pandemics. Their empirical evidence suggested that the stock price volatility of companies with good ESG performance is lower than that of companies with poor performance. Furthermore, Boubaker, Liu, and Zhan (2022) found that CSR practices improve firms' resilience to negative health crisis shocks. Their findings showed that high CSR firms gain higher cumulative abnormal returns at the time of COVID. Contrary to this line of perspectives, Demers, Hendrikse, Joos, and Lev (2021) presented that ESG offers no such positive explanatory power for companies' financial performance during the COVID crisis. Additionally, Bae, El Ghoul, Gong, and Guedhami (2021) found that there is no evidence to support the positive association between CSR practices and stock performance during global health pandemics. Based upon the above perspectives and evidence, we study stock portfolios of US companies with high vs. low environmental performance when those companies are facing global health shocks.

In this paper, we explore the relationship between environmental and financial performance through a portfolio analysis approach. We further compare whether the impact of environmental investment remains the same or changes when there is a global political conflict or public health pandemic. The emissions and environmental innovation scores are obtained from Refinitiv MarketPsych Environmental, Social, and Governance (RM-ESG) Analytics. RM-ESG encompasses a multidimensional set of asset-specific and market-wide proxies that capture key ESG themes in twelve languages. Rather than scoring sustainability from a company's own reports, the Refinitiv MarketPsych ESG Analytics feed provides external news and social media-based perspectives on ESG initiatives and performance. Emissions and environmental innovation represent a company's emission reductions and green technology development, respectively. Following the daily portfolio sorting suggested by Boehmer, Jones, and Zhang (2008) and Wang, Yan, and Zheng (2020), each day, we sort US stocks into quintiles based on emissions and environmental innovation scores during the previous five trading days.

By rebalancing a four-trading day (weekly) holding portfolio, we have shown that sorted portfolios on both emissions and environmental innovation criteria generate negative financial performance from Jan 1999 to Dec 2022. Specifically, the emissions sorted portfolio analysis indicates that a trading strategy with a long position in a High-Emission quintile and a short position in a Low-Emission quintile generates a negative annualized alpha of 3.70% (FF5 + UMD alpha); the environmental innovation sorted portfolio analysis indicates that a trading strategy with a long position in a High-Environmental-Innovation quintile and a short position in a Low-Environmental-Innovation quintile generates a negative annualized alpha of 3.18% (FF5 + UMD alpha).[1] However, the findings suggested that alphas for both High-Minus-Low emissions and environmental innovation are positive but statistically insignificant during the European Russia Ukraine War. Compared to the pre-war time, the change from a negative and statistically significant alpha to a positive alpha indicates a change in the use of environmental investment in political risk hedging. The portfolio analysis conditional on the Public Health Crisis also suggested some similar evidence that alphas for both High-Minus-Low emissions and environmental innovation become positive but statistically insignificant during the global COVID pandemic. Compared to the non-pandemic time, the change from a negative and statistically significant alpha to a positive alpha signals a change in using environmental investment in health risk hedging. Our findings for environmental performance during normal times align with the cost-concerned school that environmental investments represent increased costs – agency cost and negative cash flows, resulting in decreased earnings and lower market values (Hassel, Nilsson, and Nyquist, 2005; Kruger, 2015). However, our results also moderately support the value creation school that a strong

[1] In this paper, we calculate the annualized alpha by multiplying the daily alpha (-0.0147% and -0.0126%, respectively, in Table 2) by 252.

environmental proposition serves as a risk management tool and improves financial returns to investors (Dowell et al., 2000).

Our robustness checks of environmental sorted portfolios over business cycles further supported that environmental investment is no longer an additional cost during poor economic conditions. Our further robustness checks of environmental sorted portfolios over different market sentiment states suggested that the effect of media-based emissions and environmental innovation scores are not driven by elevated sentiments in the market.

Our study is related to the literature that empirically tests the pricing of environmental performance. Examples include Pedersen, Fitzgibbons, and Pomorski (2021); Brandon, Krueger, and Schmidt (2021); Agliardi et al. (2023), among others. Most of the literature has attributed the pricing effect of ESG as being either a risk factor or a behavioral fade. Our study tests the performances of environmental sorted portfolios across different political, public health and economic conditions. Thus, we documented a dual feature of environmental investment that manifested differently across various conditions, in which it is attributed as an additional cost during normal times but functions as a risk hedging tool when companies face elevated external risks.

Our findings further shed light on the impact of two current European and Global crises, the Russia Ukraine war and the COVID pandemic, on environmental and financial performance. As crises may accelerate or retard certain aspects of international cooperation in and transitions to a low carbon/green energy economy, how and to what extent those effects are transferred to the financial market is a much-discussed question (Demers et al., 2021; Deng et al., 2022). We offer the first study to empirically test the role of environmental investment in major global crises and try to generalize a risk hedging hypothesis to support the change in market reactions during both the Russia Ukraine war and COVID pandemic compared to non-crisis times.

Our work also contributes to the literature by measuring environmental portfolio performance through two firm-level climate change indicators, emission reductions and green technology developments. Our proxies of emissions and environmental innovation are constructed based on external news and social media-based topics on a daily basis. Compared to the internal ESG disclosure through earnings conference calls (Eccles & Serafeim, 2013; Eckerle et al., 2020) and company press releases (Capelle-Blancard & Petit, 2019), the high frequency external media ESG score better reflects investors' opinions on a firm's environmental engagements. Unlike company internal ESG reports, daily media environmental proxies avoid endogeneity issues between corporate internal activities and corporate's intrinsic characteristics.

The remainder of this paper is organized as follows. Section 2 reviews the environmental and financial performance theories and develops the hypotheses. Section 3 introduces the data and environmental portfolio construction. Section 4 discusses empirical results including portfolio analyses over the Russia Ukraine war, public health pandemics, business cycles and market sentiment states. Section 5 provides further discussions and suggests future research avenues.

2 | THEORY AND HYPOTHESIS DEVELOPMENT

2.1 | Environmental investment and stock returns

A large body of literature has investigated the relationship between environmental responsibility and financial performance. Unfortunately, the empirical evidence does not reach a consensus. Studies that used stock returns as the financial performance measure could be categorized into three groups: portfolio studies, event studies, and (multivariate) regression studies (for a review, see Berchicci and King (2007)). The current literature based on event studies mainly studies external or internal news related to environmental issues (positive or negative). Portfolio-constructing studies typically compose mutually exclusive portfolios based on various corporate social performance indicators, one or multiple of which are environmentally related. Regression-based research focuses more on pollution control initiatives (Derwall et al., 2005). Few of these studies focus solely on environment-related factors. Our research aims to complement this strand of study.

Regarding the theory, researchers within the cost-centered school argue that pollution abatement and environmental improvements are costly, with high uncertainty, and thus decrease marginal net benefits (Avramov et al., 2022). In addition, the agency cost perspective argues that environmental performance primarily benefits managers who earn a good reputation as "sustainable" or "green" corporate leaders among key stakeholders at the expense of shareholders. These two arguments propose a downward evaluation from shareholders for positive news about environmental responsibility. For example, Krüger (2015) used the event study and finds that investors respond slightly negatively to the release of positive CSR news, especially news concerning communities or the environment. He attributed the results to the agency problem and the negative short-term cash-flow implications (p. 314).

In contrast, the value creation school proposes that economic inefficiency motivates firms to be environmentally innovative, which might fully offset related costs. Specifically, managers engage with stakeholders because such environmental projects are deemed to have positive net present value (NPV). For example, Derwall, Guenster, Bauer, and Koedijk (2005) show that portfolios of companies with strong environmental responsibility generate risk-adjusted excess returns. Furthermore, environmental corporate social responsibility could generate new and competitive resources for firms. Flammer (2013) used an event study and finds that companies reporting behaving responsibly (irresponsibly) toward the environment experience a significant stock price increase (decrease).

Based on these two sides of schools, we propose a pair of hypotheses with opposite directions:

H1a: ***Investment in emission reduction and environmental technology contributes to risk premiums, in turn increasing shareholders' value.***

H1b: ***Investment in emission reduction and environmental technology generates additional costs, in turn decreasing shareholders' value.***

2.2 | Political uncertainty

Political news dominates financial markets; in addition, political uncertainty is a negative shock to the stock market, which requires a risk premium by investors, leading to a positive relationship between political uncertainty and changes in stock prices (Pástor and Veronesi 2012, 2013). The outbreak of the Russia Ukraine War on February 24, 2022, has been developed to be the most prominent political conflict in Europe since the Second World War (1939-1945). Although the Russia Ukraine War is a negative shock to the stock market, firms with better ESG performance might be able to have a buffer and suffer less. Studies based on the Russia Ukraine War find that firms with higher ESG scores will experience less negative stock market reactions after they completely exit the Russian market, indicating that ESG could help firms better navigate political uncertainty (Basnet et al., 2022). Based on this, we propose our second hypothesis as follows:

H2: ***Environmental investment alleviates political uncertainty during political conflicts.***

However, it is also possible that ESG might not provide a buffer for the firm. For example, Kalhoro et al. (2022) found that the Russia-Ukraine war is more pronounced in the western region. Their results indicated that ESG ETFs underperformed conventional ETFs in the US.

2.3 | Social and economic uncertainty

Similar to the political uncertainty's influence on the effectiveness of ESG investment, social and economic uncertainty might also have an effect. A recent global crisis is the COVID pandemic, which is considered an unprecedented worldwide health and socioeconomic crisis.

Zhou and Zhou (2021) posited that ESG performance plays a role in managing risks during global health pandemics. Their empirical evidence suggested that the stock price volatility of companies with good ESG performance is lower than that of companies with poor performance. Furthermore, Boubaker, Liu, and Zhan (2022) supported that CSR practices improve firms' resilience to negative health crisis shocks. Their findings showed that high CSR firms gain more cash support from their customers to overcome the COVID-19 pandemic, resulting in a higher cumulative abnormal return at the time of COVID. Based on this, we propose our third hypothesis as follows.

H3: ***Environmental investment mitigates social and economic uncertainty during public health crises.***

It is also possible that ESG did not play a role in alleviating the negative effect of the COVID crisis; for example, Demers et al. (2021) documented that ESG offers no such positive explanatory power for companies' financial performance during the COVID crisis. Additionally, Bae et al. (2021) found that there is no evidence to support the positive association between CSR practices and stock performance during global health pandemics.

3 | DATA AND METHODS

3.1 | Data sample

In this research, we test the effects of emissions and environmental innovation on US stock portfolios. Specifically, we study the effects of emissions and environmental innovation on the Russia Ukraine war, public health pandemics, and business cycles. Unlike financial reports, ESG data disclosure is unstructured and can be published at any time of the year. To make it useful to financial professionals, ESG reported data needs to be standardized and simplified for analysis. Our stock-specific ESG proxies come from Refinitiv MarketPsych Environmental, Social, and Governance (RM-ESG) Analytics. RM-ESG encompasses a multidimensional set of asset-specific and market-wide proxies that capture key ESG themes in thirteen languages.[2] The RM-ESG database covers over 85% of the global market cap, more than 20,000 active companies from over 120 countries, across more than 630 different ESG metrics, which largely come from corporate public reporting (annual reports, corporate social responsibility (CSR) reports, company websites and global media sources). With such a large increase in corporate sustainability reporting set to continue, the investment industry will be able to evaluate the long-term health of companies in a more holistic way, considering both financial and business sustainability dimensions.

MarketPsych uses a natural language processing (NLP) engine to crawl news and social media websites for firm-related content regarding ESG. RM-ESG is a global industry standard for textual processing in financial markets, and its sources are extensive, coming from 2000 news and 800 social media platforms around the world, including all notable news outlets from Wall Street Journal, CNBC, Bloomberg and Reuters, social media forums from Seeking Alpha and finance-specific tweets (Tham, 2022). It uses a proprietary reference bible of labeled positive or negative words and semantic inference rules to quantify text for their sentiment scores in a lexicon approach similar to Loughran and McDonald (2015).

Based on the RM-ESG user's guide, the emissions category score measures a company's commitment and effectiveness towards reducing environmental emissions in the production and operational processes; the environmental innovation category score reflects a company's reduction of environmental impact and the creation of new market opportunities through new green technologies and design. The RM-ESG analyses both news and social media news in real time and

[2] English-language text is scored starting from 1998. Arabic, Chinese, Japanese, and Portuguese-language news sources are scored since February 2020, with Dutch, French, German, Indonesian, Italian, Korean, Spanish, and Russian added in January 2021.

uses them to obtain sentiment scores for ESG topic-related news for firms ranging from 1 to 100. One indicates the most negative sentiment, and 100 indicates the most positive sentiment.

Our study utilizes a comprehensive research sample that encompasses 5,650 stocks traded between January 1, 1999, and December 31, 2022, which coincides with the availability period of the RM-ESG dataset. Out of the sample of 5,650 stocks, there are 1,844 stocks listed in NYSE, 253 stocks listed in AMEX, and 3,553 stocks listed in NASDAQ. We source the daily returns of these stocks from the Center for Research in Securities Price (CRSP) while the financial data is obtained from COMPUSTAT. To ensure the reliability of our findings in various market sentiment conditions, we employ the Baker and Wurgler (2006) and Huang, Jiang, Tu, and Zhou (2015) Sentiment Indexes as our market level sentiment proxies. Furthermore, we obtain our business cycle data from the National Bureau of Economic Research (NBER). In addition, we estimate the Beta coefficient by regressing the past 12-month daily returns on market returns. We calculate market capitalization (Size) and book-to-market equity (B/M) the same way as Fama and French (2006) do. We compute Amihud's illiquidity (Illiquid) based on Amihud (2002). We estimate idiosyncratic volatility (IVOL) for each stock using the past month (month t-1) of daily returns based on the Fama and French (1993) model, following Ang, Hodrick, Xing, and Zhang (2006).

Table 1 provides summary statistics about the variables involved in this study. US common stocks experience an average cumulative return of 0.00% from the second to the fourth day in the previous 5-day holding period, with an emission mean score of 32.23 (out of 100) and an environmental innovation mean score of 45.30 (out of 100). Note that both emissions and environmental innovation scores are left skewed and entail fat tails. The average Beta coefficient (Beta) is 1.07. The average market capitalization (Size) is $7.398 billion. The average book-to-market ratio (B/M) is 0.60. The average illiquidity ratio (ILLIQ) is 1.19. The average idiosyncratic volatility (IVOL) is 3% per day.

[Insert Table 1 Here]

3.2 | Sort portfolios

A portfolio approach is a natural way to measure these cross-sectional differences (Boehmer et al., 2008; Pan & Poteshman, 2006; Wang et al., 2020). This approach has several advantages. First, it is easy to interpret because it replicates the gross and/or risk-adjusted returns to a potential trading strategy, assuming (counterfactually) that one could observe all these real-time environmental investment data. Second, compared to a regression approach, aggregation into portfolios can reduce the impact of outliers. Finally, portfolios can capture certain non-linearities that might characterize the relationship between environmental investment activity and future returns. Thus, in the time-honored asset pricing tradition, we begin by sorting stocks into portfolios based on our emissions and environmental innovation measures. Each day, we sort into quintiles based on the prior five days of environmental investment activity.

For each formation date, we create equal-weighted portfolios with a holding period of 4 trading days. The portfolios are rebalanced daily. Specifically, we skip one day (day 1) and hold the portfolios for the next 4 days (from day 2 to day 5) to alleviate concerns about any possible microstructure effects (i.e., 5 trading days in total after the formation date, which is equivalent to a length of a week). Therefore, there are overlapping four-day holding period returns. To address this overlap, we use a calendar-time approach to calculate average daily returns (Boehmer et al., 2008; Jegadeesh & Titman, 1993; Wang et al., 2020). Each trading day's portfolio return is the simple average of four different daily portfolio returns, and 1/4 of the portfolio is rebalanced each day. We report the equal-weighted alphas based on the Capital Asset Pricing Model (CAPM) and Fama and French (1996) three-factor and Fama and French (2018) five-factor + UMD alpha, respectively.

The Fama-French five-factor + UMD alpha on portfolio p is the intercept in the following daily time-series regression:

$$\begin{aligned} R_{pt} - R_{ft} = \alpha_p + \beta_{p,1} RMRF_t + \beta_{p,2} SMB_t + \beta_{p,3} HML_t + \beta_{p,4} RMW_t \\ + \beta_{p,5} CMA_t + \beta_{p,6} UMD_t + \varepsilon_{p.t} \end{aligned} \tag{1}$$

where $R_{p,t} - R_{f,t}$ is the excess returns of portfolio p on day t, which is the portfolio average daily return minus the one-month Treasury bill daily rate. $RMRF_t$ is the daily market risk premium. SMB_t is the average return on the small stock portfolios minus the average return on the big stock portfolios. HML_t is the average return on the value portfolios minus the average return on the growth portfolios. RMW_t is the average return on the robust operating profitability portfolios minus the average return on the weak operating profitability portfolios. CMA_t is the average return on the conservative investment portfolios minus the average return on the aggressive investment portfolios. UMD_t is the average return on the up momentum portfolios minus the average return on the down momentum portfolios.

4 | EMPIRICAL RESULTS

4.1 | Environmental investment and stock returns

Table 2 presents the results to test our first hypothesis. As in prior studies (Boehmer et al., 2008; Wang et al., 2020), we exclude day 1 when calculating the portfolio returns. Our holding period is day 2 to day 5.

We find that firms that have the best environmentally related scores underperform firms with the least environmentally related scores over the holding period. For example, using Fama-French five-factor + UMD alpha as a benchmark model, we find that the best environmentally performed stocks underperform the least environmentally performed stocks by an annualized risk-adjusted return of 3.704% (t = 2.78) if the environmental performance is measured based on emissions-related news and by an annualized risk-adjusted return of 3.175% (t=2.70) if the environmental performance is measured based on environmental innovation-related news.[3]

Our results seem to support the additional cost theory, i.e., H1b, which argues that CSR primarily benefits managers at the expense of shareholders (Cheng et al., 2023) and that shareholders do not reward investment aimed at improving a firm's environmental footprint (Krüger, 2015). One of the underlying reasons might be the increasing costs related to environmental investments. Our results support the findings and argument that low environmental performance is associated with higher returns (Agliardi et al., 2023).

[Insert Table 2 Here]

We also present the FF5+UMD alpha and the average Emission score (the average Environmental Innovation score) for each portfolio in Figure 1. Panel A of Figure 1 shows that the best environmentally performed stocks earn an average score of 86.72 out of 100, while the least

[3] We calculate this annualized alpha by multiplying the daily alpha -0.0147% (-0.0126%) by 252, which equals -3.7044% (-3.1752%).

environmentally performed stocks earn an average score of 0 out of 100. On the opposite, the top performers in emissions related issues have an average annual FF5+UMD alpha of 3.074% (t = 23.21), while the bottom ones have an average annual FF5+UMD alpha of 6.779% (t = 5.81).[4] Panel A shows the opposite changes between emissions scores and the FF5 + UMD alpha. Panel B shows similar trends.

[Insert Figure 1 Here]

To test the robustness of our results, we further control cross-sectional differences by double sorting the stocks. First, we sort stocks into quintiles based on size or market-to-book ratio for the previous one month. Within a characteristic (size or market-to-book ratio) quintile, we then sort a second time into quintiles each day based on the environmental sentiment over the past 5 trading days. The result is a set of stocks that differ in the environmental investments but have similar size or market-to-book ratio.

Table 3 reports the daily Fama-French five-factor + UMD alphas between the best environmentally performed and the least environmentally performed quintiles. Panel A (Panel B) of Table 3 reports the results if the environmental performance is measured based on emissions (environmental innovation) related news. Panel A shows that for the largest firms, the more emission related investments the firms make, the better the market perceive because the best environmentally performed stocks overperform the least environmentally performed by a Fama-French five factor + UMD alphas of 2.117% (t = 1.69) per year.[5] It seems that the market rewards big firms if they are involved in helping improve the environment. Panel B shows that for the smallest sized firm, the market punishes those who overly involved in the environmental innovation, because we find that in the subsample of the smallest stocks, best environmentally performed stocks underperform by 2.621% (t = 1.81) per year.[6] Panel B also shows that for those undervalued stocks, i.e., stocks with high book-to-market ratio, the market punishes those who overly involved in the environmental innovation, because we find that in the subsample of the

[4] We calculate this annualized alpha by multiplying the daily alpha 0.0122% (0.0269%) by 252, which equals 3.0744% (-6.7788%).
[5] We calculate this annualized alpha by multiplying the daily alpha 0.0084% by 252, which equals 2.1168%.
[6] We calculate this annualized alpha by multiplying the daily alpha -0.0104% by 252, which equals -2.6208%.

highest book-to-market stocks, the best environmentally performed stocks underperform by 6.124% (t = 3.83) per year.[7]

[Insert Table 3 Here]

4.2 | Political uncertainty

Agliardi et al. (2023) argue and find that although low environmental performance is associated with higher returns, high environmental performance is positively related to reduced risk. Based on this strand of findings (Agliardi et al., 2023; Hoepner et al., 2016; Martiradonna et al., 2022), we first move on to test whether environmental investment alleviates political uncertainty during political conflicts.

We measure political uncertainty by using the post period after (including) February 24, 2020, following Basnet et al. (2022) and Deng et al. (2022). We separate our sample into the pre-War period and the post-War period. Then, we construct portfolios based on environmental investment measurements. Based on prior studies (Agliardi et al., 2023; Hoepner et al., 2016; Martiradonna et al., 2022), we predict that firms with the largest investment in environmental issues, such as emissions and innovations, are more likely to suffer less from the political uncertainty, while firms with the smallest environmental investments might suffer more in the post-War period. In addition, Deng et al. (2022) points out that given Europe's relatively pronounced dependency on Russian oil and gas, stocks with pronounced climate change opportunities and with investments in renewable energy sources are more welcomed in the market and outperform stocks without the investments.

Table 4 reports the Fama-French five-factor + UMD alphas. Panel A (Panel B) of Table 4 reports the results if the environmental performance is measured based on emissions (environmental innovation)-related news. Although we fail to find any significance based on the environmental innovation scores, the results based on the emission scores show that during the Russian-Ukrainian war period, the market reacts significantly negatively to stocks with low environmental performance (based on emissions), with a negative alpha of 11.390% (t=1.63) per

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[7] We calculate this annualized alpha by multiplying the daily alpha -0.0243% by 252, which equals -6.1236%.

year, [8] resulting in a positive alpha, i.e., the overperformance of stocks with the highest environmental investment, of 10.332% (t = 1.52) per year.[9] Compared to the pre-war time, the change from a negative and statistically significant alpha to a positive alpha indicates a change in the use of environmental investment in political risk hedging. These results resonate with the findings of prior studies (such as, Basnet et al. (2022), Deng et al. (2022)), which are that better ESG performance helps stocks to suffer less during periods of high political uncertainty.

In addition, we find that during the pre-war period, i.e., normal periods, the stocks that invest the most in environmental issues (emissions and innovations) underperform those that invest the least by 4.41% (t = 3.37)[10] per year and by 3.578% (t=3.11)[11] per year, respectively. These results show that during pre-war periods, the market prefers stocks with the lowest environmental performance.

The combined results point to the direction that during normal periods, the market treats the largest environmental investment as an additional cost. However, during periods of high political uncertainty, the market will reward those with the heaviest investment in environmental issues. One of the reasons is that Russia’s behavior during the war period, such as cutting off the supply of oil and gas, makes the market prefer stocks with investments in renewable energy sources, one outcome of which is smaller emissions (or larger investment in emissions). These results support H2, which is that environmental investment alleviates political uncertainty during political conflicts.

[Insert Table 4 Here]

4.3 | Social and economic uncertainty

After checking whether environmental investment alleviates political uncertainty during political conflicts, we test whether investment mitigates social and economic uncertainty during public health crises. We expect similar results to those of political uncertainty.

[8] We calculate this annualized alpha by multiplying the daily alpha -0.0452% by 252, which equals 11.390%.
[9] We calculate this annualized alpha by multiplying the daily alpha 0.0410% by 252, which equals 10.332%.
[10] We calculate this annualized alpha by multiplying the daily alpha -0.0175% by 252, which equals -4.41%.
[11] We calculate this annualized alpha by multiplying the daily alpha -0.0142% by 252, which equals -3.5784%.

Following Hassan, Hollander, van Lent, Schwedeler, and Tahoun (2022), we test the SARS period (March 12, 2003 to July 5, 2003), the H1N1 period (April 15, 2009 to August 11, 2010), and the COVID period (January 10, 2020 to March 8, 2021). If the environmental investment could alleviate the social and economic uncertainty during the public health crisis, then we could find mute or positive results during the public health crisis periods, and we could still find that market reward low investment in environments for other periods.

Table 5 presents the results. Panels A and B show that during the non-crisis periods, the highest environmental investment stocks underperform the lowest environmental investment stocks by 4.057% (t = 2.99) per year[12] and -2.394% (t = 2.00) per year[13], respectively. However, the underperformance is muted for the COVID period based on both measures, the SARS period for the innovation-related measurement, and the H1N1 period for the emission-related measurement. For the innovation-related measurement, we find that the highest environmental investment stocks underperform during the H1N1 period, which is similar to the results in the normal period. Although we find muted results for most periods with a public health crisis, we do not find enough evidence to strongly support the assertion that environmentally related investments could help alleviate the negative impact associated with the health crisis. Our prediction in H3 is not strongly supported. These muted results are in line with the findings of Bae et al. (2021) and Demers et al. (2021).

[Insert Table 5 Here]

One possible reason for the negative alphas during the H1N1 period for portfolios based on environmental innovation is that the H1N1 period overlaps with the recovery periods after the Global Financial Crisis and that environmental investments are treated as a cost during the non-crisis period. Matallín-Sáez, Soler-Domínguez, de Mingo-López, and Tortosa-Ausina (2019) find that the abnormal performance of US socially responsible funds is negative and significant in the expansion period but is not significant in recession periods. If this is the case in our setting, then we would find muted results in the recession periods. To test whether this is the case, we further construct the portfolios conditional on the business cycles identified by the NBER.[14] Table 6

[12] We calculate this annualized alpha by multiplying the daily alpha -0.0161% by 252, which equals -4.0572%.
[13] We calculate this annualized alpha by multiplying the daily alpha -0.0095% by 252, which equals -2.394%.
[14] The data is available at https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions.

reports the results. We find evidence supporting our argument and Matallín-Sáez et al. (2019)'s findings that during the non-recess periods, the market treats the heaviest environmental investment stocks worse than the least environmental investment stocks, contributing to the H1N1 results in panel B of Table 5.

[Insert Table 6 Here]

4.4 | Sentiment

Last, the results of political, social, and economic crises might come from lower market sentiment (Serafeim, 2020). To rule out this alternative explanation, we separate our portfolio based on the market sentiment measured by Baker and Wurgler (2006) and Huang, Jiang, Tu, and Zhou (2015) and report the results in Table 7. If what we find about the muted results during the crisis periods are the results of the low market sentiment, then we will find muted results for low sentiment periods. Our results from Table 7 find that this is not the case. We not only find that during the low sentiment periods, the highest environmental investment stocks underperform for all measurements but also for three of the measurements, the differences in alphas are larger during the low sentiment periods. These results further validate our cost-sensitive theory.

[Insert Table 7 Here]

5 | CONCLUSION

In this paper, we explore the relationship between environmental and financial performance through a portfolio analysis approach. We further compare whether the impact of environmental investment remains the same or changes when there is a global political conflict or public health pandemic. By rebalancing a four-trading day (weekly) holding portfolio, we find that sorted portfolios on both emissions and environmental innovation criteria generate negative financial performance from Jan 1999 to Dec 2022. In addition, the alphas for both High-Minus-Low emissions and environmental innovation become positive but statistically insignificant after the eruption of the European Russia Ukraine War. Compared to the pre-war time, the change from a negative and statistically significant alpha to a positive alpha indicates a change in the use of environmental investment in political risk hedging. The portfolio analysis conditional on the Public Health Crisis also provided some similar evidence that alphas for both High-Minus-Low emissions and environmental innovation become positive but statistically insignificant during the global COVID pandemic. Our findings for environmental performance during normal times align with the cost-concerned school that environmental investments represent increased costs, resulting in lower market values (Hassel, Nilsson, and Nyquist, 2005; Kruger, 2015), while our results provide partial support for the value creation school that a strong environmental proposition serves as a risk management tool during the crisis period, thus improving financial returns to investors (Dowell et al. 2000).

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Table 1 Descriptive Statistics

This table presents the descriptive statistics of variables involved in this study. The sample period is from January 1999 to December 2022. The sample consists of all CRSP common stocks traded in NYSE/AMEX/NASDAQ. The summary statistics include mean value (Mean), standard deviation (Stdev), total number of firm-month observations (N), 1st percentile, 25th percentile, 50th percentile, 75th percentile, 90th percentile and 99th percentile. Ret is the raw cumulative return from Day 2 to Day 4. *Emissions* and *Environmental Innovation* are Emissions Category Score and Environmental Innovation Category Score from Refinitive Marketpsych ESG analytics. Beta is the regression coefficient of the past12-month daily returns on market returns. Size and B/M are measured as in Fama and French (2006). Amihud is the illiquidity measure (*Illiquid*) in Amihud (2002). Idiosyncratic volatility (IVOL) is the standard deviation of residuals from a regression of daily stock returns in month t-1 on the Fama and French (1993) factors following Ang et al. (2006).

VARIABLE	N	MEAN	STDEV	1%	10%	25%	MEDIAN	75%	90%	99%
Ret	12,497,536	0.00	0.07	-0.18	-0.06	-0.03	0.00	0.03	0.06	0.21
Emissions	12,497,536	32.23	34.24	0.00	0.00	0.00	19.00	64.00	86.00	98.00
Environmental Innovation	12,497,536	45.30	34.75	0.00	0.00	6.20	48.40	77.60	91.20	99.00
Beta	12,497,536	1.07	0.54	-0.05	0.41	0.73	1.05	1.39	1.75	2.57
Size	12,497,536	7398.40	36372.97	14.00	85.07	258.78	874.23	3366.98	12716.71	133379.89
B/M	12,497,536	0.60	2.84	-0.48	0.10	0.24	0.46	0.78	1.19	3.28
Illiquid	12,497,536	1.19	18.77	0.00	0.00	0.00	0.00	0.03	0.21	19.64
IVOL	12,497,536	0.03	0.02	0.01	0.01	0.01	0.02	0.03	0.05	0.10

Table 2 Risk-Adjusted Alphas of *Emission* Portfolios

This table reports the CAPM alphas, Fama-French three-factor alphas, and Fama-French five-factor + UMD alphas of stock portfolios single-sorted on the prior-five-day average *Emissions* and *Environmental Innovation*, respectively. The differences in alphas between the high and the low portfolios are also reported. We construct overlapping portfolios with a four-day holding period (Day 2 to Day 5 after the formation date, Day 0). Daily alphas are reported in percentages. The t-statistics reported in parentheses are based on Newey–West standard errors. The sample period for *Emissions/Environmental Innovation* is Jan 7, 2008- December 31, 2022/Jan 1, 1999- December 31, 2022.

Portfolios	*Emissions*			*Environmental Innovation*		
	CAPM alpha	FF3 alpha	FF5 + UMD alpha	CAPM alpha	FF3 alpha	FF5 + UMD alpha
High	0.0087	0.0092	0.0122	0.0184	0.0134	0.0178
	(1.16)	(2.11)	(3.21)	(3.09)	(3.11)	(4.82)
4	0.0156	0.0162	0.0207	0.0257	0.0189	0.0234
	(1.65)	(3.32)	(4.85)	(3.58)	(4.24)	(6.16)
3	0.0196	0.0202	0.0247	0.0299	0.0221	0.0263
	(1.96)	(4.16)	(5.83)	(3.80)	(4.84)	(6.55)
2	0.0132	0.0132	0.0181	0.0276	0.0201	0.0259
	(1.24)	(1.78)	(2.54)	(3.01)	(3.06)	(4.25)
Low	0.0216	0.0226	0.0269	0.0325	0.0251	0.0303
	(2.13)	(4.48)	(5.81)	(4.02)	(5.12)	(6.67)
High-Low	-0.0129	-0.0133	-0.0147	-0.0141	-0.0116	-0.0126
	(-2.15)	(-2.50)	(-2.78)	(-2.73)	(-2.52)	(-2.70)

Table 3 Risk-Adjusted Alphas of *Emission* Portfolios Conditional on Size/BM

This table reports the Fama-French five-factor + UMD alphas of portfolios double-sorted first by the prior-month's Size or B/M and then by *Emissions/ Environmental Innovation*. Panels A and B report the results based on *Emissions* and *Environmental Innovation,* respectively. The differences in alphas between the high and the low portfolios are also reported. We construct overlapping portfolios with a four-day holding period (Day 2 to Day 5 after the formation date, Day 0). Daily alphas are reported in percentages. The t-statistics reported in parentheses are based on Newey–West standard errors. The sample period for *Emissions/Environmental Innovation* is Jan 7, 2008- December 31, 2022/Jan 1, 1999- December 31, 2022.

Panel A. Double sorts based on Size/BM and *Emission*				
Portfolios	Low *Size*	High *Size*	Low *B/M*	High *B/M*
High	0.0226	0.0162	0.0142	0.0186
	(1.42)	(4.26)	(3.23)	(1.80)
4	0.0332	0.0155	0.0154	0.0389
	(2.24)	(3.74)	(3.26)	(2.92)
3	0.0271	0.0100	0.0235	0.0346
	(1.80)	(2.26)	(4.97)	(2.62)
2	0.0379	0.0121	0.0108	0.0046
	(1.28)	(2.70)	(1.09)	(0.19)
Low	0.0165	0.0078	0.0193	0.0274
	(1.32)	(1.57)	(3.46)	(2.41)
High-Low	0.0061	0.0084	-0.0051	-0.0088
	(0.41)	(1.69)	(-0.81)	(-0.68)
Panel B. Double sorts based on Size/BM and *Environmental Innovation*				
Portfolios	Low *Size*	High *Size*	Low *B/M*	High *B/M*
High	0.0248	0.0138	0.0178	0.0182
	(5.29)	(3.51)	(4.25)	(3.45)
4	0.0284	0.0169	0.0190	0.0266
	(6.43)	(4.27)	(4.65)	(4.90)
3	0.0314	0.0122	0.0194	0.0282
	(6.42)	(3.02)	(4.12)	(5.26)
2	0.0376	0.0081	0.0187	0.0340
	(4.42)	(1.80)	(3.34)	(4.05)
Low	0.0352	0.0095	0.0142	0.0425
	(6.17)	(1.89)	(2.64)	(7.05)
High-Low	-0.0104	0.0044	0.0036	-0.0243
	(-1.81)	(0.96)	(0.61)	(-3.83)

Table 4 Risk-Adjusted Alphas of *Emission* Portfolios During the Russo-Ukrainian War

This table reports the Fama-French five-factor + UMD alphas of portfolios sorted by *Emissions/ Environmental Innovation* during Russo-Ukrainian war). Panels A and B report the results based on *Emissions* and *Environmental Innovation*, respectively. We check the effect of Russo-Ukrainian war within a period from Feb. 24, 2022, to Present. We also report the alphas of portfolios during normal periods, which are the periods not covered by these three public health crises. The differences in alphas between the high and the low portfolios are also reported. We construct overlapping portfolios with a four-day holding period (Day 2 to Day 5 after the formation date, Day 0). Daily alphas are reported in percentages. The t-statistics reported in parentheses are based on Newey–West standard errors. The sample period for *Emissions/Environmental Innovation* is Jan 7, 2008-December 31, 2022/Jan 1, 1999- December 31, 2022.

Panel A. Portfolios based on *Emission*		
Portfolios	Normal periods	Russo-Ukrainian war (Feb. 24, 2022-Present)
High	0.0128	-0.0042
	(3.33)	(-0.23)
4	0.0226	-0.0230
	(5.25)	(-1.29)
3	0.0259	-0.0137
	(6.30)	(-0.54)
2	0.0187	-0.0131
	(2.56)	(-0.49)
Low	0.0303	-0.0452
	(6.75)	(-1.63)
High-Low	-0.0175	0.0410
	(-3.37)	(1.52)
Panel B. Portfolios based on *Environmental Innovation*		
	Normal periods	Russo-Ukrainian war (Feb. 24, 2022-Present)
High	0.0185	-0.0100
	(4.93)	(-0.64)
4	0.0242	-0.0053
	(6.28)	(-0.31)
3	0.0275	-0.0195
	(6.79)	(-0.94)
2	0.0272	-0.0346
	(4.41)	(-1.31)
Low	0.0327	-0.0442
	(7.37)	(-1.34)
High-Low	-0.0142	0.0341
	(-3.11)	(1.14)

Table 5 Risk-Adjusted Alphas of *Emission* Portfolios Conditional on Public Health Crisis

This table reports the Fama-French five-factor + UMD alphas of portfolios sorted by *Emissions/ Environmental Innovation* conditional on three Public-health crises (i.e., SARS, H1N1, and COVID-19). Panels A and B report the results based on *Emissions* and *Environmental Innovation*, respectively. The SARS period is Mar. 12, 2003-Jul. 5, 2003, the H1N1 period is Apr. 15, 2009-Aug. 11, 2010, and the COVID-19 period is Jan. 10, 2020- Mar. 08, 2021. We also report the alphas of portfolios during normal periods, which are the periods not covered by these three public health crises. The differences in alphas between the high and the low portfolios are also reported. We construct overlapping portfolios with a four-day holding period (Day 2 to Day 5 after the formation date, Day 0). Daily alphas are reported in percentages. The t-statistics reported in parentheses are based on Newey–West standard errors. The sample period for *Emissions/Environmental Innovation* is Jan 7, 2008- December 31, 2022/Jan 1, 1999- Mar.08, 2021.

Panel A. Portfolios based on *Emission*

Portfolios	Normal periods	H1N1 (Apr. 15, 2009-Aug. 11, 2010)	COVID (Jan. 10, 2020-Mar.08, 2021)
High	0.0057	0.0327	0.0622
	(1.44)	(2.99)	(3.11)
4	0.0144	0.0471	0.0609
	(3.51)	(3.76)	(2.28)
3	0.0167	0.0554	0.0805
	(4.09)	(5.07)	(2.87)
2	0.0096	0.0372	0.0898
	(1.26)	(2.04)	(2.67)
Low	0.0218	0.0573	0.0556
	(4.86)	(3.96)	(2.31)
High-Low	-0.0161	-0.0246	0.0066
	(-2.99)	(-1.36)	(0.27)

Panel B. Portfolios based on *Environmental Innovation*

	Normal periods	SARS (Mar. 12, 2003-Jul. 5, 2003)	H1N1 (Apr. 15, 2009-Aug. 11, 2010)	COVID (Jan. 10, 2020-Mar.08, 2021)
High	0.0158	0.0609	0.0229	0.0545
	(3.98)	(1.91)	(2.73)	(3.03)
4	0.0213	0.0269	0.0336	0.0530
	(5.56)	(1.25)	(3.06)	(2.20)
3	0.0231	0.0355	0.0631	0.0522
	(5.70)	(1.33)	(4.59)	(2.09)
2	0.0189	0.3426	0.0642	0.0790
	(2.93)	(2.65)	(5.49)	(2.74)
Low	0.0252	0.0531	0.0622	0.0921
	(5.70)	(2.44)	(3.29)	(3.01)
High-Low	-0.0095	0.0078	-0.0393	-0.0376
	(-2.00)	(0.22)	(-1.88)	(-1.39)

Table 6 Risk-Adjusted Alphas of *Emission* Portfolios Conditional on Business Cycles

This table reports the Fama-French five-factor + UMD alphas of portfolios sorted by *Emissions/ Environmental Innovation* conditional on Business cycles. Panels A and B report the results based on *Emissions* and *Environmental Innovation*, respectively. Recession is an NBER's recession indicator, which equals 1 if the NBER's business cycle defines a recession that month and zero otherwise. The differences in alphas between the high and the low portfolios are also reported. We construct overlapping portfolios with a four-day holding period (Day 2 to Day 5 after the formation date, Day 0). Daily alphas are reported in percentages. The t-statistics reported in parentheses are based on Newey–West standard errors. The sample period for *Emissions/Environmental Innovation* is Jan 7, 2008- December 31, 2022/Jan 1, 1999- December 31, 2022.

Panel A. Portfolios based on *Emission*		
Portfolios	Recess periods	Non-Recess periods
High	0.0496	0.0067
	(2.70)	(1.95)
4	0.0546	0.0153
	(2.70)	(3.97)
3	0.0667	0.0199
	(3.31)	(5.26)
2	0.0522	0.0122
	(1.17)	(2.21)
Low	0.0734	0.0254
	(3.54)	(5.80)
High-Low	-0.0238	-0.0187
	(-1.05)	(-3.66)
Panel B. Portfolios based on *Environmental Innovation*		
High	0.0510	0.0133
	(3.60)	(3.64)
4	0.0604	0.0191
	(3.86)	(5.08)
3	0.0720	0.0205
	(4.26)	(5.32)
2	0.0639	0.0208
	(3.95)	(3.27)
Low	0.0834	0.0272
	(4.67)	(6.10)
High-Low	-0.0324	-0.0140
	(-1.63)	(-3.14)

Table 7 Risk-Adjusted Alphas of *Emission* Portfolios Conditional on Sentiment

This table reports the Fama-French five-factor + UMD alphas of portfolios sorted by *Emissions/ Environmental Innovation* conditional on Sentiment. Panels A and B report the results based on *Emissions* and *Environmental Innovation,* respectively. We identify high/low sentiment based on the market sentiment level at the formation date using the 50th percentile cutoff. The market sentiment is measured by Baker and Wurgler (2006)'s sentiment index and Huang, Jiang, Tu, and Zhou (2015)'s sentiment index, respectively. The differences in alphas between the high and the low portfolios are also reported. We construct overlapping portfolios with a four-day holding period (Day 2 to Day 5 after the formation date, Day 0). Daily alphas are reported in percentages. The t-statistics reported in parentheses are based on Newey–West standard errors. For Baker and Wurgler (2006)'s sentiment index, the sample period is from Jan 1999 to December 2020. For Huang, Jiang, Tu, and Zhou (2015)'s sentiment index, the sample period is from Jan 1999 to Jun 2022. The sample period for *Emissions/Environmental Innovation* is Jan 7, 2008- December 31, 2022/Jan 1, 1999- December 31, 2022.

Panel A. Portfolios based on *Emission*				
	Baker and Wurgler (2006)'s sentiment index		Huang, Jiang, Tu, and Zhou (2015)'s sentiment index	
Portfolios	Low sentiment	High sentiment	Low sentiment	High sentiment
High	0.0117	0.0139	0.0029	0.0203
	(2.46)	(2.48)	(0.61)	(3.80)
4	0.0232	0.0177	0.0199	0.0252
	(4.28)	(2.89)	(3.75)	(4.07)
3	0.0283	0.0216	0.0189	0.0320
	(5.36)	(3.58)	(3.49)	(5.42)
2	0.0298	-0.0002	0.0051	0.0255
	(3.37)	(-0.02)	(0.50)	(2.32)
Low	0.0319	0.0307	0.0259	0.0343
	(5.44)	(4.70)	(4.44)	(5.21)
High-Low	-0.0203	-0.0168	-0.0230	-0.0140
	(-3.09)	(-2.18)	(-3.43)	(-1.81)
Panel B. Portfolios based on *Environmental Innovation*				
Portfolios	Low sentiment	High sentiment	Low sentiment	High sentiment
High	0.0130	0.0224	0.0112	0.0261
	(3.07)	(3.72)	(2.86)	(4.16)
4	0.0226	0.0246	0.0220	0.0282
	(4.76)	(4.24)	(5.79)	(4.34)
3	0.0265	0.0277	0.0182	0.0371
	(5.14)	(4.57)	(4.53)	(5.47)
2	0.0278	0.0259	0.0182	0.0352
	(3.04)	(3.45)	(2.35)	(3.67)
Low	0.0369	0.0308	0.0220	0.0471
	(5.86)	(4.94)	(5.01)	(6.48)
High-Low	-0.0239	-0.0084	-0.0108	-0.0211
	(-3.66)	(-1.33)	(-2.03)	(-2.84)

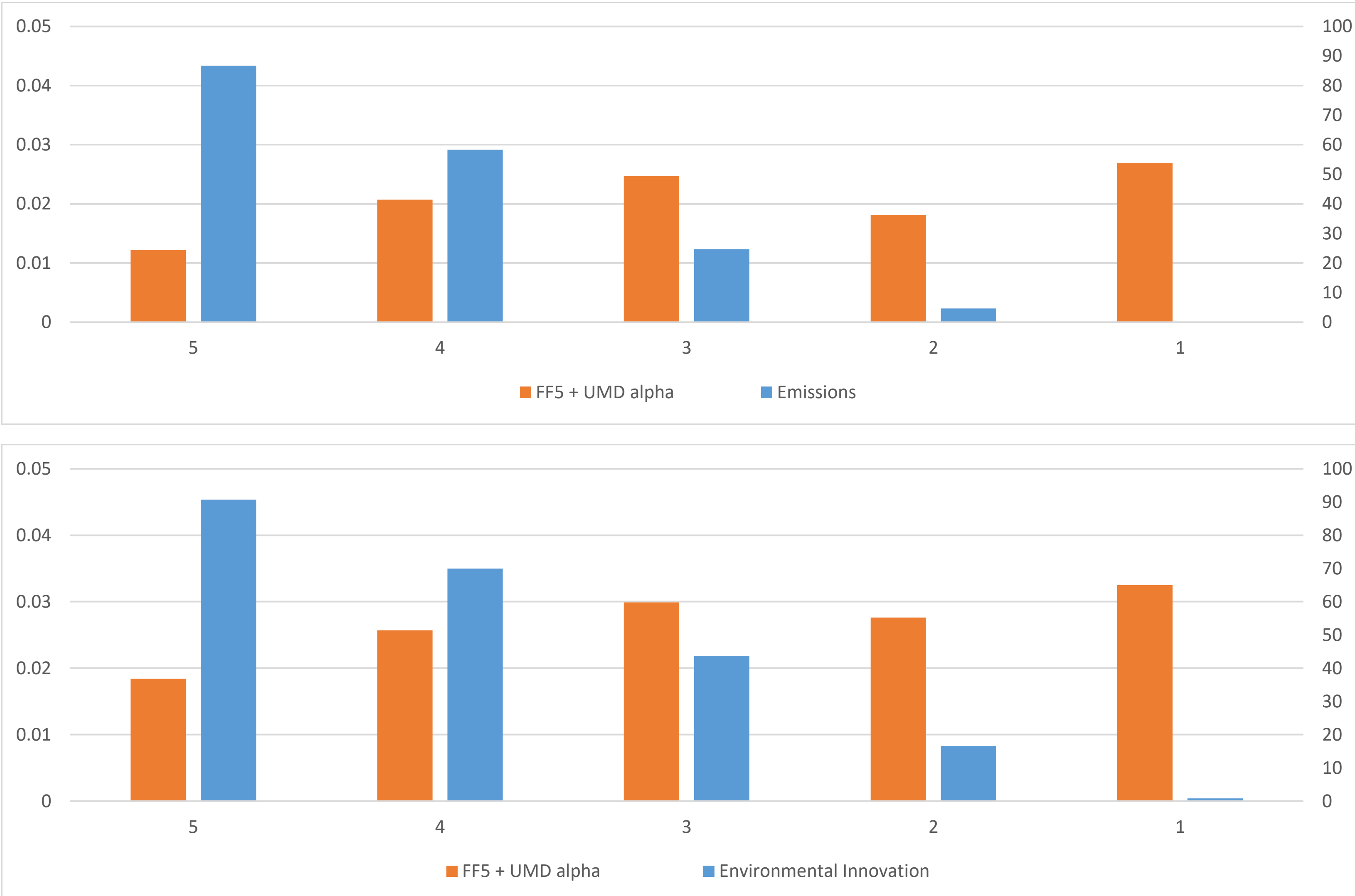

Figure 1 The Average *Emissions / Environmental Innovation* and Stock Alphas.

This figure depicts the average *Emissions/ Environmental Innovation* and Stock Alphas of five portfolios ranked by the *Emissions/ Environmental Innovation*. The sample period for Emissions/Environmental Innovation is Jan 7, 12008- December 31, 2022/Jan 1, 1999- December 31, 2022.