Environmental policies and firms'financial performance and risks : Is the environmental score of European firms a tool for financial risk mitigation and financial performance improvement after the heatwaves of August 2022?

Auteur : Orlandi, Lucas
Promoteur(s) : 20200
Faculté : HEC-Ecole de gestion de l'Université de Liège
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Environmental policies and firms' financial performance and risks

Is the environmental score of European firms a tool for financial risk mitigation and financial performance improvement after the heatwaves of August 2022?

Jury:

Promoter:

Sophie MOINAS

Reader:

Alexandre SCIVOLETTO

Dissertation by

Lucas ORLANDI

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This research is based on the Refinitiv database and the programming language RStudio.

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EXECUTIVE SUMMARY

Worldwide global warming catastrophes have devastating impacts on regions, with increased frequency and intensity. Consequently, businesses, including financial markets, are affected by these disasters. Existing literature has examined the role of Environmental, Social, and Governance (ESG) policies in enhancing firms' stability. This study focuses on the impact of environmental policies on financial indicators of firms during the post-disaster period, specifically analysing the heat waves of August 2022.

The objective is to explore the potential benefits of robust environmental policies in improving financial performance and reducing risks for companies facing significant increases in abnormal temperatures. To assess this, a net environmental index was developed to capture the performance of environmental policies, classifying firms into two samples: low and high-index enterprises. The study encompasses a broad sample of European public companies, incorporating financial risks, performance metrics, economic sectors, and environmental scores.

A difference-in-differences model was employed to regress financial data on the index, mitigating potential issues of reverse causality commonly associated with empirical ESG studies. The main findings suggest that firms with a high index experience lower systematic risk and higher year-to-date returns in the post-heatwaves period. However, other regressed variables did not exhibit significant associations with the environmental policy suggesting having a strong index after the heat waves is not improving firms' performance and risk mitigation.

These findings partially support the hypothesis that firms with a high index demonstrate greater resilience during disruptive temperature events. However, due to the limitations of relying on data from a single database and the study's restricted time interval, the conclusions drawn are not comprehensive enough. Future research should expand the time frame to account for the increasing global warming trend, include a broader range of databases covering overall market ESG ratings, and incorporate more detailed metrics underlying the three attributes of the index. These avenues of investigation hold promise for providing more significant evidence regarding the importance of environmental regulations for financial corporations' well-being.

Keyword: Environmental policy, climate change, financial performance, risk management, event-study

Word count: 16214

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GLOSSARY

ATT - Average Treatment effect on the Treated group

Beta - Systematic risk beta

BM - Book-to-Market ratio

Capex - Capital Expenditures

CSR - Corporate and Social Responsibility

DiD - Difference-in-Differences

(E) - Environmental pillar of the ESG score

EBIT - Earnings Before Interest and Taxes

(ES) - Environmental and Social pillars of the ESG score combined

ESG - Environmental, Social and (Corporate) Governance

FE – Fixed Effect

(G) - Governance pillar of the ESG score

GHG - Greenhouse gas

Gmargin - Gross Margin

H0 - The Null hypothesis

IPCC - Intergovernmental Panel on Climate Change

LTDTA - Long-Term-Debt to Total-Assets

NOAA - National Oceanic and Atmospheric Administration

OECD - Organisation for Economic Co-operation and Development

OLS - Ordinary Least Squares

QQ Plot – Quantile-Quantile Plot

ROA - Return on Assets

ROE - Return on Equity

(S) - Social pillar of the ESG score

TRBC - The Refinitiv Business Classification

UN - United Nations

UNFCCC - United Nations Framework Convention on Climate Change

US - Unites States of America

WACC - Weighted Average Cost of Capital

WACCD - Weighted Average Cost of Capital, cost of debt component

WACCEQ - Weighted Average Cost of Capital, cost of equity component

YTD - Year-to-Date return

1. Introduction

The issue of global warming has become a paramount concern in contemporary times, attracting widespread attention. Since 1987 (appendix **A1** - Yearly abnormal temperatures), there has been a worldwide increase in abnormal temperatures, providing empirical evidence that aligns with the warnings issued by scientists regarding the existence of global warming These anomalies have become more frequent in recent decades, leading to severe droughts and accelerated glacier melting. Therefore, such environmental events serve as evidence of ongoing global warming posing substantial risks to society welfare and safety, including individuals, companies or even governments). The vulnerability of regions like Europe to extreme weather conditions emphasises the potential impact on the population and various sectors[1].

Since the launch of the first climate convention by the United Nations in 1979, global environmental consciousness has been steadily growing. Ardia et al., (2022), highlighted a growing awareness for environmental preservation, which gradually transforms people's perspectives to encompass a broader business model scope[2]. Additionally, the Covid-19 pandemic has amplified climate change concerns among investors and customers (Garel & Petit-Romec, 2021), underscoring the importance of actions for the environment and societal well-being. The recurring threat of intensified heat waves permeates various aspects of individuals' personal and professional lives.
Against this backdrop of heightened environmental consciousness, this paper focuses on how efficiently corporations in European countries have adapted to climate risks. Specifically, it investigates the question whether environmental policy scores have helped these companies mitigate financial risk exposure and enhance their financial performance following the heatwaves of August 2022?

The international political community is confronted with a pivotal challenge: the imperative to recalibrate our systems toward greater sustainability. With the establishment of multiple standards by the United Nations and governments across sectors, efforts are being made to minimise

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[1] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

[2] Ardia et al., (2022) used a Media Climate Change Concern Index to track the evolution of climate concern and observed that a small increase has been noticed even though in 2019 the concerns were less important.

humanity's environmental footprint. The Paris Agreement (2015) and the reports of the United Nations Intergovernmental Panel on Climate Change have set the objective of achieving zero carbon emissions to limit global warming to 2°C. The latest IPCC report emphasises the need for all sectors to adjust their business models to align with this goal and avoid misguided approaches (Pörtner et al., 2022).

This shift towards more environmentally conscious practices also empowers consumers to align their purchasing decisions. In response to environmental risks, businesses strive to adapt their management practices and evaluate the financial consequences of environmental disasters. The urgency surrounding environmental issues has heightened businesses' interest in understanding how their environmental approach can impact long-term financial sustainability. Environment, Social, and Governance (ESG) ratings, provided by agencies, serve as indicators of businesses' engagement in environmental strategies and have a significant influence on various stakeholders. By incorporating ESG data, businesses can effectively address climate change risks and align their actions with societal expectations.

The existing literature predominantly examines the relationship between Environment, Social, and Governance (ESG) ratings and financial characteristics of firms, with limited focus on the environmental (E) ratings. Furthermore, most studies have primarily focused on US market firms and their environmental pillars. This study addresses this gap by analysing the environmental policies of firms operating in European markets, which have also experienced extreme temperature anomalies in 2022. By focusing on European firms and their environmental policies, this study contributes to the literature by expanding the understanding of the relationship between (E) ratings and financial characteristics. It also sheds light on the potential implications of environmental risks and their impact on firm performance and risk management strategies. The primary objective of this study is to assess whether the (E) score serves as an indicator for firms to maintain a certain level of performance while minimising risk exposure in the face of rising temperatures. The paper provides an initial overview of asset performance, equity, and the ability to generate higher returns. Additionally, it investigates the firms' risk exposures, including volatility, systematic risks, and the components of the weighted average cost of capital. Additionally, it seeks to contribute to the literature on the relationship between environmental practices and firm performance, thereby informing policymakers, practitioners, and scholars about the importance of sustainable business strategies in the face of climate change challenges.

The study proposes a new metric to evaluate the performance of environmental policies in each firm.[3] This metric is an index that scales the strength and concerns of each attribute within the environmental pillar (E). The final index, used as an independent variable, combines the strengths and concerns, resulting in a classification of each entity as either performing well or poorly, while avoiding large fluctuations. The purpose of this approach is to differentiate two subgroups and compare them[4].

The paper analyses a sample of 1,488 public companies, resulting in 17,376 observations (twelve observations per firm). The dataset includes the Refinitiv (E) pillar's attributes: resource use, gas emissions, and innovation[5]. Financial indicators covering dependent and control variables are also included from this database. The data are divided into two periods: pre- and post-heatwaves in August 2022, spanning from January 1, 2021, to March 31, 2023. The study employs difference-in-differences regression analyses, focusing on two categories of financial indicators: risks and performance, using established metrics from the literature. This analysis covers a 27-month timeframe and provides insights into short-term interactions between firms and the environmental (E) aspect.

In summary, this study provides strong evidence supporting the positive impact of robust environmental policies on firms' year-to-date returns during extreme positive temperature conditions. However, the hypothesis relating to risk and performance is not supported by the findings, as the selected metric fails to demonstrate a significant relationship with financial indicators and (E) scores in the aftermath of such events. These results contribute to existing literature by introducing a comprehensive metric that need to be deepened which assesses various components of the environmental pillar. While the study confirms the importance of environmental policies in driving financial performance, further research is needed to better understand the risk implications of these policies in extreme temperature scenarios.

[3] The index is inspired by the one Albuquerque et al., (2019), and Lins et al., (2017) employed.
[4] See Garel & Petit-Romec, (2021): they proved that the top ESG-rated firms demonstrated a significant stock returns difference of 3.7 compared to low ESG-rated firms.
[5] See the construction methodology: https://www.refinitiv.com/en/sustainable-finance/esg-scores and appendix A3- Refinitiv's environmental pillar methodology.

2. Context

2.1. Public authorities

Since its inception in 1979, the UN's inaugural climate convention has sparked an ongoing surge in global environmental consciousness, catalysing the signing of influential and standardised agreements among member states. Notably, the United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 as the primary treaty, charting sustainable goals aligned with Agenda 21 for participating countries. Building upon the UNFCCC, the Kyoto Protocol—an extension of the convention—aimed to curtail greenhouse gas (GHG) emissions by 5% relative to 1990 levels. Subsequently, the Paris Agreement, adopted in 2015, emerged as a transformative milestone, galvanising environmental action in the pursuit of keeping global warming below the critical 2°C threshold. Recognising the predominant role of GHG emissions in driving current global warming trends, the Paris Agreement aspires to achieve zero-carbon emissions by 2050, safeguarding against breaching the 2°C limit.

Concurrently, the United Nations Intergovernmental Panel on Climate Change (IPCC), established in 1988, serves as an assemblage of eminent scientists conducting research and publishing reports on global warming and its underlying causes. These reports have effectively heightened public and organisational awareness, underscoring their instrumental role in realising the climate change objectives outlined in the IPCC's comprehensive sixth report (Pörtner et al., 2022). The IPCC's latest findings serve as a potent reminder of the pressing imperative to transition toward greener and more sustainable economic models, accentuating the imperative of attaining net zero carbon dioxide (CO_2) emissions to mitigate anthropogenic global warming. Moreover, in 2019, the European Commission endorsed the European Green Deal—a pivotal initiative targeting GHG emissions reduction within the continent's economy. Its overarching objectives encompass promoting industrial practices that foster circular economy principles and biodiversity conservation. Collectively, these developments have engendered a robust regulatory framework within the international realm, mandating firm compliance with taxation systems and other measures[6].

[6] Governments, the EU, and the UN have established taxation and incentive mechanisms to encourage firms to reduce their environmental externalities. These include carbon taxes, emissions trading schemes, and energy taxes. These measures aim to promote responsible environmental practices and sustainability while mitigating negative ecological impacts.

2.2. Private sector response to climate change

Firms have undergone structural adjustments to comply with evolving regulatory frameworks and have implemented internal policies aimed at reducing GHG emissions, waste, pollution, and promoting environmentally friendly practices. Public authorities have played a pivotal role in driving these actions by implementing mechanisms such as taxation and ESG reporting requirements, thereby aligning firms with the objectives outlined by the IPCC. These measures provide additional incentives for firms to establish emissions reduction targets, optimise waste management, and improve energy efficiency throughout their production processes.

Implementing these strategies has significant financial implications for firms, as they consider climate risks and opportunities, facilitating a smooth transition towards ecological sustainability. Engaging in ESG policies, particularly environmental ones, enhances firms' reputation among stakeholders, signalling their preparedness to tackle climate-related events and their commitment to reducing environmental externalities. This fosters trust, mitigates reputational risks, and attracts shareholders focused on responsible investments.

In finance, decision-making processes across various asset classes have increasingly favoured green and socially responsible investments. Scholars have conducted studies on green asset classes, examining the impact of ESG indicators on financial risks and the performance of green stocks. For instance, research by Lins et al., (2017), discusses the significance of Corporate and Social Responsibility strategies in navigating external shocks, such as financial crises. Additionally, studies by Ardia et al., (2022) demonstrate the outperformance of green stocks compared to brown stocks. Consistent with the findings of Albuquerque et al., (2020), corporations that had implemented environmental and social strategies prior to the Covid-19 pandemic experienced higher returns and lower volatility during the subsequent economic shock. These policies have contributed to firms' profitability while reducing vulnerability to market fluctuations.

However, as global warming continues to escalate, it poses long-term challenges for firms and their financial stability (Bansal et al., 2016). In this context, environmental policies serve as valuable tools for firms to effectively address the negative impacts of climate risks and ensure long-term sustainability.

3. Literature review

Environmental, Social, and Governance ratings play a pivotal role in the development of stock investment plans, highlighting the importance of investors' ESG awareness. These ratings are derived from the disclosure of a corporation's responsible policies, which are considered as valuable extra financial data. Subsequently, the company's performance in each ESG pillar is evaluated and reported, serving as a guide for both external and internal stakeholders. This includes customers, governments, and market competitors, who can leverage this information to shape their purchasing decisions, regulations, and strategic adjustments. Because of the importance of ESG ratings, substantial academic study has been conducted on their impact on firms. The literature on ESG issues has emerged as a captivating subject in financial markets, offering insights on how to effectively utilise and interpret these ratings to enhance overall well-being in the current post-pandemic and climate-conscious environment.

3.1. ESG and firms' financial risk and performance

ESG policies have a profound impact on firms' day-to-day operations as they strive to establish a sustainable model for the future. This encourages corporations to adopt a different approach and attract stakeholders and customers who prioritise responsible design thinking. ESG issues have become a prerequisite for a specific category of investors, shaping their investment decision-making process and portfolio strategies.

In the literature, there has been extensive research on the incentives for ESG investment, as it has become a valuable source of information for investment decision-making. In the current context of the environmental crisis and heightened social expectations, ESG helps entities adjust their practices to align with these challenges. Companies provide direct information about their ESG implementations in accordance with shareholders' directives, and there is a growing trend of shareholder engagement in responsible and environmentally focused strategies. The increasing interest in ESG issues is a response to a shift in shareholder strategies, driven by the recognition of climate risks as financial risks (Krueger et al., (2020). These issues, including climate change, are considered long-term impacts for businesses. The risks faced by investors are not solely financial but also non-financial, with potential significant financial consequences. For instance, higher ESG ratings are associated with better reputation and potential tax benefits related to regulatory compliance (Krueger et al.,2020). Given the growing concern about global warming and the maximisation of societal welfare, these issues will persist in the future and may even intensify, as warned by Pörtner et al., (2022) regarding the exponential temperature rise. Consequently, the importance of ESG cannot be understated. As Barko et al., (2022) demonstrate, ESG engagement directly improves a company's ESG performance, particularly for companies that had low scores prior to implementing new strategies and experienced score improvements over time. This impact is further evidenced by a significant increase in the sales of these firms.

Scholars have extensively investigated the impact of ESG ratings on the financial performance of firms, particularly during recent crises such as the Covid-19 pandemic, climate urgency, and the Great Recession of 2008-2009. The literature presents two main findings that contrast the effects of ESG policies. First, studies have consistently shown that companies with higher ESG scores, indicating strong implementation of responsible policies throughout their operations, tend to perform better during crises. Precisely, Albuquerque et al., (2020) proved that firms with high ESG ratings had better stock returns during the Covid-19 pandemic. Consistent with those findings, meta-analyses conducted by Busch & Friede, 2018; Margolis et al., 2009; and Orlitzky et al., 2003)proved that ESG policies have a positive correlation with the financial performance of companies. In other research, Hoepner et al., (2016), discussed the long-term benefits of high ESG scores. Especially, the fact that implementing responsible policies will send good information to the markets and at the same time improve the accuracy of the risk management system. Thus, this implies that high ESG scoring firms are more likely to benefit from those actions.

Furthermore, the existing body of literature has presented contradictory findings regarding the positive relationship between Environmental, Social, and Governance factors and a firm's financial performance. For instance, when examining sin stocks, which encompass companies engaged in unethical practices such as tobacco production, it has been observed that these companies often yield higher returns. They tend to prioritise financial gains over responsible decision-making, indicating that the relevance of ESG indicators may vary depending on the sector and the overall strategies of investors within the industry(Hong & Kacperczyk, 2009).

Besides these specific findings, Bae et al., (2021) argued that responsible strategies may not serve as effective risk prevention tools and Demers et al., (2021) extend this argument by demonstrating that ESG ratings do not significantly correlate with companies' returns during exogenous events like the Covid-19 crisis.

Apergis et al., (2022)**,** advanced that companies with high ESG scores have relatively lower costs of debt than firms with lower ESG scores. Similarly, El Ghoul et al., (2011) utilised a dynamic panel data method to establish a negative impact of ESG activities on the cost of capital. Furthermore, Albuquerque et al., (2019) ESG activities and firm risk, revealing a negative correlation with systematic risk and a positive effect on firm value. This was supported by Heinkel et al., (2001) who established that higher ESG scores correspond to higher valuations

As against these findings, lower ESG scores have been associated with reduced diversification and higher systematic risks for non-ethical or polluting firms. Finally, some studies have examined individual impacts of the ESG pillars. For instance, given that governance is conceptually distinct and relatively more challenging to assess compared to social and environmental activities, the literature often combines the (E) and (S) pillars in various studies.

3.2. Environmental and social and firms' financial risk and performance

In the literature, the Environmental and Social strategies are often combined and referred to as Corporate Social Responsibility, which encompasses various aspects, including environmental concerns. CSR involves the activities that companies need to prioritise in order to develop a sustainable structure that encompasses three key dimensions: environment, ethics, and social considerations. Therefore, CSR represents an appropriate framework for addressing the (E) and (S) pillars in a comprehensive manner.

Initial studies in the literature focused on exploring the relationship between firm performance and CSR. Lins et al., (2017) demonstrated that non-financial firms in the US with high (ES) ratings outperformed others. These findings were further supported by Ding et al., (2021) who shown that pre-established CSR policies helped firms build stakeholder loyalty and consequently led to higher stock prices, even during a crisis.

Moreover, Lins et al., (2017) demonstrated that firms with a high intensity of CSR activities exhibited higher returns, especially during the financial crisis of 2008-2009. These CSR-intensive firms were able to strengthen their relationship with investors during a period of negative trust shock in the markets. The authors created a CSR index that combined the strengths and concerns of each environmental and social activity, revealing that a higher degree of CSR intensity was associated with increased profitability, sales growth, employee productivity, and excess returns. These findings align with the predictions of Albuquerque et al., (2019) who suggested that operating margins would be higher during periods of duress. Furthermore, CSR activities have a significant impact on the financial riskiness of corporations, as responsible policies reduce systematic risk (Albuquerque et al., 2019) and decrease returns volatility during exogenous events unrelated to the economy (Albuquerque et al., 2020). This reduction in risk exposure ultimately leads to a negative impact on the cost of capital and an increase in firm valuations. CSR strategies were also identified as a means of product differentiation, providing competitive advantages over non-CSR-oriented firms. High ES ratings were found to be associated with lower asset turnover ratios compared to firms with lower ratings. Finally, the authors suggested that ES policies may be correlated with time-varying factors that influence the financial aspects of firms.

As against these findings, Yeh et al., (2020) added that the relationship between CSR and financial indicators might differ depending on the level of development in a country. For instance, in developing countries, CSR policies may positively impact the cost of debt and negatively impact the cost of equity.

3.3. Environment and firms

3.3.1. Climate change

In various fields, including the sciences and finance, scholars have extensively studied the impact of climate change. Consequently, they have identified climate change as a major concern that businesses must address in the coming years. Further research has delved into this theory by categorising climate risks into two main categories: short-term transition risks and long-term physical risks, with transition risks posing immediate challenges and physical risks becoming increasingly threatening over a longer timeframe of approximately 30 years (Stroebel & Wurgler, 2021). Transition risks pertain to the risks associated with transitioning to a more sustainable economy, which necessitates implementing new policies and potentially facing risks such as regulatory and reputational risks. These risks have the potential to indirectly erode asset value or physically impact businesses, thereby disrupting their stability.

Alongside the growing interest in climate change risks, understanding the stakes associated with these threats is crucial for effective management. As a result, the scientific community has provided robust climate forecasts that businesses must incorporate into their future planning[7]. One approach to addressing these extreme issues is to proactively establish a robust environmental policy framework within the organisation. Scholars have emphasised that the sensitivity of environmental

[7] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

reporting policies for each firm will depend on the level of disclosure expected by shareholders (Ilhan et al., 2023).

(E) policies also serve as a tool for understanding climate risks, and the literature has developed various proxies to assess the underlying correlations behind environmental changes. For example Daniel et al., (2016) developed a pricing model for CO2 risks, which captures climate risks associated with CO2 emissions that are positively correlated when the future remains uncertain

Complementarily, Bansal et al., (2016) discussed the global threat that climate change poses to equities, highlighting a negative relationship between the risk exposure of equities and long-term temperature variations. This suggests that reducing greenhouse gas emissions would benefit all entities and their associated networks (e.g., the winter sports industry or agriculture, which will undoubtedly suffer if GHG emissions are not stabilised or reduced).

Analysing the impact of exogenous, rare, and extremely destructive shocks on the performance of responsible policies yields two important outcomes. First Garel & Petit-Romec, (2021) suggested that investors consider all rare and strong events to have similar impacts on firms. Secondly this helped to feature how shareholders adjust and optimise their responsible policies to face such events and assume by mainly focusing on the climate threats.

3.3.2. Climate change and financial indicators

Climate change poses significant risks that impact various important financial indicators and the overall risk profile of corporations. The literature often draws connections between the activities of firms and their financial indicators, shedding light on the relationship between climate-related factors and financial outcomes.

For example, Ilhan et al., (2021) found that the carbon-intensity level of companies has a positive impact on their standard deviation, indicating that low (E) scores increase the riskiness of firms. They also highlighted that climate change concerns and political uncertainty, such as those observed during the 2017 USA presidential election campaign, are priced by financial markets and negatively affect asset values.

Similarly, emissions of toxic products are negatively associated with stock prices and the return on assets, serving as indicators of expected profitability in the coming years (Hsu et al., 2019) demonstrated that climate risks and regulatory risks are incorporated into the pricing of the "pollution premium," particularly in environmentally restrictive regions where firms operate.

Matsumura et al., (2014), explained valuations decrease when markets incorporate the pricing of CO_2 emissions and the level of disclosure.

Berkman et al., (2019) linked climate risk exposure, encompassing both transition and physical risks, to lower firm values using a firm-specific climate risk proxy. Another example is the impact of drought risks on firms' capital structure, where the level of leverage decreases as firms opt for more equity financing over debt (Ginglinger & Moreau, 2022). Nguyen & Phan, (2020) argued that reduced leverage usage is a consequence of carbon risk, which increases the distress risk of firms.

Contrasting these arguments, Bolton & Kacperczyk, (2021) contended that high carbon intensity firms generate higher returns and that financial markets also price carbon premiums. They demonstrated that this relationship is stronger for firms with relatively low levels of disclosure, attracting investors seeking exposure to climate change risks and resulting in significantly higher prices. However, the literature highlights that these effects may vary depending on the industry in which the companies operate (Hong et al., 2019)[8].

3.3.3. Environmental score and financial indicators

Academic researchers have also focused their efforts on studying the individual component of the (E) pillar, specifically addressing the role of physical and transition risks. Scholars such as Görgen et al., (2010) have developed proxies to assess the sensitivity of firms during the transition to a decarbonised economy. This implies that companies establish environmental standards to enhance their environmental impact and minimise their carbon footprint. For example, studies by Ardia et al., (2022) and Pastor et al., (2019) have demonstrated that green firms outperform brown firms despite their exposure to significant transition and physical risks, and negative alpha. Moreover, Chava, (2019) has found that environmental performance and risks reduce both the interest rate and the Weighted Average Cost of Capital (WACC). Additionally, Garel & Petit-Romec, (2021) have provided robust evidence, accounting for industry effects, that high (E) firms outperform significantly when comparing the top and bottom quartiles of the sample ranked by (E) scores.

Within the (E) pillar, the three attributes are also studied independently. They are considered as additional factors, and environmental performance is not solely determined by greenhouse gas (GHG) emissions. Innovations and resource use, such as energy usage, have been shown to play a role in various aspects of firm performance. For instance, innovation is a crucial element for companies' investments and growth to maintain a competitive advantage. (Kogan & Papanikolaou,

[8] They used the food industries to prove that stock prices are not totally reflecting the related climate risks.

2012)[9] highlighted the positive relationship between technological innovations and growth, which explains part of firms' returns based on their respective industry sectors. Innovation progress is a significant factor in improving renewable technologies and reducing emissions, as highlighted by Bolton & Kacperczyk,(2021, 2022), and Daniel et al., (2016). Additionally, the resources used by firms have an undeniable impact on the environment and can lead to improvements in their (E) scores as they capture the effects of responsible policies, as indicated by (Garel & Petit-Romec, 2021).

The literature provides a relatively developed background on the relationship between climate externalities and firm behaviour. In line with previous research on the nexus between CSR policies and financial performance, scholars have examined how firms can be affected by CSR policies during specific events. These events, whether external (e.g., ratification of the Paris Agreement in 2015) or exogenous (e.g., the Covid-19 pandemic), serve as rare shocks with significant consequences for financial markets. Utilising such events helps prevent any misinterpretation arising from reverse causality, where firm performance might explain environmental outcomes instead of the other way around.

Furthermore, the principal arguments that scholars advanced is that firms engaging in responsible policies with simultaneous environment and welfare concerns will benefit from higher global performance and optimised risk management by implementing ESG policies. The latter is introduced in some way as a non-financial tool to mitigate risk exposure by “doing good” in putting the emphasis on the maximisation of the global welfare (i.e., implementing business policies that are positively impacting all stakeholders and reducing the footprints of the firm).

Furthermore, scholars have advanced the principal argument that firms engaging in responsible policies with simultaneous environmental and welfare concerns will benefit from improved overall performance and optimised risk management through the implementation of ESG policies. ESG is introduced as a non-financial tool to mitigate risk exposure by "doing good," placing emphasis on maximising global welfare through the implementation of business policies that positively impact all stakeholders and reduce the firm's environmental footprint. Consistent with these overarching findings, the impact of each pillar is often examined within the context of CSR policies. As emphasised by the Intergovernmental Panel on Climate Change (IPCC) report, the climate emergency is escalating exponentially, while environmental concerns are gradually increasing in people's beliefs.

[9] They suggested that embodied innovations are to be considered because they do not impact all the industries and could be solely positively related to a unique sector.

Consequently, empowering firms with environmental responsibility to accelerate their transition to a low-carbon operating framework becomes an imperative topic of research.

Research examining the impact of environmental policies and their performance, measured through (E) ratings, is crucial. It aims to assess whether these policies can have a positive effect, addressing short-term transition risks and preparing for unavoidable long-term physical risks (Stroebel & Wurgler, 2021). This research aligns with the urgent need to address climate change and emphasises the proactive role that businesses should play in mitigating environmental risks and embracing sustainable practices.

4. Environment and ESG limitations

4.1. ESG scores background and concept

ESG indicator studies are currently a popular focus in financial research due to their relevance in the context of climate change. However, this topic remains highly debatable, particularly regarding data quality, accuracy of strategies, and divergence in ratings.

In the past, firms were primarily defined based on shareholder interests, with a focus on profit maximisation. The traditional doctrine put forth by Milton Friedman in 1970[10] which emphasised profit maximisation as the sole responsibility of companies, is now considered outdated. It failed to recognise the importance of other stakeholders, such as employees, governments, tax authorities, and institutions, in shaping the operations and business models of firms. However, with the rise in global warming concerns, the objectives of firms have evolved. Nowadays, firms are increasingly adopting a more inclusive approach that considers the broader impacts of their actions on society and the environment.

Changes in financial behaviour "have been observed over the years, influenced by external factors such as regulations, environmental concerns, and social considerations. This has led to a rethinking of traditional investment strategies, with a growing interest in greener and more responsible investments that can help reduce overall portfolio risks. Indeed, this mechanism would adjust the level of risk bare by utilising equities that are adequately answering to so pro-social and environmental challenges.

[10] Friedman, M. 1970. The social responsibility of business is to increase its profits. New York Times Magazine, September 13: https://www.nytimes.com/1970/09/13/archives/a-friedman-doctrine-the-social-responsibility-of-business-is-to.html.

It is essential for companies to acknowledge and manage the externalities they create, as their decisions can have significant impacts on the environment and society. Maximising shareholder profit alone is no longer seen as the sole objective for corporations. Instead, companies are adopting more social and responsible business models to maximise the welfare of all stakeholders, including customers and employees.

Fama (2020)[11] highlighted the limitations of the theory proposed by Friedman (1970), which advocates for corporations to solely maximise shareholder profit. The theory fails to consider the external impact of firms' decisions. For example, in industries like petrol, with price-inelastic demand, prioritising shareholder interests could lead to increased petrol prices and higher profits. This approach exploits customer dependency for the company's gain. In contrast, modern companies are adopting a more socially and environmentally responsible business model to maximise the welfare of other stakeholders, such as clients and employees (Fama, 2020).

The implementation of ESG policies has become increasingly important since 2007, as it allows companies to address social and environmental concerns while promoting the overall well-being of their stakeholders. It highlights the notion that profit maximisation and welfare optimisation are not mutually exclusive goals.

In 1999, the first ESG scores data emerged, providing a metric to assess the performance of responsible policies in companies.[12] These ratings focused on three main axes: equality, environmental impact, and structural management of corporations. ESG scores provided additional information for capital markets, and investors began utilising them as valuable non-financial data. Companies recognised the significance of ESG policies, including the ESG scores, in enhancing their risk models in the face of climate imbalance challenges.

Matos, (2020) defined each pillar as three dimensions that firms integrate into their decision-making process. The (E) stands for the impact of corporations on several environmental aspects: the GHG emissions, their resources-energies use optimisation, their implementation of waste and recycling policies, or the integration level of innovation in their strategies. The (S) stands for the social practices of the entity in its networks and within the society. It includes all stakeholder's opinions about the firm and the services or products provided. The (G) stands for the overall functioning of the firm. The Governance pillar's purpose is to examine that all policies about shareholders,

[11] Market Forces Already Address ESG Issues and the Issues Raised by Stakeholder Capitalism, Eugene F. Fama (University of Chicago), on Friday, October 9, 2020.
[12] Research & Analytics (KLD) and Innovest Strategic Value Advisor (Innovest) companies owned by MSCI (an American company providing data, indexes, equity and analysis tools).

executives, and board members are in line with the business projects avoiding any illegal activities and controversial actions. He summarised the main concerns and issues in the table below:

Figure 1 - ESG pillars’ attributes

Environmental	Social	Governance
• Climate change and carbon emissions • Natural resource use and energy and water management • Pollution and waste • Ecodesign and innovation	• Workforce health and safety, diversity, and training • Customer and product responsibility • Community relations and charitable activities	• Shareholder rights • Composition of boards of directors (indepen-dence and diversity) • Management compensa-tion policy • Fraud and bribery

This is not an exhaustive list, but it highlights the main objectives for each pillar of the score. Every pillar is composed of many metrics (most of them are empirical) and is well acknowledged by the literature. (E), (S), and (G) scores are composed of different factors or values and will generate a final score out of 100.

Scholars have also defined ESG strategies as a long-term objective, (Hoepner et al., 2016) with particular emphasis on the environmental dimension. The profound impact of the current crisis on future generations necessitates proactive measures to minimise the consequences that have already been set in motion. Blackrock’s CEO (Larry Fink, 2020) confirmed that the climate crisis as the scientific world projected will interfere heavily with the structure of capital markets by categorising this as a ‘’long-term crisis’’[13]. Unfortunately, there are few robust research published about climate change and the (E) pillar.

Additionally, the OECD (2017)[14] introduced the concept of ESG pillars as financial indicators to be considered in investment decisions, highlighting their impact on companies' value creation. International organisations have recognised and embraced the role of ESG scores, with European countries implementing standardised frameworks for ESG disclosure. The EU directive, effective from 2017, aims to enhance transparency by requiring companies to disclose non-financial information, particularly in the environmental domain. This standardised approach facilitates ESG analysis by external stakeholders such as investors and governments. The integration of ESG factors in corporations' strategies is of paramount importance, as policymakers recognise its potential to enhance market efficiency and risk discovery (OECD, 2021).

[13] Larry Fink, “A Fundamental Reshaping of Finance,” BlackRock letter to CEOs (14 January 2020).

[14] OECD (2017), Investment governance and the integration of environmental, social and governance factors.

Companies face the challenge of integrating and disclosing ESG information to a wide range of stakeholders. Governments and institutional investors, who prioritise ESG investing, seek high ESG scores. Rating agencies play a crucial role in computing these scores, utilising algorithms to evaluate companies' sustainable practices based on the three ESG pillars. However, the variation in methodologies employed by different agencies introduces interpretive limitations in the decision-making process. Therefore, understanding the nuances of ESG ratings becomes crucial in assessing companies' sustainable approaches.

4.2. Limitations of ESG scores

The literature acknowledges certain limitations in the conceptualisation and utilisation of ESG scores. One key limitation is the variation in rating processes among agencies, leading to differences in the metrics and methodologies used to assess each ESG pillar. This divergence in opinion and approach can result in discrepancies in the final scores assigned to companies (Eccles et al., 2019). It is important to exercise caution when using ESG data and to contextualise and interpret the information appropriately.

Another limitation lies in the lack of standardised ESG disclosure frameworks internationally. While initiatives such as the EU's attempt to establish a common regulatory framework aim to facilitate interpretation of ESG scores, other countries, such as the US, have fewer regulatory restrictions on ESG policies disclosure (Eccles et al., 2019). This lack of harmonisation in data and disclosure standards poses a barrier to conduct comprehensive analyses and introduces potential biases in decision-making processes. To mitigate a “rater effect”, it may be advisable to consider multiple ESG rating agencies to avoid undue influence from a single rater and gain a broader perspective on a company's ESG performance.

Another limitation of ESG scores pertains to the overall performance assessment of a firm. While each pillar is individually evaluated and assigned a separate score, the combined ESG score may not adequately reflect the performance of each attribute score. For example, a significant increase in the environmental (E) score could be offset by a substantial decrease in the governance (G) pillar, leading to an overall score that does not accurately capture the individual performance of each pillar. To gain a more comprehensive understanding of ESG scores, it may be necessary to examine and analyse each pillar separately, possibly even breaking them down into subcategories used in their assessment.

A further limitation is the effectiveness and relevance of the regulatory frameworks established by governments within each country. Matos, (2020) emphasises the importance of well-designed policies in monitoring and reducing externalities, but also highlights the potential negative impact of ineffective policies on companies. Furthermore, coordinating policies on an international scale presents significant challenges. While policies are theoretically intended to support ESG performance, their practical implementation and impact on firms' ESG engagement can be complex and difficult to assess. The relationship between policies and ESG performance remains somewhat ambiguous and requires further investigation Rodrik, (2014).

In summary, although ESG policies have emerged in response to the growing demand for more responsible and ethical models, their conceptual limitations can pose challenges in research and interpretation of results. It is crucial to contextualise findings, considering factors such as sample characteristics (e.g., industries, market capitalisation, location) and the specific period under examination.

5. Methodology

The research aims to explore the impact of environmental policies on firms' ability to navigate the financial challenges posed by the August 2022 heat waves in Europe. Specifically, it seeks to assess the influence of these policies on firms' financial performance and risk profiles. To achieve this, the study employs a well-established and robust econometric approach known as the difference-in-differences regression model. This model, widely recognised by scholars, enables the analysis of causal effects by incorporating relevant performance and risk indicators along with environmental data. By utilising this rigorous methodology, the study aims to provide valuable insights into the relationship between environmental policies and firms' financial indicators.

5.1. The data sample

5.1.1. Sample structure and screening

The dataset used in this study consists of information from 1,448 public companies, obtained from the Refinitiv database. Refinitiv's ESG database, which is widely recognised in the literature (Albuquerque et al., 2020, and Bae et al., (2021)). has been employed for data collection. The dataset includes all the variables, including dependent, independent, and control variables, extracted directly from the Refinitiv database.

To ensure the sample size is refined and the results are more accurate, a regional filter has been applied to focus solely on European companies. This approach aligns with the predictions made by the National Oceanic and Atmospheric Administration (NOAA). Their findings, presented in **A1 - Yearly abnormal temperatures** highlight a significant increase in positive abnormal temperature differences in Europe and North America in recent years, particularly in February and August 2022 for Europe and in 2020 in British Columbia, Canada.

By narrowing the dataset to European companies, the study aims to provide specific insights into the impact of environmental policies on the financial performance and riskiness of firms operating in this region. As the ICPP warned, in the near future one of the largest climate perturbation and environmental disasters will be located in the northern parts of the earth. Hong et al., (2019), advanced that markets with no records with exogenous environmental disasters like droughts tend to underweight the impact of such events and underreact. This also completes the findings of Stroebel & Wurgler, (2021) and the scientists' opinion stating that markets are so far underestimating the climate risks.

Focusing on Europe is totally relevant as the region is not accommodated to such important and redundant events. Nonetheless, Ukraine and Russia have been excluded of the sample avoid any abnormal values or lack of data due to the war. Indeed, Russia has received international economic restrictions and Ukraine has suffered from devastating damages with large impacts on the overall sectors (industry, financial and health). Therefore, the dataset gathers all the countries in the European continent except those two.
Then to add more parameters to the creation of the dataset, we only used data from companies with market capitalisation higher than EUR 250,000,000. As Lins et al., (2017) discussed those entities tend to have a low liquidity and a relative high bid-ask spread[15]. This could mislead the research by using values that do not represent the current market perception of the firm. Although Hong et al., (2019) discussed that the markets are underreacting especially for the food industry, it has been included within a broader spectrum of economic sectors to the dataset. Therefore, the dataset extends the economic sector to all categories of the TRBC economic sector[16]. This aims to refine the

[15] The high bid-ask spread is the significant difference between the highest purchase price that the buyer is willing to offer and the lowest selling price the seller is willing to accept.
[16] The TRBC economic sector stands for The Refinitiv Business Classification. It includes the following sectors: energy, basic materials, industrials, consumer non-cyclical, financials, healthcare, technology, utilities, real

sample structure in-depth by including companies of all the categories except for financial firms. Lins et al., (2017) acknowledged that during the financial crisis of 2007, the financial industry received important help from governmental institutions. For instance, the Central Bank has lowered the interest rates enabling financial institutions to facilitate borrowing during the Covid-19 and the post-Covid-19 period[17].
Finally only firms with at least an environmental strategy implemented and disclosed are considered. This enables the research to have only corporations that are engaged into a responsible and ethical policies implementation. This means that only firms with an (E) higher than zero are added.

The periodicity of the data depends on the refreshing frequency of the ESG data on Refinitiv. Therefore, the data are manually collected from Refinitiv ESG screener at the end of each quarter from the 1st of January 2021 until the 31st of March 2023. Additionally, to capture the differences between the pre and post shock periods (pre and post heatwaves)[18], the values on the 31st of July of 2022 and the 1st of September have been added to the dataset used. This bounds August and targets capturing any direct change in outcomes from this point in time. Finally, by selecting these periods, years after 2020, the main objective was to minimise having any direct consequences linked to the lockdowns in Europe even though the pandemic might have a long-term effect (Albuquerque et al., 2020).

5.1.2. Financial indicators and environmental index

The dataset comprises four categories of data: financial performance indicators, financial risk indicators, environmental data, and control variables. To ensure data integrity, missing data points were excluded through additional manipulations. The dataset was transformed into a longitudinal format to facilitate a robust DiD regression analysis, resulting in a sample size of 17,376 observations.

i. The financial risks

The selection of dependent variables aligns with the established framework of financial performance and risks, considering their links to climate-related factors documented in the literature. In the

estate, institutions – associations and organisations, government activities and academic-educational services. See, https://www.refinitiv.com/en/financial-data/indices/trbc-business-classification.

[17] "Central Banks Have Deployed the Policy Arsenal. But Will It Be Enough?" - International Monetary Fund.

[18] Quarter 1 (Q1), quarter 2 (Q2), quarter 3 (Q3) and quarter 4 (Q4) correspond to the dates of 31st of March, 30th of June, 30th of September and 31st of December.

financial risk category, four indicators were chosen: *WACC cost of debt*, *WACC cost of equity*, stock *returns volatility*, and the systematic risk coefficient *beta*[19]. These indicators collectively capture market risks, return fluctuations, leverage-related risks, and investor perceptions of environmental strategies[20].

The *cost of equity* represents the expected rate of return demanded by investors for bearing the associated risk. Prior studies suggest a negative relationship between environmental policies and the WACC cost of equity (Chava, 2019) indicating that firms with higher environmental scores exhibit lower risk levels. The cost of debt reflects lenders' perceptions of firm risks and complements the cost of equity. Apergis et al., (2022), demonstrated the impact of ESG ratings on the *cost of debt*, implying that a stronger environmental strategy reduces firm risks and may lower the *cost of debt*.

Beta serves as a measure of systematic risk within the Capital Asset Pricing Model, providing insights into the firm's volatility compared to the market. Firms with higher environmental scores may exhibit different volatility patterns during environmental shocks. Historical *returns volatility*, inversely related to Environment and Social scores (Albuquerque et al., 2020), is included to investigate whether firms focusing on environmental factors experience lower *returns volatility* during environmental anomalies.

ii. The firm's financial performance

Regarding financial performance, four selected dependent variables align with the Fama-French three-factor model and its extensions (Eugene Fama and Kenneth French, 2015)[21]. These variables assess firms' ability to generate operating profits and reflect the profitability of assets and equities, which can be impacted by both physical and transition risks, such as asset value destruction during

[19] See appendix A2 - Variables, definitions, and sources.

[20] In appendix A2 - Variables, definitions, and sources you will find the definitions and concepts related to the dependent risk variables. The historical returns volatility is computed manually, and the appendix provides a detailed explanation of the steps used to calculate the volatilities of the firms over the specified periods.

[21] The Fama-French three-factor model is popular in finance academic research. They developed that firm stock returns are explained by the market risks, the size of the firms, their value, and their profitability. However, like every model, it is criticised on several points. First, the omitted factors that could explain the stock returns like qualitative data, then the interpretation and the relevancy of the model could be biased by the fact that it does not fit the current general context. However, as here, almost solely quantitative data are used it is relevant to refer to this model.

heatwaves. They are return on assets, return on equity, Earnings before interest and taxes and the year-to-date return.

The ROA measures profitability based on the company's assets, while ROE provides a complementary assessment by considering profitability in relation to equity. These indicators can highlight the impact of environmental scores on firm performance. For example, ROA might decrease if a firm's assets are damaged by environmental disasters. Additionally, the EBIT measures the entity's ability to generate operating revenues after heatwaves. The year-to-date total return examines returns for each calendar year and enables the analysis of returns during 2022. This will highlight the changes in returns and enables to analyses it with the implementation of the index.

In summary, the analysis covers various risk levels, leverage, market risks, and return variability, along with evaluating firms' performance in terms of assets, equity, operating incomes, and returns. The study investigates the interplay between environmental policies, risk management, and financial performance based on the chosen dependent variables. Practically, responsible policies might also reduce firms risks and increase performance (Lins et al., 2017, and Albuquerque et al.,2020).

iii. The environmental index

The independent variable in this study is the net environmental index, as introduced earlier. The purpose of constructing this index is to capture the impact of (E) scores on the financial performance and riskiness of companies. The foundation of this metric relies on data provided by Thomson Reuters' Refinitiv ESG screener, which encompasses a wide range of environmental policy characteristics evaluated through the (E) score. The methodology of the index draws inspiration from existing literature examining the relationship between ESG and finance, with firms being assigned a specific index value (Albuquerque et al., 2019, and Lins et al., 2017).

The index incorporates three key components from Refinitiv's environment pillar: environmental innovation, emissions, and resource use scores[22]. Each of these components comprises a diverse set of metrics and indicators that contribute to the overall pillars. The emissions component evaluates the entity's commitment and performance in reducing operational greenhouse gas emissions. The resource use component assesses the production model adopted by the entity to optimise water and energy usage, promoting eco-efficiency. Lastly, the environmental innovation attribute reflects firms' capacity to reduce costs and seize environmental technology opportunities in the market. These pillars serve as fundamental metrics for evaluating the strategies employed by firms and their

[22] See https://www.refinitiv.com/en/sustainable-finance/esg-scores.

relevance to climate challenges. As quantitative data, these three values form the basis for the index computations and are well-suited for regression analysis.

Based on these values, the index first distinguishes the strengths and concerns for each corporation. Strengths correspond to categories with high scores, while concerns represent attributes with low scores. At this stage, only four categories are considered: the three components and the overall environmental pillar. The number of strengths and concerns are counted separately, and then divided by the maximum number of attributes plus the (E) score, which is four. This calculation yields separate strength and concern indices for each entity. Subsequently, the scaled concern index is subtracted from the strength index to obtain the outcome index. The net environmental index ranges between -1 and 1. Scaling the indices has the advantage of reducing variations in both strengths and concerns over time, thereby mitigating potential biases arising from such fluctuations.

Finally, the index creates two subgroups: low index entities and high index entities. The high index group is defined as having a value strictly greater than zero. Consequently, in this study, the treatment group is defined as entities meeting this criterion, while the control group consists of entities that do not. This approach enables an analysis to explore whether higher performance in environmental policies is associated with financial risks and performance of firms, without introducing additional biases.

5.1.3. Control variables and fixed effect

In the final section, control variables have been incorporated into the dataset to enhance the precision of the regression analysis. These variables encompass aspects related to financial with *leverage*, *gross margin*, *book-to-market ratio* but also, *social score*, and economic *sectors*[23].

The first control variable focuses on the leverage of firms, which represents the ratio of long-term debt to total assets. This metric is frequently employed in literature when evaluating the impact of CSR or (E) scores on financial performance. Previous studies have demonstrated that leverage influences systematic risk, denoted as beta β (Beaver et al., 1970). Further studies proved that carbon risk induces firms to decrease their leverage, particularly in cases where poor responsible policies are observed (Nguyen & Phan, 2020). By controlling for firm leverage, we can isolate the impact of private and public lenders and assess additional risks associated with asset financing. This

[23] See appendix A2 - Variables, definitions, and sources.

ratio is particularly relevant as climate change risks may have compelled firms to rely on greater amounts of long-term debt, such as to address damages or cope with customer purchase behavioural shifts resulting from heatwaves.

Thereafter, the second control variable is the gross margin, which serves as an effective indicator of a firm's profitability (Novy-Marx, 2013). t serves as a control variable for both risks and performance dependent variables, except for *EBIT*. Since both variables consider changes in direct costs of goods sold and the ability to generate operating revenues, the gross margin control helps account for the relationship between a corporation's value creation and its level of risk during pre- and post-periods.
The last financial control variable is the book-to-market ratio. This ratio assesses whether a firm is stable or risky, as a high ratio is typically associated with high growth expectations. By including the book-to-market ratio as a control variable, we effectively remove the impact of a firm's valuation on estimates, thus eliminating any influence stemming from market conditions.
Next, the social score variable is introduced as a control for the external impact of social policies on overall performance. Given that (E) and (S) scores jointly influence corporate risks and performance, incorporating the (S) score as a control variable helps mitigate potential omitted variable bias, as the (S) score may explain a significant portion of the outcomes under study (Lins et al., 2017).

Lastly, sector control is implemented through sector clustering to address unobserved characteristics specific to economic sectors and mitigate endogeneity. This control involves adding a matrix of dummy variables to the dataset[24], effectively removing any additional factors associated with other industries. Each industry possesses its unique indicator standards related to risk, performance, and ESG practices. Furthermore, a sector's level of disclosure is influenced by the degree of disclosure exhibited by its competitors within the same industry (Ilhan et al., 2021). Additionally, each industry is exposed to similar climate risk exposure (Ardia et al., 2022). Consequently, the (E) score may vary across industries.
In conclusion, the regression control model incorporates additional variables to account for relationships not emphasised in the initial model. These variables serve to mitigate omitted variable bias. The added independent variables control for the level of long-term debt used for asset

[24] The sector dummies matrix was constructed based on The Refinitiv Business Classification. Each observation in the dataset is associated with a sector dummy variable, which takes a value of 1 for the corresponding sector and 0 for all other sectors. This matrix enables the identification of the specific sector for each observation, providing a valuable tool for sector-based analysis.

financing, the impact of fixed costs on operating activities, the company's valuation from a market perspective, the specific characteristics of each economic sector, and the influence of social and responsible policies.

Table 1 - Summary of descriptive statistics

Variable	Observations	Minimum	25th perc.	Median	Mean	75th perc.	Maximum
Index	17376	-1,000	-0,500		0,117	0,833	1,000
Beta	17196	-0,544	0,699	1,026	1,080	1,388	4,604
ROA	17282	-1,171	0,013	0,045	0,045	0,082	2,139
EBIT	17304	-2,176E+09	1,552E+07	1,176E+08	6,062E+08	3,780E+08	2,894E+10
YTD	17372	-0,978	-0,212	-0,019	0,008	0,164	6,261
WACCD	17202	-0,005	0,010	0,024	0,026	0,038	0,435
WACCEQ	17174	-0,027	0,066	0,092	0,101	0,123	0,753
ROE	17039	-29,612	0,039	0,111	0,096	0,191	6,420
Score.S	17147	0,944	46,555	64,021	61,588	78,353	98,272
Gmargin	16448	-4,172	0,271	0,433	0,462	0,644	1,095
LTDTA	17343	0,000	0,102	0,205	0,221	0,313	1,250
BM	17376	-7,575	0,206	0,420	0,763	0,792	410,155
Volatility	17374	0,000	0.05156	0.08304	0.09993	0.12757	1.44312

continued

Variable	Standard Error	Standard Deviation	Sample Variance	Kurtosis	Skewness	Lower CI (95%)	Upper CI (95%)
Index	0,005	0,720	0,518	-1,371	-0,250	0,106	0,128
Beta	0,004	0,563	0,317	2,220	0,907	4,595	4,612
ROA	0,001	0,104	0,011	46,902	0,212	2,137	2,140
EBIT	1,412E+07	1,857E+09	3,449E+18	6,870E+01	7,150E+00	2,892E+10	2,897E+10
YTD	0,003	0,364	0,133	24,605	2,735	6,256	6,267
WACCD	0,000	0,021	0,000	39,145	2,886	0,435	0,435
WACCEQ	0,000	0,056	0,003	12,623	2,367	0,752	0,754
ROE	0,004	0,458	0,210	2094,519	-31,738	6,413	6,427
Score.S	0,160	20,968	439,640	-0,583	-0,419	97,958	98,586
Gmargin	0,002	0,265	0,070	19,837	-1,280	1,091	1,099
LTDTA	0,001	0,153	0,024	1,277	0,845	1,247	1,252
BM	0,052	6,825	46,581	2213,747	45,504	410,053	410,256
Volatility	0,001	0,076	0,006	27,293	2,995	0,099	0,101

continued

Table 2 - Correlation matrix

	Index	WACC Cost of Debt	WACC Cost of Equity	Systematic risk beta	Historical return volatility	Return on Equity	Return on Assets	EBIT	Year-to-Date return	Long-Term Debt to Total Assets	Gross Marfin	Book-to-Market	Social score
Index	1												
Cost of Debt	-0.051	1											
Cost of Equity	-0.008	0.358	1										
Beta	0.016	0.169	0.610	1									
Volatility	-0128	0.152	0.189	0.182	1								
ROE	0.037	-0.083	-0.080	-0.093	-0.040	1							
ROA	0.028	-0.127	-0.120	-0.187	-0.054	0.366	1						
EBIT	0.254	-0.048	-0.023	-0.029	-0.086	0.034	0.033	1					
YTD	0.013	0.001	0.026	-0.030	-0.008	0.006	-0.059	0.018	1				
LTDTA	0.015	0.253	0.060	0.046	-0.020	-0.102	-0.180	0.053	-0.024	1			
Gross Margin	-0.049	-0.075	-0.200	-0.201	-0.059	0.081	0.068	0.002	-0.013	0.128	1		
BM	0.015	0.022	0.022	0.016	0.010	-0.025	-0.044	-0.001	-0.016	-0.007	-0.019	1	
Social score	0.657	-0.047	-0.010	-0.012	-0.117	0.029	-0.003	0.278	-0.021	0.084	-0.049	0.015	1

The correlation variables matrix is based on all the used data to perform the difference-in-differences regressions. This table highlights that most of the pairwise variable are only slightly correlated. Their correlation is close to 0 and exclude any perfect linearity between each couple of variables. However, certain pairs have higher correlation as predicted like *beta* and *WACC cost of equity* as *beta* is used in the computations of the WACC. Furthermore, according to the reasons of method used by Lins et al., (2017), the *index* is slightly correlated to the (S) score. This relation is consistent with their findings as well as the *index* is assessing net environment policies strengths over each firm.

5.2. The difference-in-differences model

5.2.1. Application of a DiD model with environmental policies

The core of this research revolves around a Difference-in-Differences (DiD) regression model, which offers a robust framework for estimating causal effects[25]. The model is designed to assess the impact of the treatment, represented by the previously computed index with a focus on high values. The objective is to compare financial indicators between the treated group and the control group. To analyse the treatment's impact, the model incorporates distinct periods, differentiating values before and after the occurrence of heatwaves in August 2022. This approach aims to provide evidence that environmentally performant policies have improved performance and reduced risks for the treated group following the specified time point. Specifically, there are eight observations before August and four after.

The DiD structure encompasses dummy variables that help locate observations across time and groups. Three dummy terms are included, resulting in the following estimated model:

(1) Initial difference-in-differences model

$$y_{i,t} = \beta_0 + \beta_1 E_{Treatment_i} + \beta_2 Post_{Heat_i} + \beta_3 \left(E_{Treatment_i} \times Post_{Heat_i}\right) + \epsilon_{i,t}$$

In the model equation, $y_{i,t}$ represents the financial outcomes (risk (i) and performance (ii)). The i and t defines the entity observed and t the respective period where $t = [1,12]$. $E_{Treatment_i}$ indicates that the observed value is associated with the treated group exhibiting a high environmental index. Conversely, $Post_{Heat_i}$ signifies that the observation pertains to the period after August. Thus, $E_{Treatment_i} = 1$ if the observed value is linked to the high index group and $Post_{Heat} = 1$ if $t = [9,12]$, between august 2022 and March 2023. Moreover, the interaction term $E_{Treatment_i} \times Post_{Heat_i}$=1 if and only if the named-above conditions are met: $E_{Treatment_i} = 1,\ Post_{Heat_i} = 1$.

The coefficients in this DiD regression model are the second category of components. In this simple model, there are four coefficients to consider. The intercept β_0 estimates the level of financial outcomes before August and without an environmental index considered as high enough.

The coefficients β_1 represents the average estimated effect of having a high environmental index on the financial indicators throughout the entire period. β_2 captures the estimated effect of the post-heatwave period, quantifying the average differences between the high and low index groups before

[25] For more framework details, see appendix A4- Difference-in-differences framework.

and after the event. β_3 the interaction term estimates the average difference-in-differences between the financial indicators of each group in each period and subtracts the difference between the pre and post periods. It reveals the relationship between the index and the financial indicators after the heatwaves. Finally, $\epsilon_{i,t}$ corresponds to the error terms.

One of the primary advantages of this model is its ability to address reverse causality between ESG policies and financial performance. The event-study design allows for a clear differentiation of trends before and after the heatwaves by defining distinct periods. This approach enables an investigation into whether the high environmental index group's trends before August 2022 are different from those observed after the event and facilitates a comparison of the two groups' post-event trends. As a result, this model circumvents any issues related to the interpretation of the causal effect of the environmental index on financial risk and performance.
Furthermore, the exogenous nature of the anomalies in August temperatures ensures they have no economic or financial origins, thereby avoiding any biases in interpretation or omitted variables that could misestimate the impact of the high index on the financial indicators.
This model is specifically designed to analyse the impact of environmental policies. It examines the trends of both the low and high index groups prior to the heatwave, assesses the differences between the two groups over the specified period, and ultimately determines the significance of the environmental index in explaining the financial indicators.
Using a rigorous DiD regression framework, this methodology provides valuable insights into the causal effects of the treatment and addresses confounding factors and reverse causality. It offers a sophisticated approach to understanding the relationship between environmental performance and financial outcomes, supporting informed decision-making and sustainable business practices.

5.2.2. Other control applications

After estimating the presented DiD model, additional regressions were conducted to enhance the assessment of the causal effect on financial outcomes, specifically β_3.
The control regressions incorporated several control variables, including Long-Term Debt To Assets (LTDTA), Gross Margin, Book-to-Market ratio (BM), Social Score, and a sector fixed effect[26] (as explained in section 5.1.3). These control variables were included to mitigate the potential bias caused by omitted variables, as each variable has shown significance in relation to the outcomes. The control variables were incrementally added in a step-by-step manner, starting with financial

[26] See part 5.1.3 – Control variables.

covariates, followed by the social score, and finally, the sector clustering. Thus, the model used to control for and estimate the high index treatment effect on financial outcomes (*YTD, ROA, ROE, EBIT, WACCD, WACCEQ, beta,* and *Volatility*) is as follows:

(2) Controlled difference-in-differences model

$$y_{i,t} = \beta_0 + \beta_1 E_{Treatment_i} + \beta_2 Post_{Heat_i} + \beta_3\left(E_{Treatment_i} \times Post_{Heat_i}\right) + \beta_4 X_{i,t} + \beta_6 Sector\ FE + \in_{i,t},$$

From equation (1) Initial difference-in-differences modelare added $X_{i,t}$, a vector of control variables that includes *LTDTA*, *Gmargin*, *BM*, *Score.S*. and the term $Sector\ FE$, representing to the sector clustering.

All regressions were accompanied by the computation of standard errors. Two types of standard errors were calculated: heteroskedasticity-robust standard errors and clustered-robust standard errors. Additionally, a parallel trend assumption was tested, which is crucial in DiD regression. This assumption posits that the high and low environmental index groups follow the same trends before the occurrence of heatwaves. If this assumption is invalidated, it suggests that the model and estimations are statistically insignificant and biased. To perform the test, another regression has been performed based on the initial model of the equation (1) Initial difference-in-differences model The new model includes a supplement term. The latter is an interaction term between the pre-shock period and the treatment, $E_{Treatment_i} \times Pre_{Heat_i}$. Thus, the model used is built as follow:

(3) Parallel trend assumption test model

$$y_{i,t} = \beta_0 + \beta_1 E_{Treatment_i} + \beta_2 Post_{Heat_i} + \beta_3\left(E_{Treatment_i} \times Post_{Heat_i}\right)\beta_4\left(E_{Treatment_i} \times Post_{Heat_i}\right) + \in_{i,t}$$

In this test, the coefficient estimate of interest is $\beta_{3,}$ which indicates the significance of the treatment before August 2022. The objective is to have a coefficient close to or equal to zero. A non-significant interaction term between the pre-period and the treatment implies that the control group and treated group have similar trends. This strengthens the argument that any differences observed in the post-shock period may be attributed to the treatment effect. Finally, the visualisation of quantile-quantile plots aims to provide additional robustness to the effect of the index after the heatwaves by assessing the normal distribution of the residuals.

6. Results

The objective of this analysis is to investigate the effectiveness of implementing an environmental policy strategy as a means for businesses to enhance their financial sustainability in the context of heatwaves and droughts in Europe. The study examines two sub-hypotheses: whether environmental scores mitigate corporations' risks and whether they improve financial performance. To assess these hypotheses, a difference-in-differences (DiD) regression model is employed, utilising a net environmental index across eight financial indicators.

To refine the estimate of the index effect after August 2022, control regressions are conducted, progressively incorporating financial variables, the social pillar, and sector fixed effects. The inclusion of these control variables aims to enhance the accuracy of the estimates and determine the suitability of the computed environmental index as a reliable metric. Furthermore, additional robustness testing is performed to validate the DiD model, including the assessment of parallel trends and QQ plot visualisation.

6.1. Financial indicators and net environmental index

The results of the first estimations are presented in **Table 3 - Difference-in-differences regression - Initial model,** displaying the estimators for each independent variable and indicating their significance for each financial indicator. The regression model used in these estimations follows the formulation presented earlier:

$$(1) \quad y_{i,t} = \beta_0 + \beta_1 E_{Treatment_i} + \beta_2 Post_{Heat_i} + \beta_3 \left(E_{Treatment_i} \times Post_{Heat_i}\right) + \epsilon_{i,t}$$

The results presented in **Table 3 - Difference-in-differences regression - Initial model** show the estimations from the difference-in-differences regressions without any control variables. The focus of this regression is to identify any significant treatment effect of the environmental index, indicating a statistically significant level that ensures the robustness of the results. The factor of interest to interpret is *E_Treatment*Post_Heat*.

Regarding the financial risk indicators, the analysis suggests that environmental policies, when active and efficient, can reduce risk, which aligns with previous literature. However, the treatment effect appears to increase *return volatility* and perturbations during heatwave periods, although these findings are not statistically significant. Hence, no concrete interpretations should be made based on these initial estimations. At this stage of the analysis, the computed metric, the net index, does not demonstrate significance in mitigating risks after the shock.

Interestingly, despite these inconsistent results with the literature and the lack of statistical significance, the dummy variable of the treatment remains significant throughout the entire study period for the *cost of debt* and *systematic risks*. This implies that, in the absence of extreme temperature conditions, firms with a strong environmental index and effective policies experience a reduction in debt-related risks, aligning with previous findings Heinkel et al., (2001) Firms with a strong index and effective policies experience a decrease in their cost of debt by 0.001, while their beta increases by 0.018, both significant at the 1% and 5% levels, respectively.

Table 3 - Difference-in-differences regression - Initial model
Net environmental index on financial risk-performance indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Cost of Debt	Cost of Equity	Systematic risk beta	Historical Return Volatility	Return on Equity	Return on Assets	EBIT	YTD
*E_Treatment*Post_Heat*	-0.00000	-0.0001	-0.013	0.003	0.001	0.002	-0.00001	0.054***
	(0.001)	(0.002)	(0.018)	(0.002)	(0.015)	(0.003)	(58,830,059)	(0.011)
E_Treatment	-0.001***	-0.00002	0.018**	-0.017	0.026***	0.003*	792,929,908***	-0.015**
	(0.0004)	(0.001)	(0.014)	(0.001)	(0.009)	(0.002)	(33,966,059)	(0.007)
Post_Heat	-0.0003	-0.0001	0.028	0.001	-0.018	0.016***	0.00001	-0.221***
	(0.001)	(0.001)	(0.014)	(0.002)	(0.011)	(0.003)	(43,627,442)	(0.008)
Intercept	0.027***	0.101***	1.063***	0.109***	0.088***	0.037***	170,157,301***	0.080***
	(0.0003)	(0.001)	(0.008)	(0.001)	(0.006)	(0.006)	(25,188,316)	(0.005)
Observations	17,202	17,174	17,196	17,174	17,039	17,282	17,304	17,372
R^2	0.001	0.00000	0.0005	0.00001	0.001	0.006	0.045	0.063
Adjusted R^2	0.001	-0.0002	0.0003	0.092	0.001	0.006	0.045	0.063

This table is summarising all the estimations obtained of the difference-in-differences regressions. They are performed on a quarterly data basis with three additional point in time, 1st January 2021, 31st July 2022, and 1st September 2022 in order to have a starting value and to bound August 2022 data. Overall height regressions have been performed with two blocks in order: one financial risk and one financial performance. From (1) to (4) are the risk-related outcomes while the others are the performance ones. *Post Heat* equals 0 if and only if the observation is prior August 2022, otherwise it is 2; *E_Treatment* is equal to if the observation is having an environmental index strictly higher than 0. Additionally, the appendix **A2** - Variables, definitions, and sources gives more definitions to each variable. In parentheses are the *t-statistics* of each estimation. The related p-values are translated through stars notations: *p < 0.1; **p < 0.05; ***p < 0.01.

Moving on to the financial performance indicators, the results are not statistically significant overall. The estimated coefficients for return on equity, return on assets, and earnings before interest and taxes show mixed and inconclusive effects of the environmental index on financial performance.

However, one notable exception is the year-to-date return, where the coefficient of the *E_Treatment*Post_Heat* interaction term is 0.054 and significant at the 1% level. This implies that firms with a strong index experience higher average returns in the post-shock period of heat waves.

Furthermore, the estimates for the control variable *Post_Heat* show a significant effect on *ROA* and *YTD* returns at the 1% level. This indicates that, on average, firms demonstrate improved profitability and higher returns on assets during the post-shock period, even though overall returns have reduced in 2022 and 2023. The estimated coefficients are 0.016 for ROA and -0.222 for YTD returns.
Furthermore, the estimates for the control variable Post_Heat These findings may deviate from the expectations set by Lins et al., (2017), who suggested that firms with social interests would exhibit lower risk levels in non-shock scenarios. However, it is crucial to acknowledge that the results are not consistently statistically significant across all financial performance indicators. Therefore, caution must be exercised when drawing concrete interpretations from these initial estimations.

In summary, the initial results from the DiD analysis provide insights into the relationship between environmental policies and financial sustainability. The findings indicate that in general firms with a strong environmental index experience reduced financial risk in terms of lower debt costs and higher systematic risks. However, the impact on return volatility and financial performance indicators is not statistically significant, except for a higher year-to-date return in the post-shock period. The following steps tend to refine the analysis by adding control variables.

6.2. Robustness controls

Secondly, robustness controls were conducted in two steps. First a succession of controlled regressions to efficiently isolate the impact of the index treatment and then a parallel trend test and finally the computations of the standard errors (robust and clustered). This will avoid facing some biases (omitted variables…) in the inference's interpretations.

6.2.1. Financial relations control

A difference-in-differences series of regressions were performed adding control variables by category. The **Table 4 – Controlled difference-in-differences – Financial control** is reporting the estimates of the confounding variables, and the dummy variables included in the initial regression model (1) Initial difference-in-differences model. Therefore, the model is controlling for *LTDTA*, *Book-to-Market* ratio, and *Gross Margin.* These regressions aim to isolate the impact of the use of debt financing asset, the market valuation of firms and their ability to create profit.

The treatment effect's estimate is more accurate but exactly as **Table 3 - Difference-in-differences regression - Initial model**, it is only statistically significant for the *Year-to-Date returns*. Indeed, the estimate is reduced to 0.051 at a significance level of 1%. This is due to the controls implemented with the financial covariates that are significant in explaining the average *YTD*. Regarding the seven other dependent variables, the ATT of the index seems to globally reduce the risks (columns (1), (2) and (3)) of firms but the estimators are not significant. Moreover, the performance of the firms appears to be less clear as the estimates are divergent. Precisely, *EBIT* would decrease while *ROA* of firms with high index after heat waves show a better rate. These two opposite estimations are not interpretable as they are not significant. This adds more precision to the *E_Treatment* binary variable.

Table 4 – Controlled difference-in-differences – Financial control
Net environmental index financial risk-performance indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Cost of Debt	Cost of Equity	Systematic risk beta	Historical Return Volatility	Return on Equity	Return on Assets	EBIT	YTD
*E_Treatment*Post_Heat*	-0.0001	-0.0001	-0.015	0.003	-0.001	0.002	-297,649.500	0.051***
	(0.001)	(0.002)	(0.018)	(0.002)	(0.015)	(0.003)	(58,904,451)	(0.012)
E_Treatment	-0.003***	-0.002	0.006	-0.017***	0.040***	0.006***	781,483,901***	-0.012*
	(0.0004)	(0.001)	(0.011)	(0.001)	(0.009)	(0.002)	(34,171,006)	(0.007)
Post_Heat	-0.0004	-0.0002	0.029**	0.001	-0.015	0.015***	-566,865.800	-0.219***
	(0.0005)	(0.001)	(0.014)	(0.002)	(0.011)	(0.002)	(43,684,476)	(0.009)
Gmargin	-0.009***	-0.045***	-0.452***	-0.018***	0.169***	0.035***		-0.016
	(0.001)	(0.002)	(0.017)	(0.002)	(0.0113)	(0.003)		(0.010)
LTDTA	0.037***	0.037***	0.312***	0.002	-0.394***	-0.137***	352,750,421***	-0.044***
	(0.001)	(0.003)	(0.029)	(0.004)	(0.025)	(0.005)	(90,670,856)	(0.018)
BM	0.0001***	0.0001**	0.001	0.0001	-0.002***	-0.001***	-850,839.900	-0.001**
	(0.00002)	(0.0001)	(0.001)	(0.0001)	(0.0005)	(0.00001)	(2,018,664)	(0.0004)
Intercept	0.023***	0.115***	1.216***	0.116***	0.089***	0.051***	99,931,324***	0.096***
	(0.0004)	(0.002)	(0.012)	(0.002)	(0.010)	(0.002)	(31,85,90)	(0.008)
Observations	16,309	16,285	16,286	16,446	16,200	16,356	17,272	16,443
R^2	0.078	0.050	0.048	0.014	0.024	0.059	0.046	0.064
Adjusted R^2	0.078	0.050	0.047	0.014	0.023	0.059	0.046	0.063

This table is reporting all the estimates including the coefficient from the initial DiD (1) Initial difference-in-differences model.It is built like the **Table 3 - Difference-in-differences regression - Initial model**. The sole exception is the regression performed on *EBIT*. *Grmargin* is not included within the model because of the theoretical correlation in fundamentals about profitability, (i.e., they both capture the ability of firms to create operating profits). It is regressed with the same periodicity of the first table. In parentheses are the *t-statistics* of each estimation. The related p-values are translated through stars notations: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Furthermore, excluding the tempority and the heatwaves, the table reports that the treatment effect is not significant for *cost of equity* and *beta.* The index seems to reduce the *cost of debt*, *volatility* and

YTD of firms while increasing their *ROA*, *ROE,* and *EBIT*. This suggests that on general firms with higher policies engagement and performance would generate higher profits from their equity and assets and is consistent with the first findings and the literature.

Overall, as predicted by the literature, the control variables are significant in the average estimates of the outcomes. For instance, higher *gross margin* reduces risks and therefore the returns, as higher is the risk higher is the expected return. Also, higher *book-to-market ratio* leads to lower the *YTD* as market might perceives firms during the period with lower growth opportunities. This explains a sensible part of the decrease in expected returns. Thereafter, *LTDTA* is increasing the considered risk factors and, oppositely higher *Gmargin* positively affects their *cost of debt*, *of equity*, and *beta*. This proves that controlling for these variables are theoretically robust. Higher *LTDTA* corresponds to a higher use of leverage, increasing the risk of default but as shown in the table above it is also increasing profitability. This lead to decrease the riskiness of the firms as generating profits is a proof of value creation. In this period firms have been using on average higher debt to finance their activities but at the same time increased their profits.

In summary, the findings after controlling for financial indicators are more precise but the model estimates highlight that the index remains insignificant for firms to enhance their performance and mitigate their risk exposure. The only exception is again for the year-to-date return that is still higher for high index companies after the heatwaves.

6.2.2. Social score

Although ESG policies are divided into three dimensions, (E) and (S) are frequently studied as a single variable. In the purpose to obtain more details about the inferences of solely the (E) on firms, (S) has been incorporated within the analysis. This will investigate and refine the already proved relation of the ethical and social influence on firms discussed by Albuquerque et al., (2020).

Table 5 - Controlled difference-in-differences - Financial and social indicators shows the (S) score is significantly mitigating the risks of the firms on the four financial risk factors as expected while it increases the performance of the firms that have a *social score*. As expected, the social dimensions of firms are efficiently explaining a difference between firms poorly rated, and the ones truly engaged in improving the welfare of individuals. Only *ROA* remains negatively impacted by (S) but at a non-significant level.

The index provided in this tables are consistent with the ones in the previous regression tables. Only *YTD* is significantly and positively related to the treatment effect. Hereunder, strong environmental policies, while controlling for financial and social engagement, are helping firms to perform 0.057 higher than less green firms. The *YTD* estimate is also higher than in the previous regressions. Unexpectedly, the ATT of the environmental index is not significant in the reduction of risk exposure. Both groups would have sensible same exposures. However, the treatment variable is still consistent for six out of the height outcomes. Environmental policies index without heatwaves shock is only significant for firms' indicators in generating profits or reducing their risks. This complete the prior findings that the index is having a significant impact on the outcomes but still is not significantly important while firms are experiencing climate extreme abnormal temperatures increase.

Table 5 - Controlled difference-in-differences - Financial and social indicators
Net environmental index financial risk-performance indicators

	(1) Cost of Debt	(2) Cost of Equity	(3) Systematic risk beta	(4) Historical Return Volatility	(5) Return on Equity	(6) Return on Assets	(7) EBIT	(8) YTD
*E_Treatment*Post_Heat*	0.00000	0.00003	-0.015	0.003	-0.0003	0.002	2,950,611	0.057***
	(0.001)	(0.002)	(0.019)	(0.002)	(0.015)	(0.003)	(58,542,049)	(0.012)
E_Treatment	-0.002***	-0.001	0.031**	-0.009***	0.024**	0.006****	260,625,406***	0.0002
	(0.0005)	(0.001)	(0.013)	(0.002)	(0.010)	(0.002)	(39,512,858)	(0.008)
Post_Heat	-0.001	-0.003	0.029**	0.001	-0.016	0.015***	-9,293,137	-0.226***
	(0.001)	(0.001)	(0.014)	(0.002)	(0.011)	(0.002)	(43,618,914)	(0.009)
Gmargin	-0.009***	-0.046***	-0.453***	-0.018***	0.171***	0.035***		-0.017
	(0.001)	(0.002)	(0.017)	(0.002)	(0.014)	(0.003)		(0.011)
LTDTA	0.038***	0.038***	0.319***	0.003	-0.399***	-0.138***	323,803,946***	-0.043**
	(0.001)	(0.003)	(0.029)	(0.004)	(0.025)	(0.005)	(90,321,404)	(0.018)
BM	0.0001***	0.0001	0.001	0.0001*	-0.002***	-0.001***	-1,370,755	-0.001**
	(0.00002)	(0.0001)	(0.001)	(0.0001)	(0.0005)	(0.0001)	(1,992,535)	(0.0004)
Social score	-0.00005***	-0.0001**	-0.001***	-0.0003***	0.001***	-0.00001	20,979,653***	-0.001***
	(0.00001)	(0.00003)	(0.0003)	(0.00003)	(0.0002)	(0.00004)	(809,198.100)	(0.0002)
Intercept	0.0026***	0.118***	1.267***	0.130***	0.058***	0.051***	-892,169,696***	0.127***
	(0.001)	(0.002)	(0.017)	(0.002)	(0.014)	(0.003)	(49,334,511)	(0.011)
Observations	16,122	16,098	16,102	16,254	16,011	16,167	17,047	16,251
R^2	0.081	0.051	0.048	0.019	0.024	0.059	0.082	0.066
Adjusted R^2	0.080	0.051	0.048	0.019	0.024	0.059	0.081	0.066

This table reports the regressions controlling for *LTDTA*, *Gmargin*, *BM* and with the *Social score*. As the previous tables, *Gmargin* is not included to control in the regression of the *EBIT* outcome. The social score isolates the impact of socially responsible policies on firms' financial factors. In parentheses are the *t-statistics* of each estimation. It is regressed with the same periodicity of the first table. The related p-values are translated through stars notations: **p* < 0.1; ***p* < 0.05; ****p* < 0.01.

6.2.3. Economic sector clustering

The ultimate regression control aims to incorporate a sector fixed effect to exclude any specificity that the literature shown and is intrinsically related to the sector of the firm. In fact, the regressions dataset is made up of enterprises from various economic sectors. There are criteria and characteristics in each industry that, if not included, skew the estimates. De facto, those industries have features that must be distinguished in order to undertake a valid study. The fourth model then includes a fixed effect for the economic sector.

Table 6 - Controlled difference-in-differences - Financial, social, and economic sector
Net environmental index financial risk-performance indicators

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Cost of Debt	Cost of Equity	Systematic risk beta	Historical Return Volatility	Return on Equity	Return on Assets	EBIT	YTD
*E_Treatment*Post_Heat*	0.00002	0.0001	-0.015	0.003	-0.0005	0.002	3,115,646	0.057***
	(0.001)	(0.002)	(0.018)	(0.002)	(0.015)	(0.003)	(57,973,138)	(0.012)
E_Treatment	-0.002***	0.003**	0.032***	-0.008***	0.031***	0.006***	217,698,579***	-0.002
	(0.0005)	(0.001)	(0.012)	(0.002)	(0.010)	(0.002)	(39,751,309)	(0.008)
Post_Heat	-0.001	-0.0004	0.028**	0.001	-0.015	0.015***	-9,856,920	-0.226***
	(0.001)	(0.001)	(0.013)	(0.002)	(0.011)	(0.002)	(43,195,046)	(0.009)
Gmargin	-0.009***	-0.037***	-0.359***	-0.017***	0.172***	0.035***		0.006
	(0.001)	(0.002)	(0.017)	(0.002)	(0.014)	(0.003)		(0.011)
LTDTA	0.038***	0.038***	0.367***	0.010**	-0.384***	-0.140***	306,697,008***	-0.034*
	(0.001)	(0.003)	(0.029)	(0.004)	(0.026)	(0.005)	(91,533,465)	(0.019)
BM	0.00004*	0.00002	0.0004	0.0001	-0.001**	-0.001***	-4,675,666***	-0.002***
	(0.00002)	(0.0001)	(0.001)	(0.0001)	(0.001)	(0.0001)	(1,987,819)	(0.0004)
Social score	-0.00005***	-0.00004	-0.001***	-0.0003***	0.001***	0.00002	21,059,719***	-0.001***
	-0.00001)	(0.00002)	(0.0002)	(0.000003)	(0.0002)	(0.00004)	(811,469.300)	(0.0002)
Sector.Academic-Education	-0.014**	0.032**	0.710***	0.039*	-0.11	0.004	804,136,672.000	0.013
	(0.006)	(0.003)	(0.155)	(0.021)	(0.132)	(0.027)	(369,463,065)	(0.103)
Sector.Basic Materials	0.007***	0.032***	0.493***	0.015***	0.011	0.013**	-471,079,921***	-0.026
	(0.001)	(0.003)	(0.031)	(0.004)	(0.026)	(0.005)	(80,748,173)	(0.020)

continued

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Sector.Consumer Cyclicals	0.009***	0.045***	0.652***	0.018***	-0.066***	-0.0005	-404,888,139***	0.085***
	(0.001)	(0.003)	(0.030)	(0.004)	(0.025)	(0.005)	(75,854,751)	(0.019)
Sector.Consummer Non-cyclicals	0.007***	0.001	0.205***	-0.004	0.006	0.0004	21,631,301	-0.059***
	(0.001)	(0.003)	(0.031)	(0.004)	(0.027)	(0.005)	(83,274,071)	(0.021)
Sector.Energy	0.015***	0.064***	0.722***	0.037***	-0.127***	-0.023***	558,147,571***	0.129***
	(0.001)	(0.003)	(0.034)	(0.005)	(0.028)	(0.006)	(92,528,172)	(0.022)
Sector.Healthcare	0.009***	0.006*	0.288***	0.018***	-0.042	-0.012**	-207,812,638**	-0.057***
	(0.001)	(0.003)	(0.031)	(0.004)	(0.027)	(0.005)	(82,245,743)	(0.021)
Sector.Industrials	0.006***	0.032***	0.569***	0.014***	-0.017	-0.005	-483,314,030***	-0.044**
	(0.001)	(0.003)	(0.029)	(0.004)	(0.025)	(0.005)	(74,205,648)	(0.019)
Sector.Real Estate	0.007***	0.011***	0.249***	-0.003	-0.017	0.010*	-449,663,788***	-0.097***
	(0.001)	(0.003)	(0.032)	(0.004)	(0.025)	(0.006)	(86,606,550)	(0.021)
Sector.Technology	0.006***	0.024***	0.465***	0.019***	0.011	0.005	-406,380,727***	-0.061***
	(0.001)	(0.003)	(0.030)	(0.004)	(0.025)	(0.005)	(77,582,980)	(0.020)
Intercept	0.019***	0.087***	0.747***	0.116***	0.078***	0.051***	-548,858,941***	0.167***
	(0.001)	(0.003)	(0.033)	(0.004)	(0.028)	(0.006)	(84,191,045)	(0.021)
Observations	16,122	16,098	16,102	16,254	16,011	16,167	17,047	16,251
R^2	0.095	0.133	0.136	0.035	0.030	0.067	0.100	0.082
Adjusted R^2	0.094	0.133	0.135	0.034	0.029	0.066	0.099	0.081

This table reports the regressions controlling for *LTDTA*, *Gmargin*, *BM*, *Social score,* and a *sector* dummy matrix. It aims to isolate the impact of each sector. As the previous tables, *Gmargin* is not included to control in the regression of the *EBIT* outcome. In parentheses are the *t-statistics* of each estimation. It is regressed with the same periodicity of the first table. The related p-values are translated through stars notations: *p < 0.1; **p < 0.05; ***p < 0.01.

The above table reports all estimates of each sector that are for most of the outcomes significant. This also includes the other control variables.

The findings of the analysis continue to support the significance of the environmental index, particularly in relation to the year-to-date (YTD) financial performance measure. The results align with prior research, specifically the work conducted by Albuquerque et al., (2020) and indicate that firms with a higher environmental index exhibit an increase in their year-to-date returns following extreme temperature events, specifically during the latter half of 2022 and the first quarter of 2023. However, it is important to note that despite the existing body of literature emphasising the role of environmental, social, and governance (ESG) factors, including environmental sustainability (ES), in times of disruptive events, the proposed metric demonstrates no significant impact on risk and performance indicators across the four regression models specifically focused on abnormal environmental temperatures. These results suggest that while the environmental index shows significance in relation to year-to-date returns following extreme temperature events, it does not exhibit a significant association with risk and performance indicators. This finding emphasises the complexity of the relationship between (E) scores, and financial outcomes during periods of environmental disruption.

In fact, after adjusting for all of the extra covariates, only the p-value of the estimations of the *E_Treatment*Post_Heat* allows to claim that having a high index helps enterprises to face heatwaves while boosting their *YTD*. This implies that enterprises in the treated group would earn 0.057 more than firms in the low index control group.

Despite the inconsistency of those findings with previous papers, the *E_Treatment* is still more significant with this model. This suggests that the treatment on the complete frame time has a positive effect on its financial indicators. While the treatment affects the risk components analysed in various ways, it generally reduces their exposure to financial markets risk and default risk. Since they are more adequately prepared for environmental disasters, organisations that implement strong environmental policies may provide the market with better information and be less volatile. This can lead firms to attract stakeholders who are concerned about the impact of climate change, as they have physically adjusted their operating activities to create a more environmentally friendly system.

6.3. Additional testing

In addition to the control variables, two robustness tests have been conducted to address any potential violations of assumptions underlying the Difference-in-Differences Ordinary Least Squares regression employed in the study.

The first test focuses on the crucial assumption of parallel trends, which assumes that the treatment and control groups had similar trends in the pre-shock period in the absence of the treatment. To examine this assumption, an additional term was introduced in equation (3) Parallel trend assumption test model of the regression model, namely the interacting term[27], *E_Treatment*Pre_Heat*. This term aims to isolate the potential effect of the environmental index prior to the occurrence of heatwaves and determine whether the values before the shock were similar or divergent.

[27]See (3) Parallel trend assumption test model.

The estimates presented in **Table 7 - Parallel trend assumption regression** reveal that there is no significant impact of the index during the period preceding August 2022. All the reported coefficients (β_3) associated with *E_Treatment*Pre_Heat* are found to be close to zero and statistically insignificant[28]. This finding indicates that the treatment had no discernible effect during the initial period and validates the parallel trends assumption. Consequently, the applied model is deemed valid and provides robust estimates.

Table 7 - Parallel trend assumption regression

	(1) Cost of Debt	(2) Cost of Equity	(3) Systematic risk Beta	(4) Historical Return Volatility	(5) Return on Equity	(6) Return on Assets	(7) EBIT	(8) YTD
β_3	0.0000	0.0001	0.013	-0.03	0.001	-0.002	0.0000	-0.054

In addition to the parallel trend assumption test, a visual inspection of residual plots was conducted to assess the normality distribution assumption and further validate the robustness of the DiD OLS regression. The appendix **A4-** Difference-in-differences framework presents the plots of quartiles for both observed and predicted values, aiming to evaluate the normality of residuals. The plots for models (1) Initial difference-in-differences model and (2) Controlled difference-in-differences model include a reference line, against which the residuals should align to validate the assumption.

In the first set of plots, it is observed that the residuals for the dependent variables closely follow the reference line, except for some deviations in the tails. However, even after controlling for additional independent variables, the extreme values in the residuals are not effectively reduced or aligned with the reference line. The plot trend does not completely flatten in the controlled model. These extreme residual values may be attributed to data issues such as missing values. Overall, while the model partially supports the assumption of normality distribution in residuals, it suggests the need for cautious interpretation and potential improvements in data fitness and model robustness.

These tests were conducted to address any potential violations of assumptions underlying the DiD OLS regression. To account for heteroscedasticity in the standard errors, additional computations were performed to determine the significance of the estimates. The tests included heteroscedasticity-consistent robust standard errors and sector-clustered standard errors. Thus, two

[28] The estimates of the

additional sets of standard errors and estimators were computed for the four regressions previously conducted.

The adjusted estimated coefficients, along with the heteroscedasticity-consistent robust standard errors, demonstrate that the treatment effect remains significant only for the YTD variable. The coefficients remain stable, with slight fluctuations in the standard errors due to the new computations. Similarly, employing the clustered sector robust standard errors technique yields the same results, indicating the robustness of the performed regressions when addressing heteroscedasticity and clustering at the economic sector level. Although the estimates are robust to these issues, they remain statistically insignificant for most of the outcomes.

These findings provide evidence of the regression's robustness, despite the presence of heteroscedasticity and the consideration of economic sector clustering. However, it should be noted that despite the adjustments made, the estimated coefficients remain insignificant for the majority of the outcomes.

7. Discussion

The primary focus of this study is to investigate the impact of environmental policies on firms, specifically their financial performance and risk indicators in the aftermath of the exogenous environmental disaster of August 2022, namely the heatwaves. The analysis is centred on publicly traded companies based in European countries and utilises a comprehensive net index that captures the scaled environmental performance. The effectiveness of the index is crucial as the results are contingent upon its efficiency.

The first hypothesis is testing whether a high environmental performance index is interfering in the risk's indicators of a firm during temperature anomalies. Regarding the financial risks associated with factors such as the *WACC cost of debt*, *WACC cost of equity*, systematic risk *beta*, and *return volatility*, the findings reveal a lack of significance in the treatment effect after controlling for financial indicators, social pillars, and sectors. These results deviate from the prevailing evidence in the literature, which supports the notion that responsible policies and high environmental, social, and governance ratings effectively mitigate firms' risks. Surprisingly, there is no negative impact observed either. These findings align with the observations made by Demers et al., (2021) and indicate that ESG and (E) scores remain insignificant in the context of extreme temperature events. Consequently, the relationship between the environmental metric proposed in this paper and financial risk indicators fails to provide conclusive evidence.

Notably, the *cost of debt* demonstrates an increase, implying a potential risk of financial distress or default, contradicting the predictions put forth by Yeh et al., (2020). This contradicts the findings of Apergis et al., (2022) who suggested that ESG activities reduce the cost of debt. Furthermore, the expected reductions in the cost of capital and returns volatility, indicating that investors perceive "green" and ethical firms as less risky and more stable during environmental events, are not substantiated by the results. These observations challenge the notion that having an efficient and proactive climate risk management approach enables firms to effectively mitigate their risk exposure during environmental abnormal temperature conditions. As a result, the hypothesis is invalidated due to the lack of significance observed in the environmental index, which hinders the interpretation of any causal effects.

The second hypothesis, which examines the financial performance of firms with a high environmental index following the shock, is tested across four indicators: *return on assets*, *return on equity*, *earnings before interest and taxes* and *year-to-date return*.

The findings of the study consistently show that only the year-to-date return produces an interpretable result. Firms with a higher index exhibit a 0.057 increase in returns after accounting for covariates. This suggests that these firms may have been better equipped to outperform their counterparts during the period, particularly when faced with extreme temperatures. This aligns with the existing literature, which suggests that firms with high environmental, social, and governance scores are more likely to outperform others during environmental disasters.

However, it is important to note that the hypothesis can only be validated if returns are considered the sole performance indicator. The financial performance assessed in this paper encompasses equity performance, assets performance, and the firms' ability to generate revenues from their operations. Considering the climate risks faced by these firms, it is logical to expect potential negative impacts on these factors if firms are not actively adjusting their business practices to mitigate environmental risks. These impacts could manifest as physical damages affecting asset values, reputational damage leading to decreased revenues, or constraints imposed by environmental regulations. As discussed Krueger et al., (2020) investors conditionally consider climate risks as financial and non-financial risks when making investment decisions.

The findings indicate a slight positive impact on return on assets when firms integrate climate risk considerations into their policies. Conversely, equity performance appears to be negatively affected during the period, potentially due to increased investments in "green" sectors as financial markets respond to environmental disasters or less efficiency from equity structure in generating profits. On the other hand, earnings before interest and taxes do not demonstrate any significant relevance in the analysis, with estimates fluctuating and consistently insignificant.

Overall, while there is significant evidence supporting the treatment effect on year-to-date returns, the performance of firms in terms of generating revenues and equity profitability does not align with the existing literature. Despite the lack of significance in the treatment impact estimates, firms that are prepared for climate change and its associated risks tend to exhibit a certain level of asset performance. However, the confirmation of this second hypothesis remains uncertain. The ability of enterprises with high environmental scores to outperform their competitors during extreme temperature events remains questionable and warrants further examination.

Throughout the research, several issues were encountered during the experimental phase, which affected the estimates and the overall analysis. The environmental issues are perceived as long-term event impact (Stroebel & Wurgler, 2021). One major limitation was the short time window considered in the study, spanning only two years and one quarter. This limited availability of data and could have led to missing values and biased estimations, particularly for variables computed annually.

Additionally, the dataset was influenced by the Russian and Ukrainian war, which had significant impacts on businesses in Europe. The conflict disrupted supply chains, affected raw material prices, and led to increased inflation rates. These external factors might have introduced biases in the sample and influenced the financial indicators considered in the analysis.

Then, the dataset and the model have been relatively difficult to adjust as some data were missing and this have led in a first time the data to not match the research framework as interesting variables were not complete. In addition, when regressing with some control variable there was the presence of multicollinearity within the model and biased the results. This was the case with capex and the variable has been excluded of the research design.

Adjusting the dataset and the model also posed challenges. Data inconsistencies and multicollinearity issues were addressed by excluding certain variables and modifying the dataset. However, this process resulted in some data loss and potentially affected the overall robustness of the analysis.

The index used to capture environmental performance was relatively underdeveloped, consisting of only four components. This limited differentiation between firms with high and low index scores and potentially weakened the treatment effect. A more precise clustering of high and low index groups and a deeper development of the (E) pillar attributes could have enhanced the research's cohesion.

Furthermore, the lack of significance in the estimated model raises difficulties in providing robust evidence of the causal effect of having a high index that complements the existing literature. However additional tests might have been better to conduct like a Placebo Test by introducing a random date or treatment or a Sensitivity Analysis by modifying the length of the studied period. These tests could have provided more precise and robust results, allowing for better interpretations of the metric regressed through the DiD model.

It is important to note that only the performance hypothesis, specifically the YTD return, is partially validated, while other estimates do not exhibit statistical significance. Conclusions must be drawn with caution, as reverse causality and other factors may alter the observed associations. Overall, these limitations and challenges highlight the need for further research and improvements in data quality, model specification, and index development to obtain more reliable and robust findings.

8. Conclusion

This paper investigates the causal effect of environmental policies on the financial risk mitigation and performance of European corporations during a period of abnormal positive temperatures. Using an index developed in the research which scales the environmental performance of the (E) pillar of ESG ratings, the paper analyses the data through a difference-in-differences regression model.

The findings do not align with the expected causal effect suggested by existing literature. While firms with a high index score experience higher year-to-date returns after the heatwaves, no significant impact is observed on other financial risk indicators, asset and equity performance, or revenue generation. Therefore, the evidence does not support the notion that being environmentally oriented and performing well helps firms reduce financial risk exposure or perform better in the context of temperature anomalies.

However, from a managerial perspective, environmental approaches can still be beneficial for firms in terms of reducing financial risk exposure and enhancing financial performance, despite the lack of direct impact demonstrated in this study. Such approaches involve developing cautious business models that positively influence stakeholders and enhance the firm's reputation, which can be advantageous in navigating transition risks with growing environmental concerns.

This research contributes to the literature by analysing the relationship between environmental policies and financial indicators in the context of extreme abnormal temperatures, adding nuance to previous studies. The results shed light on the underestimation of climate risks by markets, indicating the need for further research to explore the limits of current environmental policies and examine the underlying economic mechanisms that may have a more significant impact.

In terms of future research, it would be valuable to refine the metric used in this study by isolating each environmental attribute with its own metric, allowing for a more detailed investigation into the influence of different pillars on firms' performance during the climate crisis. This would provide more evidence on which specific attributes within the (E) pillar are most significant in explaining financial indicators, guiding governments, and supporting firms in their ecological transition efforts. Additionally, exploring the impact of environmental policies on other indicators or economic mechanisms, such as reputation or sustainability investing, would provide further insights into the broader effects of environmental strategies. Furthermore, a potential avenue for future research would be to place emphasis on top- and low-ranking index firms based on their environmental scores. By refining the sample to study extreme low and high scores (by quartiles), following the approach of Garel & Petit-Romec, (2021), a more nuanced understanding of the relationship between environmental performance and firm outcomes can be gained.

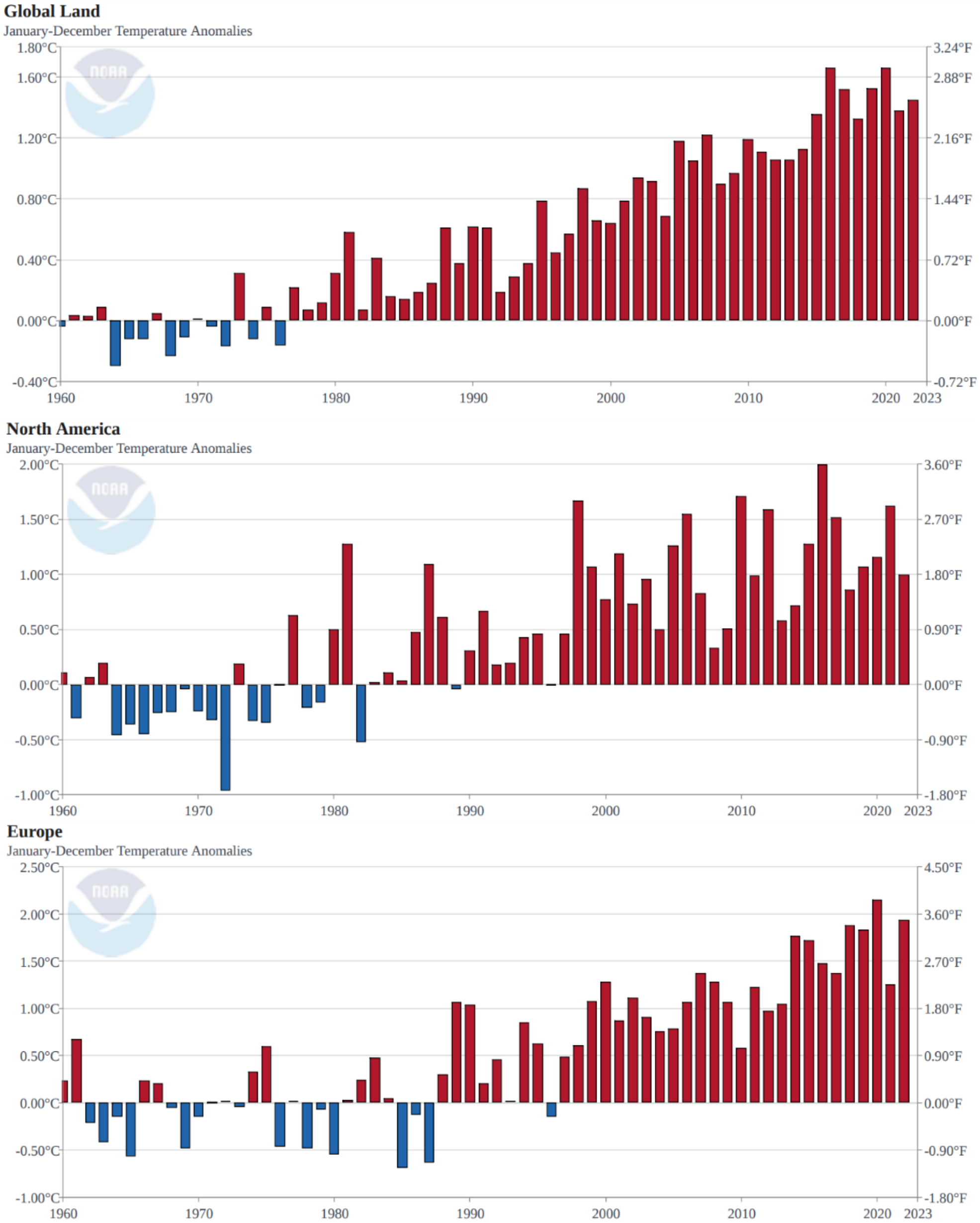
Extending the analysis over a longer time frame and considering additional exogenous events, such as geopolitical conflicts or pandemics, would offer a more comprehensive understanding of the long-term effects of environmentally performant strategies in the presence of additional shocks.

Moreover, the study is including only European countries, it might be interesting to cross these findings over different regions. As some regions have lower ESG regulatory framework, as the US. Therefore, some firms scores might rely on different quantity of information leading firms to have different ESG reporting process. Thus, (E) findings need to be contextualised regarding the region studied.

In conclusion, this thesis contributes to the literature by examining the relationship between environmental policies and financial indicators during a period of abnormal temperatures. The findings challenge previous assumptions and highlight the need for further research to explore the nuances of environmental strategies' impact on firms' performance and risk mitigation in different contexts.

APPENDICES

A1 - Yearly abnormal temperatures - Global, North America, and Europe (1960 - 2023)



Source : NCEI - NOAA

Figure 2 - Yearly abnormal temperatures Global, North America, and Europe (1960 - 2023)

A2 - Variables, definitions, and sources

Variable	Definitions	Source
E	The environmental pillar measures a company's impact on living and non-living natural systems, including the air, land, and water, as well as complete ecosystems. It reflects how well a company uses best management practices to avoid environmental risks and capitalise on environmental opportunities in order to generate long term shareholder value.	Thomson Reuter's Refinitiv ESG
E_treatment	First, an environmental index is constructed using the three attributes of the E pillar (resource use, emissions, and environmental innovations) along with the E pillar itself. This index differentiates between a strength (score > 50) and a concern (score ≤ 50). Next, a scaling process is applied to normalise each index between -1 and 1. Finally, a netting step is conducted to calculate a final net-scaled environmental index. This process ensures that the index captures the overall environmental performance by considering both positive and negative aspects.	Calculations based on Thomson Reuter's Refinitiv ESG
Beta	CAPM Beta. A measure of how much the stock moves for a given move in the market. It is the covariance of the security's price movement in relation to the market's price movement. A beta value of 1 suggests that the firm's returns are expected to move in tandem with the market's systematic risk. Beta is one of the components of the cost of equity and provides valuable insights into the relationship between market volatility and firm-specific risks.	Thomson Reuter's Refinitiv ESG
BM	The calculation of the BM is done by computing the product of the outstanding number of shares and the book value per share. Then this product is divided by the market capitalisation of the entity. It compares the book value of the entity to its market value. Therefore, this interacts directly with market valuation of the company. $\left(\frac{Book\ value\ per\ share \times number\ of\ outstanding\ shares}{Market\ capitalization}\right)$.	Calculations based on Thomson Reuter's Refinitiv ESG
EBIT	EBIT is computed as Total Revenues for the fiscal year minus Total Operating Expenses plus Operating Interest Expenses, Unusual Expenses/Income and Non-Recurring Items for the same period. This definition excludes non-operating income and expenses. It captures the overall profitability of a firm's core business activities linked to its assets. Higher EBIT indicates greater revenue generation and operational profitability. Note that EBITDA focuses solely on cash flow creation.	Thomson Reuter's Refinitiv ESG
Gmargin	Represents Gross Profit divided by Revenue. Gross Margin is not available if either Gross Profit or Revenue is missing or if Revenue is negative.	Thomson Reuter's Refinitiv ESG
LTDTA	This is the ratio of Long-Term Debt at the end of the fiscal period divided by the Total Assets for the same period and is expressed as a percentage. This ratio indicates how much of the assets of the entity is financed through long term debt.	Thomson Reuter's Refinitiv ESG
Post_Heat	Dummy variable created that is taking the value of 1 if the value is observed after August 2022 (consistent with the heatwaves of August 2022). Otherwise, it is equal to 0.	

continued

A2 - Variables, definitions, and sources - continued

Variable	Definitions	Source
ROA	This value is calculated as the Income After Taxes for the fiscal period divided by the Average Total Assets and is expressed as percentage. Average Total Assets is the average of Total Assets at the beginning and the end of the year. This ratio is relevant and often used in assessing the firm's performance as it assesses how much profit is generated by each unit of asset of the entity.	Thomson Reuter's Refinitiv ESG
ROE	This value is calculated as the Net Income Before Extraordinary Items for the fiscal period divided by the same period's Average Total Equity and is expressed as a percentage. Average Total Equity is the average of Total Equity at the beginning and the end of the year. It assesses how the firm generate profits from the equity (shareholders equity).	Thomson Reuter's Refinitiv ESG
Score.S	The social pillar measures a company's capacity to generate trust and loyalty with its workforce, customers, and society, through its use of best management practices. It reflects the company's reputation and the health of its license to operate, which are key factors in determining its ability to generate long-term shareholder value.	Thomson Reuter's Refinitiv ESG
Sector	The Refinitiv Business Classification (TRBC) Economic Sector Description. TRBC Classifies companies with increasing granularity by Economic Sector, Business Sector, Industry Group, Industry and Activity.	Thomson Reuter's Refinitiv ESG
Sector matrix	A matrix of sector dummies variables has been computed. There is a sole variable for each economic sector of the TRBC and it takes the value of 1 if the company is specialised in the sector. Otherwise, the variable takes the value of 0.	Manipulations based on Thomson Reuter's Refinitiv ESG
Volatility	Volatility serves as a metric for the uncertainty of stock price movements, capturing the standard deviation of price. The computations are based on calculating the returns of the companies using *Close Price*. Then the historical return volatility is computed. $\frac{Close\ Price_t - Close\ Price_{t-1}}{Close\ Price_{t-1}}$, Where t corresponds to the current period and $t-1$ corresponds to the previous period price	Calculations based on Thomson Reuter's Refinitiv ESG
WACCD	The cost of debt represents the marginal cost to the company of issuing new debt now. It is calculated by adding the weighted cost of short-term debt and the weighted cost of long-term debt based on the 1-year and 10-year points of an appropriate credit curve. A higher cost of debt indicates an increased risk of default.	Thomson Reuter's Refinitiv ESG
WACCEQ	The return a firm theoretically pays its equity investors for bearing specific levels of risk. It is calculated by multiplying the equity risk premium of the market with the beta of the stock plus an inflation-adjusted risk-free rate. The equity risk premium is the expected market return minus the inflation-adjusted risk-free rate.	Thomson Reuter's Refinitiv ESG
YTD	The YTD return incorporates the price change and any relevant dividends over the period of the year to date. It provides insights into yearly performance and the return up to a specific period.	Thomson Reuter's Refinitiv ESG

Table 8 - Variables, definitions, and sources

A3- Refinitiv’s environmental pillar methodology

The environmental pillar, which is a crucial component of the ESG score, consists of three components: emissions, resource use, and environmental innovation. These components are further composed of a wide range of metrics that assess different aspects within each component. The appendix provides a detailed breakdown of how the (E) used in the computation of the index of this paper score is constructed.

In terms of weightage, both emissions and resource use contribute 35% each to the overall (E) score, while environmental innovation represents 29% of the score. This indicates the relative importance of each component in assessing a company's environmental performance. Overall, the (E) pillar accounts for 44% of the final ESG score, underscoring its significance in evaluating environmental practices.

Within the emission attribute, there are 185 metrics that evaluate a company's engagement and performance in reducing its operational gas emissions. These metrics assess factors such as the implementation of climate risk management processes and emission reduction targets.

The resource use attribute focuses on evaluating a company's production model and its optimisation of water and energy usage. It encompasses 45 related characteristics and examines factors such as water efficiency policies and the number of resources purchased or produced.

The environmental innovation attribute measures a company's capacity to reduce costs and capitalise on new environmental technology opportunities. It comprises 39 metrics and evaluates aspects such as the company's investment in green capital expenditure and its revenue generation from green products.

These metrics collectively contribute to the computation of scores for each attribute within the (E) pillar, with each attribute rated on a scale of 0 to 100. This comprehensive database of metrics provides a detailed assessment of a company's environmental performance across various dimensions, enabling a more nuanced evaluation of its environmental practices.

A4- Difference-in-differences framework

The Difference-in-Differences regression model, commonly used in economics and finance (Olden et al., 2020), is the focus of this appendix, which provides a detailed background and mathematical explanation of the concept. DiD is considered an effective method for assessing the impact of policies. While the literature acknowledges its understanding and advantages, some biases may persist, making a triple DiD approach more informative for further research (Olden et al., 2020, and Lechner et al., 2016).

1. Purpose of a DiD

The primary objective of the DiD model, as outlined by Baker et al., (2022) is to estimate the causal effects of a treatment on a group. The model compares two groups: the treated group, which receives the treatment (X), and the control group, which does not receive the treatment. The analysis focuses on identifying the causal relationship between outcomes and policies in the presence of an exogenous shock. To account for this shock, the research design divides the analysis into two distinct time periods: a pre-shock period t_1 and a post-period t_2 where the consequences can be estimated. The regression primarily examines the outcomes of the treated group during the second period t_2, and the number of periods is determined by the events included in the research methodology.

2. The system and mathematical concept

The DiD model uses the average of the data subsets to conduct the analysis. It compares the outcomes (Y) between the treated and control groups, determining significant inferences between the dependent and independent variables.

Mathematically, the DiD model employs ordinary linear regression using the ordinary least squares method. OLS assumes that observations are independent and identically distributed, meaning they are not related to each other. The model estimates coefficients $\beta_i$hat reflect the impact of a one-unit increase in $X_{i,t}$ on $Y_{i,t}$ while holding all other terms constant at zero in the DiD framework.

Dummy variables play a crucial role in constructing the model. It includes a dummy treatment variable, a dummy post-shock period variable, and an interacting term that represents the interaction between the treatment and post-shock period. These binary variables take the value of one if specific conditions are met, capturing the relationship between the variables, and allowing for statistical inference and quantification of the treatment effect.

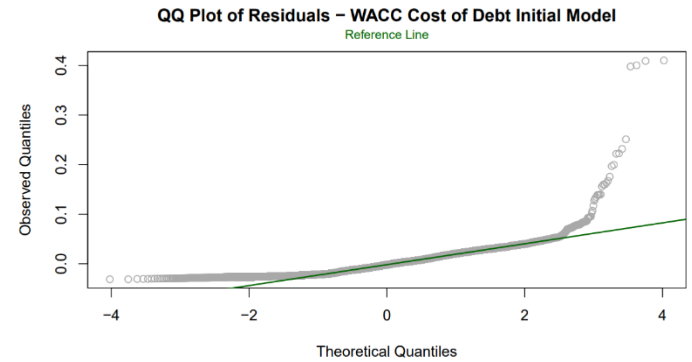
The DiD model computes the average difference in differences using the formula:

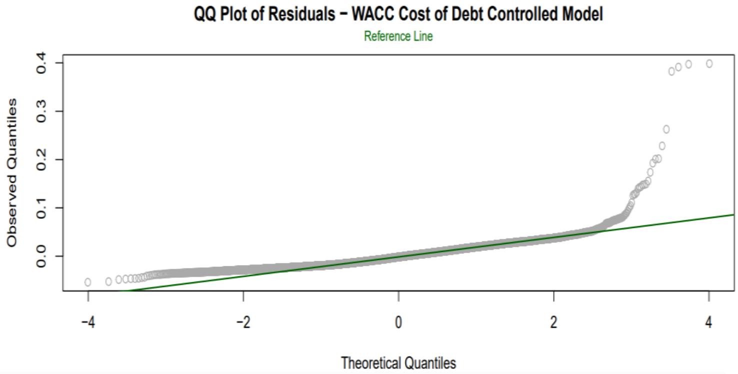
$$(Y_2^{Trea} - Y_2^{Co}) - (Y_1^{Trea} - Y_1^{Co}),$$

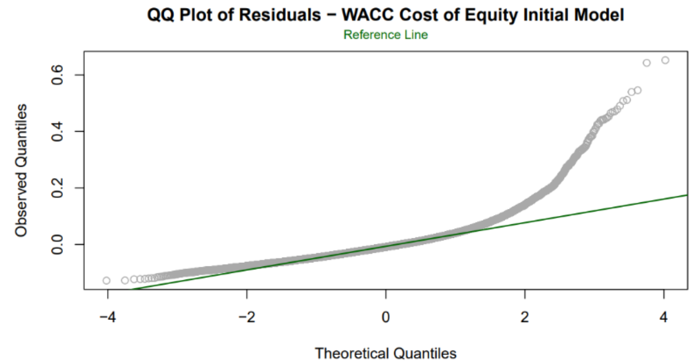
Where Y_t^{Trea} and Y_t^{Co} represent the observations of the treated and control groups for period t. This calculation captures the difference-in-differences, providing an estimate of the average treatment effect on the treated group (Clarke et al., 2023).

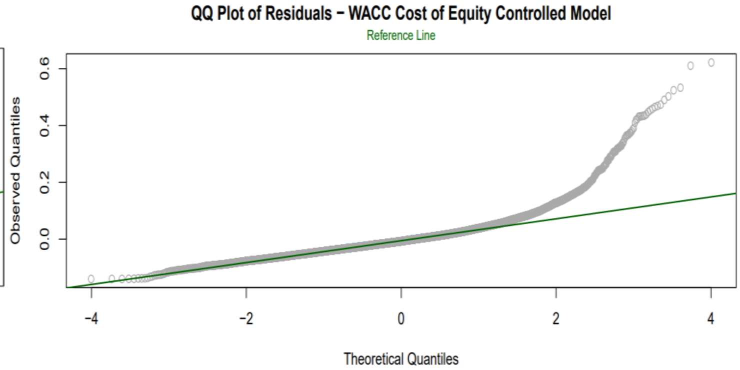
In practice, the DiD approach allows for the inclusion of additional treatment periods and covariates ((Angrist, 2008).

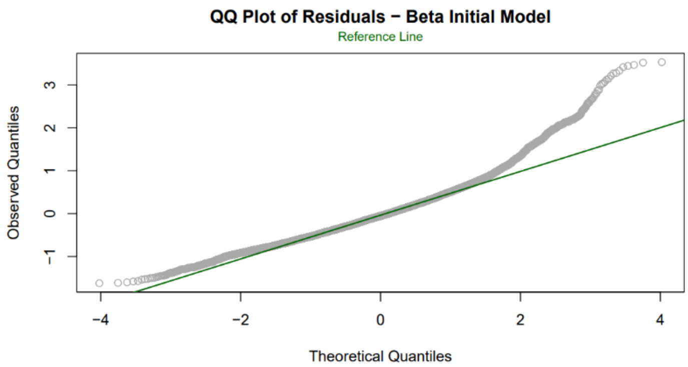
A5 - QQ Plots – Difference-in-differences regressions residuals

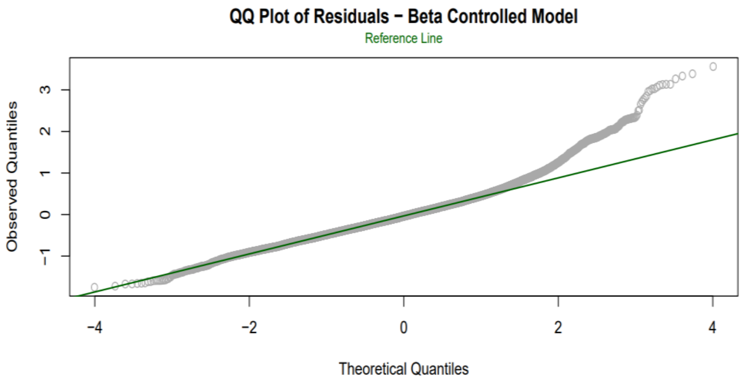


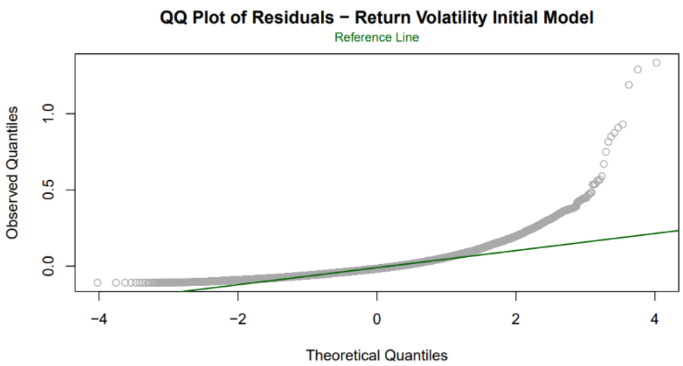


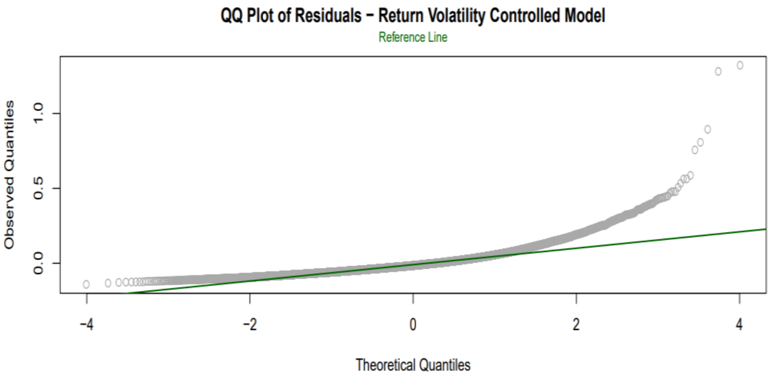












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A5 - QQ Plots – Difference-in-differences regressions residuals - *continued*

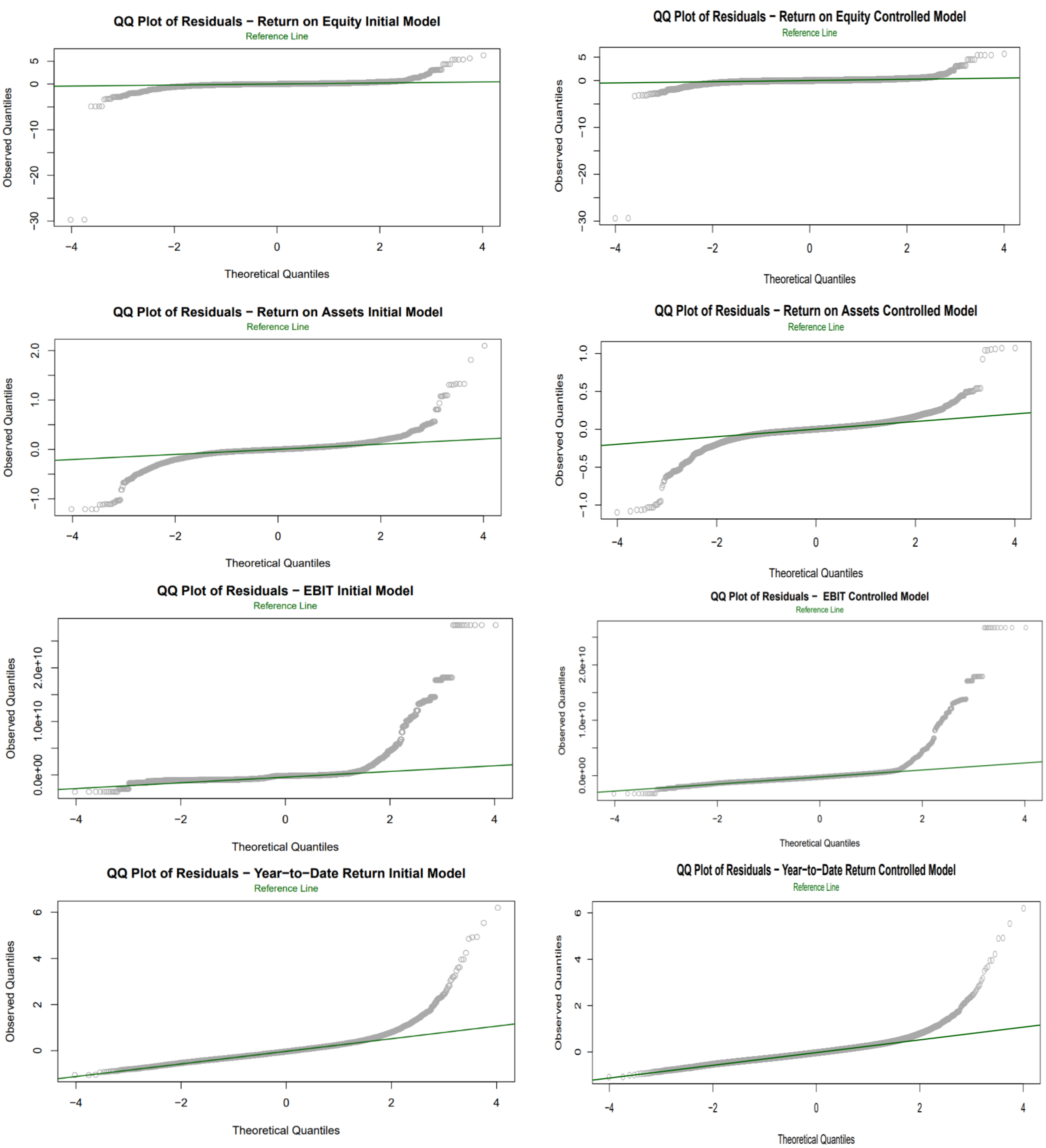

Figure 3 - Difference-in-differences regressions residuals

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