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Does ESG matter in times of Natural Disasters? A case study on U.S. companies during the billion-dollar hurricanes in 2017.

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Dissertation

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Abstract

2017 was a devastating year for natural disasters in the United States. Within a month, Hurricanes Harvey, Irma and Maria caused more than 3000 casualties and provoked estimated losses of $300 billion. These disasters provide a unique opportunity to analyze the impact of climate extreme events on the stock market. Mainly this dissertation has two goals. First, I test if these events provoked losses in the stock market. Second, I test if firms' ESG scores impact their returns during these extreme events.

The results suggest that extreme natural disasters negatively impact the stock market, and the closer firms are located to the natural disaster, the more negatively affected their returns are. Moreover, firms with intermediate ESG scores perform worse in periods of natural disasters than firms with extreme levels of ESG investment (either low or high). This paper highlights the importance of companies' ESG investment level and the importance of a higher level of ESG in companies based in locations where the chances of being affected by natural disasters are higher.

Key words: Climate Change; Environmental, Social and Governance; Natural Disasters; Stock Returns

JEL Classification Codes: G12; M14; Q54

Resumo

2017 foi um ano devastador para as catástrofes naturais nos Estados Unidos. No espaço de um mês, os Furacões Harvey, Irma e Maria causaram mais de 3000 mortes e provocaram perdas estimadas em 300 mil milhões de dólares. Estas catástrofes proporcionam uma oportunidade única para analisar o impacto de eventos climáticos extremos nos retornos das empresas. Esta dissertação tem dois objetivos. Primeiro, testar se estes eventos provocaram perdas no mercado de ações. Segundo, testar se a pontuação ESG das empresas teve impacto nos retornos durante estes eventos extremos.

Os resultados sugerem que os desastres naturais afetam negativamente o mercado de ações, e quanto mais perto as empresas se encontram da catástrofe natural, mais negativamente os seus retornos são afetados. Além disso, as empresas com pontuações intermédias de ESG têm pior desempenho em períodos de desastres naturais do que as empresas com níveis extremos de investimento ESG (baixos ou altos). Esta dissertação salienta a importância do nível de investimento ESG das empresas e a importância de um nível mais elevado de ESG em empresas sediadas em locais onde a probabilidade de serem afetadas por catástrofes naturais é maior.

Palavras-Chave: Alterações Climáticas; Environmental, Social and Governance; Desastres Naturais; Retornos Financeiros

Classificação JEL: G12; M14; Q54

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Abbreviations used

CAPM – Capital Asset Pricing Model

CPI – Consumer Price Index

CSR – Corporate Social Responsibility

ESG – Environmental, Social and Governance

GFC – Global Financial Crisis

ROA – Return on Assets

U.S. – United States

1. Introduction

In 2017, within a month, three hurricanes caused more than 3000 casualties and provoked estimated losses of $300 billion in the U.S. (NOAA, 2022). Concerns about climate change and its impact on our lives are growing, reflecting the exponential increase in the number of occurrences of natural disasters. Investors are looking for solutions to protect against this risk, and consumers are more aware of the reality of the products they consume in their daily lives. Including Environmental, Social and Governance (ESG) factors in strategy may thus become critical to the companies' success. In this sense, international investors with global investment portfolios increasingly call for high-quality, transparent, reliable and comparable reporting by companies on climate and other ESG matters (ISSB, 2022). Yet, the level of investment in ESG differs from company to company, and its investment rhythm is also very distinct. We see companies with an ambition of achieving high ESG score levels in the short-term while other companies have longer-term goals. Thus, is the level of ESG scores an advantage for companies in times of natural disasters?

So far, the literature on ESG has taken two distinct directions. On the one hand, several studies discuss the advantages and disadvantages of corporate investment in sustainability policies (Lins, Servaes, & Tamayo, 2017). On the other hand, other studies use turbulent periods of financial stress, such as the Covid-19 and the Global Financial Crisis, to study the impact of ESG scores on firms' returns (Demers, Hendrikse, Joos, & Lev, 2021). While the analysis of turbulent financial periods may be of value, to the best of my knowledge, accounting for the impact of ESG scores on firms' returns during turbulent environmental periods has not been addressed by the literature.

Hence, this dissertation intends to analyze the impact of ESG on companies' financial returns during natural disasters. To do so, I depart from the literature on ESG in two ways. First, instead of considering a turbulent financial period, I use a period of three extremely historical large billion-dollar natural disasters - Hurricane Harvey, Hurricane Irma and Hurricane Maria. These three natural disasters occurred between August and September 2017 and, in less than a month, caused damage of around $300 billion, higher than the total losses registered in the second most-damaging year (2005). The devastating impact of these three events allows us to consider them a natural experiment. To validate these events' relevance for the financial markets, I study their impact on firms' daily returns. Afterwards,

I analyze the impact of ESG scores on firms' abnormal returns during the three events together as well as for each particular event.

Second, since the literature on ESG has identified advantages and disadvantages associated with ESG, I introduce a quadratic term for the ESG score. This quadratic term allows me to study the possibility of a u-shape relationship between ESG scores and firms' financial returns. It may be the case that, at some levels of ESG scores, the disadvantages surpass the advantages of ESG investment.

The main findings are as follows. First, the results suggest that, on average, these three extreme events resulted in losses in the firms' daily returns. Moreover, the closer firms are located to the natural disaster, the more negatively affected their returns are. These results motivate the need to study the impact of ESG on firms' financial returns during these events. Second, the results suggest the ESG score does not linearly impact firms' returns, but they seem to indicate a u-shape relationship: firms with intermediate scores perform worse than firms with extreme levels of ESG (either higher or lower) during these extreme events. At the intermediate level of ESG investment, the disadvantages may outweigh the advantages, and companies may not benefit from the investment made in ESG.

The results presented in this study have important corporate policy implications. First, the location of company headquarters should be a growing concern for both owners and investors as the trend of natural disasters is also growing. Second, companies should evaluate the amount of ESG investment with caution because it may be very expensive to attain a level where they can benefit from ESG.

The remainder of this dissertation is structured as follows. Chapter 2 reviews the selected literature developed on ESG. In Chapter 3, I describe the methodology and the models used to examine the impact of ESG on firms' returns during severe periods of natural disasters. Chapter 4 describes the sample and variables. Chapter 5 reports the empirical results on the relationships between firms' financial returns, extreme events and firms' ESG scores. Chapter 6 concludes.

2. Literature Review

This chapter reviews the selected literature on ESG. Chapter 2.1. defines the key concepts throughout this dissertation. Chapter 2.2. presents the different perspectives of the benefits and costs of investing in corporate social policies, such as ESG and Corporate Social Responsibility (CSR). Chapter 2.3. describes the literature that studies the impact of such policies on firms' financial returns.

2.1. Definitions

This dissertation has three key concepts: ESG, natural disasters and stock returns. First, in recent years, we have seen numerous companies announcing, in addition to financial data, their environmental (e.g., carbon emissions, water consumption, amount of waste produced), social (e.g., human rights, product responsibility, community) and governance data (e.g., political lobbying, anti-corruption programs, board diversity). The literature calls this ESG data (Albuquerque, Koskinen, Yang, & Zhang, 2020; Kuna-Marszalek & Klysik-Uryszek, 2020; Ouchen, 2021). Such corporate social policies can be defined as a long-term commitment to ethical business conduct in which economic objectives are combined with measures to improve the quality of life of the workforce and society as a whole (Kuna-Marszalek et al., 2020).

Second, a natural disaster can be defined as some rapid, instantaneous or profound impact of the natural environment upon the socio-economic system. A natural disaster can be an avalanche, coastal erosion, drought, earthquake, flood, frost, hail, hurricane, landslide, lightning, a snowstorm in an urban area, tornado, tsunami, volcanic eruption or windstorm (Alexander, 2018).

Finally, stock returns are the percentage change in the price of a stock over time. In this dissertation, I use two types of stock returns: normal and abnormal returns. The normal return is simply the change in the face value of a stock over time. The abnormal return is the change over time in the difference between the stock's face value and the stock's expected value. To compute the stock's expected value, I follow the literature and use the CAPM model (Albuquerque et al., 2020).

2.2. Benefits and Costs of Corporate Social Policies

There is extensive and voluminous literature devoted to ESG investing and thousands of research studies focused on sustainable investing and ESG, highlighting both positive and negative impacts (Anson, Spalding, Kwait, & Delano, 2020).

Corporate social policies represent an ongoing commitment by the firm to behave ethically, creating safe, healthy workplaces and improving the quality of life of its employees (and their families), the local community and society (Watts & Holme, 1999). These policies aim to engage in ethical business practices, provide enduring, reliable services to customers, and invest in the local environment and community more generally (Ding, Levine, Lin, & Xie, 2021). For example, these initiatives range from voluntary programmes and partnerships to mitigate the environmental impact of industrial facilities and production methods (Rondinelli & Berry, 2000) to the development of sourcing and marketing initiatives that protect social welfare and commit to environmental benefits (Bekin, Carrigan, & Szmigin, 2007; Roberts, 2003).

The evolution of the presentation of this data has been exponential over the past few years. While in 1990, only 20 companies disclosed ESG data in integrated or sustainability reports, in 2016, there were about 9000 (Amel-Zadeh & Serafeim, 2018). This exponential increase in data submission goes hand in hand with increased investor interest in this issue, which has also grown rapidly (Amel-Zadeh et al., 2018).

Numerous studies have documented that investing in corporate social policies, such as ESG, is associated with several benefits that may arise internally and externally, i.e., from the firm's external environment. On the one hand, environmental, social, and governance activism may contribute to changes in the management style, which can add value to the firm. For example, according to Dimson, Karakaş, and Li (2015), a more active ownership may attenuate managerial myopia, helping minimize intertemporal profit losses and negative externalities.

On the other hand, several studies point out that corporate social policies can strengthen firms' connections with stakeholders (Albuquerque et al., 2020; Ding et al., 2021; Lins et al., 2017). From these connections, the literature has devoted much attention to two in particular. First, the connection between firms and clients is positively affected by these policies. In this sense, several studies suggest that corporate social policies can act as a

product differentiation strategy, strengthening customer loyalty and reducing a corporation's susceptibility to economic downturns (Albuquerque et al., 2020). There are several examples of this strategy: Patagonia uses only organic cotton in its outdoor clothing and supports conservation efforts; Apple is switching to 100% renewable energy; and TOMS donates a pair of shoes for every pair bought (Albuquerque et al., 2020). This way, companies promote customers' interests, creating a more loyal customer base and a lower price elasticity of demand for their products. A less price-elastic demand allows the firm to charge higher prices and have higher profit margins, which consequently increases the firm's value (Lins et al., 2017).

Second, several studies suggest that corporate social policies have greatly improved the connection between firms and investors. According to Deng, Kang, and Low (2013), such policies signal a firm's commitment to satisfying implicit contracts, which in turn boosts investors' willingness to support the firm's operations, especially in difficult times. In fact, trust is stated as one of the most important values generated by these policies. Accordingly, Lins et al. (2017) suggest that these activities serve as a measure of firms' social capital because they generate social capital and trust.

The increase in investors' trust in the firm may have two important implications. On the one hand, several studies suggest that corporate social policies lower the firm's cost of capital because investors recognize a higher investor base and, consequently, a lower perceived risk (e.g., Chen, Chen, and Wei (2009); El Ghoul, Guedhami, Kwok, and Mishra (2011); McGuire, Sundgren, and Schneeweis (1988)). Thus, ESG disclosures are associated with lower capital constraints (Cheng, Ioannou, & Serafeim, 2014) and lower capital costs (Dhaliwal, Li, Tsang, & Yang, 2011).

On the other hand, if high social capital firms are perceived as more trustworthy, investors may place a valuation premium on these firms (Guiso, Sapienza, & Zingales, 2008). The reason behind this premium relies on the reciprocity concept (i.e., the idea that "I will be good to you because I believe you will be good to me at some point in the future"), which suggests that investors are more likely to help high social capital firms (Lins et al., 2017). Thus, higher trust tends to go hand in hand with firms' valuation and lower stock price synchronicity (Grewal, Hauptmann, & Serafeim, 2017).

Because of these benefits, numerous studies suggest that these corporate social policies contribute to favorable evaluations in capital markets (e.g. Flammer (2013); Franco, Caroli,

Cappa, and Del Chiappa (2020); Qiu, Jiang, Liu, Chen, and Yuan (2021)) and are good predictors of companies' future financial performance (Khan, Serafeim, & Yoon, 2016).

The advantages of investing in corporate social policies are numerous, but several authors also highlight some disadvantages (Lee, Singal, & Kang, 2013). First, according to Lee et al. (2013), these policies often incur substantial extra costs which can undermine firms' financial well-being.

Second, several studies propose an agency theory perspective of ESG investments, suggesting that ESG-related activities may destroy value (Demers et al., 2021). This point of view indicates that executives may choose to improve their company's ESG scores at the expense of shareholders. This controversial decision may be motivated by the fact that managers want to build their own personal reputations or because managers may retrieve some utility from the satisfaction of some personal or moral imperative (Bae, El Ghoul, Gong, & Guedhami, 2021). From this perspective, these investments may be wasteful and potentially harmful to shareholders (e.g., increasing the propensity for management entrenchment and the ensuing value destruction).

Besides the disadvantages associated with corporate social policies, several studies suggest a key factor that may undermine the impact of ESG scores on firms' valuation: ESG scores may fail to reliably measure the alleged social capital that environmentally and societally friendly firms have accrued through their initiatives (Demers et al., 2021). In this sense, Chatterji, Durand, Levine, and Touboul (2016) estimate very weak correlations between six different ESG rating systems and note that users of social ratings should be cautious in interpreting their link to actual corporate social responsibility. In addition, when analyzing differences between five scoring systems for the year 2014, Berg, Kölbel, and Rigobon (2022) attribute 50% of the variations in the result to measurement error. Thus, investors may react to this noise by disregarding low levels of ESG investment.

Concluding, it is therefore important to clarify if all the advantages listed cover the disadvantages presented as well. In other words, it may be the case that there is an optimal ESG score that allows companies to be comfortable with ESG policies and develop their activity in a clean and real way.

2.3. Impact of ESG on Financial Returns during Turbulent Financial Periods

Financial crises coincide with a period of risk aversion or a flight toward safe-haven asset classes or investment strategies (Coudert & Gex, 2008). In this way, investors become more attentive to corporate fundamentals in an attempt to avoid downside risk during an economic slowdown (Hirshleifer (2008); Nofsinger and Varma (2014); Lins et al. (2017)).

To test this hypothesis, several studies analyze turbulent periods, such as the 2008–2009 GFC or the Covid-19 period, and find that ESG scores may indeed offer such downside risk protection in times of crisis (Albuquerque et al. (2020); Demers et al. (2021); Singh (2020)). For example, Singh (2020) finds that the ESG portfolio accounted for a decent recovery after the declaration of COVID-19 as a pandemic. According to the author, the ESG behavior during the pandemic helps explain why the ESG approach generates positive returns during periods of crisis. The ESG provides a refuge for investors as they become more mindful of business fundamentals during an economic downturn.

Although several studies find positive results concerning the performance of firms with higher ESG scores during periods of financial turbulence, Demers et al. (2021) refute the importance of ESG in explaining stock returns for US equity securities during the recent pandemic. According to these authors, earlier GFC period findings of ESG as a resilience factor may not be consistent across crises, which calls into question the robustness of the risk management perspective of ESG as protection against downside risk.

Besides analyzing turbulent periods, some studies focus on large periods to study the impact of ESG scores. On the one hand, Nofsinger et al. (2014) argue that companies that exhibit ESG responsibility are less likely to suffer large, negative events in ESG areas during both bull and bear market periods. On the other hand, Broadstock, Chan, Cheng, and Wang (2021) find that the importance of ESG performance is attenuated in normal times, but strengthened during times of crisis. This view is consistent with the assertion that investors in stocks attach higher importance to ESG performance as a signal of future stock performance and/or risk mitigation.

The literature often mentions the effect ESG has on firm performance and price resilience in periods of instability. However, to the best of my knowledge, there is no study on the impact of ESG in periods of natural disasters.

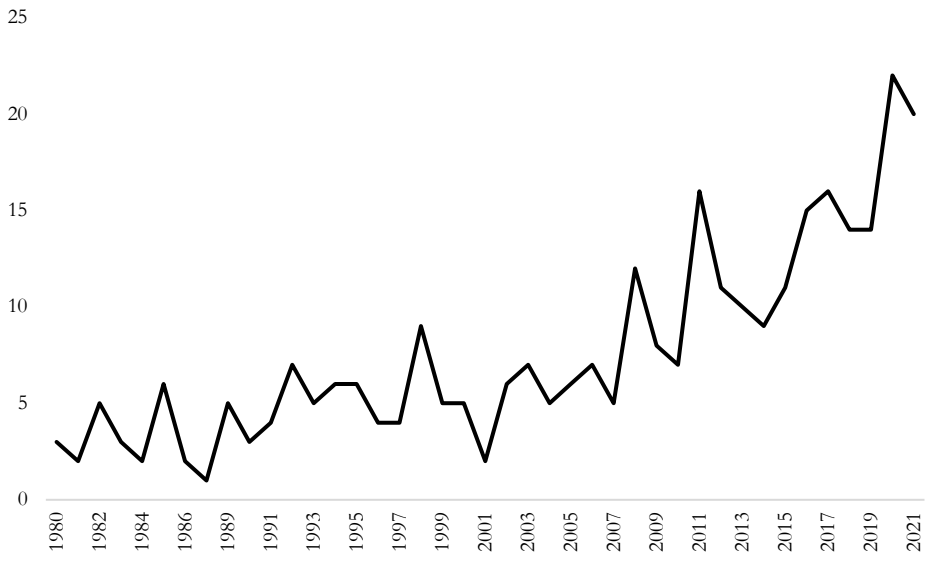
3. Methodology

This chapter has five subchapters and describes the methodology used to examine the impact of ESG on firms' returns during severe periods of natural disasters. In Subchapter 3.1., I present the Natural Disaster Data that is used to define the scope of this study. In the following three subchapters, I present the three sets of explanatory variables, i.e. ESG variable and the firms' financial and non-financial variables, respectively. Finally, Subchapter 3.5. presents the empirical design.

3.1. Natural Disasters

Natural disaster data comes from the NCEI (National Centers for Environmental Information) database. NCEI is NOAA's (National Oceanic and Atmospheric Administration) official data repository, offering access to a comprehensive environmental data archive. The dataset provides information about weather and climate, which have caused Billion-Dollar Disasters to affect the U.S. from 1980 to 2021. More specifically, this dataset reports the damage and the number of deaths of a total of 310 natural disasters for seven categories of natural disasters: Drought, Flooding, Freeze, Severe Storm, Tropical Cyclone, Wildfire and Winter Storm.

Figure 1 - Billion-Dollar Natural Disasters in U.S. per year

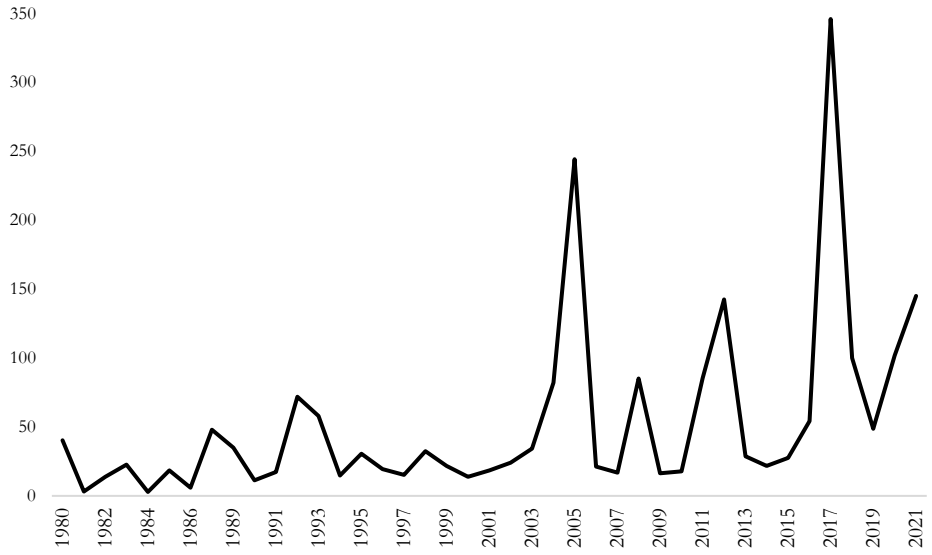


This graph plots the number of billion-dollar natural disasters in the USA between 1980 and 2021. Source: NOAA (2022)

Figure 1 plots the number of billion-dollar natural disasters in the USA between 1980 and 2021. The figure shows a significant increase, and the trend has intensified in recent years. Since 1980, 2020 registered the highest value with 22 billion-dollar natural disasters, followed by 2011 and 2017 with 11 natural disasters.

Figure 2 draws the total CPI-adjusted costs of the billion-dollar natural disasters between 1980 and 2021. This figure shows that 2017 stands out as the most devastating year in terms of losses, with a total loss of 319 billion dollars. Following 2017, 2005 accounted for a loss value of 242 billion dollars. From 1980 to 2021, the average losses are around 100 billion dollars. Thus, 2017 was an extremely historic year in terms of natural disasters.

Figure 2 - Total CPI-Adjusted Cost (Billion of Dollars) in U.S. per year



This graph plots the total CPI-Adjusted Cost (billion of dollars) of natural disasters in the USA between 1980 and 2021. Source: NOAA (2022)

Analyzing with more detail 2017, there were three major natural disasters, which have occurred within 27 days: Hurricane Harvey in August, Hurricane Irma and Hurricane Maria, both in September. Table 1 presents the dates of these events, the total CPI-adjusted costs and the number of deaths. According to this table, the three natural disasters caused damages of around 300 billion dollars and around 3000 deaths. Recall that the second most-damaging year, 2005, registered a total amount of losses of 250 billion dollars, which is below the losses of these three events.

Table 1 - Three major billion-dollar natural disasters in the U.S.

Name	Disaster	Begin Date	End Date	Total Cost CPI-Adjusted (Billions of Dollars)	Deaths
Hurricane Harvey	Tropical Cyclone	25/08/2017	31/08/2017	141.25	89
Hurricane Irma	Tropical Cyclone	06/09/2017	12/09/2017	56.5	97
Hurricane Maria	Tropical Cyclone	19/09/2017	21/09/2017	101.7	2981

This table describes the three billion-dollar natural disasters in the USA between 1980 and 2021. Source: NOAA (2022)

The information from natural disasters is very sensitive to the time period of the natural disaster and even the intensity it presents over days (Worthington & Valadkhani, 2004). Because of that, I now describe each of these events.

First, Hurricane Harvey was a tropical cyclone that made landfall in the state of Texas in the United States. Although the NCEI database gives us the information that the hurricane started on 25 August 2017 and ended on 31 August, Hurricane Harvey began to intensify rapidly on 24 August, regaining tropical storm status and becoming a hurricane later that day. Moving generally to the northwest, the intensification phase of Hurricane Harvey remained slightly stable overnight from 24 to 25 August, but Hurricane Harvey soon resumed strengthening late on 25 August. Hours later, Hurricane Harvey hit the ground in Rockport, Texas, at its maximum intensity. For the remaining days, Hurricane Harvey was much less intense and far away from the Texas area. Hurricane Harvey caused an estimated 89 deaths. Estimated economic losses are between 141.25 billion dollars.

Second, Hurricane Irma was a tropical cyclone that, among several regions, hit the state of Florida in the United States as a major hurricane. It was the strongest hurricane ever recorded in the Atlantic Ocean basin outside the Caribbean and Gulf of Mexico. Hurricane Irma developed on 30 August near the Cape Verde islands. On 5 September, it reached its highest intensity. On the remaining days, it had lower intensities as it passed over Cuba, but it increased in intensity again as it crossed warmer waters between Cuba and the Florida Keys. This hurricane essentially hit the islands and eastern United States (especially Florida). The remaining days of the hurricane had lower intensities, with the end of the hurricane

occurring on 12 September. It resulted in 97 deaths and estimated losses of 56.5 billion dollars.

Finally, Hurricane Maria was a tropical cyclone that hit land twice in the Caribbean region, first on the island of Dominica, located in the Windward Islands, and then on the island of Puerto Rico, affecting other Caribbean regions such as the Dominican Republic and the Turks and Caicos Islands. Hurricane Maria formed on 16 September in a tropical wave and peaked in intensity between 19 and 21 September 2017. It resulted in 2981 deaths and estimated losses of 101.7 billion dollars. This hurricane resulted in the most deaths between 1980 and 2021, according to the NCEI database.

Because these devastating natural disasters of 2017 occurred within a narrow duration and provoked record losses, they created an opportune and unique episode to analyze how U.S. financial markets reacted to them. Moreover, in 2017, ESG databases on U.S. companies were already robust. Because of these two conditions, I argue that this particular period is the most favorable period to examine the impact of ESG on firms' returns during severe periods of natural disasters. Thus, the scope of this analysis focuses on these three disasters.

3.2. ESG

Investors, asset managers, and other stakeholders largely rely on third-party companies to provide ESG ratings and reports to facilitate decision-making (Huang, Li, Lin, & McBrayer, 2022). Using a variety of quantitative and qualitative indicators, several companies use different formulas to obtain a singular value for the ESG rating. In this dissertation, I use the ESG score by Refinitiv, which is calculated as a combination of the three pillars (Environment, Social, and Governance).

The Environmental score is a combination of three scores: resource use, emissions and innovation. First, the resource use score reflects a company's performance and capacity to reduce the use of materials, energy or water and to find more eco-efficient solutions by improving supply chain management. Second, the emissions reduction score measures a company's commitment and effectiveness towards reducing environmental emissions in its production and operational processes. Finally, the innovation score reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed products.

The Social score is computed as a combination of four scores: workforce, community, human rights, and product responsibility. First, the workforce score measures a company's effectiveness in terms of providing job satisfaction, a healthy and safe workplace, maintaining diversity and equal opportunities, and development opportunities for its workforce. Second, the community score measures the company's commitment to being a good citizen, protecting public health and respecting business ethics. Third, the human rights score measures a company's effectiveness in terms of respecting fundamental human rights conventions. Finally, the product responsibility score reflects a company's capacity to produce quality goods and services, integrating the customer's health and safety, integrity and data privacy.

Last, the Governance score is a combination of three scores: management, shareholders, and CSR strategy. First, the management score measures a company's commitment and effectiveness towards following best practice corporate governance principles. Second, the shareholders score measures a company's effectiveness towards equal treatment of shareholders and the use of anti-takeover devices. Finally, the CSR strategy score reflects a company's practices to communicate that it integrates economic (financial), social and environmental dimensions into its day-to-day decision-making processes.

Table 2 systematizes the Refinitiv' ESG score, presenting the three pillars of the ESG and respective dimensions.

Table 2 - The three pillars of the ESG and their indicators based on the Refinitiv

Environmental	Resource Use
	Emissions
	Innovation
Social	Workforce
	Human Rights
	Community
	Product Responsibility
Governance	Management
	Shareholders
	CSR strategy

This table describes the three pillars of the ESG and their indicators. Source: Refinitiv database

Refinitiv offers one of the most comprehensive ESG databases in the industry, covering over 80% of the global market capitalization, across more than 500 different ESG metrics, with a record dating back to 2002. The universe of companies for which ESG data is maintained and ESG scores are calculated consists of 9,000 companies globally.

These categories result in a score starting at A for "ESG leaders" companies and ending at D for "ESG laggards". 'A' score indicates excellent relative ESG performance and a high degree of transparency in reporting material ESG data publicly. On the other hand, the 'D' score indicates poor relative ESG performance and an insufficient degree of transparency in reporting material ESG data publicly. An ESG leader company must have a score range between 0.75 and 1, while an ESG laggard company has a score range between 0 and 0.25. Table 3 presents the ESG grades and the respective scores.

Table 3 - Refinitiv ESG score

Score Range	Grade	Description
0.0<=score<=0.083333	D -	***D*** score indicates poor relative ESG performance and insufficient degree of transparency in reporting material ESG data publicly.
0.083333<score<=0.166666	D	
0.166666<score<=0.250000	D +	
0.250000<score<=0.333333	C -	***C*** score indicates satisfactory relative ESG performance and moderate degree of transparency in reporting material ESG data publicly.
0.333333<score<=0.416666	C	
0.416666<score<=0.500000	C +	
0.500000<score<=0.583333	B -	***B*** score indicates good relative ESG performance and above average degree of transparency in reporting material ESG data publicly.
0.583333<score<=0.666666	B	
0.666666<score<=0.750000	B +	
0.750000<score<=0.833333	A -	***A*** score indicates excellent relative ESG performance and high degree of transparency in reporting material ESG data publicly.
0.833333<score<=0.916666	A	
0.916666<score<=1	A +	

This table describes the Refinitiv ESG score. Source: Refinitiv database

3.3. Firm Financial Characteristics

To study the effect of ESG on firms' financial returns, I follow the literature to identify variables that control for several firm financial characteristics. I choose the following firm financial characteristics: firm size, leverage, cash ratio, ROA, long-term debt, short-term debt, market to book value, momentum and tobin's q (Albuquerque et al. (2020); Bae et al. (2021); Demers et al. (2021); Ding et al. (2021); Lins et al. (2017)). Table 4 defines these variables.

Table 4 - Firm Financial Characteristics

Firm Financial Characteristics	Definition
Firm Size	Natural logarithm of the book value of total assets.
Leverage	Ratio of total debt divided by total assets.
Cash	Total amount of cash and short-term investments divided by total assets.
ROA	Ratio of net income to total assets.
Long Term Debt	All interest-bearing financial obligations, excluding amounts due within one year. It is shown net of premium or discount.
Short Term Debt	Represents that portion of debt payable within one year including current portion of long-term debt and sinking fund requirements of preferred stock or debentures.
Market to Book Value	The market value of the firm's equity divided by its book value of equity at fiscal-year end.
Momentum	The growth rate of the market value one year before.
Tobin's q	Book value of assets minus the book value of equity plus the market value of equity, all divided by book value of assets.

This table describes the Firm Financial Characteristics.

3.4. Firm Non-Financial Characteristics

In order to complete the set of control variables, I add industry fixed effects to isolate the industry's effect. I also add the distance to the natural disaster to analyze the impact that the distance between the areas most affected by natural disasters and the firms' headquarters may have on the financial returns. Table 5 defines these variables.

Table 5 - Firm Non-Financial Characteristics

Firm Non-Financial Characteristics	Definition
Industry Code	Represents a four-digit numeric code assigned to the company to represent its industry group. Each company is classified into a major industry group, represented by the first two digits of the code. In addition, each company is further classified within its major group into a subordinated industry group.
Distance	Represents the linear distance between the areas most affected by natural disasters and the firm's headquarters.

This table describes the Firm Non-Financial Characteristics.

3.5. Empirical Design

The goal of this study is twofold. First, the goal is to assess whether those three billion-dollar natural disasters that occurred in 2017 impacted firms' financial returns. To this end, the regression model is a fixed-effect model and is the following:

$$return_{i,t} = \alpha + \beta disaster_t + \varepsilon_{i,t} \quad (1)$$

where $return_{i,t}$ is the daily financial return of firm *i* at day *t*, $disaster_t$ is a dummy variable that is equal to one if, at day *t*, one of the three disasters is active, α is the constant coefficient, and β is the coefficient associated with the impact that these disasters may have on the firms' returns. The use of a panel context, specifically the use of a fixed-effect model, allows assessing the average effect that these disasters may have had on each firm's financial returns, avoiding, at the same time, the use of control variables and abnormal returns.

The second and main objective is to assess whether the ESG performance impacted firms during those natural disasters. To do so, I propose three models that allow different forms of accounting for the effect of ESG scores. The first model assesses the linear impact of ESG scores. The model is the following:

$$Performance_i = \alpha + \beta_1 ESG_i + \beta_2 Firm\ Fin\ var_i + \beta_3 Firm\ Non\_Fin\ var_i + \varepsilon_i \quad (2)$$

where $Performance_i$ is the CAPM adjusted return of firm *i*, ESG_i is the ESG score of firm i, $Firm\ Fin\ var_i$ is a vector of the firm i's financial characteristics presented in Chapter 3.3., $Firm\ Non\_Fin\ var_i$ is a vector of the firm i's non-financial characteristics presented in Chapter 3.4., α, β_1, β_2, and β_3 are the coefficients to be estimated. Naturally, the focus is on the β_1 coefficient that represents the linear effect that the ESG may have during these events. Regarding the dependent variable $Performance_i$, the main focus of this dissertation is analyzing the impact of the ESG on the joint performance during the three events. However, for robustness purposes, I also analyze the performance during each of these events. Thus, I have four different dependent variables: the buy-and-hold adjusted returns across the three events and the buy-and-hold adjusted returns for each of the three events.

Following the literature, in the second model, I assess the non-linear impact of ESG scores, using quartiles (Albuquerque et al., 2020; Lins et al., 2017). The empirical model is the following:

$$Performance_i = \alpha + \beta_{11} ESG\_2Q_i + \beta_{12} ESG\_3Q_i + \beta_{13} ESG\_4Q_i +$$
$$+\beta_2 Firm\ Fin\ var_i + \beta_3 Firm\ Non\_Fin\ var_i + \varepsilon_i. \quad (3)$$

The terms in Equation (3) are defined in a similar way to those of Equation (2). ESG_2Q_i (ESG_2Q_i) is a dummy variable that is equal to one if the firm has a ESG score higher than the first (second) quartile and below or equal than the second (third) quartile of the ESG scores in the sample. ESG_4Q_i is a dummy variable that is equal to one if the firm has a ESG score higher than the third quartile.

Finally, I also assess whether there is a quadratic relationship between the ESG scores and the firms' financial returns. This specification allows me to study a possible turning point from which the advantages of the ESG can surpass the disadvantages of ESG and vice-versa. The empirical model is the following:

$$Performance_i = \alpha + \beta_{11} ESG_i + \beta_{12} ESG_i^2 + \beta_2 Firm\ Fin\ var_i +$$

$$+\beta_3 Firm\ Non\_Fin\ var_i + \varepsilon_i. \quad (4)$$

The terms in Equation (4) are defined in a similar way to those of Equation (2). ESG_i^2 represents the quadratic term of the ESG score of firm i.

4. Data

I obtain data from Refinitiv. Refinitiv collects information from corporate annual reports, sustainability reports, nongovernmental organizations, and news sources for publicly traded companies at an annual frequency. I consider all U.S. companies, with information available in Refinitiv for 31 December 2016. I chose 2016 for data selection because it is the last full fiscal year with financial information before the period I want to analyze. Following the literature, I remove from the sample financial and micro-cap firms, i.e. firms with a market capitalization below $250 million as of year-end 2016 (Lins et al., 2017). These steps resulted in a dataset composed of 3243 companies.

Regarding the data necessary to compute the dependent variables, my dataset starts on 11 August 2017 and ends on 3 October 2017. I chose these dates so to create a balanced dataset. To this end, the period encompassing the three extreme natural disasters is in the middle of the sample and corresponds to 50% of our sample. This sample period is particularly relevant to estimating the model represented in Equation (1), as the fixed-effects model needs observations to assess the average effect of each firm.

Table 6 reports the summary statistics on the firm-specific variables that were listed in Chapters 3.2. to 3.4. The first row of Table 6 shows that the primary variable of interest, ESG, has a mean value of 0.39 and a median value of 0.34, representing a mean score of C. The C score indicates a satisfactory ESG performance and a moderate degree of transparency in reporting material ESG data publicly. The next three rows show that firms, on average, have lower environmental scores, averaging 0.24, than governance and social scores, 0.48 and 0.41, respectively. The 75th percentile value shows us that companies are, on average, more concerned with governance.

The average returns during all three events are positive, both when I consider the events individually and together. However, 25% of the companies in the sample have a negative return during Hurricane Irma and Hurricane Maria, with the latter presenting the lowest values. Effectively, Hurricane Maria was the one with the highest number of deaths and the second with the most billions in losses, which is also reflected in the results of the firms' returns.

Table 6 - Summary Statistics

Summary Statistics	Mean	SD	25th Perc.	Median	75th Perc.
ESG	0,39	0,20	0,24	0,34	0,52
Environment	0,24	0,28	0,00	0,13	0,44
Social	0,41	0,21	0,25	0,38	0,56
Governance	0,48	0,22	0,29	0,48	0,66
Financial Characteristics					
Cash	0,13	0,15	0,03	0,08	0,18
Debt LT	0,27	0,24	0,09	0,24	0,39
Debt ST	0,02	0,05	0,00	0,01	0,03
Leverage	0,68	9,31	0,06	0,56	1,22
Market to Book Value	2,87	28,76	1,82	2,90	4,95
Momentum	0,12	0,30	-0,09	0,09	0,29
Tobin's q	2,45	1,75	1,39	1,86	2,88
ROA	0,01	0,19	0,00	0,04	0,08
Size	14,76	1,71	13,52	14,65	15,94
Distance					
Joint Events (mean)	2513,43	889,96	1972,35	2225,70	3014,01
Hurricane Harvey	1717,93	746,96	1384,39	1715,35	2197,84
Hurricane Irma	2285,66	1018,13	1712,80	1965,32	2899,12
Hurricane Maria	3537,86	1194,12	2575,82	3190,15	4376,79
Returns					
Joint Events	0,05	0,12	0,00	0,05	0,09
Hurricane Harvey	0,03	0,07	0,01	0,03	0,05
Hurricane Irma	0,02	0,05	-0,01	0,02	0,04
Hurricane Maria	0,00	0,07	-0,02	0,00	0,02

This table displays summary statistics for variables used in this dissertation. Source: Author's calculations based on data from Refinitiv database.

5. Results

This chapter has three subchapters. In Subchapter 5.1, I present and discuss the estimates for the impact of billion-dollar natural disasters on firms' returns. In subchapter 5.2, I analyze the impact of the ESG score on firms' abnormal returns during the billion-dollar natural disasters together and during each disaster.

5.1. The Impact of Natural Disasters on Returns

Table 7 presents estimates for the first regression model, specified in Equation (1) in Subchapter 3.5. This model allows for assessing the impact of the three billion-dollar natural disasters on firms' daily returns. According to Table 7, the results indicate that a day of a billion-dollar hurricane provokes, on average, a reduction of 0.18% in the daily stock returns. The negative impact of extreme natural events on firms' financial returns is consistent with the literature, for example, Worthington et al. (2004) and Cagle (1996).

Two additional remarks are in order. First, as stated in Chapter 3.1, these extreme events are becoming increasingly frequent. Because of these events' negative impact on firms' financial returns, the increasing trend may imply that, in the future, there will be additional volatility in the stock market caused by these events. Second, this additional volatility reinforces the need to study if ESG scores affect firms' financial returns during these events.

Table 7 - US companies' returns on billion-dollar natural disasters

Variable	Daily Returns
Billion Dollar Hurricanes	-.0018***
	(.00016)
Constant	.0025***
	(.0001)
Statistics	
Number of Observations	41033
Number of companies	1109
Adj. R^2	.0032
F stat	132.36

This table presents regression estimates for Equation (1) presented in Chapter 3.5. The control variables and returns are winsorised at the 5th and 95th percentiles. Heteroskedasticity-consistent standard errors are presented in parentheses. ***,**, and * indicate the parameter estimate is significantly different from zero at the 1%, 5%, and 10% level, respectively.

5.2. The Impact of ESG on Returns during Natural Disasters

5.2.1. Joint Events

Table 8 presents estimates for the regression models specified in Equations (2) to (4) in Chapter 3.5. These models allow for assessing the impact of the ESG scores on firms' CAPM adjusted returns during the three billion-dollar natural disasters. As mentioned in Chapter 3.5., the difference between these three models is how the effect of the ESG scores is modelled. Thus, for each column in Table 8, I have different specifications of how ESG scores may impact firms' abnormal returns during these extreme events.

Starting with column (1) of Table 8, the results suggest that ESG scores do not have a linear impact on firms' financial abnormal returns during these extreme events. These results are in line with some studies, such as Demers et al. (2021). As stated earlier, several reasons may explain why ESG investment may not serve as a downside risk protection. For example, ESG costs are quite high and, in periods of extreme events, the advantages may not compensate (Lee et al., 2013).

Turning to column (2), I estimate Model 3, i.e. instead of including the linear measure of ESG, I include ESG quartile dummies. This approach allows assessing whether the effect of natural disasters on firms' abnormal returns is more pronounced at higher ESG levels or lower ESG levels. According to column (2), the results indicate that firms that invest less in ESG may have better returns in periods of natural disasters than those that invest at an intermediate level (quartiles 2 and 3). These results seem to indicate a u-shape rather than a linear relationship between the ESG score and firms' abnormal returns. This is because firms with higher levels of ESG appear to have better returns than those that invest at an intermediate level, but still slightly lower than those that invest little. On average, the difference in abnormal returns between firms in the intermediate level of ESG and firms in the lowest level of ESG, as captured by the coefficient on ESG3, is 1.2 percentage points.

To test the u-shape hypothesis, column (3) of Table 8 presents the estimates for Model 4, where I add the ESG score squared to model 2. Adding the quadratic term allows for testing the u-shape hypothesis, i.e. whether firms with intermediate levels of ESG scores have lower performance than firms with extreme (low or high) levels of ESG. According to column (3), the results suggest the possibility of a quadratic relationship between firms' ESG scores and performance during the three billion-dollar extreme events.

To the best of my knowledge, this study is the first to propose the u-shape hypothesis for the ESG impact on firms' financial returns. I argue three key factors can explain this u-shape hypothesis. First, according to Avramov, Cheng, Lioui, and Tarelli (2021), investor demand for ESG ratings is reduced in periods of uncertainty, especially for ESG-sensitive investors. According to these authors, investors are still conservative towards ESG, and in troubled times, they tend to seek refuge assets. To this end, companies with a medium level of ESG disclosure may be the most affected by the response of conservative investors toward ESG.

Second, since ESG activities have high fixed costs and some of the advantages associated with ESG are reputational, it may be the case that the advantages may outweigh the disadvantages only with high ESG scores. Finally, since ESG scores have some measure problems (Berg et al., 2022; Demers et al., 2021), it may be the case that investors may react to these problems by disregarding low levels of ESG investment.

Table 8 - CAPM adjusted returns of joint events

Variables	Model 2 (1)	Model 3 (2)	Model 4 (3)
Distance	.0052**	.0053**	.0053**
	(.0024)	(.0024)	(.0024)
ESG	-.0078		-.1003**
	(.0136)		(.0474)
ESG^2			.1052**
			(.0479)
ESG2		-.0122*	
		(.0066)	
ESG3		-.0121**	
		(.0061)	
ESG4		-.0020	
		(.0072)	
Cash	.0616**	.0625**	.0617**
	(.0244)	(.0244)	(.0244)
Debt LT	.0015	.0020	.0011
	(.0149)	(.0148)	(.0149)
Debt ST	.1038	.0911	.1009
	(.0724)	(.0730)	(.0726)
Leverage	.0034	.0036	.0035
	(.0033)	.0036	(.0033)
Market to Book Value	-.0006	-.0006	-.0006
	(.0010)	(.0010)	(.0010)
Momentum	.0038	.0033	.0032
	(.0079)	(.0080)	(.0080)
Tobin's q	-.0086***	-.0091***	-.0089***
	(.0027)	(.0027)	(.0027)
ROA	-.1676***	-.1659***	-.1666***
	(.0260)	(.0257)	(.0258)
Size	-.0039*	-.0052***	-.0044**
	(.0021)	(.0020)	(.0021)
Constant	.0726**	.0971***	.0979***
	(.0304)	(.0315)	(.0325)
Industry	yes	yes	Yes
N	1108	1108	1108
Fstat	22.13	20.71	21.39
R-squared	0.2809	0.2858	0.2839

This table presents regression estimates for Equation (2), (3) and (4) presented in Chapter 3.5. The control variables and returns are winsorised at the 5th and 95th percentiles. Heteroskedasticity-consistent standard errors are presented in parentheses. ***,**, and * indicate the parameter estimate is significantly different from zero at the 1%, 5%, and 10% level, respectively.

Regarding the control variables, two remarks are in order. First, Table 8 indicates that the distance effect is positive across the three models. This result suggests that firms further away from the natural disaster sites have higher abnormal returns than those closer to the hurricane-affected areas. This result may justify the fact that, according to Huang et al. (2022), firms that are closer to catastrophes invest more in transparently disclosing ESG scores because managers increase their preference for transparency as their risk salience increases. Second, cash, Tobin's Q, ROA and size are significant in all three models tested, similar to Albuquerque et al. (2020).

In order to further test these results, I test models 2 and 4 individually for each of the hurricanes: Hurricane Harvey, Hurricane Irma and Maria. The following chapter presents and discusses these results.

5.2.2. Three Hurricanes: Harvey, Irma and Maria

This chapter presents additional analysis carried out to check the robustness of the results. More specifically, Table 8 displays the estimates for the regression models specified in Equations (2) and (4) in Chapter 3.5 for the observations during each of the three major billion-dollar natural disasters that occurred in 2017 (Hurricane Harvey, Irma, and Maria). Since the results in the previous chapter seemed consistent across the three models, this chapter focuses only on models 2 and 4.

For all hurricanes, the results are widely similar to those in the previous chapter. With the exception of hurricane Irma, the other two hurricanes are in line with the results I find for the events as a whole. Thus, for hurricanes Harvey and Irma, the results suggest a u-shape relationship between the ESG and firms' abnormal returns, i.e. firms with extreme scores of ESG (high and low) tend to have less negative returns than those with an intermediate ESG score.

Table 9 - Estimations for the CAPM Adjusted Returns during each of the three Hurricanes: Harvey, Irma and Maria

Variables	Hurricane Harvey		Hurricane Irma		Hurricane Maria	
	Model 2	**Model 4**	**Model 2**	**Model 4**	**Model 2**	**Model 4**
Distance	.0006	.0006	.0016*	.0017*	.0006	.0006
	(.0012)	(.0012)	(.0009)	(.0009)	(.0007)	(.0007)
ESG	-.0023	-.0348*	.0029	-.0358*	-.0121**	-.0366*
	(.0054)	(.0183)	(.0059)	(.0208)	(.0058)	(.0202)
ESG^2		.0370**		.0440**		.0278
		(.0182)		(.0210)		(.0202)
Cash	.0350***	.0350***	.0142	.0143	.0129	.0130
	(.0096)	(.0096)	(.0104)	(.0104)	(.0102)	(.0102)
Debt LT	-.0012	-.0013	.0013	.0011	.0073	.0072
	(.0057)	(.0057)	(.0064)	(.0064)	(.0065)	(.0065)
Debt ST	.0521*	.0511	.0383	.0371	.0046	.0039
	(.0313)	(.0313)	(.0307)	(.0309)	(.0316)	(.0316)
Leverage	.0015	.0016	-.0015	-.0015	.0026**	.0027**
	(.0013)	(.0013)	(.0014)	(.0014)	(.0013)	(.0013)
Market to Book Value	-.0003	-.0003	.0006	.0006	-.0004	-.0004
	(.0004)	(.0004)	(.0004)	(.0004)	(.0004)	(.0004)
Momentum	.0009	.0007	-.0002	-.0005	.0035	.0034
	(.0031)	(.0031)	(.0035)	(.0035)	(.0034)	(.0034)
Tobin's q	-.0041***	-.0042***	-.0029**	-.0030**	-.0022**	-.0023**
	(.0011)	(.0011)	(.0012)	(.0012)	(.0011)	(.0011)
ROA	-.0578***	-.0575***	-.0172	-.0168	-.0636***	-.0633***
	(.0107)	(.0107)	(.0113)	(.0112)	(.0108)	(.0109)
Size	-.0021***	-.0023***	-.0011	-.0013	-.0005	-.0007
	(.0008)	(.0008)	(.0009)	(.0009)	(.0008)	(.0008)

(continued)

Table 9 - Estimations for the CAPM Adjusted Returns during each of the three Hurricanes: Harvey, Irma and Maria (continued)

Variables	Hurricane Harvey		Hurricane Irma		Hurricane Maria	
	Model 2	**Model 4**	**Model 2**	**Model 4**	**Model 2**	**Model 4**
Constant	.0485***	.0574***	.0137	.0243*	.0162	.0229*
	(.0119)	(.0127)	(.0127)	(.0137)	(.0123)	(.0131)
Industry Fixed-Effects	yes	yes	yes	yes	yes	yes
N	1108	1108	1108	1108	1111	1111
Fstat	17.62	17.09	7.70	7.62	24.01	22.90
R-squared	0.2421	0.2446	0.1149	0.1183	0.2591	0.2603

This table presents regression estimates for Equation (2) and (4) presented in Chapter 3.5. The control variables and returns are winsorised at the 5th and 95th percentiles. Heteroskedasticity-consistent standard errors are presented in parentheses. ***,**, and * indicate the parameter estimate is significantly different from zero at the 1%, 5%, and 10% level, respectively.

Hurricane Maria is the only event where the results do not support a u-shape relationship, but they rather suggest a linear negative relationship, i.e. firms with higher ESG have poorer returns during this extreme event. Two specific characteristics from this event may help explain the difference in the results. First, Hurricane Maria peaked over the weekend, implying that investors could only react in the aftermath of that event. Second, this hurricane had a major impact on Puerto Rico but did not create large expenses on the mainland. This characteristic may also explain why the distance variable is insignificant during this event.

6. Concluding Remarks

The year 2017 was an ideal opportunity to study the impact of ESG on corporate returns during periods of natural disasters. Hurricane Harvey, Irma and Maria occurred between August and September and, in less than a month, caused damages of around 300 billion dollars and around 3000 deaths. I use these three events to test whether firms' investment in ESG can be the source of higher returns during periods of natural disasters. Specifically, I developed the study in three stages. First, I tested if natural disasters affect firms' returns. Second, I also tested if the distance of firms' headquarters from the center of the hurricanes impacts their returns. Finally, the main objective of study was to understand the impact that investment in ESG has on firms' returns during these periods. In order to obtain the desired results, I estimated four different models.

My main findings are as follows. First, the results suggest that billion-dollar natural disasters negatively impact firms' financial returns. On average, a day of a billion-dollar hurricane may cause a 0.18% reduction in firms' daily returns. Second, firms whose headquarters are closer to the center of the hurricanes have higher losses in financial returns.

Finally, our key results suggest that companies with intermediate ESG scores have lower returns during the disaster period than companies with extreme ESG scores (high or low). This result seems to indicate a u-shape effect.

The propensity for natural disasters to occur has increased significantly in recent years. Since the results suggest that the location of firms' headquarters impacts their returns during these periods, this study calls for the importance of the location of firms' headquarters. Having headquarters in a location prone to natural disasters can be detrimental to the company, not only because of the impact it has on financial returns but also because investors are increasingly taking these issues into consideration and can be a reason for disinvestment.

These findings have potentially important implications for both researchers and practitioners. Firstly, since all companies already have or are starting to have ESG concerns, it is essential to understand how ESG can improve company performance. Secondly, environmental concerns are more and more implicit in our daily life as the occurrence of natural disasters has increased due to climate change.

Throughout the study, I realized that the ESG score might not be properly measured. It seems important that future studies invest in the knowledge and study of ESG

measurement as this issue may become a real problem for companies with the exponential increase in ESG investment.

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