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Climate Change Fear: Natural Disasters and Investor Behavior

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ABSTRACT

Although an increasing number of papers analyze losses due to natural disasters, there is no evidence that climate change events have an impact on Sustainable Investment Decisions. Our paper proves, by using data on natural disasters, that these natural disasters have a substantial influence on the returns of Exchange-traded Funds (ETF), showing that investors react to natural disasters by investing in sustainable financial products. Our findings suggest that large-scale natural disasters significantly increase investors' preferences for sustainable ETFs. Finally, we also provide evidence that investors' sentiment toward the sustainability theme has changed over time.

Keywords: Sustainable investments, climate change, natural disasters, ETF

JEL Codes: G11, G12, G18

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1 Introduction and Motivation

Climate change is a global challenge affecting all human and non-human habitants. As reported by the United Nations webpage "*Climate change is the defining issue of our time and we are at a defining moment. From shifting weather patterns that threaten food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly*".[1] Not surprisingly, a large number of initiatives have been recently developed both at the worldwide[2] and country[3] levels. Where we consider natural disasters as a part of climate change, which means, we assume that climate change causes natural disasters, not vice-versa, and, thus, climate change using natural disasters increases the attention of investors, our paper measures natural disasters and their effect on investment decisions. Our paper considers the following types of natural disasters: drought, extreme temperature, flood, landslide, mass movement (dry), storm, volcanic activity, and wildfire.[4] Research on the relationship between climate change and natural disasters is broadly examined by non-economic studies for a long time already (to name a few: Anderson and Bausch,

[1] https://www.un.org/en/sections/issues-depth/climate-change (31 August 2019).

[2] E.g. The "United Nations Framework Convention on Climate Change," signed by 195 members and 180 new participants in Paris in 2015, deals with greenhouse-gas-emissions mitigation, adaptation, and financing. Also, the "Sustainable Development Goals (SDG)," signed in 2015 by 193 members of the United Nations and global civil society in 2015, identifies 17 goals related to the planet protection, peace and prosperity promotion and poverty decline to be achieved between 2015 and 2030.

[3] Among all, we remind the Presidential Climate Action Plan (2013) in the US aiming to reduce carbon dioxide emissions. In China, the Government established its Green Finance Taskforce in 2014: the task force recommendations were applied by Central Council in 2015 and reflected in Green Financial Guidelines in 2016. In the same year, China also turned into the largest issuer of green bonds and provided legal support to growing green products. Other governments (e.g. South Africa, Malaysia, China, EU, and Brazil) obliged large companies to disclose their sustainable business practices together with financial data. The number of companies disclosing their sustainability actions has increased from 30 in 1990 up to more than 7000 in 2014 worldwide (Khan *et al.*, 2016). COP 26 hosted in Glasgow in 2021 finalized the elements of the Paris Agreement in 2015: commitment to support developing countries in dealing with consequences of climate change, adoption of the global methane pledge and finalization of the Paris rulebook.

[4] We consider that while the effect of climate change on drought, extreme temperature, flood, landslide, wildfire, for example, is obvious due to greenhouse effect in the atmosphere that boost temperatures and human activity, the relationship between climate change and natural disasters such as earthquakes is not fully scientifically proven. https://climate.nasa.gov/news/2926/can-climate-affect-earthquakes-or-are-the-connections-shaky/.

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2006;[5] Dixon *et al.*, 2019; Fang *et al.*, 2019; Lee *et al.*, 2020; Van Aalst, 2006). All these studies explain the relationship between different natural disaster events and climate change. According to the National Aeronautics and Space Administration Earth Observatory,[6] climate change will create conditions more favorable to the formation of severe thunderstorms and tornadoes, where, in modern conditions of climate change and the probable increase of natural disasters due to its effects, it is getting more crucial for investors to both protect their portfolios from financial risks caused by catastrophic events and grab new opportunities resulting from new market conditions although, even though such aforementioned effects are not detectable in observations today, there is evidence that tornadoes have become more frequent in recent years. Moreover, driven by the evolution of legislation related to the new European Union Climate Benchmarks, we are observing the creation of new UCITS instruments (e.g., Climate transition mutual funds) which are offered to both retail and institutional customers and targeted to a fair and green transition. The financial system plays an essential role in achieving sustainable development. The United Nations Environment established the "Inquiry into the Design of a Sustainable Financial System" in 2014 to contribute to the transition of the financial system to a green and inclusive one. This inquiry was followed by a wide number of policy regulators, financial institutions, and civil society from more than 20 countries around the world in 2018. Not surprisingly, there is an increasing interest in sustainable and responsible investing also driven by various initiatives, such as the Financial Stability Board's "Task Force on Climate-Related Financial Disclosures"[7] or the "Network of Central

[5]Fang *et al.* (2019) show that climate change and GDP have no positive impacts on the growth of natural capital. By contrast, natural disaster frequency contributes to the accumulation of natural capital in G20 countries, while an inverted U-shaped relationship between the growth of natural capital and the magnitude of natural disasters is observed. Dixon *et al.* (2019), in a survey experiment involving three different natural hazards find that emphasizing the role of climate change in these hazards produced unintended effects for climate change sceptics. Anderson and Bausch (2006) provide the clear influence of climate change on heatwaves and intense rainfall and the emerging evidence of hurricanes which are going to become more severe through the years. Van Aalst (2006) describes such catastrophic events as Hurricanes Katrina (2005) and Wilma (2005) and provides evidence that the intensity of tropical cyclones in the Atlantic has been increasing since 1995 and explain by a sea-level rise which results in much higher storm surge damage, and it incorporates some of the effects of global climate change. Lee *et al.* (2020) provide evidence that climate change on disaster events results in various disasters (earthquakes, typhoons, floods, and landscape hazards) and classify disaster events into natural disasters (24.5%), disasters associated with technology (64.5%) and those associated with security or violence (11.0%).

[6]https://earthobservatory.nasa.gov/features/RisingCost/rising_cost5.php.

[7]Task Force on Climate-Related Financial Disclosures (TCFD), set up in 2015 by the Financial Stability Board, to develop voluntary, consistent climate-related financial risk disclosures for use by companies, banks, and investors in providing information to stakeholders.

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Banks and Supervisors for Greening the Financial System".[8] Almost all main stock exchanges have enhanced sustainability reporting to improve corporate transparency, risk management and engagement with stakeholders: as of 15 March 2018, there are 38 exchanges worldwide providing Environmental, Social, and Corporate governance (ESG) guidance (Sustainable Stock Exchanges Initiative under United Nations[9]).

No wonder, the number of studies investigating the effect of sustainability issues on a very wide number of financial items is fast growing. In the first group of papers literature deals with "Corporate Social Responsibility" with a focus on environmental consciousness (Di Giuli and Kostovetsky, 2014; Tang and Zhang, 2020; Zerbib, 2019). The second group of papers use natural disasters and climate changes as an exogenous shock to test the reaction of various types of financial products, such as credit supply, real estate prices, and financial instruments. The third group of papers outlines how investment decisions are influenced by ESG or Socially Responsible Investing (SRI) items.

Our paper provides a substantial contribution to both groups of papers, with our paper being at the intersection between the second and the third group of studies: specifically, we use worldwide natural disasters as an exogenous shock, and we measure the investors' reaction just after the shock by comparing ESG-oriented investments and other (normal) investments. In comparison to papers investigating the relationship between ESG and investors' decisions, we propose a new focus based on the analysis of Exchange-traded Funds (ETF), that is, investment funds that track an index, a commodity or bonds and are traded on stock exchanges. A common feature of all papers assessing the relationship between ESG items and investors' decision, where the ESG rating assignment is a non-fully standardized process: an ESG rating reflecting both the weighted average of the ESG values of single loadings of mutual funds, but also being influenced by rating agencies' subjective evaluation policies (Escrig-Olmedo *et al.*, 2019), is their focus on mutual funds and, especially, their ESG ratings. As such, ESG ratings produced by different rating agencies are not comparable and their adoption may introduce arbitrary factors in empirical analysis. In our paper, we focus on ETF investments, rather than mutual funds, since ETFs enable us to have an objective assessment of ETFs related to sustainability themes (i.e., we define ESG-oriented ETFs using the following two complementary and objective criteria: (1) the ETF name contains either

[8]The Network of Central Banks and Supervisors for Greening the Financial System was originally set up by eight central banks and supervisors at the end of 2017. As of October 15th, 2019, the network includes 46 members and 9 observers. Network for Greening the Financial System (NGFS), places central banks in a unique position to influence broader financial market behaviors and accelerate the transition to a more socially and environmentally sustainable economy and financial system, due to the fact that climate change is a key area of focus given the potential risks it poses to financial stability.

[9]https://sseinitiative.org/home-slider/sri-lankan-exchange-launches-sustainability-guidance/.

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"ESG" or "SRI"; (2) self-declared sustainable-oriented ETF: that ETF asset manager declares itself when dealing with sustainability macro themes). There are also various factors making ETFs attractive for investors, in place of mutual funds. ETF allows better targeting for a thematic investment, as the ESG and the ESG-oriented investments. ETFs are highly trading flexibility instruments (allowing investors to enter and exit very quickly from an investment thematic strategy: Sherrill *et al.*, 2017). ETFs also have lower fees than mutual funds and ETFs might be preferred by investors with higher liquidity and trading needs and/or higher marginal taxes (Agapova, 2011). Focusing on the past decade (January 2009–December 2018), we selected 848 natural disaster events from 147 countries in our paper: this enables us to investigate the reaction of worldwide investments using quite 1500 ETFs.

Further, in our paper, to measure the gravity of the disaster, we collect data on single natural disasters from a novel database of natural disaster events worldwide that provide us with different parameters (number of deaths, number of injuries, and value of damages).

Our novel identification approach enables us to answer the following research questions: do worldwide investments react to natural disasters? We show that there is an increase in investment demand after the occurrence of natural disasters, signaling the need for additional sustainable investments. We also find that investment activity toward sustainable financial products is influenced by the asset class type (fixed income or equity). Moreover, we evaluate whether investment returns after natural disasters can differ across time, considering that the climate change topic has acquired increasing attention by the market sentiment, in particular after the occurrence of very popular international conferences such as the 2015 Paris COP 21. The basic assumption is that the sentiment on climate change changes over time according to the increase in media attention and the interest in the international political agenda, over this topic.

Our main contribution is that we provide readers with empirical evidence of "whether" and "to what extent" investors change their investment attitudes after natural disasters. By analyzing a large dataset, including international natural disasters and a very extensive dataset of sustainable ETF, our empirical results indicate that investment demand increases significantly after natural disasters, suggesting the necessity of additional sustainability investments after climate shocks' occurrence. A study investigating the investment activity in response to climate change events, considering the expectation that scientists have regarding the possible increase in frequency and intensity of natural disasters, may help, with particular reference to emerging market countries characterized by climate change events of a particular intensity, to ensure the best use of anti-climate change measures.

The rest of this paper is organized as follows. In Section 2, we review past papers, and we formulate our research hypothesis. In Section 3, we describe our data and variables. Then, we illustrate our identification approach in

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Section 4., we present our results in Section 5 and we report robustness checks in Section 6. We conclude in Section 7.

2 Literature and Hypotheses Development

There is fast growing literature investigating the effect of ESG issues on a very wide number of financial items. Although the heterogeneity of these studies, we group them into three main areas. The first branch of literature deals with "Corporate Social Responsibility" with a focus on environmental consciousness suggesting that the standard profit maximization model is evolving toward complex profit maximization strategies including constraints related to a minimal degree of satisfaction of the other stakeholders (e.g., Becchetti *et al.*, 2015; Ferrell *et al.*, 2016). The second group of papers uses natural disaster and climate changes phenomena as an exogenous shock to test the reaction of various type of financial products, such as credit supply (Berg and Schrader, 2012; Cortés and Strahan, 2017; Koetter *et al.*, 2020), real estate prices (e.g. Bernstein *et al.*, 2019) and the issuance of financial instruments (Painter, 2020). The third group of papers focus on the effect of ESG items on financial markets focusing on stock prices (Oestreich and Tsiakas, 2015; Tang and Zhang, 2018; Zerbib, 2019), weather derivatives market (Pérez-González and Yun, 2013; Purnanandam and Weagley, 2016), and investment decisions (Hartzmark and Sussman, 2019; Renneboog *et al.*, 2011; Trück and Weron, 2016; Riedl and Smeets, 2017).

ESG in the form of green finance is called to support economic growth with less pressure on the environment, by taking into account social and governance parameters (EU Commission). Modern definitions of Corporate Social Responsibility (CSR) include the sustainability part as well. Therefore, ESG deals very closely with CSR practices in the part of environment dimension, however, there are two different streams of literature dedicated to CSR and ESG as the whole units with their specific dimensions. According to Carroll's Pyramid of CSR (Carroll, 1979), and although modern scholars also include an environmental responsibility dimension to Carroll's Pyramid of CSR (Lee *et al.*, 2019; Weber, 2008 to name a few), the CSR activities are classified as economic, legal, ethical, and discretionary (philanthropic), where sustainability is only partially included as a part of legal responsibility. World Business Council for Sustainable Development divides modern CSR into three main dimensions of sustainable development, such as environment, economy, and society. Therefore, we can relate environmental consciousness as an important part of CSR.

There is a large literature dealing with the effect of CSR (related to environmental consciousness) on firm returns, cash flows, value, and investor behaviors, when regarding the first branch of literature dealing with climate finance.

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The first group of papers focus on stock returns reaching mixed evidence: Di Giuli and Kostovetsky (2014) show that CSR rating improvements might lead to negative future stock returns and declines in ROA, Humphrey *et al.* (2012) do not find differences in terms of risk or return; Gao and Zhang (2015) and Lins *et al.* (2017) conversely show that CSR increases earnings-return relationship, especially in times of financial crisis. Another group of papers show that the relationship between CSR and firm value is positive (Dutordoir *et al.*, 2018; Ferrell *et al.*, 2016). Adhikari (2016) underlines that the firm value is influenced by the financial analyst coverage while investors indicate a "strong negative" reaction to negative events, and a "weakly negative" reaction to positive events concerned with a firm's CSR (Krüger, 2015). Overall, investors evidence their selective preferences to the presence of environmental and social indicators (Arouri *et al.*, 2019; Nofsinger *et al.*, 2019).

The second group of papers is devoted to credit supply: Berg and Schrader (2012), Cortés and Strahan (2017) and Koetter *et al.* (2020) show that financially integrated banks reallocate funds toward markets with high credit demand and away from other markets ("connected markets") in which they lend, in response to local, exogenous shocks to credit demand stimulated by natural disasters. Berg and Schrader (2012) indicate that while credit demand increases due to volcanic activity, access to credit is restricted. There are also a few papers about the effect of the natural disaster on other items such as real estate prices (e.g., Bernstein *et al.*, 2019[10]), and the issuance of financial instruments (Painter, 2020[11]). Weather and Natural disasters-related research, assessing the negative impact between extreme events and stock return natural include Bourdeau-Brien and Kryzanowski (2017) and Cao and Wei (2005) and Klomp (2017), Lanfear *et al.* (2019). Other papers focus on the weather derivatives market (Pérez-González and Yun, 2013; Purnanandam and Weagley, 2016), where they reveal that derivatives experience great price declines during the financial crisis, and they significantly reduce the ability of firms to hedge weather risks.

The third branch of literature focuses on the effect of ESG on financial markets. Several papers focus on stock prices (Lanfear *et al.*, 2019; Oestreich and Tsiakas, 2015; Tang and Zhang, 2018; Zerbib, 2019) showing a positive effect on the market value, connected to a good performer in terms of ESG criteria. Finally, under this research stream, a group of papers investigates the influence of ESG and SRI issues on investment decisions (Hartzmark and Sussman, 2019; Renneboog *et al.*, 2008, 2011; Riedl and Smeets, 2017;

[10]Bernstein *et al.* (2019) show that coastal properties exposed to projected sea level rise have a 7% lower selling price relative to observably equivalent unexposed properties equidistant from the beach

[11]Painter (2020) proved that counties more likely to be affected by climate change pay more in underwriting fees and initial yields to issue long-term municipal bonds compared to counties unlikely to be affected by climate change.

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Trück and Weron, 2016). All those papers focus on mutual funds and show that: (a) investors in SRI expect to earn lower returns rather than those on conventional funds. Renneboog *et al.* (2008) find that SRI funds globally underperform their domestic benchmarks but on average the risk-adjusted returns of SRI funds are not statistically different from the performance of conventional funds), and forgo financial performance for the benefit of their social preferences (Riedl and Smeets, 2017); (b) SRI are less related to past fund returns than are conventional fund flows, but more sensitive to past positive returns than are conventional fund flows (Renneboog *et al.*, 2011); (c) investors collectively put a positive value on sustainability (Hartzmark and Sussman, 2019), that is, a "low sustainability" categorization of a fund results in net outflows, while a "high sustainability" categorization led to net inflows; (d) companies' environmental and social performance increase when investors have strong understanding of importance of ESG (Dyck *et al.*, 2019; Nofsinger *et al.*, 2019).

Based on past papers, we posit various research hypotheses. Our first research question is the following:

H1. *Investors increase investment in sustainable instruments after natural disasters.*

This question is based on the view that natural disasters are stark signs of climate change and investors' decision-making, which shows their selective preferences to the presence of environmental and social indicators (Arouri *et al.*, 2019; Nofsinger *et al.*, 2019), is oriented toward sustainable financial instruments based on their values and personal priorities to contribute to climate change mitigation. While they put a positive value on sustainability, we see Hartzmark and Sussman (2019), showing that a "low sustainability" categorization of funds results in net outflows, while a "high sustainability" categorization led to net inflows.

Natural Disasters influence the investment targets of issuers of ESG-oriented ETFs because investment targets are represented in the form of companies 'stocks as a part of fund holdings. The pressure on buying the performance of such companies is seen in the increase in stock price and, hence, the rise of ETFs' Net Asset Value. This is consistent with the focus on the performance of ESG-oriented ETFs. Thus, we expect a statistically significant relationship between natural disasters and returns of sustainable investing instruments.

In the second step, as indeed the climate change topic has acquired an increasing concern in the political agenda and mass media, we expect that investment returns after a natural disaster can differ over time. This might have influenced the formation of the so-called "collective consciousness." This leads us to the following hypothesis:

H 2. *The relationship between natural disasters and sustainable investing increased over time.*

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Furthermore, we explore the differences between equity and bond investment. The difference in investors' behavior between equity and bond has been largely explored by past papers. When investors' sentiment-induced trading behavior changes in response to the decline of financial market sentiments compared to the historical average, investor sentiment changes induce investors to adjust their asset allocation decisions, with investors tending to switch from riskier to safer assets and moving their investments from equity funds to bond funds when the sentiment gets worse (Da *et al.*, 2015).

3 Data and Variables

Data have been collected from different sources. Data related to natural disasters are collected from the "Emergency Events Database" (EM-DAT):[12] this contains core data on both the occurrence and the effects of worldwide mass disasters from 1900. Where ETF returns data are collected from Thomson Reuters DataStream: we collect monthly total returns for ETFs traded worldwide traded (both dead and still alive, to avoid survivorship bias) between the January 2009 and December 2018 period, the database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies. Over the sample period (January 2009–December 2018), our sample includes 848 natural disaster events from 147 countries and 1244 ETFs from 187 financial companies.

3.1 Measuring Natural Disaster

We consider the following natural disasters in our database: drought, extreme temperature, flood, landslide, mass movement (dry), storm (including hurricanes) and wildfire. We measure nature disaster events (848) that occurred in 147 countries (panels B and C of Table 1) by the meaning of total damages (in thousands of Us dollars). Table 1 reports some descriptive statistics.

3.2 Measuring Sustainability

The wealth management industry has developed various financial products for investors wishing to invest in sustainable instruments over the past decade. In 2018, more than one out of every four dollars under professional management was invested under ESG criteria 2018 (Connaker and Madsbjerg, 2019). Since

[12]EM-DAT is the "Emergency Events Database" (www.emdat.be). In 1988, the Centre for Research on the Epidemiology of Disasters of the Université Catholique de Louvain in Belgium launched the Emergency Events Database (EM-DAT) with the aims of rationalizing decision making for disaster preparedness and providing an objective base for vulnerability assessment and priority setting.

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1976 (when Vanguard launched the first open-end index mutual fund), ETFs have constantly grown up over time reaching an asset value (of global ETFs) of 4.7 USD trillion in 2018 and representing one of the main financing sources for companies. ETFs can take one of the following organizational forms: trusts,[13] mutual funds, and holders.[14] By focusing on ETFs, we can have a direct and

Table 1: Descriptive statistics.

Panel A: *ETF Sample – Descriptive Statistics*

	Auto Declared Sustainable Strategy				ESG & SRI Strategy			
	Mean	Max	Min	St. Dev	Mean	Max	Min	St. Dev
Returns	0.005	0.140	−0.154	0.058	0.001	0.140	−0.154	0.018
Dividend Yield	1.354	11.020	0.000	1.200	1.839	11.020	0.000	1.840
Age	90.214	116.000	2.000	41.877	34.337	116.000	0.000	33.754
Size	0.004	3.024	1.890	0.629	4.557	5.370	0.000	1.684

Panel B: *ETF Sample – Asset Type - Descriptive Statistics*

	Equity ETF (1)				Bond ETF (2)				(1)–(2)
	Mean	Max	Min	St. Dev	Mean	Max	Min	St. Dev	
Returns	0.006	0.139	−0.153	0.045	0.001	0.039	−0.020	0.007	0.005***
Dividend Yield	1.152	11.020	0.000	1.370	0.522	3.000	0.000	1.080	0.630***
Age	30.360	116.000	0.000	38.140	18.440	93.000	2.000	26.940	11.915***
Size	2.289	5.370	0.000	1.374	2.228	5.370	0.000	1.423	0.0610***

Panel C: *Natural Disaster Sample – Descriptive Statistics*

	Mean	Max	Min	St.Dev	p25	p75	p90
Total deaths	369	222,570	1	7553	5	45	143
Total affected	1,058,330	134,000,000	1	6,610,290	3562	241,734	1,498,408
Total damage ('000 US$)	1,327,812	210,000,000	2	8,679,864	20,000	600,000	2,000,000

This table reports the summary statistics for the whole sample. Panel A reports the summary statistics for the whole ETF sample. We disentangle ESG-oriented ETFs in two groups: (1) ETFs whose name contains either "ESG" or "SRI" (ESG & SRI Strategy), given that these two specifications are the most commonly used to identify sustainable instruments; and (2) ETFs that self-declare being sustainable-oriented (Auto Declared Sustainable Strategy). Panel B provides the asset type breakdown (bond and equity, respectively). Panel C and D is the summary statistics for the natural disaster sample. The sample time range corresponds to January 2009 – December 2018 period. Age is the seniority of the single ETF (measured in terms of months since inception). Div_yeld_{t-1} stands for Dividend Yield return. Size is the natural logarithm of the Total Asset Under Management (Million $). All variables are taken with a one-month lag and are winsorized at 1 and 99 percentiles. Panel C reports the number of natural disasters analyzed in our empirical investigation. The natural disaster database is based on EM-DAT. $p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

[13]These are exchange-traded mutual fund offering a fixed (unmanaged) portfolio of securities with a definite life.

[14]ETFs holders have a direct ownership of the securities held by the ETF holder and the investor retains all rights such as voting rights.

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Table 1: Continued.

Panel D: *Natural Disaster Sample – Number of Events and Year of Occurrence*

Year	Number of events	Total deaths	Total affected	Total damage (USD th)
2009	72	6122	93,140,958	30,816,621
2010	69	234,722	190,618,784	106,561,220
2011	74	27,619	156,417,664	338,734,766
2012	95	5141	70,918,287	54,642,271
2013	120	17,629	76,525,314	100,948,787
2014	102	3647	63,810,290	56,517,314
2015	97	12,061	22,626,002	47,287,771
2016	97	5412	166,371,463	102,894,918
2017	110	5877	71,268,207	309,245,094
2018	42	5501	17,516,849	18,169,810
Total	878	323,731	929,213,818	1,165,818,572

Panel E: *Natural Disaster Sample – Number of Events by Type and Geographical Areas*

	Total deaths	Total affected	Total damage (USD th)
Africa			
Flood	1839	12,920,684	3,595,715
Landslide	1132	11,932	58,036
Storm	565	2,045,927	1,186,500
Wildfire	9	5500	420,000
Asia			
Extreme temperature	2	4,033,472	281,000
Flood	25,349	563,718,762	224,589,993
Landslide	2473	407,394	1,687,378
Mass movement (dry)	46	2	8000
Storm	17,691	198,500,930	106,418,416
Volcanic activity	39	115,160	186,000
Wildfire	233	32,259	2,271,000
Europe			
Flood	641	2,879,505	34,515,728
Storm	148	543,789	10,103,875
Wildfire	142	10,613	1,025,820
North America			
Flood	158	376,518	30,417,000
Landslide	64	1516	870,000
Storm	1257	86,531,196	243,976,000
Wildfire	94	51,116	22,497,000
South America			
Extreme temperature	3	120,000	500,000
Flood	2827	8,995,016	12,190,716
Landslide	904	130,080	967,000
Storm	1744	15,593,221	107,063,252
Wildfire	24	19,705	784,000
Total	323,731	929,213,818	1,165,818,572

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safe method for identifying ESG-oriented investments. Rather than focusing on the ESG ratings (as Ferrell *et al.*, 2017; Hartzmark and Sussman, 2019; Riedl and Smeets, 2017) that are also influenced by rating agencies' subjective policy evaluations, we believe that the most straightforward approach for an investor to make a sustainability-related investment is through the purchase of a thematic ETF. Specifically, we define ESG-oriented ETFs using the following two complementary and objective criteria: (1) the ETF name contains either "ESG" or "SRI," given that these two specifications are the most commonly used to identify sustainable instruments; (2) self-declared sustainable-oriented ETF: that ETF asset manager declares itself when dealing with sustainability macro themes. Therefore, the sample construction was primarily based on self-declared "Sustainability oriented strategies".[15] The name of an investment strategy is of paramount relevance in the wealth management industry. The SEC generally requires that any mutual fund or ETF with a name suggesting that it focuses on a particular type of investment must invest at least 80% of its assets in the type of investment suggested by its name. In the same fashion UK FCA, under the OEIC Regulation 15(9), sections 243(8) and 261D(10), require that "an authorized fund's name must not be undesirable or misleading".[16] Secondly, we checked the asset allocation objectives of underlying investment strategies by referring to their fact sheets. To the best of our knowledge, it is the first time that academic literature addresses a similar mutual fund sample.

Our control sample is composed of all worldwide non-ESG-oriented ETFs with that same currency (British Pound, Canadian Dollar, Euro, Japanese Yen, Korean (South) Won, New Zealand Dollar, Swiss Franc, and US Dollar), same country-domicile (Canada, France, Ireland, Japan, Luxembourg, New Zealand, South Korea, Switzerland, and the United States), same fund-type (bond and equity) of ESG-oriented ETFs. Our final sample consists of 139 ESG-oriented ETFs, that is, 84 ETFs containing ESG in the name, 40 containing SRI in the name and 15 self-declaring ESG-oriented ETFs (all equity type). Most of the ESG-oriented ETFs focusing focus on equity (126) and few on bonds (13). The control sample is composed of 1105 non-ESG-oriented ETFs, (209 focusing on bonds and 896 on equity). In terms of assets under management, our sample of ESG-oriented ETFs value about 12 billion US dollars and the control sample 1.7 Trillion US dollars (as of 01/10/2018): our sample represents almost 90% of the universe of worldwide ESG-oriented ETFs ($13.5 billion in assets under management at the end of August 2018[17]).

[15]We check periodically the characteristics of the ETFs, according to their ESG-oriented investor scheme, with respect to our selection criteria, with particular reference to any change in the name of the underlying strategy.

[16]https://www.handbook.fca.org.uk/handbook/COLL/6/9.html.

[17]Source of data: https://www.pionline.com/interactive/esg-etf-assets-surge-2019.

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3.3 Measuring ETFs Returns and ETF Characteristics

We measure ETF returns using the log rate of change of monthly ETF prices between January 2009 and December 2018 (collected from Thomson Reuters Eikon), as follows:

$$\text{ETF Ret}_{i,\,t+1} = \text{Ln}(\text{ETF}_{i,\,t+1}/\text{ETF}_{i,\,t}) \tag{1}$$

where $\text{ETF}_{i,t}$ is the *i-th* ETF price at month t. A positive ETF return (i.e., ETF price increase) shows an increase in prices of the ETF constituent stocks and bonds: once we observe an increase in the ETF return, this suggests that there is excess demand in the constituents' bonds and equity (thus increasing their prices). We considered the following ETF characteristics: *Age* - the seniority of the single ETF (measured in terms of months since inception), *Div_ yeld* - Dividend Yield return, and *Size* - Fund asset size. Age and Dividend Yield are expected to act with a positive meaning over the return. ETF characteristics are taken from the Refinitiv.

4 Identification Strategy

Our empirical approach to investigate whether ESG-oriented ETFs achieve different performance in comparison to other ETFs is based on the following model:

$$\begin{aligned} \text{Y}_{i,t} = \alpha + \beta_1 SUST_{i,t} + \beta_2 DAM_{j,t-1} + \beta_3 SUST_i DAM_{j,t-1} \\ + \gamma X_{i,t-1} + A_i + B_t + \varepsilon_{i,t}, \end{aligned} \tag{2}$$

where the dependent variable (Y) is the log monthly ETF return measured at month t for the fund I. Our main variable of interest is $SUST_DAM$, that is, the interaction between $SUST$ (a dummy variable related to sustainable instruments, takes a value of one for ESG-oriented ETF, or zero otherwise) and the lagged value of DAM (our indicator of the relative importance of disastrous events). There are several potential explanations for why ESG-oriented ETFs may obtain greater performance than other ETFs, including the fact that, in reaction to "climate change signals" in the form of extreme weather events we should expect a change in the investor sentiment, and it can play a role in allocating investments contributing to a more sustainable future. $SUST$ is our classification variable capturing sustainable instruments (taking a value of 1 the ETF is associated with the sustainability umbrella, and 0 otherwise). $DAM_{j,t-1}$ stands for the disaster event intensity measured by the meaning of the total damages (in thousands of US dollars) that occurred during last month in the country j. $X_{i,t-1}$ stands for control variables and includes: $Size_{t-1}$ (Fund asset size) is a total market value (Total Asset Under Management –

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Million \$) of the ETF as observed at the end of month t; Age_{t-1}(ETF Age) is ETF seniority (number of months since inception); Div_yield_{t-1} is a Dividend Yield return. All dependent variables are one period lagged and are winsorized at 1 and 99 percentiles. In our main models, we include fund fixed effects (A) considering the asset management company and the country where ETFs are domiciled, and the month dummy variables (B). We consider robust standard errors clustered at the ETF level. We perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages, which is unlike most of the academic literature in this area (see among others, Martí-Ballester, 2019 and Soler-Domínguez *et al.*, 2021), to address potential endogeneity problems.

To provide additional support for our choice of instruments, in each of the 2SLS regressions we perform the following three tests: (1) a Cragg and Donald (1993) instrument relevance test to confirm the relevance of the instrumental variables; (2) a Sargan (1958) overidentification test to examine the exogeneity of the instrumental variables; (3) a Stock and Yogo minimum eigenvalue statistics that is a test for underidentification. All the diagnostics reported at the bottom of all tables, satisfy the validity of the instruments. Our identification approaches present two unique and novel elements: firstly, we focus on ETF (that enable an objective identification of ESG investments), and secondly, we run a worldwide analysis both in terms of disasters, and investments.

5 Empirical Results

5.1 Baseline Analysis: Sustainability and Natural Disaster

First, we analyze the relationship between the performance of sustainability-related ETFs and our disaster indicator (lagged by one period) to test our first hypothesis (H_1: *Investors increase investment in sustainable instruments after natural disasters*). Table 2 shows the climate change effect on Sustainable Investment Decisions with the main dependent variable ETF Log Return. Our main variable of interest is *SUST_DAM*. Looking at *SUST_DAM*, we are able to estimate the relationship between stock market reactions and ESG-oriented ETFs investing in countries experiencing severe disastrous events.

Focusing on the whole sample (Panel A), we find a positive and statistically significant relationship between our main independent variable *SUST_DAM* and the ETF returns. Our evidence suggests that natural disasters influence investors' decisions toward sustainable instruments (*SUST_DAM*), especially on the equity side (Panel B). Our results show a positive reaction, when a disaster event occurs, of approximatively 20bp, when looking at the magnitude of the effect. Overall, the results also show no particular predisposition toward

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Table 2: The climate change effect on Sustainable Investment Decisions: Returns.

Panel A – All sample

	$y = log\ returns$ (1)	$y = log\ returns$ (2)	$y = log\ returns$ (3)
$SUST$	-1.873^{***}		
	(0.569)		
DAM_{-1}	-0.018^{**}	-0.013^{*}	-0.849^{***}
	(0.008)	(0.008)	(0. 011)
$SUST_DAM_{-1}$	0.143^{***}	0.143^{***}	0.215^{***}
	(0.039)	(0.038)	(0. 038)
$Size_{t-1}$	$-0.161***$	-0.736^{***}	-0.736^{***}
	(0.023)	(0.044)	(0.045)
Age_{t-1}	0.004^{***}		
	(0.001)		
Div_yeld_{t-1}	-0.031^{***}	0.142^{***}	$0.\ 139^{***}$
	(0.012)	(0.015)	(0.018)
No. observations	74.294	74.294	74.294
Company-FE	Yes	No	No
Country*Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Estimation approach	OLS	OLS	IV-2SLS
Tests:			
Underidentification (p-value)			0.000
Weak identification (p-value)			0.000
Overidentification (p-value)			0.000
			1st stage results
Total deaths			0.478^{***}
			(0.000)
Total affected			0.315^{***}
			(0.000)

The main dependent variable is ETF Log Return. The main independent variable is $SUST_DAM_{-1}$. The variable $SUST_DAM_{-1}$ is an interaction dummy between $SUST$ and the lagged value of DAM. $SUST$ variable is a dummy variable related to sustainable instruments (dummy takes a value of 1 if we consider ETF associated with sustainability umbrella, otherwise it equals 0). DAM captures the severity of natural disasters, and it is the log value of damages. We include the following control variables related to ETFs' characteristics: $Size_{t-1}$ stands for fund asset size; Age_{t-1} is the seniority of the single ETF (measured in terms of months since inception); Div_yeld_{t-1} means the Div Yield return. Fixed Effects are considered as follows: Asset Manager level, Country (domicile)*Month and ETF. In panel A, we use our entire sample: in columns (1) and (2), we estimate the model using OLS. In column (3), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). In panel B, we split our sample between ETF investing in equity and bonds: in columns (1) and (3), we estimate the model using OLS. In columns (2) and (4), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). Standard errors are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Table 2: Continued.

Panel B – Equity & Bond

	$y = log$ *returns*	$y = log$ *returns*	$y = log$ *returns*	$y = log$ *returns*
	Equity (1)	Equity (2)	Bonds (3)	Bonds (4)
SUST				
DAM_{-1}	-0.021^{**}	-1.868^{***}	0.050^{***}	-0.035
	(0.008)	(0.094)	(0.008)	(0.095)
$SUST_DAM_{-1}$	0.153^{***}	2.001^{***}	0.011	0.095
	(0.040)	(0.092)	(0.026)	(0.096)
$Size_{t-1}$	-0.776^{***}	-0.753^{***}	-0.344^{***}	-0.352^{***}
	(0.049)	(0.049)	(0.051)	(0.056)
Age_{t-1}	0.002^{***}		0.000	
	(0.001)		(0.001)	
Div_yeld_{t-1}	0.154^{***}	0.088^{***}	0.021	0.018
	(0.017)	(0.019)	(0.017)	(0.017)
No. observations	66.254	66.254	8.040	8.040
Company-FE	NO	NO	NO	NO
Domicile*Month FE	Yes	Yes	Yes	Yes
ETF-FE	Yes	Yes	Yes	Yes
Estimation approach	OLS	IV-2SLS	OLS	IV-2SLS
Tests:				
Underidentification (p-value)				0.000
Weak identification (p-value)				0.000
Overidentification (p-value)				0.004
				1st stage results
Total deaths				0.480^{***}
				(0.000)
Total affected				0.311^{***}
				(0.000)

sustainable financial instruments in the whole (Panel A) sample period (*SUST*). Indeed, the *SUST* variable related to sustainable instruments takes a negative sign of 1% statistical significance. Furthermore, we observe a decrease in market returns after natural disasters. *DAM*, is the log value of total damages and it is highly statistically significant at 1% level.

We also include various control variables such as Age_{t-1} (the seniority of the single ETF, measured in terms of months since inception), Div_yeld_{t-1} (the Div Yield return), and $Size_{t-1}$ (fund asset size). All variables are taken with one month lag.

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5.2 The Time Evolution Effect

In this section, we test whether the relationship between natural disasters and sustainable investing has increased over time. Specifically, we select two time periods pre and post-Paris agreement, that is, 2013–2015, and 2016–2018. Following various papers (among others, Diaz-Rainey *et al.*, 2021; Kinley, 2019), we consider Paris agreement as a kind of watershed in creating strong market sentiment concerning climate and sustainable finance themes, with the basic assumption being that the sentiment on climate change has been growing over time. So it is reasonable to assume that critical awareness has evolved over time and that the common thinking of a few years ago has profoundly changed in the light of the broad information campaign performed by different media over the years. Also, critical awareness is followed by an increase in interventions regarding the effects of climate change over time from both national governments and international organizations. The results are shown in Tables 3 and 4 for the time evolution of ETF reaction to the disaster from 2013 to 2015 and 2016 to 2018, respectively.

SUST_DAM is the variable of main interest capturing the market reaction to ESG-oriented ETFs after natural disasters. The interaction dummy *SUST_DAM* gets positive (significant at the 1% level) in the second period 2016–2018 (Table 3) while it results in not statistically significant evidence in the first period, we labeled as pre-Paris agreement. This is an important and novel result. From this evidence, in fact, it would seem that investors' interest in sustainable investments has changed in the aftermath of the Paris agreement. The Paris agreements with the great publicity campaign that accompanied the work of the committees have certainly represented a great media event in the field of climate finance. From our findings it seems that all of this has somehow impacted investor awareness, shifting their selections to build more sustainable portfolios, in response to events potentially linked to a deterioration in global climatic conditions.

6 Additional Test

We run some robustness checks by rerunning the basic model with a different measure of market reaction (Tables 5, 6 and 7).

We also validate our main findings by changing our dependent variables. To be specific instead of return, we consider turnover by volume, representing the total number of constituent shares traded on a particular day. Similarly, to the rationale of the analysis that takes into consideration the reaction of the price, and therefore of the return, of the sustainable instruments, in the same fashion, the turnover by volume reacts to the increase in demand pressure by investors.

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Table 3: Climate Change Awareness: the time evolution of ETFs reaction to disasters. All Sample PRE-Paris agreement (2013–2015).

	$y = log\ returns$ (1)	$y = log\ returns$ (2)	$y = log\ returns$ (3)
$SUST$	0.724		
	(2.580)		
DAM_{-1}	0.257^{***}	0.247^{***}	0.345^{***}
	(0.022)	(0.021)	(0.035)
$SUST_DAM_{-1}$	−0.033	−0.045	−0.143
	(0.172)	(0.172)	(0.178)
$Size_{t-1}$	-0.306^{***}	-2.389^{***}	-2.377^{***}
	(0.051)	(0.156)	(0.157)
Age_{t-1}	0.013^{***}		
	(0.002)		
Div_yeld_{t-1}	-0.183^{***}	0.011	0.010
	(0.026)	(0.050)	(0.050)
No. observations	22.490	22.490	22.490
Company-FE	Yes	NO	NO
Domicile*Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Estimation approach	OLS	OLS	IV-2SLS
Tests:			
Underidentification (p-value)			0.000
Weak identification (p-value)			0.000
Overidentification (p-value)			0.000
			1st stage results.
Total deaths			0.529^{***}
			(0.004)
Total affected			0.327^{***}
			(0.002)

The main dependent variable is ETF Log Return. The main independent variable is $SUST_DAM_{-1}$. The variable $SUST_DAM_{-1}$ is an interaction dummy between $SUST$ and the lagged value of DAM_{t-1}. $SUST$ variable is a dummy variable related to sustainable instruments (dummy takes a value of 1 if we consider ETF associated with sustainability umbrella, otherwise it equals 0). DAM_{t-1} determines the relative importance of disastrous events that occurred during the previous month. This disaster metric is linked to damages in thousands of dollars. We include the following control variables related to ETFs' characteristics: $Size_{t-1}$ stands for fund asset size; Age_{t-1} is the seniority of the single ETF (measured in terms of months since inception); Div_yeld_{t-1} means the Div Yield return. Fixed Effects are considered as follows: Asset Manager level, Country (domicile)*Month and ETF. In columns (1) and (2), we estimate the model using OLS. In column (3), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). Standard errors are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Table 4: Climate Change Awareness: the time evolution of ETFs reaction to disasters. All Sample POST-Paris agreement (2016–2018).

	$y = log\ returns$ (1)	$y = log\ returns$ (2)	$y = log\ returns$ (3)
$SUST$	$-1.167**$		
	(0.505)		
DAM_{-1}	0.287^{***}	-0.149^{***}	0.280^{***}
	(0.009)	(0.015)	(0.008)
$SUST_DAM_{-1}$	0.101^{***}	0.525^{***}	0.100^{***}
	(0.034)	(0.037)	(0.034)
$Size_{t-1}$	-0.065^{***}	-1.106^{***}	-0.817^{***}
	(0.021)	(0.093)	(0.084)
Age_{t-1}	0.002^{***}		
	(0.001)		
Div_yeld_{t-1}	-0.045^{***}	0.099^{***}	0.102^{***}
	(0.009)	(0.025)	(0.024)
No. observations	33.356	33.356	33.356
Company-FE	Yes	NO	NO
Domicile*Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Estimation approach	OLS	OLS	IV-2SLS
Tests:			
Underidentification (p-value)			0.000
Weak identification (p-value)			0.000
Overidentification (p-value)			0.000
			1st stage results
Total deaths			0.329^{***}
			(0.005)
Total affected			0.267^{***}
			(0.004)

The main dependent variable is ETF Log Return. The main independent variable is $SUST_DAM_{-1}$. The variable $SUST_DAM_{-1}$ is an interaction dummy between $SUST$ and the lagged value of DAM_{t-1}. $SUST$ variable is a dummy variable related to sustainable instruments (dummy takes a value of 1 if we consider ETF associated with sustainability umbrella, otherwise it equals 0). DAM_{t-1} determines the relative importance of disastrous events that occurred during the previous month. This disaster metric is linked to damages in thousands of dollars. We include the following control variables related to ETFs' characteristics: $Size_{t-1}$ stands for fund asset size; Age_{t-1} is the seniority of the single ETF (measured in terms of months since inception); Div_yeld_{t-1} means the Div Yield return. Fixed Effects are considered as follows: Asset Manager level, Country (domicile)*Month and ETF, In columns (1) and (2), we estimate the model using OLS. In column (3), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). Standard errors are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Table 5: The climate change effect on Sustainable Investment Decisions: Change in Market reaction variable – Trading Volume.

Panel A – All sample

	$y = TR_Vol$ (1)	$y = TR_Vol$ (2)	$y = TR_Vol$ (3)
$SUST$	-1.262^{***}		
	(0.449)		
DAM_{-1}	0.003	0.006	-0.115^{*}
	(0.005)	(0.005)	(0.060)
$SUST_DAM_{-1}$	0.089^{***}	0.090^{***}	0.211^{***}
	(0.032)	(0.031)	(0.067)
$Size_{t-1}$	-0.038^{*}	-0.151^{***}	-0.159^{***}
	(0.022)	(0.029)	(0.029)
Age_{t-1}	-0.000		
	(0.001)		
Div_yeld_{t-1}	-0.001	0.008	0.005
	(0.007)	(0.007)	(0.007)
No. observations	42.801	42.801	42.801
Company-FE	Yes	NO	NO
Domicile*Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Estimation approach	OLS	OLS	IV-2SLS
Tests:			
Underidentification (p-value)			0.000
Weak identification (p-value)			0.000
Overidentification (p-value)			0.942
			1st stage results.
Total deaths			0.421^{***}
			(0.013)
Total affected			0.369^{***}
			(0. 011)

The main dependent variable is ETF Trading Volume (TR_Vol). The main independent variable is $SUST_DAM_{-1}$. The variable $SUST_DAM_{-1}$ is an interaction dummy between $SUST$ and the lagged value of DAM_{t-1}. $SUST$ variable is a dummy variable related to sustainable instruments (dummy takes a value of 1 if we consider ETF associated with sustainability umbrella, otherwise it equals 0). DAM_{t-1} determines the relative importance of disastrous events that occurred during the previous month. This disaster metric is linked to damages in thousands of dollars. We include the following control variables related to ETFs' characteristics: $Size_{t-1}$ stands for fund asset size; Age_{t-1} is the seniority of the single ETF (measured in terms of months since inception); Div_yeld_{t-1} means the Div Yield return. Fixed Effects are considered as follows: Asset Manager level, Country (domicile)*Month and ETF. In panel A, we use our entire sample: in columns (1) and (2), we estimate the model using OLS. In column (3), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). In panel B, we split our sample between ETF investing in equity and bonds: in columns (1) and (3), we estimate the model using OLS. In columns (2) and (4), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). Standard errors are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Table 5: Continued.

Panel B – Equity & Bond

	$y = TR_Vol$	$y = TR_Vol$	$y = TR_Vol$	$y = TR_Vol$
	Equity (1)	*Equity* (2)	*Bond* (3)	*Bond* (4)
SUST				
DAM_{-1}	0.007	−0.112*	−0.003	−0.146
	(0.005)	(0.064)	(0.022)	(0.095)
$SUST_DAM_{-1}$	0.077**	0.196***	0.305**	0.446***
	(0.030)	(0.069)	(0.127)	(0.155)
$Size_{t-1}$	−0.155***	−0.161***	−0.099	−0.130
	(0.029)	(0.030)	(0.125)	(0.129)
Age_{t-1}	−0.000		0.000	
	(0.001)		(0.001)	
Div_yeld_{t-1}	0.010	0.007	−0.019	−0.026
	(0.007)	(0.007)	(0.023)	(0.023)
No. observations	39.000	39.000	3.801	3.801
Company-FE	NO	NO	NO	NO
Domicile*Month FE	Yes	Yes	Yes	Yes
ETF-FE	Yes	Yes	Yes	Yes
Estimation approach	OLS	IV-SLS	OLS	IV-SLS
Tests:				
Underidentification (p-value)		0.000		0.000
Weak identification (p-value)		0.000		0.000
Overidentification (p-value)		0.775		0.886
		1st stage results		1st stage results
Total deaths		0.550***		0.469***
		(0.051)		(0.054)
Total affected		0.402***		0.315***
		(0.033)		(0.045)

We use this new measure to run the basic model. In Table 5 we show the climate change effect on Sustainable Investment Decisions and change in the market reaction variable – turnover by volume. Looking at the results, the main result, corresponding to the market reaction of sustainable investments (measured in terms of ETF) to extreme natural events is unchanged. Both for all samples and equity, we find positive (and statistically significant at the 1% level) estimates in terms of sustainable instruments variable. Table 5 highlights a positive correspondence between extreme natural events and investor demand pressure concerning investments with sustainability macro themes. This is especially true for the equity asset class. The relative importance of disastrous

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Table 6: Climate Change Awareness: the time evolution of ETFs reaction to disasters. All Sample PRE-Paris agreement (2013–2015).

	$y =$ *TR_ Vol* (1)	$y =$ *TR_ Vol* (2)	$y =$ *TR_ Vol* (3)
SUST	−0.725		
	(1.261)		
DAM_{-1}	−0.014	−0.013	0.009
	(0.012)	(0.012)	(0.021)
$SUST_DAM_{-1}$	0.051	0.039	0.017
	(0.087)	(0.084)	(0.088)
$Size_{t-1}$	−0.038	−0.089	−0.087
	(0.032)	(0.058)	(0.058)
Age_{t-1}	0.001		
	(0.001)		
Div_yeld_{t-1}	0.001	0.001	0.000
	(0.010)	(0.010)	(0.010)
No. observations	12.478	12.478	12.478
Company-FE	Yes	NO	NO
Domicile*Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Estimation approach	OLS	OLS	IV-SLS
Tests:			
Underidentification (p-value)		0.000	
Weak identification (p-value)		0.000	
Overidentification (p-value)		0.013	
			1st stage results.
Total deaths			0.515^{***}
			(0.006)
Total affected			0.334^{***}
			(0.003)

The main dependent variable is ETF Trading Volume (*TR_ Vol)*. The main independent variable is $SUST_DAM_{-1}$. The variable $SUST_DAM_{-1}$ is an interaction dummy between *SUST* and the lagged value of DAM_{t-1}. *SUST* variable is a dummy variable related to sustainable instruments (dummy takes a value of 1 if we consider ETF associated with sustainability umbrella, otherwise it equals 0). DAM_{t-1} determines the relative importance of disastrous events that occurred during the previous month. This disaster metric is linked to damages in thousands of dollars. We include the following control variables related to ETFs' characteristics: $Size_{t-1}$ stands for fund asset size; Age_{t-1} is the seniority of the single ETF (measured in terms of months since inception); Div_yeld_{t-1} means the Div Yield return. Fixed Effects are considered as follows: Asset Manager level, Country (domicile)*Month and ETF. In columns (1) and (2), we estimate the model using OLS. In column (3), we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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Table 7: Climate Change Awareness: the time evolution of ETFs reaction to disasters. All Sample POST-Paris agreement (2016–2018).

	$y =$ *TR_ Vol* (1)	$y =$ *TR_ Vol* (2)	$y =$ *TR_ Vol* (3)
SUST	-1.996^{***}		
	(0.615)		
DAM_{-1}	0.028^{***}	0.030^{***}	0.024^{*}
	(0.007)	(0.006)	(0.013)
$SUST_DAM_{-1}$	0.143^{***}	0.142^{***}	0.148^{***}
	(0.042)	(0.039)	(0.039)
$Size_{t-1}$	-0.031	-0.283^{***}	-0.288^{***}
	(0.029)	(0.073)	(0.074)
Age_{t-1}	-0.000		
	(0.001)		
Div_yeld_{t-1}	-0.020^{***}	0.000	0.000
	(0.009)	(0.011)	(0.011)
No. observations	21.741	21.741	21.741
Company-FE	Yes	NO	NO
Domicile*Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Estimation approach	OLS	OLS	IV-SLS
Tests:			
Underidentification (p-value)			0.000
Weak identification (p-value)			0.000
Overidentification (p-value)			0.000
			1st stage results.
Total deaths			0.313^{***}
			(0.011)
Total affected			0.255^{***}
			(0.009)

The main dependent variable is ETF Trading Volume (*TR_ Vol*). The main independent variable is $SUST_DAM_{-1}$. The variable $SUST_DAM_{-1}$ is an interaction dummy between *SUST* and the lagged value of DAM_{t-1}. *SUST* variable is a dummy variable related to sustainable instruments (dummy takes a value of 1 if we consider ETF associated with sustainability umbrella, otherwise it equals 0). DAM_{t-1} determines the relative importance of disastrous events that occurred during the previous month. This disaster metric is linked to damages in thousands of dollars. We include the following control variables related to ETFs' characteristics: $Size_{t-1}$ stands for fund asset size; Age_{t-1} is the seniority of the single ETF (measured in terms of months since inception); Div_yeld_{t-1} means the Div Yield return. Fixed Effects are considered as follows: Asset Manager level, Country (domicile)*Month and ETF. In columns (1) and (2), we estimate the model using OLS. In column 3, we perform 2SLS regression analyses using the total number of deaths and the total number of affected as instrumental variables for the damages (DAM_{t-1}). Standard errors are reported in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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events shows a 5% level of positive statistically significant results for all samples and equity.

Then, we control for climate change awareness and investigate the time evolution effect of ETF reaction to a natural disaster like in Tables 3 and 4 but changing our main dependent variable and previous results still hold.

7 Conclusion

How do international investors react to climate change? Surprisingly, there are no papers showing "whether" and "to what extent" investments change after natural disasters. Our paper is a first attempt to fill this gap in the literature by analyzing a rich dataset of worldwide natural disasters. Specifically, we use monthly data on return and trading volumes to examine the link between natural disasters and investments in sustainability ETFs. We find that natural disasters have a statistically significant link with ETFs returns.

Our contribution is threefold. First, our paper focuses on ETFs instruments, that enable us to identify sustainable investments. We believe that this is the most direct way from the point of view of resource allocation mechanisms that trigger the occurrence of events related to climate change. Secondly, both in terms of geographical coverage and type of disasters and losses measures, we use a large sample of natural disasters. Lastly, for the first time, we investigate investment decisions addressed to sustainable investing in reaction to climate change extreme events.

Our main finding indicates that investments increase significantly after natural disasters, suggesting the necessity of additional sustainability investments after climate shocks' occurrence. As expected, we also show that investments in sustainable financial products are influenced by the asset class type (fixed income or equity). Furthermore, we find that *ceteris paribus* investors have lower demand for ESG investments: on average, investors are not willing to invest *tout court* in ESG-oriented instruments but when solicited by external events (natural disaster), investors spontaneously activate a sort of social awareness that makes them deviate from their usual investment strategy.

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Appendix

Table A1: Variable description.

This table defines the variables used in the paper and the sources of data.

Variables	Symbol	Definition and calculation method	Exp. Sign	Source
Dependent Variables:				
ETF return	*log returns*	The log difference in price between two consecutive months for a given ETF.		Thomson Reuters Data
Trading Volume	*TR_ Vol*	Total monthly trading volumes for a given ETF.		Thomson Reuters Data
Independent Variables:				
Sustainable Investments	$SUST_{t-1}$	A dummy variable taking the value of 1 if an ETF is associated with sustainability themes, and 0 otherwise.	+/−	Authors computation on Thomson Reuters Data
Natural disasters impact on sustainable investments	$SUST_DAM_{t-1}$	The interaction between *SUST* and the lagged value of *DAM*.	+	Authors computation on Thomson Reuters Data & EM-DAT database
Damages (Disaster Intensity)	DAM_{t-1}	*DAM* capture the severity of disastrous events that occurred during the previous month. This disaster metrics is represented by Logarithm of total damages in thousands of dollars.	+/−	Authors computation on EM-DAT database
Control Variables:				
Fund asset size	$Size_{t-1}$	Total market value of the ETF as observed at the end of month t.	−	Thomson Reuters Data
ETF age	Age_{t-1}	ETF seniority (number of months since inception).	+	Thomson Reuters Data
Div yield return	Div_yield_{t-1}	Dividend Yield return.		Thomson Reuters Data

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