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Climate change shocks and socially responsible investments

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Abstract

Climate change's impact on investor behavior is a scantly investigated area in finance. This paper examines the performance of socially responsible exchange trade funds (ETFs) concerning conventional ETFs, in response to climate change events. We proxy climate change signals with a list of natural disaster events that NASA scientists relate to climate change. We contribute to existing literature, by using a very extensive information set of ETF strategies, not influenced by rating agencies' subjective evaluation policies, and covering almost 90% of the universe of worldwide sustainability thematic-oriented ETFs. This sample allows us to identify the socially responsible investment behavior in response to unpredictable climate change shocks. Our identification strategy accounts for endogeneity concerns and relies on two-stage least square (2SLS) approach finding that responsible investors react to climate change events by purchasing socially responsible investments. The relationship between climate change signals and return of investment in themes linked to the development of sustainability is positive. Interestingly enough, the sign of this relationship is different, when we disentangle the empirical results according to the asset type, confirming that investors shift their investments from equity funds to bond funds when market sentiment worsens. Our results indicate that policymakers should increase the support of firms adopting environmentally conscious business practices, while managers should boost a sustainable business strategy.

KEYWORDS
climate change, ETF, natural disasters, sustainable investments

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1 | INTRODUCTION AND MOTIVATION

Climate change is a global challenge that affects all human and non-human habitats. Not surprisingly, a large number of initiatives have been recently developed both at the worldwide and country levels. Nevertheless, the effects of climate change on investor behavior remain a scantly investigated area. Over the last decade, the wealth management industry has developed various financial products for investors wishing to invest in sustainable instruments.

Socially responsible (SR) Exchange Trade Funds (ETF) aim to meet the United Nation (UN) sustainable development goals (SDGs).[2] They grew in popularity among fund investors, leading to a rapid increase in global investment in SRI, which represented more than 30 trillion US dollars[3] at the beginning of 2018 (Soler-Domínguez et al., 2021). Under the umbrella of SRI, investors play a vital role in the global effort to achieve SDGs by ensuring that capital is appropriately raised and allocated (Widyawati, 2020). Indeed, the integration of SRI criteria in ETFs could channel private resources into the funding of environmentally related projects implemented by firms contributing to sustainable development (Marti-Ballester, 2019).

The motivation of the paper is to verify whether investors react to unfavorable events connected to climate change by addressing the preference of their investments in sustainable assets. In this context, sustainable investing constitutes an opportunity for managers and well-diversified investors, who play a central role in taking action on a real threat and combat the dramatic consequences of global warming, climate change, and environmental pollution, while capitalizing on the transition toward a lower carbon economy (Soler-Domínguez et al., 2021). Although SR investment is consolidating its leading position as a preferred investment alternative for investors interested in sustainability and environmental protection (Soler-Domínguez et al., 2021), the relationship between climate change effects and investment decisions remains a scantly investigated area.

In line with NASA scientists, we see natural disasters as the effects of climate change, and we consider such climate change effects as exogenous shocks to test the reaction of responsible investors by examining investment themes linked to the development of sustainability under the scheme of socially responsible (SR) exchange trade funds (ETFs). We show that there is an increase in investment demand after the occurrence of climate change events, hopefully signaling the need for additional sustainable investments. We also find that investment activity toward sustainable financial products is influenced by the specific ETF strategy and the asset class type (fixed income or equity). Our results are robust after considering several additional tests.

Our paper contributes to previous academic findings in several aspects. Firstly, to our best knowledge, this is one of the very few papers that uses climate change shocks as a natural experiment to analyze investors' behavior. In this way, we provide evidence on the added value that environmental investments may provide in the context of SR investments, especially in a critical situation, and we expand the idea of the connection between financial performance and the achievement of sustainable development.

Secondly, a common feature of the most of papers assessing the relationship between environmental, social, and governance (ESG) items and investors' decision is their focus on mutual funds by considering ESG ratings (see among others Hartzmark & Sussman, 2019 and Van Duuren et al., 2016), we propose a new focus based on the analysis of ETFs. The Mutual Fund ESG-rating assignment is a non-fully standardized process influenced by rating agencies' subjective evaluation policies. As noted by Escrig-Olmedo et al. (2019), the proliferation of rating agencies and the diversity of their assessment methodologies pose various limitations of ESG ratings, such as lack of transparency, commensurability, trade-offs among criteria, and standardization in the use of ESG metrics by socially responsible investments (SRI) analysts (Juravle & Lewis, 2008). As such, ESG ratings produced by different rating agencies are not comparable and their adoption may introduce arbitrary factors in empirical analysis (Dimson et al., 2020).

Thirdly, in comparison to papers using specific natural disasters as an external shock, we analyze a very large set of data on every single natural disaster by applying a database of more than 800 climate change events in the form of natural disasters worldwide and by using different parameters (death people, injuries, and damages) to measure the gravity of the event.

Lastly, unlike most of the academic literature in this area (see among others, Marti-Ballester, 2019 and Soler-Domínguez et al., 2021), we account for the endogeneity concerns by running an IV strategy. The rest of this paper is organized as follows. In Section 2, we review past papers and formulate our research hypothesis. In Section 3, we describe our data and variables. Then, in Section 4, we present our identification strategy and empirical results are presented in Section 5. We report robustness checks in Section 6 and we conclude in Section 7.

2 | LITERATURE AND HYPOTHESES DEVELOPMENT

Our paper is at the intersection of two strands of literature. One is dealing with the influence of corporate social responsibility (CSR) over the firm performance, and the other one—with the effects of climate change and natural disasters on financial markets and the economy. A group of papers uses natural disaster and climate changes phenomenon as an exogenous shock to test the reaction of various types of financial products, such as credit supply (Berg & Schrader, 2012; Cortés & Strahan, 2017; Koetter et al., 2020), real estate prices (e.g., Bernstein et al., 2019), and the issuance of financial instruments (Painter, 2020[4]). Another group of papers studies the effect of ESG and CSR items on financial markets focusing on stock prices (Bourdeau-Brien & Kryzanowski, 2017[5]; Krüger, 2015; Lanfear et al., 2019[6]; Oestreich & Tsiakas, 2015; Tang & Zhang, 2020); green bonds (Zerbib, 2019[7]); weather derivatives market (Pérez-González & Yun, 2013; Purnanandam & Weagley, 2016); and lastly, investment decisions (Hartzmark & Sussman, 2019; Renneboog et al., 2011; Riedl & Smeets, 2017; Trück & Weron, 2016).

Concerning the latter group of papers, there is a strand of literature explaining the importance of investor decision based on low environmental impact. This literature finds that financial performance is strongly linked to the environmental performance perceived by investors and shows that: (a) overall, investors evidence their selective preferences to the presence of environmental and social indicators (Arouri et al., 2019; Nofsinger et al., 2019), while investors collectively put a positive value on sustainability (Hartzmark & Sussman, 2019), that is, a "low sustainability" categorization of fund results in net outflows, while a "high sustainability" categorization leads to net inflows. Investors into socially responsible investments (SRI) expect to earn lower returns rather than into conventional funds (Renneboog et al., 2008), and forgo financial performance for the benefit of their social preferences (Riedl & Smeets, 2017); (b) Investors into socially responsible investments (SRI) are less related to past fund returns (Peifer, 2014) than conventional fund investors, but are more sensitive to past positive returns (Renneboog et al., 2011); (c) lastly, in terms of institutional investors, Alda (2020) analyzed the increase of practices concerningESG factors by conventional pension funds and found that higher ESG screening intensity is characterized by greater return and larger flows. Nofsinger et al. (2019) discover that long-horizon institutional investors' stocks with negative ESG indicators are underweighted. Matallín-Sáez et al. (2019) proved no incompatibility between higher sustainable values and greater financial performance from investments when fund managers have enough skills to choose the right socially responsible funds. Ceccarelli et al. (2019) discussed the link between investors' climate preferences and the importance of financial intermediaries' climate responsibility as they seek to take advantage of growing demand opportunities. Lastly, Alda et al. (2020) highlight the relevance of the societal and environmental concerns by institutional investors in socially responsible mutual funds (a systematic literature review of socially responsible investment is described in Widyawati, 2020).

Based on the past papers, our research question is the following:

Hypothesis 1 *Socially responsible (SR) exchange trade funds (ETFs) are able to perform better than their conventional peers when a climate change signal occurs because SR investors push to invest in sustainable investing.*

There are several potential explanations of why environmental, social, and governance (ESG or socially responsible investments, SRI)-oriented ETF may obtain greater performance than other ETFs, including the reaction to "climate change signals" in the form of extreme weather events. According to previous scholars (Pastor et al., 2020; Hartzmark & Sussman, 2019 among others), we observe that the change in the time-varying investor risk preference (Guiso et al., 2018), caused by increased fear of climate change due to natural disasters, represents the channel through which portfolio reallocation takes place in favor of more sustainable assets. Firstly, the fear of climate change induced by the occurrence of natural disasters is well-known evidence for the scientific community (e.g., NASA scientists[8] say that natural disasters are stark signs of climate change). Secondly, and in line with the above, we should expect a change in investor time-varying risk attitude, causing a change in their asset allocation.

This increasing attention to climate change and the consequent portfolio reallocation can be connected mainly to four motivations. First, when investors' awareness of environmental issues increases, sustainable investors (e.g., El Ouadghiri et al., 2021, Gutsche and Ziegler, 2019) might prefer to reallocate their portfolios by buying stocks of sustainable firms and divesting stocks of conventional firms to avoid the transition risk. Second, the increased public environmental concern may raise the environmental awareness also of traditional investors to the point of changing their preferences to more sustainable stocks (e.g., El Ouadghiri et al., 2021). Choi et al. (2020) find that when the weather is abnormally warm, stocks of carbon-intensive companies underperform the low carbon companies, while asset portfolios in vulnerable industries show a negative reaction to climate change (e.g., temperature) shocks (Balvers et al., 2017). Third, companies that are more virtuous according to ESG criteria show lower volatility of equity returns than less virtuous companies in the same sector (Ashwin et al., 2016, and Giese et al., 2019).[9] This assumption, which is directly related to the change in time-varying investor risk preference, goes in line with previous scholars who considered sustainable ETFs to be safe haven tools during disaster periods (Lee and Chen, 2020). Fourth and last, the change of time-varying risk attitude by investors is also in line with the evidence of previous scholars in the context of exogenous economic shocks not closely connected to the climate change concern. When seeing climate change as a challenge to the global economy, investors show the growing demand for sustainable portfolios, which explains the better performance of sustainable ETFs, when the economy is experiencing shocks (Climent and Soriano, 2011; Bollen, 2007). At the same time, in adverse market stages, the trust between a firm and its stakeholders and investors, built through investments in social capital, pays off when the overall level of trust in corporations and markets suffers a negative shock (Lins et al.; 2017).

Finally, the time-varying risk preferences' channel acts over the price and consequently over the asset return by the meaning of a very known price pressure effect. To be specific, the pressure on buying stocks from sustainable companies is coupled with an upward stock price reflected in the rise of ETF price. In the same fashion, Flammer (2013) confirms that socially responsible investment (SRI)-oriented ETFs might display greater resiliency to natural disasters due to the fact that investor action might result in higher demand pressure for sustainable financial instruments.[10] This rationale is also consistent with previous US specific findings, our estimates confirm that investors might be reacting to non-pecuniary shocks by increasing the weight of SRI investment vehicles in their portfolio (Pastor et al., 2020; Hartzmark & Sussman, 2019; Białkowski and Starks, 2015).

Furthermore, ETFs following different SR strategies may differ in terms of their portfolio assets and their sustainability goals, and these differences may, therefore, affect their financial and sustainable performances (Soler-Domínguez et al., 2021). To this end, we

disentangle the effect concerning equity and fixed income sides. The difference in behavior between equity and bond investors is well known by previous academic findings. Shifts in investor sentiment induce investors to reconsider their asset allocation decisions. When investors' sentiment-induced trading behavior changes in response to the decline of financial market sentiments compared to the historical average, investors tend to switch from riskier to safer assets (and also from volatile to safe stocks, DeVault et al., 2019; Griffin et al., 2011), as they become more risk adverse during crisis times (Ben-Rephael et al., 2012; Da et al., 2015; Islam, 2021). Moreover, investors move their investments from equity funds to bond funds when the sentiment gets worse (Da et al., 2015). The development of hypothesis is schematized in Figure 1.

3 | DATA AND VARIABLES

3.1 | Measuring the climate change effect

In this paper, we proxy the climate change effect (*CLIMATE*) over investor behavior by considering extremely adverse climatic events. Under this rationale, 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 & Bausch, 2006; Van Aalst, 2006; Fang et al., 2019; Dixon et al., 2019). According to NASA Earth Observatory,[11] climate change will create conditions more favorable to the formation of severe climate conditions.[12]

Data related to climate change as proxied by natural disasters are collected from the EM-DA database[13]: EM-DAT contains core data on both the occurrence and the effects of worldwide mass disasters from 1900, including nearly 7000 disaster events. The database is compiled from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes, and press agencies. The following natural disasters related to climate change[14] were taken from the EM-DAT: drought, extreme temperature, flood, landslide, mass movement (dry), storm, and wildfire. Over the sample period (January 2009–December 2018) we analyzed 878 natural disaster events from 147 countries. We evaluate the impact of natural disasters by catching the emergencies from our database, which are grouped based on three loss measures, that are dead, affected, and damaged (in terms of natural logarithm). The first two loss measures account for the first stage of IV and the latter for the final specification.

3.2 | Identifying socially responsible investments

According to Widyawati (2020), we consider the practice of integrating sustainability criteria (particularly ESG aspects), known as socially responsible investing (SRI). In our paper, a novel element concerning previous academic literature is that we focus on ETFs. 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). Not surprisingly, institutional investors extensively use ETFs in their portfolio allocation decisions.

While a common feature of most papers on the relationship between ESG items and investors' decision is their focus on mutual funds by considering ESG ratings (see among others Hartzmark & Sussman, 2019 and Van Duuren et al., 2016), we in our turn check out ETFs; thus, we are able to have direct and safe methods to identify ETFs related to sustainability themes. Say differently, rather than focusing on the ESG ratings (as Ferrell et al., 2016; Riedl & Smeets, 2017; and Hartzmark & Sussman, 2019) that are also influenced by rating agencies' subjective policy evaluations, we believe

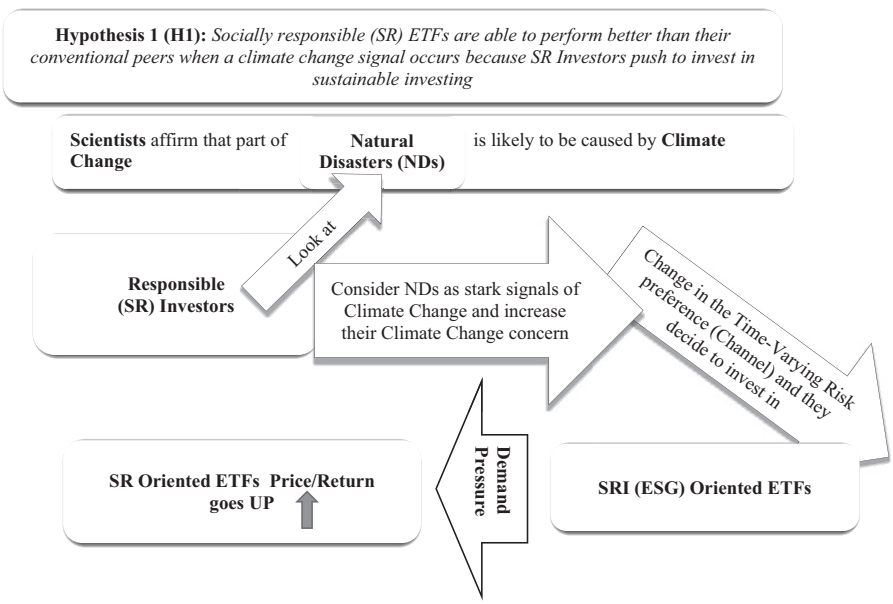

FIGURE 1 —Development of hypothesis.
Source: Authors' own elaboration.

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 as socially responsible (SR)-oriented ETFs using the following three complementary and objective criteria: (1) the ETF name[15] contains either "ESG" or "SRI",[16] given that these two specifications are the most commonly used to identify sustainable instruments[17]; (2) self-declared sustainable-oriented ETF that ETF asset manager declares itself when dealing with sustainability macro themes (in the same spirit of Albino et al., 2009 and Venagopal & Shukla, 2019, e.g., ETFs investing in companies distributing sustainable energy products); (3) lastly, we check that the investment target reported in the fund prospectus corresponds to a sustainable investing theme. SR-oriented ETFs are not homogeneous investment vehicles following high standard ethical criteria in their investment decisions while being different in varied SR investment strategies (Soler-Domínguez et al., 2021). To the best of our knowledge, it is the first time that academic literature addresses a similar mutual fund sample. Exchange trade fund (ETF) returns data are collected from Thomson Reuters Datastream: We collect monthly total returns for ETF traded worldwide between January, 2009 and December, 2018. Variable description is reported in Table 1.

The importance of sustainable funds is supported by growth in a number of financial companies issuing these funds (from 35 financial companies in 2009 to 45 in 2018) and total assets under their management (Look at Figure 2 Panel C).

Our control sample (Not SR-oriented ETFs) is composed of all worldwide non-sustainable investing-oriented ETFs that have the same currency (British Pound, Canadian Dollar, Euro, Japanese Yen, Korean [South] Won, New Zealand Dollar, Swiss Franc, and US Dollar), the same country domicile (Canada, France, Ireland, Japan, Luxembourg, New Zealand, South Korea, Switzerland, and United States), the same fund type (Bond and Equity) of ESG-oriented ETFs. Our final sample consists of 139 ESG-oriented ETF, that is, 84 ETF containing ESG in the name (*SUST_ESG*), 40 containing SRI in the name (*SUST_SRI*), and 15 self-declaring (*SUST_SELF*) ESG-oriented ETFs (all equity type). Most of the ESG-oriented ETFs focus on equity (126) and few on bonds (23). The control sample is composed of 1105 non-ESG-oriented ETFs, (209 focusing on bonds and 896 on equity). In terms of asset 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[18]). Table 2 reports some descriptive statistics both of the ETF and natural disaster sample.

4 | IDENTIFICATION STRATEGY

In line with previous scholars (Kappou & Oikonomou, 2016; Statman, 2006; Widyawati, 2020) on the same topic, generally comparing the performance of socially responsible investment (SRI) portfolios with either conventional portfolios or market benchmarks, our empirical approach to investigate whether SR-oriented ETFs achieve better performance in comparison to other ETFs is based on the following models:

$$Y_{i,t} = \alpha + \beta_1 \text{SUST_SELF}_{i,t} + \beta_2 \text{DIS}_{j,t} + \beta_3 \text{SUST_SELF}_{i,t}{}^{*} \text{CLIMATE}_{j,t} + \gamma X_{i,t-1} + A_i + B_t + \varepsilon_{i,t}, \tag{1}$$

$$Y_{i,t} = \alpha + \beta_1 \text{SUST_ESG}_{i,t} + \beta_2 \text{DIS}_{j,t} + \beta_3 \text{SUST_ESG}_{i,}{}^{*} \text{CLIMATE}_{j,t} + \gamma X_{i,t-1} + A_i + B_t + \varepsilon_{i,t}, \tag{2}$$

$$Y_{i,t} = \alpha + \beta_1 \text{SUST_SRI}_{i,t} + \beta_2 \text{DIS}_{j,t} + \beta_3 \text{SUST_SRI}_{i,t}{}^{*} \text{CLIMATE}_{j,t} + \gamma X_{i,t-1} + A_i + B_t + \varepsilon_{i,t}, \tag{3}$$

where the dependent variable (*Y*) is the log monthly ETF return measured at month *t* for fund *i*, SUST is our ETF classification variable capturing socially responsible (SR)-oriented ETFs (taking a value of 1 the ETF is associated with sustainability investing themes—as we defined above in terms of *SUST_ESG*, *SUST_SRI*, and *SUST_SELF*—and 0 otherwise). $CLIMATE_{j,t}$ is a variable capturing the climate change effects, in terms of the magnitude of disastrous events that occurred (natural logarithm of total damages due to natural disasters that occurred in a month).

The coefficient $\beta_{3,}$ coupled with the interaction between *SUST_(SELF, ESG or SRI, respectively) and CLIMATE*, is the coefficient of main interest capturing the effect of climate change over the ETFs price. We posit that β_3 is positive and statistically significant, assessing the fact that after the occurrence of climate change signals, socially responsible investors react by changing their time-varying risk preference to reallocate their portfolios in order to match their socially responsible investment decisions. As reported above, the change in time-varying investor risk preferences influenced by fear of climate change due to natural disasters, it is likely to be coupled with a portfolio reallocation in favor of more sustainable assets. We also include various control variables such as age (the seniority of the single ETF, measured in terms of months since inception) and Div_yeld (the dividend yield return). All variables are 1-month lagged. In our main models, we include fund fixed effects (A) considering the asset management company and the country where ETFs are domiciled, and (B) the time (months). We consider robust standard errors clustered at the ETF level.

Our identification approaches present two unique and novel elements: firstly, we focus on ETF (that enable an objective identification of SR investments), and secondly, we run a worldwide analysis both in terms of climate change events and SR investments. Unlike most of the academic literature in this area (among others, Marti-Ballester, 2019; and Soler-Domínguez et al., 2021), we address potential endogeneity problems by performing a two-stage least square (2SLS) analysis. Specifically, we instrument the variable damages by using the exclusion conditions: specifically, the total number of deaths and the total number of affected are good predictors of the value of damages (relevance condition), and these do not have a direct effect on market returns (validity condition): their effect on market return (the dependent variable) is not direct but via the value of damages. Although the number of deaths and injured has

TABLE 1 Variable description

Variables	Symbol	Definition and calculation method	Source
ETF age	*Age*	ETF seniority (number of months since inception)	Thomson Reuters Data
Climate change effects	*CLIMATE*	Value of damages (total damages) occurred in a natural disaster (thousand dollars)	EM-DA database
Causalities	*Total deaths*	Number of death people in a natural disaster	EM-DA database
Div Yield return	*Fund dividend yield*	Dividend yield return	Thomson Reuters Data
Affected	*Total affected*	Number of affected people occurred in a natural disaster	EM-DA database
Name of ESG strategy	*SUST_ESG*	A dummy taking the value of 1 if the fund is named ESG, and 0 otherwise.	Authors computation on Thomson Reuters Data
Name effect over ESG sustainable strategy	*SUST_ESG_CLIMATE*	The interaction between the *SUST_ESG* and *CLIMATE*	Authors computation on Thomson Reuters Data & EM-DA database
Name of SRI strategy	*SUST_SRI*	A dummy variable taking the value of 1 if the fund has an SRI name, and 0 otherwise	Authors computation on Thomson Reuters Data
Name effect over SRI sustainable strategy	*SUST_SRI_CLIMATE*	The interaction between the *SUST_SRI* and *CLIMATE*	Authors computation on Thomson Reuters Data & EM-DA database
Name of self-declared sustainable strategy	*SUST_SELF*	A dummy taking the value of 1 if the fund has a name connected to strategies (that we have defined self-declared and that are connected to environmental issues such as clean energy and water), and 0 otherwise.	Authors computation on Thomson Reuters Data
Name effect over self-declared sustainable strategy	*SUST_SELF_CLIMATE*	The interaction between the *SUST_SELF* and *CLIMATE*	Authors computation on Thomson Reuters Data & EM-DA database
Sustainable investments	*SUST*	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_CLIMATE*	The interaction between *SUST* and *CLIMATE*	Authors computation on Thomson Reuters Data & EM-DA database

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

an impact on investors' sentiment about the magnitude of natural disasters, these are a first proxy of the value of damages that are indeed the variable influencing market returns.

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.

5 | EMPIRICAL RESULTS

Thematic socially responsible (SR) ETFs are used to transmit the response of responsible investors to climate change concerns. As such, the variables of main interest are the interaction variables *SUST_ESG*, *SUST_SRI*, and *SUST_SELF*. They are obtained by the interaction of the climate change indicator (*CLIMATE*) and the ETF category. Respectively, *SUST_SELF* takes the value of one if the ETF implements a strategy based on sustainable themes (e.g., clean energy and water) and zero if otherwise, *SUST_ESG* takes the value of one if the fund is named "ESG" and zero if otherwise, and *SUST_SRI* takes the value of one if the fund has an "SRI" name and zero if otherwise.

Our results are represented as follows. Table 3 shows empirical results for *SUST_SELF*, Tables 4 and 5 report evidence for *SUST_ESG* and *SUST_SRI* strategies.

We first regress the SR ETF returns on *SUST_(SELF, ESG or SRI)_CLIMATE* and the usual controls. OLS estimation is presented in columns 1 and 2. In the first specification, we include fixed effects, accounting for Domicile × Month FE and Company-FE, and in the second, fixed effects accounting for Domicile × Month FE and ETF-FE. Lastly, due to endogeneity concerns, we consider IV estimates in the third column.

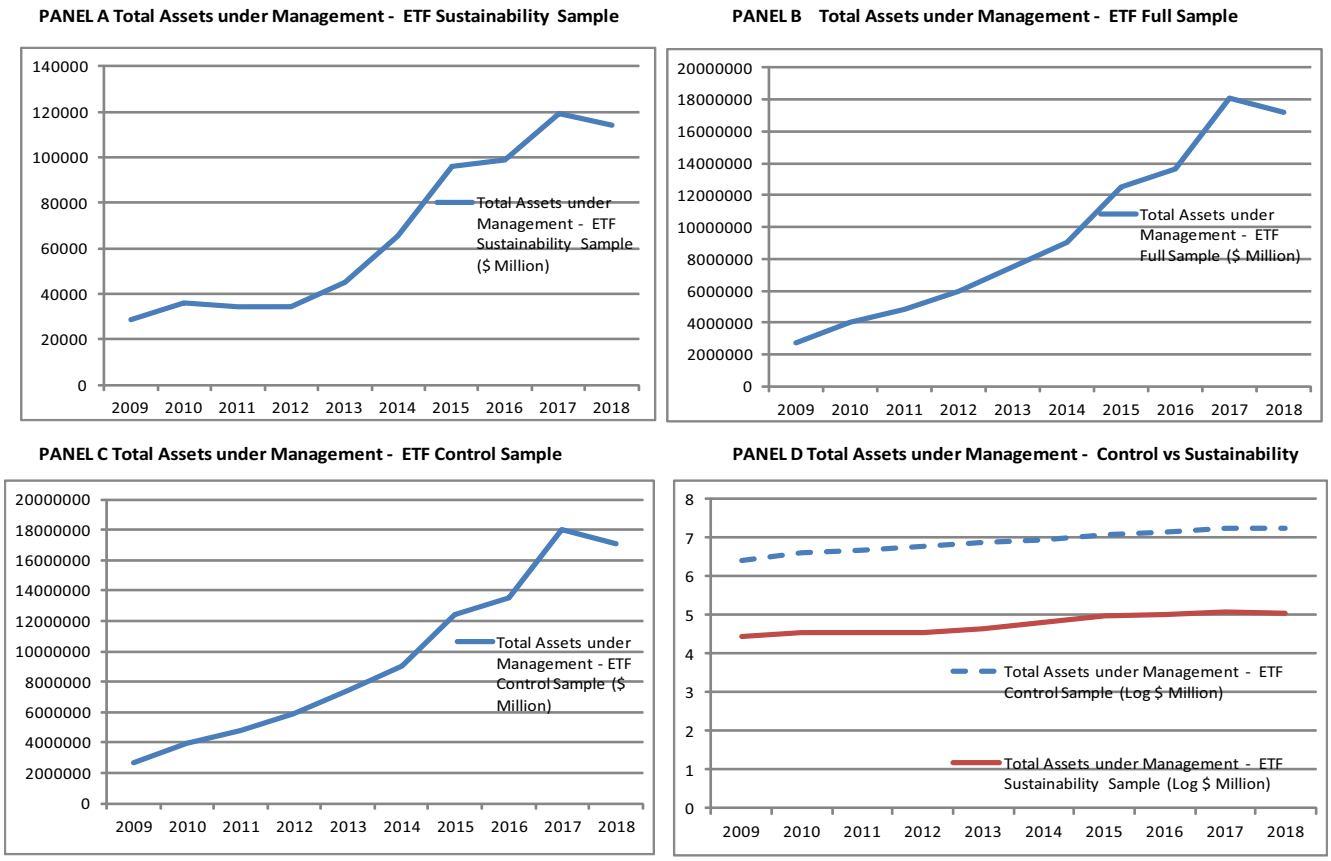

FIGURE 2 —Socially responsible (SR)-oriented ETFs and control sample.
Source: Authors' own elaboration. Data from Refinitiv.

Overall Tables 3–5 show the way climate change produces a statistically significant influence over socially responsible (SR)-oriented ETF. To be specific, in the first-stage regressions reported in columns 1 and 2, *SUST_(SELF, ESG, or SRI)_CLIMATE* always enters with a positive and significant coefficient, as expected. Moreover, we see that both instruments are statistically significant, which seems to validate their use. Therefore, we turn to the second stage (IV). Results confirm our previous OLS findings in that the occurrence of climate change events is positively associated with the raise up of SR-oriented ETF returns. This provides evidence that natural disasters, as signals of climate change, influence the action of responsible investors toward high sustainability financial instruments, and this finding is not likely due to unobserved characteristics.

Concerning self-declared sustainable-oriented ETF (*SUST_SELF*) that is self-declared strategies connected to environmental issues, such as clean energy and water, the coefficient coupled to variable *SUST_CLIMATE* (our main interest variable) is positive with a value of 0.097, and it exhibits a high level of statistical significance.

When we consider the ESG labeled ETF strategy (*SUST_ESG*), we observe that the coefficient is positive, corresponding to a value of 0.349, highly significant, and, in line with our hypothesis (H1). The coefficient in magnitude is larger than that shown by the self-declared sustainable-oriented ETF (*SUST_SELF*) strategies. This empirical result is in line with a rationale, according to which a self-declared sustainable-oriented ETF (*SUST_SELF*) in terms of overall portfolio diversification could represent a very specific investment strategy (being concentrated on a restricted number of stocks or bond issuers) and, therefore, it should be less appealing. A strategy that focuses only on a specific area of sustainable investing (e.g., green energy), in theory, should contribute less to the diversification of the portfolio than it can provide a strategy that considers a plurality of sectors as are the strategies labeled ESG (*SUST_ESG*) and SRI (*SUST_SRI*).

When we consider the strategies labeled as SRI (*SUST_SRI*), we observe the confirmation of this rationale from the results. Here, the coefficient of *SUST_SRI_CLIMATE* is positive, and statistically significant, with a value of 0.349, larger than the coefficient of *SUST_SELF* strategies.

Interestingly enough is the negative coefficient for the sustainability dummy, for two groups of ETFs (representing the vast majority of the sample). This indicates that all else equal, investors have lower demand for ESG. This result is very interesting in light of the paper's story because it underlines the fact that, on average, in the period analyzed, investors are not willing to invest tout court in ESG-oriented instruments, but do so, when they are solicited by an external event like a natural disaster.

The control variables exhibit the expected direction. Damages are negative, while the fund asset size parameter is negative

TABLE 2 Descriptive statistics

Panel A: ETF sample—Descriptive statistics

	Auto-declared sustainable strategy				ESG & SRI strategy			
	Mean	Max	Min	*SD*	Mean	Max	Min	*SD*
	Return				**Return**			
Sample sustainability	0.005	0.140	−0.154	0.058	0.001	0.140	−0.154	0.018
Matching sample	0.004	0.140	−0.154	0.059	0.005	0.140	−0.154	0.048
	Dividend yield				**Dividend Yield**			
Sample sustainability	1.354	11.020	0.000	1.200	1.839	11.020	0.000	1.840
Matching sample	1.875	11.020	0.000	2.132	2.073	11.020	0.000	1.936
	Age				**Age**			
Sample sustainability	90.214	116.000	2.000	41.877	34.337	116.000	0.000	33.754
Matching sample	87.328	116.000	2.000	36.027	62.578	116.000	0.000	41.107

Panel B: Natural disaster sample—Descriptive statistics

	Mean	Max	Min	*SD*	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
Disaster index (*DIS*)	49.2	72.5	22.6	9.8	42	55.5	63.8

Panel C: Natural disaster sample—Number of events and year of occurrence

Year	Number of events	Total deaths	Total affected	Total damage (USD thousand dollar)
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 D: Natural disaster types—Summary statistics

Disaster type	*N*	Mean	*SD*	Min	Max
Drought					
Total deaths	1	11		11	11
Total affected	19	28,122,121	74,757,774	62,000	33,000,000
Total damages (USD thousand dollar)	29	2,806,558.6	3,672,690.4	1200	20,000,000
Extreme temperature					
Total deaths	111	618.802	5293.055	1	55,736
Total affected	29	198,540.38	760,899.39	11	4,033,472
Total damages (USD thousand dollar)	12	671,733.42	751,263.89	20,200	2,500,000

TABLE 2 (Continued)

Panel D: Natural disaster types—Summary statistics					
Disaster type	***N***	**Mean**	***SD***	**Min**	**Max**
Flood					
Total deaths	455	56.807	307.944	1	6054
Total affected	494	1,143,690.9	7,774,962.7	3	13,400,000
Total damages (USD thousand dollar)	298	1,063,486.3	3,274,777.4	1400	40,000,000
Landslide					
Total deaths	79	53.633	196.914	3	1765
Total affected	45	56,453.733	313,735.9	1	2,100,000
Total damages (USD thousand dollar)	12	229,691.67	341,939.94	2000	900,000
Mass movement (dry)					
Total deaths	3	23.333	20.033	8	46
Total affected	2	101	140.007	2	200
Total damages (USD thousand dollar)	1	8000		8000	8000
Storm					
Total deaths	428	19.315	50.973	1	884
Total affected	348	594,860.16	4,880,134.5	1	85,000,012
Total damages (USD thousand dollar)	371	1,568,271.5	6,508,740	500	95,000,000
Wildfire					
Total deaths	51	16.216	31.667	1	180
Total affected	64	14,695.563	60,050.608	3	409,664
Total damages (USD thousand dollar)	51	1,131,690.6	2,964,713.2	2000	16,500,000

Note: This table reports the summary statistics for the whole sample. Panel A reports the summary statistics for the whole ETF sample. Panel B reports the summary statistics for the natural disaster sample (based on EM-DAT). 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* stands for dividend yield return. All variables are taken with 1-month lag and are winsorized at 1 and 99 percentiles. Panel C reports the number of natural disasters analyzed in our empirical investigation.

corroborating a wide part of the literature on this (see among others, Reuter and Zitzewitz, 2010; Zhu, 2018). The fund dividend yield coefficient is positive, that is the higher the dividend yield, the higher the return of the ETF should be.

In the second step, we analyze the market reaction taking into account the asset type. We can perform this analysis for ETFs that exhibit strategies with the name ESG or SRI because in the case of *SUST_SELF*, we only have equity strategies within the sample.

In Column 3, we consider the IV specification. In Columns 1 and 2, we report the OLS estimation coefficients. Interestingly, it should be noted both in the case of strategies with ESG name (*SUST_ESG*) and SRI name (*SUST_SRI*), a different reaction between equity ETFs with underlying assets represented by stocks compared to fixed income ETFs with underlying assets including government and companies' bond.

Interestingly, in the IV estimation, our results show positive statistical significance (1% level) for interaction variable *SUST_(ESG or SRI)_CLIMATE* for the equity side of the ETF sample, and negative and statistical significance for the ESG with fixed income (Bond) underlying securities. Bond investors seem to be more careful and tend to perform an exit strategy when a disaster occurs. This evidence is entirely consistent with the risk–return profile of this investment usually selected by more conservative investors.

6 | ADDITIONAL TEST

6.1 | Propensity score matching (PSM) approach

Our first robustness check is based on estimating our main model using different measures of the fund performance.[19] Given the significant difference between socially responsible for ETFs and other ETFs, we control for the pricing factors in evaluating the performance. Under this perspective, it is quite a traditional treatment introducing unconditional (single or multi) factor model, that is dealing with Jensen (1968), Fama and French (1993), or Carhart (1997) Alpha, when computing fund performance. As a preliminary consideration, we must report that the use of factor models to evaluate fund performance is common when investigating the skills of fund managers. ETFs represent mostly passive mutual funds that are passive strategy. Therefore, apparently, it seems less relevant to adopt factor models to address their performance (Bogle, 2016). Nevertheless, we deepen our analysis by introducing a framework of

TABLE 3 Climate change shocks and socially responsible investments: SR ETFs—SELF declared

All sample SELF			
	y = log returns	*y = log returns*	*y = log returns*
	(1)	(2)	(3)
SUST_SELF	−0.2510		
	(0.5298)		
CLIMATE	−0.0128*	−0.0084	−0.0785***
	(0.0077)	(0.0075)	(0.0104)
SUST_SELF_CLIMATE	0.0164	0.0271	0.0972***
	(0.0338)	(0.0346)	(0.0347)
Fund asset size	−0.1628***	−0.7366***	−0.7369***
	(0.0225)	(0.0438)	(0.0437)
Fund age	0.0038***		
	(0.0006)		
Fund dividend yield	−0.0325***	0.1425***	0.1401***
	(0.0117)	(0.0154)	(0.0154)
No. of observations	74,294	74,294	74,294
Company-FE	Yes	No	No
Domicile × Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Tests			
Under identification (*p*-value)			0.0000
Weak identification (*p*-value)			0.0000
Over identification (*p*-value)			0.0000
First-stage results			
Total deaths			0.4851***
(*SE*)			(0.0181)
Total affected			0.3197***
(*SE*)			(0. 0013)

Note: The main dependent variable is ETF log return. SUST is a dummy variable taking the value of 1 if an ETF is associated with sustainability themes, and 0 otherwise according to the sample (respectively, *SELF*, *ESG*, and *SRI*). *SUST_SELF* is a dummy that equals 1 if the fund has a name connected to strategies that we have defined self-declared and that are connected to environmental issues such clean energy and water. *SUST_ESG* variable is a dummy equal to 1 if the ETF-fund is named ESG. *SUST_SRI* variable is a dummy variable equal to 1 if the ETF-fund has an SRI name. *CLIMATE* is an aggregate measure of climate change effects as described in Table 1. Age is the seniority of the single ETF (measured in terms of months since inception). Div_yeld means the Div Yield return. Standard errors in parentheses. ***, ** and * denote significance at 1, 5 and 10 per cent levels. Regressions do include country/domicile, time, and type fixed effects. In PANEL A, OLS estimation is presented in columns 1 and 2; in the first, the specification includes fixed effects (Domicile × Month FE and Company-FE), and in the second, fixed effects accounting for Domicile × Month FE and ETF-FE. Lastly, due to endogeneity concern, we have IV estimates in the third column.

performance measures, active mutual fund alike. We rely on the fact that sustainable ETFs are quite different from traditional ETFs that perfectly reflect passive investment strategy. To this end (see among others, Sherrill et al., 2017; Crane, & Crotty, 2018), we have considered CAPM Alfa (Jensen, 1968), three-factor Fama–French (Fama & French, 1993) and Carhart (Carhart, 1997) multifactor models in our analysis.

We assume that natural disasters create the wider need in investments toward sustainable ETFs, rather than in traditional ETFs; therefore, we apply additional tests to ensure that the relationship is not driven by other fundamentals of the ETFs and follow Hameed and Xie (2019) approach. First, we run the propensity score matching (PSM), in a one-to-one matching context, to find a set of comparable control funds (which is conventional ETFs) corresponding to sustainability ETFs. To get the PSM comparable control funds, we use as covariate variables the same used in the IV-2SLS estimation that is: size, age, and dividend yield.[20] Second, considering that the events corresponding to climate change signals are natural disaster, we look at the difference between alphas from the Jensen CAPM (Jensen, 1968), Fama and French (1993), and Carhart (1997) multifactor model, respectively, of sustainability-oriented and conventional ETFs (control sample after the PSM) before and after the events (Climate Change signals).

TABLE 4 Climate change shocks and socially responsible investments: SR ETFs—ESG label

Panel A—All sample ESG			
	y = log returns	*y = log returns*	*y = log returns*
	(1)	**(2)**	**(3)**
SUST_ESG	−3.8631***		
	(1.2967)		
CLIMATE	−0.0163**	−0.0115	−0.0812***
	(0.0076)	(0.0074)	(0.0103)
SUST_ESG_CLIMATE	0.2986***	0.2798***	0.3495***
	(0.0911)	(0.0874)	(0.0876)
Fund asset size	−0.1617***	−0.7361***	−0.7363***
	(0.0224)	(0.0438)	(0.0437)
Fund age	0.0040***		
	(0.0006)		
Fund dividend yield	−0.0319***	0.1422***	0.1397***
	(0.0116)	(0.0154)	(0.0154)
No. of observations	72,771	74,294	74,294
Company-FE	Yes	NO	NO
Domicile × Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Tests			
Under identification (*p*-value)			0.0000
Weak identification (*p*-value)			0.0000
Over identification (*p*-value)			0.0000
First-stage results			
Total deaths			0.4855***
(*SE*)			(0.0017)
Total affected			0.3210***
(*SE*)			(0.0014)

Panel B—ESG equity & bond				
	y = log returns	*y = log returns*	*y = log returns*	*y = log returns*
	ESG equity	*ESG equity*	*ESG bond*	*ESG bond*
	(1)	**(2)**	**(3)**	**(4)**
SUST_ESG				
CLIMATE	−0.0185**	−0.1082***	0.0502***	0.1694***
	(0.0081)	(0.0108)	(0.0078)	(0.0141)
SUST_ESG_CLIMATE	0.3106***	0.4005***	0.0134	−0.1046***
	(0.1007)	(0.1009)	(0.0310)	(0.0335)
Fund asset size	−0.7761***	−0.7753***	−0.3439***	−0.3316***
	(0.0489)	(0.0488)	(0.0506)	(0.0513)
Fund age				
Fund dividend yield	0.1537***	0.1504***	0.0212	0.0264
	(0.0169)	(0.0168)	(0.0166)	(0.0171)

(Continues)

TABLE 4 (Continued)

Panel B—ESG equity & bond				
	y = log returns	*y = log returns*	*y = log returns*	*y = log returns*
	ESG equity	*ESG equity*	*ESG bond*	*ESG bond*
	(1)	(2)	(3)	(4)
No. of observations	66,254	66,254	8040	8040
Company-FE	No	No	No	No
Domicile × Month FE	Yes	Yes	Yes	Yes
ETF-FE	Yes	Yes	Yes	Yes
Tests				
Under identification (*p*-value)				0.0000
Weak identification (*p*-value)				0.0000
Over identification (*p*-value)				0.0043
First-stage results				
Total deaths				0.4582***
(*SE*)				(0.0069)
Total affected				0.3477***
(*SE*)				(0.0060)

Note: The main dependent variable is ETF log return. SUST is a dummy variable taking the value of 1 if an ETF is associated with sustainability themes, and 0 otherwise according to the sample (respectively, *SELF*, *ESG*, and *SRI*). *SUST_SELF* is a dummy that equals 1 if the fund has a name connected to strategies that we have defined self-declared and that are connected to environmental issues such clean energy and water. *SUST_ESG* variable is a dummy equal to 1 if the ETF-fund is named ESG. *SUST_SRI* variable is a dummy variable equal to 1 if the ETF-fund has an SRI name. *CLIMATE* is an aggregate measure of climate change effects as described in Table 1. Age is the seniority of the single ETF (measured in terms of months since inception). Div_yeld means the Div Yield return. Standard errors in parentheses. ***, ** and * denote significance at 1, 5 and 10 per cent levels. Regressions do include country/domicile, time, and type fixed effects. In Panel A, OLS estimation is presented in columns 1 and 2, in the first, the specification includes fixed effects (Domicile × Month FE and Company-FE), and in the second, fixed effects accounting for Domicile × Month FE and ETF-FE. Lastly, due to endogeneity concern, we have IV estimates in the third column.

Results are showed in Table 6. The main result is the ATT (average treatment effect among treated). By looking at our empirical results, we observe that all alpha estimates, regardless of the market model from which it comes (single or multiple factor specification), are higher in the column number five: Difference, when considering sustainable ETFs (*Treated*). For the sake of additional robustness, we also consider the change in volume variable (*Cha_Vol*), measuring the ETFs volume changing after the events, providing a further confirmation of the evidence that after events corresponding to climate change signal, investors change their time-varying investor risk preference and change their portfolio reallocation in favor of more sustainable assets.

6.2 | Changing independent variables

As an additional test, we 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 SR-oriented ETFs, the turnover by volume reacts to the increasing pressure on the demand side by SR investors.

We use this new measure to run the basic model. Due to space limitations, we do not exhibit variables below, but tables are available upon request. The main result is unchanged with respect to the previous specification. We find a positive (and statistically significant at the 1% level) relationship between extreme natural events and investors' demand pressure both for all sample and equity SR ETF strategies.

7 | DISCUSSION AND POLICY IMPLICATIONS

Socially responsible (SR)-oriented ETFs could play an important role as financial instruments for channelizing private resources into climate finance if managers are able to increase investor wealth by adopting SR principles in their portfolios. We aimed to extend previous findings in terms of SR investments, by considering the market reaction of SR investments to climate change signals.

We assume together with NASA scientists and a large group of scholars[21] that natural disasters are a signal of climate change. From one side, we proxy the climate change events accounting for more than 800 international natural disasters of various types and classified according to different loss metrics. On another side, we deal

TABLE 5 Climate change shocks and socially responsible investments: SR ETFs—SRI label

Panel A—All sample SRI			
	y = log returns	*y = log returns*	*y = log returns*
	(1)	**(2)**	**(3)**
SUST_SRI	−1.8852*		
	(1.1186)		
CLIMATE	−0.0139*	−0.0093	−0.0787***
	(0.0076)	(0.0075)	(0.0103)
SUST_SRI_CLIMATE	0.1549**	0.1535**	0.2229***
	(0.0772)	(0.0781)	(0.0784)
Fund asset size	−0.1625***	−0.7360***	−0.7359***
	(0.0225)	(0.0438)	(0.0437)
Fund age	0.0039***		
	(0.0006)		
Fund dividend yield	−0.0323***	0.1424***	0.1399***
	(0.0117)	(0.0154)	(0.0154)
No. of observations	74,294	74,294	74,294
Company-FE	Yes	No	No
Domicile × Month FE	Yes	Yes	Yes
ETF-FE	No	Yes	Yes
Tests			
Under identification (*p*-value)			0.0000
Weak identification (*p*-value)			0.0000
Over identification (*p*-value)			0.0044
First-stage results			
Total deaths			0.4585***
(SE)			(0.0069)
Total affected			0.3488***
(SE)			(0.0060)

Panel B—SRI equity & bond				
	y = log returns	*y = log returns*	*y = log returns*	*y = log returns*
	SRI equity	*SRI equity*	*SRI bond*	*SRI bond*
	(1)	**(2)**	**(3)**	**(4)**
SUST_SRI				
CLIMATE	−0.0161**	−0.1055***	0.0504***	0.1684***
	(0.0082)	(0.0108)	(0.0077)	(0.0140)
SUST_SRI_CLIMATE	0.1637**	0.2532***	−0.0011	−0.1186***
	(0.0818)	(0.0822)	(0.0216)	(0.0248)
Fund asset size	−0.7758***	−0.7747***	−0.3440***	−0.3315***
	(0.0489)	(0.0488)	(0.0506)	(0.0513)
Fund age				
Fund dividend yield	0.1540***	0.1509***	0.0212	0.0269
	(0.0169)	(0.0168)	(0.0166)	(0.0172)

(Continues)

TABLE 5 (Continued)

Panel B—SRI equity & bond				
	y = log returns	*y = log returns*	*y = log returns*	*y = log returns*
	SRI equity	*SRI equity*	*SRI bond*	*SRI bond*
	(1)	(2)	(3)	(4)
No. of observations	66,254	66,254	8040	8040
Company-FE	No	No	No	No
Domicile × Month FE	Yes	Yes	Yes	Yes
ETF-FE	Yes	Yes	Yes	Yes
Tests				
Under identification (*p*-value)	0.0000		0.0000	
Weak identification (*p*-value)	0.0000		0.0000	
Over identification (*p*-value)	0.0000		0.0000	
First-stage results				
Total deaths			0.4847***	
(SE)			(0.0025)	
Total affected			0.3169***	
(SE)			(0.0016)	

Note: The main dependent variable is ETF log return. SUST is a dummy variable taking the value of 1 if an ETF is associated with sustainability themes, and 0 otherwise according to the sample (respectively, *SELF*, *ESG*, and *SRI*). *SUST_SELF* is a dummy that equals 1 if the fund has a name connected to strategies that we have defined self-declared and that are connected to environmental issues such clean energy and water. *SUST_ESG* variable is a dummy equal to 1 if the ETF-fund is named ESG. *SUST_SRI* variable is a dummy variable equal to 1 if the ETF-fund has an SRI name. *CLIMATE* is an aggregate measure of climate change effects as described in Table 1. Age is the seniority of the single ETF (measured in terms of months since inception). Div_yeld means the Div Yield return. Standard errors in parentheses. ***, ** and * denote significance at 1, 5 and 10 per cent levels. Regressions do include country/domicile, time, and type fixed effects. In Panel A, OLS estimation is presented in columns 1 and 2; in the first, the specification includes fixed effects (Domicile × Month FE and Company-FE), and in the second, fixed effects accounting for Domicile × Month FE and ETF-FE. Lastly, due to endogeneity concern, we have IV estimates in the third column.

TABLE 6 Climate change shocks and socially responsible investments: Propensity score matching (PSM) approach

Variable	Sample	Treated (sustainability-oriented ETFs)	Controls	Difference	*SE*	T-stat
Jensen Alfa	Unmatched	1.27	0.68	0.59	0.03	21.89
ATT	1.27	0.69	0.57	0.05		12.06
Fama–French Alfa	Unmatched	1.11	0.59	0.52	0.03	17.55
ATT	1.11	0.60	0.51	0.05		9.61
Carhart Alfa	Unmatched	1.05	0.57	0.48	0.03	14.20
ATT	1.05	0.55	0.51	0.06		8.53
Cha_Vol	Unmatched	1.63	1.47	0.15	0.04	3.51
ATT	1.63	1.45	0.18	0.07		2.63

Note: We run the propensity score matching (PSM), in a one-to-one matching context, to find a set of comparable control funds (which is conventional ETFs) corresponding to the sustainability ETFs. We use as covariates the same variables used in the IV-2SLS estimation that is: size, age, and dividend yield. Second, we look at the difference between alphas from the Jensen CAPM (Jensen, 1968), Fama and French (1993), and Carhart (1997) multifactor model, respectively, of sustainability-oriented and conventional ETFs (control sample after the PSM) before and after the events (climate change signals). The main result is the ATT (average treatment effect among treated). We also consider the change in volume variable (*Cha_Vol*), measuring the ETFs volume changing. By looking at our empirical results, we observe that all the alpha estimates, regardless of the market model from which it comes (single or multiple factor specification), are higher when considering sustainable ETFs (treated).

with a very extensive dataset of SR-oriented ETFs covering quite 90% of the total investable universe. To distinguish the effect, a very large sample (over 1000 single securities) of bond and equity ETFs is considered in terms of the control sample. As we combine this set of data with information on natural disasters during the same time, we are able to exploit a "natural experiment" allowing us to identify the socially responsible investment behavior in response to unpredictable climate change shocks. We find the following: (i) a significant

sustainable investment activity exists in response to natural disasters (all else equal, investors exhibit lower demand for SR-oriented investments during the sample period, but their behavior changes in response to climate change shock); (ii) the underlying strategy influences the relation between return and climate change events; (iii) the asset type (equity or bond) of the underlying SR-oriented ETFs strategy influences the relation between return and climate change events.

The study of investment activity in response to climate change events may help ensure the best use of anti-climate change measures, such as fiscal incentives coupled to sustainability like financial products to encourage the mobilization of private capital into climate finance. Under this perspective, policymakers should increase the support for firms that adopt environmentally conscious business practices such as the conservation of natural resources, the production of alternative energy sources, or among other green-based initiatives, the implementation of clean air and water projects. Under the manager perspective, the evidence that sustainable investments are good performers also contributes to the spread of sustainable corporate culture that helps firms to implement a sustainable business strategy. In the same line, showing that funds with greater sustainability investment targets are also the ones that achieve the best results would imply tilting the balance in favor of sustainable investment.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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ENDNOTES

[1] https://www.unpri.org/pri/what-are-the-principles-for-responsible-investment.

[2] United National Global Impact https://www.unglobalcompact.org/take-action/action/private-sustainability-finance.

[3] Global Sustainable Investment Alliance, 2018 Report.

[4] 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.

[5] Bourdeau-Brien and Kryzanowski (2017), observe that the volatility of local stock returns more than double when extreme climate change events occur.

[6] Krüger (2015) and Lanfear et al. (2019) document strong abnormal effects due to U.S. landfall hurricanes.

[7] Zerbib (2019) evaluate the effect of pro-environmental preferences behind investors' preferences for green bonds.

[8] https://climate.nasa.gov/.

[9] The biggest effect on stock returns and volatilities of firms is seen during the peak of disaster news coverage and the following 2 or 3 months (Bourdeau-Brien & Kryzanowski, 2017).

[10] Out of the crisis time, the effectiveness of SRI-oriented ETFs as a financial instrument to mobilize private capital for climate investment depends on their managers' ability to generate positive financial performance for investors by channelizing private financial resources, particularly from environmentally aware investors, by purchasing stocks and bonds of firms investing in social capital and climate-related projects (Marti-Ballester, 2019).

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

[12] NASA scientists assume that Global warming could affect storm formation by reducing the temperature difference between the poles and equator, and with the increase of these differences the number and intensity of storms raises.

[13] 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.

[14] We exclude earthquake and Vulcanic activity.

[15] Due to the fact that investors are not professionally experienced persons the name of investment strategy play a key role in their asset allocation decisions.

[16] Bilbao-Terol et al. (2017) proved that SRI label is valued favorably on the market, such funds experience a higher growth in assets than conventional funds.

[17] With respect to the relevance of the name of a mutual fund, firstly we should remember that on march 2001, the Securities and Exchange Commission adopted a new rule under the Investment Company Act of 1940 to address certain broad categories of investment company names that are likely to mislead investors about an investment company's investments and risks. 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 (https://www.handbook.fca.org.uk/handbook/COLL/6/9.html).

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

[19] We would like to thank an anonymous referee for this suggestion.

[20] At extraction time, these variables corresponding to the complete information set, int terms of quantitative metrics, available for ETFs in EIKON Refinitiv

[21] See for example Dixon et al. (2019).

REFERENCES

Agapova, A. (2011). Conventional mutual index funds versus exchange-traded funds. *Journal of Financial Markets*, *14*(2), 323–343.

Albino, V., Balice, A., & Dangelico, R. M. (2009). Environmental strategies and green product development: An overview on sustainability driven companies. *Business Strategy and the Environment*, *18*(2), 83–96. https://doi.org/10.1002/bse.638

Alda, M. (2020). ESG fund scores in UK SRI and conventional pension funds: Are the ESG concerns of the SRI niche affecting the conventional mainstream? *Finance Research Letters*, *36*, 101313.

Anderson, J., & Bausch, C. (2006). Climate change and natural disasters: Scientific evidence of a possible relation between recent natural disasters and climate change. In *Policy department economic and scientific policy* (Vol. 2, pp. 1–30). Institute for European Environmental Policy (IEEP).

Arouri, M., Gomes, M., & Pukthuanthong, K. (2019). Corporate social responsibility and M&a uncertainty. *Journal of Corporate Finance*, *56*, 176–198.

Ben-Rephael, A., Kandel, S., & Wohl, A. (2012). Measuring investor sentiment with mutual fund flows. *Journal of Financial Economics*, *104*(2), 363–382.

Berg, G., & Schrader, J. (2012). Access to credit, natural disasters, and relationship lending. *Journal of Financial Intermediation*, *21*(4), 549–568.

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics*, *134*, 253–272.

Bilbao-Terol, A., Álvarez-Otero, S., Bilbao-Terol, C., & Cañal-Fernández, V. (2017). Hedonic evaluation of the SRI label of mutual funds using matching methodology. *International Review of Financial Analysis*, *52*, 213–227.

Bogle, J. C. (2016). The index mutual fund: 40 years of growth, change, and challenge. *Financial Analysts Journal*, *72*(1), 9–13.

Bourdeau-Brien, M., & Kryzanowski, L. (2017). The impact of natural disasters on the stock returns and volatilities of local firms. *The Quarterly Review of Economics and Finance*, *63*, 259–270.

Carhart, M. (1997). On persistence in mutual fund performance. *The Journal of Finance*, *52*(1), 57–82.

Ceccarelli, M., Ramelli, S., & Wagner, A. F. (2019). *When investors call for climate responsibility, how do mutual funds respond?* (Research Paper Series, 19–13). Swiss Finance Institute.

Cortés, K. R., & Strahan, P. E. (2017). Tracing out capital flows: How financially integrated banks respond to natural disasters. *Journal of Financial Economics*, *125*, 182–199.

Cragg, J. G., & Donald, S. G. (1993). Testing identifiability and specification in instrumental variable models. *Econometric Theory*, *9*, 222–240.

Crane, A. D., & Crotty, K. (2018). Passive versus active fund performance: Do index funds have skill? *Journal of Financial and Quantitative Analysis*, *53*(1), 33–64.

Da, Z., Engelberg, J., & Gao, P. (2015). The sum of all FEARS investor sentiment and asset prices. *The Review of Financial Studies*, *28*(1), 1–32.

DeVault, L., Sias, R., & Starks, L. (2019). Sentiment metrics and investor demand. *The Journal of Finance*, *74*(2), 985–1024.

Dimson, E., Marsh, P., & Staunton, M. (2020). Divergent ESG ratings. *The Journal of Portfolio Management*, *47*(1), 75–87.

Dixon, G., Bullock, O., & Adams, D. (2019). Unintended effects of emphasizing the role of climate change in recent natural disasters. *Environmental Communication*, *13*(2), 135–143.

Escrig-Olmedo, E., Fernández-Izquierdo, M. Á., Ferrero-Ferrero, I., Rivera-Lirio, J. M., & Muñoz-Torres, M. J. (2019). Rating the raters: Evaluating how ESG rating agencies integrate sustainability principles. *Sustainability*, *11*(3), 915.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics*, *33*(1), 3–56.

Fang, J., Lau, C. K. M., Lu, Z., Wu, W., & Zhu, L. (2019). Natural disasters, climate change, and their impact on inclusive wealth in G20 countries. *Environmental Science and Pollution Research*, *26*(2), 1455–1463.

Ferrell, A., Liang, H., & Renneboog, L. (2016). Socially responsible firms. *Journal of Financial Economics*, *122*(3), 585–606.

Griffin, J. M., Harris, J. H., Shu, T., & Topaloglu, S. (2011). Who drove and burst the tech bubble? *The Journal of Finance*, *66*(4), 1251–1290.

Guiso, L., Sapienza, P., & Zingales, L. (2018). Time varying risk aversion. *Journal of Financial Economics*, *128*(3), 403–421.

Hameed, A., & Xie, J. (2019). Preference for dividends and return comovement. *Journal of Financial Economics*, *132*(1), 103–125.

Hartzmark, S. M., & Sussman, A. B. (2019). Do investors value sustainability? A natural experiment examining ranking and fund flows. *The Journal of Finance*, *74*(5), 2153–2199.

Islam, M. A. (2021). Investor sentiment in the equity market and investments in corporate-bond funds. *International Review of Financial Analysis*, *78*, 101898.

Jensen, M. C. (1968). The performance of mutual funds in the period 1945–1964. *The Journal of Finance*, *23*(2), 389–416.

Juravle, C., & Lewis, A. (2008). Identifying impediments to SRI in Europe: A review of the practitioner and academic literature. *Business Ethics: A European Review*, *17*(3), 285–310. https://doi.org/10.1111/j.1467-8608.2008.00536.x

Kappou, K., & Oikonomou, I. (2016). Is there a gold social seal? The financial effects of additions to and deletions from social stock indices. *Journal of Business Ethics*, *133*(3), 533–552. https://doi.org/10.1007/s10551-014-2409-z

Koetter, M., Noth, F., & Rehbein, O. (2020). Borrowers under water! Rare disasters, regional banks, and recovery lending. *Journal of Financial Intermediation*, *43*, 100811.

Krüger, P. (2015). Corporate goodness and shareholder wealth. *Journal of Financial Economics*, *115*(2), 304–329.

Lanfear, M. G., Lioui, A., & Siebert, M. G. (2019). Market anomalies and disaster risk: Evidence from extreme weather events. *Journal of Financial Markets*, *46*, 100477.

Marti-Ballester, C. P. (2019). The role of mutual funds in the sustainable energy sector. *Business Strategy and the Environment*, *28*(6), 1107–1120.

Matallín-Sáez, J. C., Soler-Domínguez, A., Tortosa-Ausina, E., & de Mingo-López, D. V. (2019). Ethical strategy focus and mutual fund management: Performance and persistence. *Journal of Cleaner Production*, *213*, 618–633.

Nofsinger, J. R., Sulaeman, J., & Varma, A. (2019). Institutional investors and corporate social responsibility. *Journal of Corporate Finance*, *58*, 700–725.

Oestreich, A. M., & Tsiakas, I. (2015). Carbon emissions and stock returns: Evidence from the EU emissions trading scheme. *Journal of Banking & Finance*, *58*, 294–308.

Painter, M. (2020). An inconvenient cost: The effects of climate change on municipal bonds. *Journal of Financial Economics*, *135*, 468–482.

Peifer, J. L. (2014). Fund loyalty among socially responsible investors: The importance of the economic and ethical domains. *Journal of Business Ethics*, *121*(4), 635–649. https://doi.org/10.1007/s10551-013-1746-7

Pérez-González, F., & Yun, H. (2013). Risk management and firm value: Evidence from weather derivatives. *The Journal of Finance*, *68*(5), 2143–2176.

Purnanandam, A., & Weagley, D. (2016). Can markets discipline government agencies? Evidence from the weather derivatives market. *The Journal of Finance*, *71*(1), 303–334.

Renneboog, L., Ter Horst, J., & Zhang, C. (2008). The price of ethics and stakeholder governance: The performance of socially responsible mutual funds. *Journal of Corporate Finance*, *14*(3), 302–322.

Renneboog, L., Ter Horst, J., & Zhang, C. (2011). Is ethical money financially smart? Nonfinancial attributes and money flows of socially responsible investment funds. *Journal of Financial Intermediation*, *20*(4), 562–588.

Riedl, A., & Smeets, P. (2017). Why do investors hold socially responsible mutual funds? *The Journal of Finance*, *72*(6), 2505–2550.

Sargan, J. D. (1958). The estimation of economic relationships using instrumental variables. *Econometrica: Journal of the Econometric Society*, *26*, 393–415.

Sherrill, D. E., Shirley, S. E., & Stark, J. R. (2017). Actively managed mutual funds holding passive investments: What do ETF positions tell us about mutual fund ability? *Journal of Banking & Finance*, *76*, 48–64.

Soler-Domínguez, A., Matallín-Sáez, J. C., de Mingo-López, D. V., & Tortosa-Ausina, E. (2021). Looking for sustainable development: Socially responsible mutual funds and the low-carbon economy. *Business Strategy and the Environment*, *30*(4), 1751–1766.

Statman, M. (2006). Socially responsible indexes. *Journal of Portfolio Management*, *32*(3), 100–109.

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, *61*, 101427.

Trück, S., & Weron, R. (2016). Convenience yields and risk premiums in the EU-ETS—Evidence from the Kyoto commitment period. *Journal of Futures Markets*, *36*(6), 587–611.

Van Aalst, M. K. (2006). The impacts of climate change on the risk of natural disasters. *Disasters*, *30*(1), 5–18.

Van Duuren, E., Plantinga, A., & Scholtens, B. (2016). ESG integration and the investment management process: Fundamental investing reinvented. *Journal of Business Ethics*, *138*(3), 525–533.

Venagopal, A., & Shukla, D. (2019). Identifying consumers' engagement with renewable energy. *Business Strategy and the Environment*, *28*(1), 53–63. https://doi.org/10.1002/bse.2185

Widyawati, L. (2020). A systematic literature review of socially responsible investment and environmental social governance metrics. *Business Strategy and the Environment*, *29*(2), 619–637.

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*, *98*, 39–60.

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