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Imane El Ouadghiri, Khaled Guesmi, Jonathan Peillex and Andreas Ziegler

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Coordination: Bernd Hayo • Philipps-University Marburg
School of Business and Economics • Universitätsstraße 24, D-35032 Marburg
Tel: +49-6421-2823091, Fax: +49-6421-2823088, e-mail: hayo@wiwi.uni-marburg.de

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Imane El Ouadghiri
Pôle Universitaire Léonard de Vinci, Research Center
20 avenue Léonard de Vinci, 92400 Courbevoie, France
E-Mail: imane.el_ouadghiri@devinci.fr

Khaled Guesmi
Paris School of Business (PSB)
59 rue National, 75013 Paris, France
E-Mail: k.guesmi@psbedu.paris

Jonathan Peillex
Pôle Universitaire Léonard de Vinci, Research Center
20 avenue Léonard de Vinci, 92400 Courbevoie, France
E-Mail: jonathan.peillex@devinci.fr

Andreas Ziegler
University of Kassel, Institute of Economics
Nora-Platiel-Str. 5, 34109 Kassel, Germany
E-Mail: andreas.ziegler@uni-kassel.de
Phone: +49/561/804-3038, Fax: +49/561/804-2501

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Abstract

This paper empirically examines the effect of public attention to climate change and pollution on the weekly returns on US sustainability stock indices (i.e. the DJSI US and the FTSE4Good USA Index) in comparison to their conventional counterparts (i.e. the S&P 500 Index and the FTSE USA). In addition to unexpected global climate-related natural weather disasters, we consider two complementary measures of public attention to these environmental issues: (i) US media attention to climate change and pollution and (ii) the US Google Search Volume Index for these two keywords. Robust to several sensitivity analyses, our econometric analysis for the period from 2004 to 2018 reveals that public attention to environmental issues has a significantly positive (negative) effect on the returns on US sustainability (conventional) stock indices. A possible explanation of this result is that high public attention to environmental issues may drive traditionally sustainable investors, neo-sustainable, and opportunistic self-interested investors to favor stocks of sustainable firms. The insights from our empirical study are important for private and institutional investors, managers of firms, and public policy.

Keywords: Public attention, environmental issues, stock returns, sustainability stock indices, asset pricing models

JEL: Q51, G14, Q53, Q54

1. Introduction

Environmental pollution is considered as crucial societal challenge in most parts of the world. With respect to climate change, for example, several cross country studies report strong individual concerns (e.g., Tjernström and Tietenberg, 2008; Carlsson et al., 2012; Dienes, 2015; Ziegler, 2017). While these studies reveal that US residents belong to the least concerned citizens worldwide, even in this country a large majority is worried (see also Survey AXA/IPSOS, 2012). Therefore, dealing with this global challenge and also generally protecting the environment are considered as top priorities for the president and Congress with the strongest increase between 2011 and 2019 (e.g., Pew Research Center, 2019). In addition, many US citizens are not only concerned about environmental pollution including climate change, but are also voluntarily pro-environmentally active. For example, they tend to buy energy-efficient appliances, reduce the consumption of meat products, or use energy from renewable sources (e.g., Lange et al., 2017; Schwirplies, 2018). Another increasingly popular direction of voluntary pro-environmental activities refers to financial investments. The market for sustainable or socially responsible investments (SRI) (i.e. investments applying ecological, social, and ethical criteria to select sustainable firms) has particularly grown dynamically during the last years (e.g., Mollet and Ziegler, 2014; Peillex and Ureche-Rangau, 2016). For example, US SIF (2018) reports that US-domiciled assets under management using SRI strategies increased by 38% between 2016 and 2018, which reveals the rising popularity of SRI among private and institutional investors.

Due to the similar temporal development of concern about environmental issues and of SRI (or other voluntary pro-environmental activities), it can be hypothesized that public attention to climate change and pollution may have an effect on the financial performance of green firms. This paper empirically examines this relationship for the more general case of sustainability stock indices, which comprise environmentally as well as socially and ethically responsible firms. It thus complements previous studies in this field such as econometric analyses at the firm level, which examine the effect of corporate sustainable performance on corporate financial performance, measured with accounting data based indicators (e.g., McWilliams and Siegel 2000; King and Lenox, 2002; Telle, 2006; Lioui and Sharma, 2012) or stock returns (e.g., Filbeck and Gorman, 2004; Arx and Ziegler, 2014). The consideration of stock returns is also a main element of portfolio analyses, which compare the risk-adjusted stock returns on sustainable and conventional mutual funds (e.g., Bauer et al., 2005; Muñoz et al., 2014) or focus on specific corporate sustainability performance assessments, such as those by ASSET4 (e.g., Ziegler et al., 2011), Innovest (e.g., Derwall et al., 2005), or KLD Research & Analytics (e.g., Kempf and Osthoff, 2007; Benlemlih et al., 2018).

Some sustainability stock indices are based on the aforementioned assessments by ASSET4 and KLD. Further popular indices are the Dow Jones Sustainability Index (DJSI) family (e.g., Ziegler and Schröder, 2010), which is based on firm assessments by RobecoSAM (formerly SAM group), and the FTSE4Good Index Series (e.g., Ferri et al., 2016), which is based on firm assessments by FTSE Russell. Several previous studies empirically examine the financial performance of firms that are included in these indices. For example, in a panel econometric analysis of European firms, Ziegler (2012) considers the effect of the inclusion in the DJSI World on corporate financial performance. However, most of these studies are based on the event study methodology, which is also common for the analysis of stock market effects of new unexpected sustainability relevant information at the firm level (e.g., Klassen and McLaughlin, 1996; Dasgupta et al., 2001; Capelle-Blancard and Laguna, 2010; Fisher-Vanden and Thorburn, 2011; Carpentier and Suret, 2015). Event studies on sustainability stock indices examine, for example, the stock market reaction to (the announcement of) the inclusion of UK firms in FTSE4Good indices (e.g., Curran and Moran, 2007). Similarly, Cheung (2011) for US firms, Oberndorfer et al. (2013) for German firms, and recently Hawn et al. (2018) for firms from several countries examine the effects of the inclusion in different indices from the DJSI family.

This paper examines the returns on sustainability stock indices instead of returns on single stocks. This is in line with former empirical studies comparing the financial performance of indices from the DJSI family (e.g., Bauer et al., 2005) or the FTSE4Good Series (e.g., Belghitar et al., 2014) with similar conventional stock indices, respectively. However, not only the pure financial performance of such indices is interesting for investors, but also factors that influence their financial performance, for example, new relevant information. In this paper, we analyze information about environmental issues. Besides general air or water pollution (e.g., due to the burning of fossil fuels or due to plastic waste), climate change is certainly the most discussed environmental issue worldwide. According to several assessment reports from the Intergovernmental Panel on Climate Change (IPCC), global warming is unequivocal and human activities are very likely to have contributed to the increase of global temperatures (e.g., IPCC, 2013, summary for policymakers of the Working Group I). As a consequence, the media increasingly report events that are connected with climate change such as natural weather disasters or the annual global climate conferences. This increasing public attention has certainly strongly contributed to the rising individual concern about climate change.

In this context, this paper examines the effect of public attention to climate change and pollution on the returns on the DJSI US and the FTSE4Good USA Index in comparison to their conventional counterparts, i.e. the S&P 500 Index and the FTSE USA Index. The main contribution of our empirical analysis to previous studies is two-fold: First, in contrast to many firm-level studies as discussed above or also to Lei and Shcherbakova (2015) analyzing the effect of the Fukushima nuclear disaster on the financial performance of portfolios of renewable, nuclear, and coal firms and to Kollias and Papadamou (2016) analyzing the effects of natural weather disasters on the returns on a sustainability stock index, we do not only apply the common event study methodology. Such event studies generally consider a short period around the event date and assume that capital markets are sufficiently efficient to react upon unexpected events (i.e. new information) regarding expected future profits of affected firms. However, they mostly do not consider whether and how strongly the new information is penetrated on the capital markets. Exceptions are Fisher-Vanden and Thorburn (2011) or Carpentier and Suret (2015), who additionally analyze the press coverage of climate change or the number of press releases for the events in subsequent cross-sectional econometric analyses of the abnormal returns at the firm level. In contrast, we do not connect public attention with the abnormal returns of specific events, but directly consider the penetration of information about environmental issues on the capital market and examine the corresponding effects on the returns on sustainability stock indices.

Second, our paper contributes to previous studies about public attention. One direction of these studies refers to media attention such as press releases or articles in newspapers, which is often considered in event studies for the identification of exact environmentally related dates (e.g., Fisher-Vanden and Thorburn, 2011; Carpentier and Suret, 2015). Media attention is additionally considered in other econometric analyses of stock returns (e.g., Fang and Peress, 2009, using the LexisNexis database) or specifically returns on initial public offering (IPO) stocks (e.g., Da et al., 2011, using the Factiva database). Another popular direction of these studies refers to the Google Search Volume Index (GSVI) (e.g., Ben-Raphael et al., 2017), which considers the extent of using the Google search engine for specific keywords. It is, for example, analyzed with respect to returns on IPO stocks (e.g., Da et al., 2011), corporate earnings announcements (e.g., Drake et al., 2012), stock market volatility (e.g., Vlastakis and Markellos, 2012), the financial performance of security indices in several broad investment categories (e.g., Vozlyublennaia, 2014), oil prices (e.g., Han et al., 2017), or energy price volatility (e.g., Afkhami et al., 2017). Recently, El Ouadghiri and Peillex (2018) examine the effect of both media attention in four major US newspapers and the GSVI for Islamic terrorism on the returns on US Islamic stock indices. To the best of our knowledge, however, media attention or the GSVI were not used in terms of environmental issues and their effects on the returns on sustainability stock indices so far.

As aforementioned, Kollias and Papadamou (2016) examine how the financial performance of a sustainability stock index (i.e. the STOXX Global ESG Environmental Leaders Index) reacts to major natural weather disasters (i.e. extreme temperatures, storms, floods, and wildfires). They argue that these natural events can intensify media and other public environmental attention such as for climate change. This increasing attention can motivate investors to allocate their capital towards SRI and thus also to firms in sustainable stock indices so that their returns would increase. However, their empirical analysis reveals that these events have no significant effects on the returns on the sustainability index. A possible explanation for this result is the use of the event study methodology and thus an only indirect proxy for attention to environmental issues, i.e. their study is based on the strong assumption that a natural weather disaster contributes to public environmental attention. Therefore, we extend the empirical analysis of Kollias and Papadamou (2016) by examining the direct effects of (the strength of) media attention and the GSVI in terms of environmental issues on the returns on sustainability and conventional stock indices.

We argue that public attention to climate change and pollution has positive effects on the returns on sustainability indices for several reasons. First, sustainable investors who take into account the sustainable performance of firms (e.g., Riedl and Smeets, 2017; Gutsche et al., 2019; Gutsche and Ziegler, 2019) might accelerate the process of buying stocks of green and thus sustainable firms to reward them and to divest stocks of conventional firms to punish them if their awareness to environmental issues increases. Second, an increase of public environmental attention might grow the environmental awareness and preferences of some more traditional investors and convince them to also become sustainable investors. These growing environmental preferences might be influenced by the view that traditional investments are riskier in phases of high public environmental attention. Third, by anticipating an excess demand for stocks of green and thus sustainable firms and a reduction of the demand for stocks of conventional firms when public attention to environmental issues is particularly strong, the investors without any awareness and preferences for sustainability could engage in opportunistic and self-interested profit-seeking strategies (e.g., Derwall et al., 2011). These investors might temporarily find it beneficial to invest in stocks of sustainable firms, which might become overpriced, or divest stocks of conventional firms, which might become underpriced. In sum, an increase of public attention to environmental issues can drive traditionally sustainable, neo-sustainable, and opportunistic investors to favor stocks of sustainable firms so that the returns on corresponding sustainable stock indices should increase.

Our econometric analysis of weekly returns on the DJSI US and the FTSE4Good USA Index in comparison to the S&P 500 Index and the FTSE USA Index for the period from 2004 to

2018 is mainly based on an extended four-factor model according to Carhart (1997) that includes a GARCH process. As indicator for media attention, we consider the weekly number of articles about climate change and pollution that are released in four major US newspapers. As a complementary indicator for public attention, we consider the weekly GSVI, which refers to the extent of using the Google search engine for the two keywords “climate change” and “pollution” in the USA. While some investors do not actively search information on climate change and pollution on Google, other investors do not necessarily read corresponding newspaper articles. Therefore, it is useful to jointly analyze both types of public attention. In line with the empirical analysis of Kollias and Papadamou (2016), we additionally examine the effects of global natural weather disasters (i.e. extreme temperatures, storms, droughts, floods, and wildfires) that are connected with climate change. The only inclusion of the corresponding event dates then leads to a common event study.

Our econometric analysis including several robustness checks reveals that the global climate-related natural weather disasters have a significantly positive effect on the returns on sustainability stock indices and a significantly negative effect on the returns on conventional stock indices. Furthermore, in line with our expectations, both indicators for public attention to climate change and pollution also have significant effects in the same directions. These results suggest that not only firm-specific or general new information on environmental issues, as considered in previous event studies, can have strong stock market effects, but also general public attention to environmental issues that need not necessarily be connected with unexpected events. The results especially support the view that investors develop preferences for sustainable stocks when their awareness to environmental issues increases. In addition, the results are in line with the view of sustainable investments by opportunistic investors as discussed above. However, the insights of our empirical study are not only relevant for private and institutional investors, but also for managers of firms and public policy. While firms can recognize that high public environmental attention is able to create shareholder wealth in the short run, a possible “weak” policy approach towards sustainable development could be the reinforcement of public attention to environmental issues to complement alternative policy instruments such as taxes, subsidies, or regulations in order to correct for market failures due to negative (e.g., environmental) external effects.

The remainder of this paper is organized as follows. The methodology and the data are described in Section 2. The empirical results are presented and discussed in Section 3. Section 4 concludes the paper.

2. Methodological approach, variables, and data

2.1. Methodological approach

The dependent variables in our econometric analysis refer to the weekly returns on four stock indices, i.e. two sustainability and two conventional stock indices. Our main explanatory variables refer to public attention to climate change and pollution in addition to global climate-related natural weather disasters. However, it is also important to base the explanation of stock returns over time on asset pricing models. In line with previous studies such as portfolio analyses (e.g., Derwall et al., 2005; Ziegler et al., 2011; Benlemlih et al., 2018), we use the four-factor model according to Carhart (1997). Following, for example, Oberndorfer et al. (2013), Kollias and Papadamou (2016), or El Ouadghiri and Peillex (2018), we additionally extend this common multifactor model by the inclusion of a GARCH process. These processes allow for a varying conditional variance in the weekly stock returns, which is very common on the stock market. We specifically consider a GARCH-M (i.e. GARCH in mean) model (e.g., Elyasiani and Mansur, 1998). The specific four-factor model with a GARCH(1,1)-M process can therefore be formulated as follows ($i = 1,\ldots, N$; $t = 1,\ldots, T$)

Return equation:

$$R_{it} = \alpha_i + \beta_{i1} Disasters_t + \beta_{i2} \ln(1 + MA_t) + \beta_{i3} \ln(1 + GSVI_t) + \beta_{i4} RM_t + \beta_{i5} SMB_t + \beta_{i6} HML_t + \beta_{i7} MOM_t + \beta_{i8}' Years_t + \beta_{i9} \sqrt{h_{it}} + \eta_{it}$$

Variance equation:

$$h_{it} = \gamma_{i0} + \gamma_{i1} \eta_{i,t-1}^2 + \gamma_{i2} h_{i,t-1}$$

In these models R_{it} is the weekly return on stock index *i* in week *t*. $Disasters_t$ denotes a dummy variable that takes the value one if a climate-related natural weather disaster has taken place in *t*. While MA_t is media attention for either climate change (MA_CC_t) or pollution (MA_POL_t), $GSVI_t$ is the GSVI for either climate change ($GSVI\_CC_t$) or pollution ($GSVI\_POL_t$) in week *t*, respectively. In our econometric analysis, we use $\ln(1+MA_t)$ and $\ln(1+GSVI_t)$, i.e. the natural logarithm of one plus the values MA_t and $GSVI_t$, as it is common in previous studies (e.g., Hillert et al., 2014; Aouadi et al., 2018). RM_t, SMB_t, HML_t, and MOM_t are the four risk factors according to Carhart (1997) in week *t*. While RM_t is the return on a US market portfolio, SMB_t ("Small minus Big") is the size factor (i.e. the difference between the returns on portfolios comprising stocks of "small" firms and portfolios comprising stocks of "big" firms), HML_t ("High minus Low") is the value factor (i.e. the difference between returns on portfolios comprising stocks of firms with a "high" book-to-market equity ratio and portfolios comprising stocks of firms with a "low" book-to-market equity ratio), and MOM_t is the momentum factor (i.e. the difference between the returns on portfolios comprising stocks of recent "winners" and portfolios comprising stocks of recent "losers"). In order to control for time effects, the (column) vector $Years_t$ comprises 14 dummy variables for the years from 2004 to 2017 that take the value one if week t belongs to the corresponding year (the year 2018 is used as base year).

The final components refer to the GARCH(1,1)-M process. The conditional variance h_{it} of η_{it} is a function of the squared value $\eta^2_{i,t-1}$ of the lagged error term in week t-1 reflecting the ARCH factor and of the lagged conditional variance $h_{i,t-1}$ reflecting the GARCH character of the model. Since Jarque-Bera tests reveal that the hypothesis of normally distributed returns can be rejected at very low significance levels for all four stock indices, the error term η_{it} is assumed to be t-distributed with v degrees of freedom, whereby v is estimated. This is in contrast to Kollias and Papadamou (2016), who assume normally distributed error terms. The constant α_i, the beta parameters $\beta_{i1}, \ldots, \beta_{i7}$ and β_{i9} as well as the beta parameters in the (column) vector β_{i8} belong to the return equation, whereby β_{i9} specifies the trade-off parameter, which expresses the relationship between the risk and the expected returns on the four stock indices. In contrast, the constant γ_{i0} as well as the gamma parameters γ_{i1} of the squared and lagged error term and γ_{i2} of the lagged conditional variance belong to the variance equation. The sum of γ_{i1} and γ_{i2} represents the volatility persistence that should be between zero and one. All parameters were estimated by the maximum likelihood method (ML).

2.2. Dependent variables

As discussed above, the dependent variables refer to the weekly returns on the DJSI US, the FTSE4Good USA Index, and their conventional counterparts, i.e. the S&P 500 Index and the FTSE USA Index (therefore, N = 4). The DJSI US and the FTSE4Good USA Index are two indices which comprise the leading US firms in terms of sustainability performance including environmental and social performance. The overall sustainability performance of every single firm is assessed from a set of indicators provided by RobecoSAM for the DJSI and FTSE Russell for the FTSE4Good. The underlying weekly stock prices for these two sustainability stock indices and their conventional counterparts are collected from the Bloomberg terminal for the period from January 9, 2004, which is the launch year of Google Trends as the basis for the GSVI, to June 29, 2018 (so that T = 756). We consider continuous returns R_{it} = $\ln(P_{it}/P_{i,t-1})$, measured in %, whereby P_{it} is the closing price or value of stock index i in week t which is denominated in US dollars.

Launched in 1999, the DJSI family is jointly created by S&P Dow Jones Indices and RobecoSAM. S&P Dow Jones Indices is the largest global resource for index-based concepts, data, and research as well as home to financial market indicators such as the S&P 500 Index.

RobecoSAM (a sister company of the Dutch investment management firm Robeco) is an investment specialist that focuses on sustainability investing. The DJSI family tracks the financial performance of firms that are sector leaders in terms of sustainability performance. The inclusion in a sustainability stock index is based on corporate sustainability assessments by RobecoSAM, whereby the information on environmental, social, and economic performance (including issues such as corporate governance, risk management, climate change mitigation, supply chain standards, labor practices) stems from an annual survey as well as from firm documentation, media and stakeholder analyses (e.g., media coverage, stakeholder commentaries, or other publicly available sources), and personal contacts with the firms. The assessment process follows the so-called best-in-class approach identifying sustainability leaders within a sector. The DJSI family contains one main global index, i.e. the DJSI World, and several indices based on geographic regions. We consider the DJSI US that comprises all US stocks which are members of the DJSI North America. The latter index comprises the 20% most sustainable firms among the largest 600 North American firms in the S&P Global Broad Market Index.

Launched in 2001, the FTSE4Good Index Series is generated by the FTSE Group (i.e. FTSE International Limited trading as FTSE Russell), which is a British provider of stock market indices and associated data services. The indices are based on assessments of environmental, social, and governance (ESG) practices of firms in FTSE indices such as the FTSE Developed Europe Index or the FTSE USA Index. These assessments are exclusively based on publicly available data, i.e. data or information privately provided by firms are not used. The ratings for the three ESG pillars refer to overall 300 single indicators across 14 themes (e.g. climate change, corporate governance, or human rights). For each firm, this leads to an aggregated ESG rating between zero and five. For the inclusion in the FTSE4Good Index Series in a developed market, a firm must have a rating of at least of 3.1. However, this requirement is only a necessary condition, i.e. several groups of firms are generally excluded from the indices such as firms from the tobacco, weapons, and coal sectors. All firms that pass these eligibility criteria are potential members of the appropriate FTSE4Good Index. Among all these US firms, the FTSE4Good USA Index finally consists of the largest 100 firms with the highest market values.

Figure 1 shows the distribution of P_{it} (i = 1,…, 4), i.e. the weekly index values for all four stock indices, in the observation period from January 2004 to June 2018. The figure reveals a very similar course of the curves and a strong influence of the global financial crisis in 2008 for all four stock indices. In addition, the first four lines in Table 1 report some descriptive statistics for their returns. The table shows rather small deviations between the two sustainability and conventional stock indices in terms of means and standard deviations.[1] In particular, the values for the FTSE4Good USA Index are extremely similar to the values for the two conventional stock indices. These results are in line with Belghitar et al. (2014), who also report only slight differences between the FTSE4Good USA Index and its conventional counterpart between 2001 and 2010 in terms of the mean-variance profile. While the DJSI US is slightly less volatile, it also has lower average returns than the S&P 500 Index and the two FTSE indices. This result is in line with Statman (2006), who shows that the S&P 500 Index has a higher performance than the DJSI US in terms of the Sharpe ratio and Jensen's alpha between 1999 and 2004.[2]

2.3. Explanatory variables

This paper examines the effect of public attention to the most relevant environmental issues. The identification of these issues in the USA is based on two steps. First, we built an extensive list of 22 keywords for environmental issues[3] from four main sources (i.e. surveys published by Gallup on the US public opinion to environment issues, United Nations websites devoted to the environment, the official Wikipedia page dedicated to environmental issues, and specific blogs on ecology such as Conserve Energy Future and Help Save Nature). Second, on the basis of the LexisNexis database of articles and press releases (e.g., Miles and Morse, 2007; Fisher-Vanden and Thorburn, 2011), we examined the media coverage of these 22 keywords in four US newspapers (i.e. The New York Times, The Wall Street Journal, The Washington Post, and USA Today) with a broad circulation and influence in investors and national culture spheres (e.g., Fang and Peress, 2009). Specifically, we measure media coverage by the number of articles related to each keyword and thus environmental issue. Table 2 shows that "climate change" has by far the highest media coverage, especially if taking into account that the keyword "global change", which is often used as a synonym for climate change, has the third largest coverage. Furthermore, Table 2 reveals that the number of articles for "pollution" is second highest. Therefore, we consider these two environmental issues in our empirical analysis.

[1] This also leads to very similar Sharpe ratios.

[2] Further calculations additionally show that the returns on the four stock indices are leptokurtic and skewed to the left so that the hypothesis of normally distributed returns can be rejected at very low significance levels as discussed above. This result seems to be rather common when weekly returns on stock indices are considered for a period that contains the global financial crisis of 2008 (e.g., El Ouadghiri and Peillex, 2018). In addition, an ARCH test suggests the presence of an ARCH effect, which supports our use of GARCH models. The corresponding results are not reported due to brevity, but are available upon request.

[3] Acid rain, climate change, CO_2 emissions, climate disasters, consumerism, deforestation, desertification, ecological disasters, ecosystem destruction, endangered species, global warming, intensive farming, loss of biodiversity, natural disasters, overpopulation, ozone depletion, pollution, resource depletion, resource scarcity, species extinction, urban sprawl, waste disposal.

Media attention, as our first indicator for public attention, is simply characterized by the weekly number of articles that refer to climate change and pollution in these four US newspapers, respectively. As explained above, we use logarithmized values instead of the raw numbers in the empirical analysis. As second indicator, we consider the scaled frequency of search queries in Google, which is by far the most popular search engine worldwide and also in the USA and thus extremely attractive for our analysis (e.g., Han et al., 2017). The corresponding GSVI is provided by Google Trends. Launched in 2004, this website provides the search volume index for any keyword in any region for each week within any interval over time (e.g., Da et al., 2011; Vozlyublennaia, 2014; Afkhami et al., 2017). However, the GSVI does not provide absolute frequencies of search queries for a keyword, but normalized (and thus relative) values between 0 and 100, whereby 100 is assigned to the date within the considered time interval when the number of searches for that keyword is maximal and zero when the number of searches is below a certain threshold. As discussed above, we consider the two keywords "climate change" and "pollution" for the GSVI in the USA, whereby we again consider the natural logarithms of one plus the raw numbers in the empirical analysis.

Table 1 reports some descriptive statistics of the raw and logarithmized values for the number of articles and the GSVI for climate change and pollution, respectively. In line with Table 2, it reveals that average media attention for climate change is strongly higher than for pollution. In contrast, the mean values for the GSVI are more similar and the mean of GSVI_POL is even higher than the mean of GSVI_CC, which results from the scaling of the frequency of search queries in Google. Figure 2 reports the distribution of the two indicators for public attention to climate change over time. The values for MA_CC have a clearly growing trend, which is due to the increasing relevance of climate change over time. In contrast, the volatility of GSVI_CC is very similar throughout the whole observation period from 2004 to 2018 without a clear trend, which is again due to the scaling of the underlying values. Interestingly, many annual UN climate conferences of the United Nations Framework Convention on Climate Change (UNFCCC) are connected with peaks of the two indicators over time, which underlines the appropriateness of MA_CC and GSVI_CC as indicators for public attention to climate change.

We do not only examine these indicators for public attention to climate change as the most relevant environmental issue, but also (unexpected) natural disasters as they are also analyzed in previous studies. Specifically, we consider global climate-related natural weather disasters. In line with, for example, Pérez-Maqueo et al. (2007) and Kollias and Papadamou (2016), the corresponding data were collected from the Emergency Events Database (EM-DAT), which is provided by the Center for Research on the Epidemiology of Disasters (CRED). EM-DAT was created with the initial support of the World Health Organisation (WHO) and the Belgian government. On the basis of different sources such as UN agencies, NGO, insurance companies, research institutes, and press agencies, the database contains information of over 22,000 natural and technological disasters around the world since 1900. We specifically consider the most important climate-related natural weather disasters in terms of victims (i.e. the number of killed plus the number of additionally affected persons) in the USA and in each single continent. Table 3 reports the 30 disasters that are included in our empirical analysis. It shows that the number of totally affected persons strongly varies across the disasters, for example, between 188 and 831,852 in the USA. Furthermore, the table reveals that the number of victims is higher for some disasters in Africa and especially Asia. However, the number of victims is not necessarily strictly correlated with public attention so that we do not weight them, i.e. we only analyze whether at least one of these climate-related natural weather disasters has taken place in week *t* or not, as explained above. Table 1 reveals that in 28.8% of all T = 756 weeks such disasters took place.

Besides the time dummy variables, we finally include the factors of the four-factor model according to Carhart (1997) as control variables (measured in %) in order to combine our GARCH(1,1)-M process with an asset pricing model. The used weekly values of the market factor RM, the size factor SMB, the value factor HML, and the momentum factor MOM are drawn from the Kenneth R. French data library, respectively. A summary of the definition of all explanatory variables can be found in Table 4.

3. Estimation results

3.1. Main results

While Table 5 reports the ML estimation results in four-factor models with a GARCH(1,1)-M process for the analysis of weekly stock returns on the DJSI US and the S&P 500 Index, Table 6 reports the corresponding estimation results for the stock returns on the FTSE4Good USA Index and the FTSE USA Index. The estimation results for the four stock indices in both tables are based on the same structure of four different model specifications. Mimicking a pure event study, Model 1 only includes the dummy variable for the unexpected global climate-related natural weather disasters besides the financial control variables according to Carhart (1997), the year dummy variables, and the GARCH factors. In contrast, Model 2 only includes media attention to climate change and Model 3 only includes the GSVI for climate change as main explanatory variables. Finally, Model 4 includes both indicators for public attention to climate change in addition to the dummy variable for the disasters as main explanatory variables, respectively. The estimation results in Tables 7 and 8 are based on the same model structures as those in Tables 5 and 6. The only difference is that the models according to Tables 5 and 6 refer to public attention to climate change, whereas the models in Tables 7 and 8 refer to public attention to pollution.

The upper parts of Tables 5-8 report the estimation results from the return equations. As expected and in line with previous studies (e.g., Kollias and Papadamou, 2016; El Ouadghiri and Peillex, 2018), the tables reveal that the inclusion of the risk factors is highly relevant since most parameters are strongly significantly different from zero. While the parameter estimates for RM are often slightly lower than one, the parameter estimates for SMB, HML, and MOM are mostly negative. The tables additionally reveal the relevance of including the GARCH process. In line with, for example, Elyasiani and Mansur (1998), the estimated parameters for the conditional standard deviation of the error term are always positive and significantly different from zero, mostly at the 1% significance level. This result implies that an increase in the volatility of the weekly returns on all four stock indices tends to increase their expected returns. According to the lower parts of the four tables, which report the estimation results from the variance equations, the estimated parameters of $\eta^2_{i,t\text{-}1}$ and $h_{i,t\text{-}1}$ are always positive and mostly significantly different from zero. This supports the assumption of time varying volatility for the weekly returns on all four stock indices.

As discussed above, Model 1 refers to a pure event study about the effect of the unexpected global climate-related natural weather disasters according to Table 3, respectively.[4] Tables 5-8 report significantly positive effects of the disasters on the weekly returns on both sustainability stock indices, i.e. the DJSI US and the FTSE4Good USA Index, as well as significantly negative effects on the returns on both conventional stock indices, i.e. the S&P 500 Index and the FTSE USA Index. These results are in contrast to Kollias and Papadamou (2016), who report insignificant effects, but in line with previous event studies on other environmental disasters. For example, Klassen and McLaughlin (1996) report negative abnormal returns for firms that are affected by environmental crises (e.g., oil spills or gas leaks), Capelle-Blancard and Laguna (2010) reveal negative abnormal returns for firms that are affected by chemical disasters, and Carpentier and Suret (2015) report negative abnormal returns for firms that are affected by environmental accidents. While the effects of the climate-related natural weather disasters are statistically highly significant, the economic significance is moderate. Tables 5 and 7 suggest an estimated positive abnormal return of 0.043% for the DJSI US, while Tables 6 and 8 suggest an estimated positive abnormal return of 0.057% for the FTSE4Good USA

[4] It should be noted that the estimation results for Model 1 in Tables 5 and 7 are identical and that the corresponding results in Tables 6 and 8 are identical since they are based on the same model specifications. The estimation results are reported twice, respectively, in order to directly compare them with the different estimation results in Models 2-4.

Index. The estimated negative abnormal returns for the conventional stock indices are even smaller with 0.023% for the FTSE USA Index and only 0.007% for the S&P 500 Index.

However, the main estimation results refer to the indicators for public attention to climate change and pollution, which are qualitatively very similar to the previously reported effects. For Models 2 and 3, Tables 5 and 6 report significantly positive effects of media attention and the GSVI for climate change on the weekly returns on both sustainability stock indices as well as significantly negative effects on the returns on both conventional stock indices. Similarly, Tables 7 and 8 report significantly positive effects of media attention and the GSVI for pollution on the weekly returns on both sustainability stock indices as well as significantly negative effects on the returns on both conventional stock indices. In addition, Tables 5-8 report that these effects are not only significant if public attention to climate change and to pollution are separately included in the econometric analysis, but also in Model 4 when both indicators together with the dummy variable for the disasters are jointly incorporated. In sum, these results show that not only unexpected new information on environmental issues may have strong stock market effects, as examined in previous event studies, but also public attention to environmental issues (e.g., due to an international climate conference) that is not necessarily related with unexpected events. Furthermore, the results suggest that public attention to environmental issues influences the returns on sustainability and conventional stock indices irrespective of global climate-related natural weather disasters. Similarly, the results suggest that these disasters influence the returns on sustainability and conventional stock indices irrespective of public attention to (other) environmental issues.

3.2. Robustness checks

In order to test the robustness of the previous estimation results, we conducted several additional sensitivity analyses. First of all, we applied alternative asset pricing models, i.e. the three-factor model according to Fama and French (1993) without the momentum factor as well as a one-factor model without the size, value, and momentum factors, both in combination with a GARCH(1,1)-M process. Based on these modified model specifications, the estimation results for our main explanatory variables are qualitatively almost identical to the results in Tables 5-8.[5] Furthermore, we analyzed an alternative approach for media attention. In order to mimic the normalization approach of the GSVI, we additionally considered a relative indicator instead of the absolute number of newspaper articles, i.e. we calculated the relation between the number of newspaper articles about climate change or pollution in one week and the average number of the articles during the previous 52 weeks. In line with the two previous

[5] The estimation results are not reported due to brevity, but are available upon request.

indicators for public attention, we again used the natural logarithm of one plus these relative values. The application of the corresponding modified four-factor models with a GARCH(1,1)-M process leads to qualitatively very similar estimation results, i.e. this alternative indicator of media attention for climate change or pollution also has a significantly positive effect on the returns on both sustainability stock indices and a significantly negative effect on the returns on both conventional stock indices.[6]

In the next step, we summarize the weekly stock returns on the two sustainability and the two conventional stock indices in a pooled linear panel model instead of examining them separately, whereby the N = 4 stock indices are the cross-sectional units. This leads to $N \cdot T$ = 3024 observations in total. The dependent variables refer to the weekly returns on the four stock indices. The main explanatory variables again refer to public attention to climate change and pollution in addition to global climate-related natural weather disasters. However, in order to analyze the effects of public attention to environmental issues on the returns on sustainability or conventional stock indices, not only the pure variables have to be included in the panel approach, but also interaction terms of these variables and the dummy variable SSI that takes the value one if the index is a sustainability stock index, i.e. the DJSI US or the FTSE4Good USA Index. As control variables, the four risk factors according to Carhart (1997) and the time dummy variables are again included. In addition, the panel models also incorporate the dummy variable DJ that takes the value one if the stock index is provided by the Dow Jones Index family, i.e. if it is the DJSI US or the S&P 500 Index. The parameters were estimated by the ordinary least squares (OLS) method.

Table 9 reports the corresponding estimation results. Model 1 refers to a pure event study and thus mimics Model 1 in Tables 5-8. Similarly, the two Models 2 only include media attention to climate change or pollution as main explanatory variable, whereas the two Models 3 only include the GSVI for climate change or pollution as main explanatory variable. Models 2 and 3 in Table 9 thus mimic Models 2 and 3 in Tables 5-8. In line with Tables 5-8, Table 9 reveals similar estimation results for the four risk factors, which strengthens the relevance of including the financial control variables. Furthermore, the results for DJ imply significantly lower returns on both Dow Jones indices than for the FTSE indices. In addition, the table reveals that the returns on the sustainability stock indices are significantly lower in periods of no global climate-related natural weather disasters, no media attention to climate change or pollution, or a hypothetical GSVI value of zero for climate change or pollution. In contrast, all estimated parameters of the interaction terms are significantly positive, which strongly sup-

[6] The estimation results are again not reported due to brevity, but are also available upon request.

ports the previous main estimation results that global climate-related natural weather disasters and especially public attention to environmental issues have significantly positive effects on the weekly returns on both sustainability stock indices, i.e. the DJSI US and the FTSE4Good USA Index.

In the final robustness check, we do not consider the raw weekly stock returns on the two sustainability and the two conventional stock indices as dependent variables, but the differences in the weekly returns between the sustainability stock indices and their conventional counterparts, i.e. between the DJSI US and the S&P 500 Index as well as between the FTSE4Good USA Index the FTSE USA Index. Similar to the previous panel approach, we summarize the differences in the weekly returns, which leads to overall 1512 observations in this pooled linear panel model. The structure of the models according to Table 10 is similar to the previous model structures, i.e. Model 1 as well as the two Models 2 and 3 mimic Models 1, 2, and 3 in Tables 5-9. The estimated parameters for Disasters, ln(1+MA), and ln(1+GSVI) are significantly positive and thus again confirm the previous main estimation results for global climate-related natural weather disasters and especially public attention to climate change and pollution.

4. Conclusions

This paper examines the effect of public attention to environmental issues, measured by climate change and pollution, on the returns on US sustainability stock indices (i.e. the DJSI US and the FTSE4Good USA Index) in comparison to their conventional counterparts (i.e. the S&P 500 Index and the FTSE USA) for the period from 2004 to 2018. As indicator for public attention, we consider two approaches, i.e. media attention and the GSVI. Therefore, our empirical analysis is not only based on the common event study methodology that mostly considers the short-term effect of unexpected events and thus new information, for example, about environmental issues on stock returns. Nevertheless, our econometric analysis on the basis of an extended four-factor model according to Carhart (1997) that includes a GARCH(1,1)-M process also reveals that unexpected global climate-related natural weather disasters have significantly positive effects on the weekly returns on both sustainability stock indices and significantly negative effects on the returns on both conventional stock indices. However, our main estimation results refer to public attention to climate change and pollution and reveal that also these indicators have significantly positive effects on the weekly returns on the DJSI US and the FTSE4Good USA Index and significantly negative effects on the returns on the S&P 500 Index and the FTSE USA. These results are strongly confirmed in several robustness checks with different methodological approaches and indicators for public attention to environmental issues.

In sum, these results suggest that not only unexpected new information on environmental issues, as considered in previous event studies, may have strong stock market effects, but also public attention to environmental issues (e.g., due to an international climate conference) that is not necessarily related with unexpected events. The results especially support the view that investors develop preferences for sustainable stocks when their awareness to environmental issues increases. This development of preferences can be activated by traditionally sustainable investors who might accelerate the process of buying stocks of sustainable firms and to divest stocks of conventional firms when their awareness to environmental issues increases. In addition, the development of preferences can also be triggered by another investor group, i.e. neo-sustainable investors who increase their environmental awareness and thus become sustainable investors, for example, due to the view that traditional investments are riskier in phases of high public environmental attention. Finally, a third opportunistic investor group without any awareness and preferences for sustainability might temporarily engage in self-interested strategies if they find it beneficial to invest in stocks of green and other sustainable firms or divest stocks of conventional firms when public environmental attention increases.

Against this background, our estimation results are not only relevant for private and institutional investors, but also for the corporate strategies of managers of firms by recognizing how high public environmental attention to environmental issues can create shareholder wealth in the short run. In addition, our estimation results are relevant for public policy in order to support the sustainable performance of firms and thus to contribute to sustainable development including a mitigation of climate change and pollution. Since public attention to environmental issues obviously has a positive effect on the returns on sustainable stock indices and thus, at least indirectly, on sustainable corporate activities, a possible policy instrument is the reinforcement of this public attention, for example, by additional information campaigns. This rather "weak" public policy approach can therefore complement alternative market-based policy instruments (e.g., taxes or subsidies) or traditional (e.g., command and control) regulations in order to correct for market failures due to negative (e.g., environmental) external effects. However, in order to develop effective information campaigns, it would be helpful to know which investor groups are relevant for the stock market effects. An interesting direction for further research is therefore to analyze traditionally sustainable, neo-sustainable, and opportunistic investors towards stocks of sustainable firms separately in phases of different public attention to environmental issues, for example, on the basis of empirical analyses at the investor level.

Another direction for further research that is more directly related to our study is the analysis of alternative sustainability and conventional stock indices (also considering artificial portfolios that only include non-sustainable firms) or single stocks as well as an international comparison. While our empirical analysis refers to stock indices in the USA, an analysis of other important stock markets such as the European or East-Asian stock markets would certainly also be interesting. Furthermore, future research might also examine the effect of public attention to environmental issues on the returns on sustainable and conventional bonds instead of stock indices. A final possible direction for further research refers to the analysis of the effects on the volatility of returns instead of the absolute values of the returns.

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Appendix

Figures

Figure 1: Development of the weekly values of stock indices in the period from January 2004 to June 2018

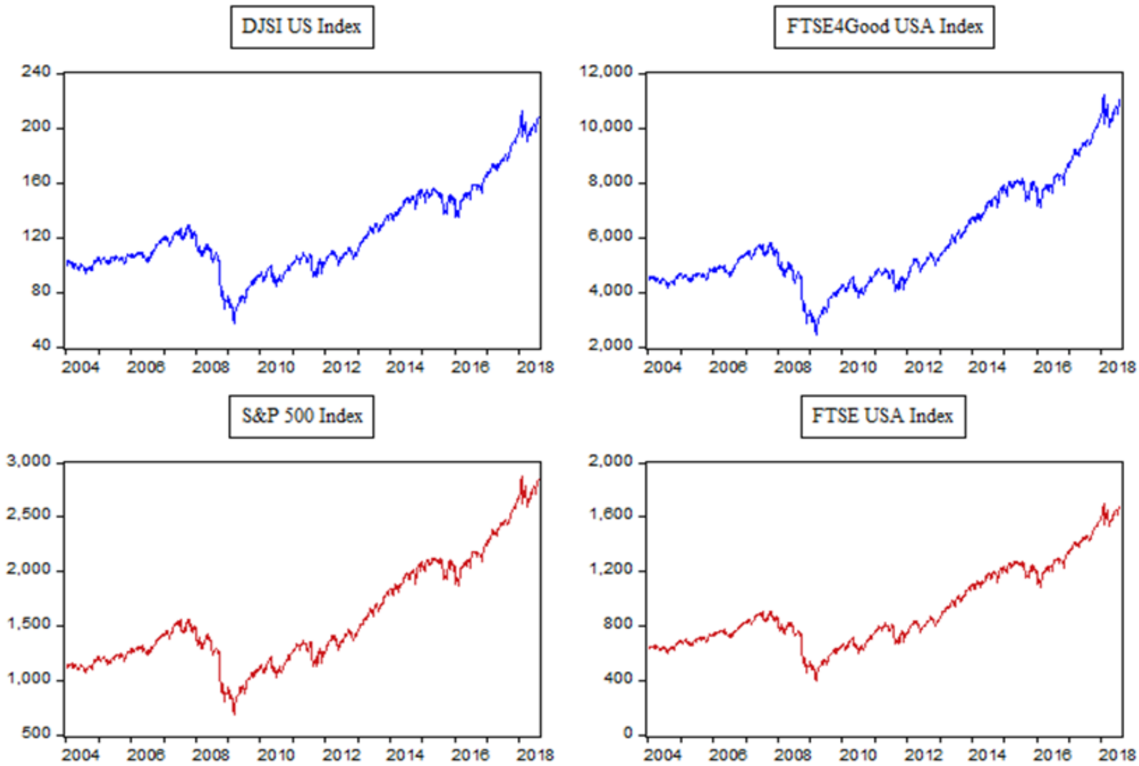
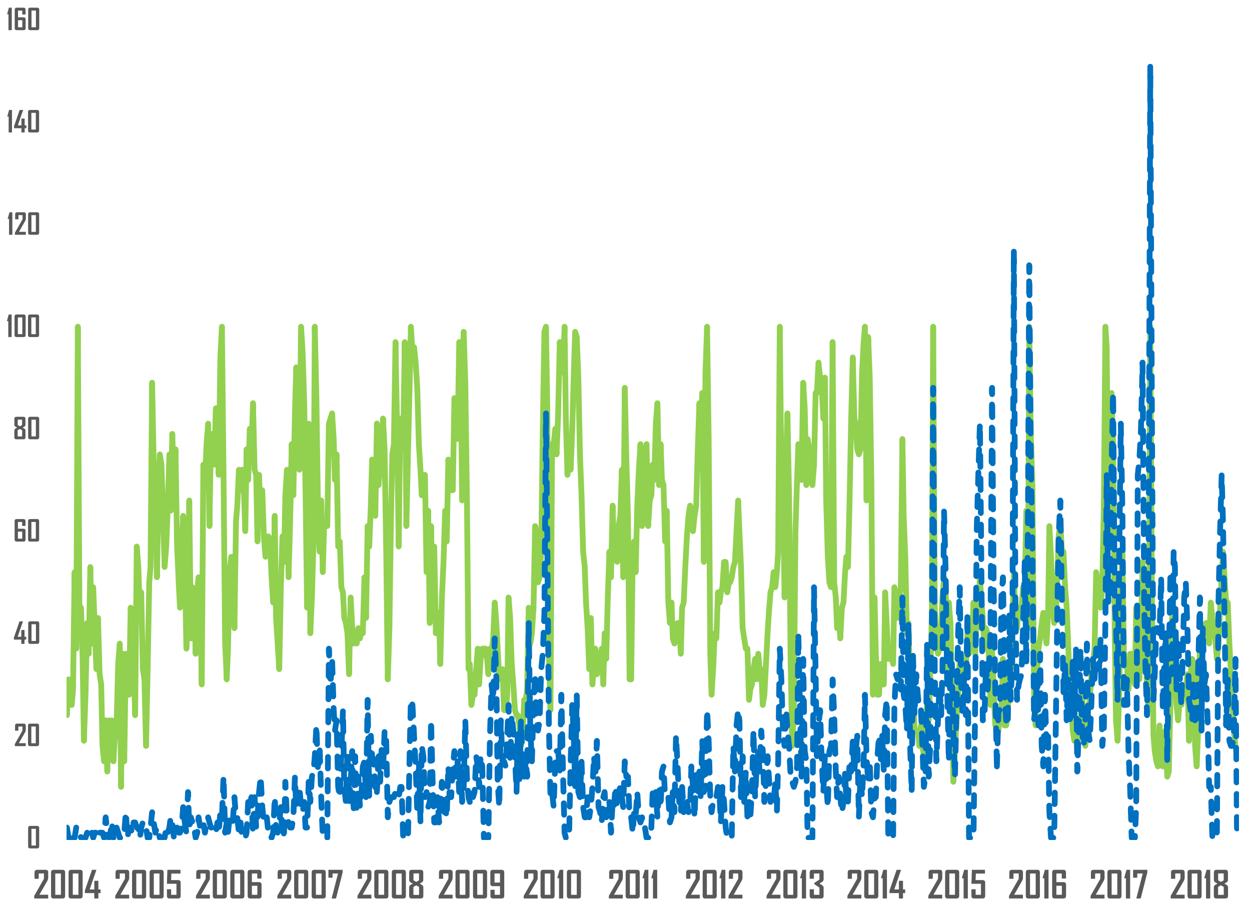


Figure 2: Development of MA_CC (dotted line) and GSVI_CC (solid line) across all weeks in the period from January 2004 to June 2018



Tables

Table 1: Descriptive statistics for all weeks in the period from January 2004 to June 2018

Variables	Mean	Median	Standard deviation	Mini-mum	Maxi-mum
Return DJSI US	0.095	0.156	2.177	-18.311	9.763
Return S&P 500 Index	0.123	0.207	2.300	-20.083	11.355
Return FTSE4Good USA Index	0.120	0.216	2.348	-20.418	11.667
Return FTSE USA Index	0.129	0.242	2.368	-19.861	12.041
MA_CC	16.923	11.000	18.217	0.000	151.000
MA_POL	7.566	7.000	4.467	0.000	33.000
GSVI_CC	50.984	47.000	21.555	10.000	100.000
GSVI_POL	57.928	61.000	21.126	16.000	100.000
Ln(1+MA_CC)	2.319	2.484	1.199	0.000	5.023
Ln(1+MA_POL)	2.012	2.079	0.536	0.000	3.526
Ln(1+GSVI_CC)	3.841	3.842	0.461	2.234	4.615
Ln(1+GSVI_POL)	3.985	4.127	0.437	2.043	4.615
Disasters	0.288	0.000	0.453	0.000	1.000
RM	0.195	0.272	2.341	-17.980	12.617
SMB	0.028	0.060	1.145	-3.620	6.040
HML	0.004	-0.060	1.373	-8.680	9.920
MOM	-0.029	0.040	0.823	-8.210	2.840

Table 2: Media coverage of the ten most relevant environmental issues (measured by the number of corresponding articles) in four US newspapers (The New York Times, The Wall Street Journal, The Washington Post, USA Today) from January 2004 to June 2018

Environmental issues	Media coverage (number of articles)
Climate change	12,791
Pollution	5,720
Global warming	4,393
Natural disasters	2,032
Endangered species	1,652
Climate disasters	1,168
Species extinction	688
Consumerism	583
Waste disposal	499
Deforestation	443

Source: LexisNexis

Table 3: Climate-related natural weather disasters and their consequences

	Start dates	End dates	Country	Disaster type	Disaster sub-type	Number of killed persons	Number of totally affected persons	Damage (in million US$)
USA	08/29/2005	09/19/2005	USA	Storm	Tropical cyclone	1,852	831,852	157,530,000
	06/10/2006	10/02/2006	USA	Extreme temperature	Heat wave	188	188	-
	06/01/2007	11/30/2007	USA	Storm	Hurricane season	160	1,537	4,600,000
	06/28/2011	11/11/2011	USA	Storm	Convective storm	701	19,294	35,400,000
	06/01/2015	11/30/2015	USA	Storm	Convective storm	188	3,964	12,620,000
America without USA	09/14/2004	09/17/2004	Haiti	Storm	Tropical cyclone	2,757	324,851	51,000
	09/18/2004	09/19/2004	Haiti	Flood	Riverine flood	2,665	33,948	-
	10/01/2005	10/05/2005	Guatemala	Storm	Tropical cyclone	1,513	476,827	988,300
	08/28/2008	09/07/2008	Haiti	Storm	Tropical cyclone	698	246,974	-
	01/11/2011	01/11/2011	Brazil	Flood	Riverine flood	978	1,216,578	1,002,000
Europe	01/20/2006	02/01/2006	Ukraine	Extreme temperature	Cold wave	801	60,401	-
	06/26/2006	07/30/2006	Western Europe	Extreme temperature	Heat wave	3,328	3,328	-
	06/25/2010	08/08/2010	Russia	Extreme temperature	Heat wave	55,736	55,736	400,000
	07/13/2013	07/19/2013	United Kingdom	Extreme temperature	Heat wave	760	760	-
	06/29/2015	07/05/2015	France	Extreme temperature	Heat wave	3,275	3,275	-
Asia	11/11/2007	11/16/2007	Bangladesh	Storm	Tropical cyclone	4,275	8,983,041	2,300,000
	04/27/2008	05/02/2008	Myanmar	Storm	Tropical cyclone	138 366	2,558,366	4,000,000
	06/14/2013	06/17/2013	India	Flood	Riverine flood	6,373	1,425,846	1,362,000
	11/03/2013	11/11/2013	Philippines	Storm	Tropical cyclone	7,415	17,951,986	10,136,563
	05/25/2015	06/03/2015	India	Extreme temperature	Heat wave	2,248	2,248	-
Oceania	11/12/2007	11/20/2007	Papua New Guinea	Storm	Tropical cyclone	172	162,312	-
	01/25/2009	09/02/2009	Australia	Extreme temperature	Heat wave	347	2,347	-
	02/07/2009	03/14/2009	Australia	Wildfire	Land fire	180	10,134	1,300,000
	01/01/2014	02/28/2014	Australia	Extreme temperature	Heat wave	139	139	-
	02/07/2016	02/26/2016	Fiji	Storm	Tropical cyclone	47	545,605	600,000
Africa	03/01/2004	03/18/2004	Madagascar	Storm	Tropical cyclone	395	1,032,824	250,000
	08/06/2006	08/06/2006	Ethiopia	Flood	Riverine flood	453	424,503	-
	08/06/2006	08/07/2006	Ethiopia	Flood	Flash flood	498	10,594	3,200
	07/01/2011	08/30/2012	Somalia	Drought	Drought	20,000	4,020,000	-
	07/02/2012	10/09/2012	Nigeria	Flood	Riverine flood	363	7,001,230	500,000

Table 4: Definition of explanatory variables

Variables	Variable description	Source
MA_CC	Media attention to climate change, measured by the number of weekly articles published in four US newspapers (The New York Times, The Wall Street Journal, The Washington Post, USA Today).	LexisNexis
MA_POL	Media attention to pollution, measured by the number of weekly articles published in four US newspapers (The New York Times, The Wall Street Journal, The Washington Post, USA Today).	LexisNexis
GSVI_CC	Public attention to climate change, measured by the weekly normalized search volume in Google for the keyword "climate change" in the USA.	Google Trends
GSVI_POL	Public attention to pollution, measured by the weekly normalized search volume in Google for the keyword "pollution" in the USA.	Google Trends
Ln(1+MA_CC)	Natural logarithm of one plus MA_CC.	LexisNexis
Ln(1+MA_POL)	Natural logarithm of one plus MA_POL.	LexisNexis
Ln(1+GSVI_CC)	Natural logarithm of one plus GSVI_CC.	Google Trends
Ln(1+GSVI_POL)	Natural logarithm of one plus GSVI_POL.	Google Trends
Disasters	Dummy variable that takes the value one if a global climate-related natural weather disaster has taken place.	EM-DAT
RM	Return on a US market portfolio.	Kenneth R. French data library
SMB	Size factor, i.e. the difference between the returns on portfolios comprising stocks of "small" firms and portfolios comprising stocks of "big" firms.	Kenneth R. French data library
HML	Value factor, i.e. the difference between returns on portfolios comprising stocks of firms with a "high" book-to-market equity ratio and portfolios comprising stocks of firms with a "low" book-to-market equity ratio.	Kenneth R. French data library
MOM	Momentum factor, i.e. the difference between the returns on portfolios comprising stocks of recent "winners" and portfolios comprising stocks of recent "losers".	Kenneth R. French data library

Table 5: ML estimation results in four-factor models with a GARCH(1,1)-M process, dependent variables: weekly returns on the DJSI US and the S&P 500 Index, main explanatory variables: public attention to climate change

Return equation	DJSI US				S&P 500 Index			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Constant	-0.384 (0.00)***	-0.247 (0.00)***	-0.215 (0.00)***	-0.314 (0.00)***	-0.132 (0.00)***	-0.114 (0.00)***	-0.086 (0.00)***	-0.050 (0.00)***
Disasters	0.043 (0.00)***	--	--	0.020 (0.04)**	-0.007 (0.00)***	--	--	-0.037 (0.00)***
Ln(1+MA_CC)	--	0.015 (0.00)***	--	0.013 (0.03)**	--	-0.004 (0.00)***	--	-0.007 (0.00)***
Ln(1+GSVI_CC)	--	--	0.011 (0.00)***	0.018 (0.03)**	--	--	-0.024 (0.00)***	-0.023 (0.00)***
RM	0.917 (0.00)***	0.937 (0.00)***	0.943 (0.00)***	0.943 (0.00)***	0.996 (0.00)***	0.995 (0.00)***	0.997 (0.00)***	0.986 (0.00)***
SMB	-0.188 (0.00)***	-0.190 (0.00)***	-0.166 (0.00)***	-0.193 (0.00)***	-0.137 (0.00)***	-0.135 (0.00)***	-0.134 (0.00)***	-0.127 (0.00)***
HML	-0.017 (0.00)***	-0.029 (0.00)***	-0.022 (0.00)***	-0.037 (0.00)***	-0.012 (0.00)***	-0.012 (0.00)***	-0.012 (0.00)***	-0.003 (0.00)***
MOM	-0.054 (0.00)***	-0.046 (0.00)***	-0.023 (0.00)***	-0.036 (0.00)***	0.004 (0.00)***	-0.004 (0.00)***	-0.001 (0.65)	0.003 (0.02)**
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\sqrt{h_t}$	0.340 (0.00)***	0.264 (0.06)*	0.202 (0.03)**	0.259 (0.00)***	0.234 (0.00)***	0.291 (0.00)***	0.379 (0.00)***	0.283 (0.00)***
Variance equation								
Constant	0.408 (0.00)***	0.105 (0.00)***	0.104 (0.01)**	0.109 (0.00)***	0.015 (0.00)***	0.021 (0.00)***	0.027 (0.00)***	0.052 (0.00)***
η_{t-1}^2	0.024 (0.44)	0.244 (0.00)***	0.267 (0.00)***	0.216 (0.00)***	0.066 (0.00)***	0.462 (0.00)***	0.510 (0.00)***	0.153 (0.00)***
h_{t-1}	0.440 (0.00)***	0.458 (0.00)***	0.438 (0.01)**	0.518 (0.00)***	0.520 (0.00)***	0.400 (0.00)***	0.371 (0.00)***	0.474 (0.00)***
Adjusted R^2	0.947	0.945	0.945	0.945	0.973	0.974	0.973	0.974

Note: The basis of the estimation results in this table are data for T = 756 weeks from January 2004 to June 2018. While the estimation results in the left part of the table refer to the returns on the DJSI US, the estimation results in the right part refer to the returns on the S&P 500 Index. Besides the four risk factors according to Carhart (1997), the time dummy variables, and the GARCH factors, Model 1 only includes the dummy variable for the global climate-related natural weather disasters, respectively. In contrast, Model 2 only includes media attention to climate change and Model 3 only includes the GSVI for climate change as main explanatory variables. Model 4 includes the dummy variable for the global climate-related natural weather disasters and both indicators for public attention to climate change, respectively. While the upper part of the table reports the parameter estimates from the return equation, the lower part reports the parameter estimates from the variance equation. The corresponding p-values are in parentheses. * (**, ***) means that the estimated parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 6: ML estimation results in four-factor models with a GARCH(1,1)-M process, dependent variables: weekly returns on the FTSE4Good USA Index and the FTSE USA Index, main explanatory variables: public attention to climate change

Return equation								
	FTSE4Good USA Index				FTSE USA Index			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Constant	-0.248 (0.00)***	-0.214 (0.00)***	-0.288 (0.00)***	-0.245 (0.16)	-0.124 (0.00)***	-0.118 (0.00)***	-0.042 (0.12)	-0.084 (0.00)***
Disasters	0.057 (0.00)***	--	--	0.020 (0.00)***	-0.023 (0.00)***	--	--	-0.018 (0.00)***
Ln(1+MA_CC)	--	0.020 (0.00)***	--	0.022 (0.00)***	--	-0.005 (0.00)***	--	-0.004 (0.00)***
Ln(1+GSVI_CC)	--	--	0.046 (0.00)***	0.044 (0.00)***	--	--	-0.021 (0.00)***	-0.030 (0.00)***
RM	0.987 (0.00)***	0.973 (0.00)***	0.984 (0.00)***	0.980 (0.00)***	1.002 (0.00)***	1.003 (0.00)***	0.997 (0.00)***	0.999 (0.00)***
SMB	-0.174 (0.00)***	-0.162 (0.00)***	-0.165 (0.00)***	-0.015 (0.00)***	-0.012 (0.00)***	-0.012 (0.00)***	-0.015 (0.00)***	-0.015 (0.00)***
HML	-0.018 (0.00)***	-0.073 (0.00)***	-0.063 (0.00)***	-0.024 (0.00)***	-0.001 (0.00)***	-0.002 (0.01)**	-0.001 (0.00)***	-0.000 (0.00)***
MOM	-0.014 (0.00)***	-0.020 (0.07)*	-0.014 (0.01)**	-0.062 (0.00)***	-0.012 (0.00)***	-0.010 (0.00)***	-0.009 (0.00)***	-0.003 (0.00)***
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\sqrt{h_t}$	0.235 (0.00)***	0.158 (0.00)***	0.094 (0.00)***	0.447 (0.00)***	0.242 (0.00)***	0.252 (0.00)***	0.356 (0.00)***	0.327 (0.00)***
Variance equation								
Constant	0.183 (0.00)***	0.373 (0.00)***	0.155 (0.00)***	0.185 (0.00)***	0.014 (0.00)***	0.013 (0.00)***	0.023 (0.00)***	0.076 (0.00)***
η_{t-1}^2	0.192 (0.00)***	0.449 (0.00)***	0.445 (0.01)**	0.404 (0.06)*	0.148 (0.00)***	0.134 (0.00)***	0.007 (0.06)*	0.081 (0.00)***
h_{t-1}	0.608 (0.00)***	0.142 (0.18)	0.371 (0.01)**	0.435 (0.00)***	0.342 (0.00)***	0.354 (0.00)***	0.415 (0.06)*	0.513 (0.00)***
Adjusted R^2	0.947	0.946	0.946	0.939	0.974	0.974	0.974	0.974

Note: The basis of the estimation results in this table are data for T = 756 weeks from January 2004 to June 2018. While the estimation results in the left part of the table refer to the returns on the FTSE4Good USA Index, the estimation results in the right part refer to the returns on the FTSE USA Index. Besides the four risk factors according to Carhart (1997), the time dummy variables, and the GARCH factors, Model 1 only includes the dummy variable for the global climate-related natural weather disasters, respectively. In contrast, Model 2 only includes media attention to climate change and Model 3 only includes the GSVI for climate change as main explanatory variables. Model 4 includes the dummy variable for the global climate-related natural weather disasters and both indicators for public attention to climate change, respectively. While the upper part of the table reports the parameter estimates from the return equation, the lower part reports the parameter estimates from the variance equation. The corresponding p-values are in parentheses. * (**, ***) means that the estimated parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 7: ML estimation results in four-factor models with a GARCH(1,1)-M process, dependent variables: weekly returns on the DJSI US and the S&P 500 Index, main explanatory variables: public attention to pollution

Return equation	DJSI US				S&P 500 Index			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Constant	-0.384 (0.00)***	-0.218 (0.00)***	-0.278 (0.00)***	-0.229 (0.00)***	-0.132 (0.00)***	-0.131 (0.00)***	-0.058 (0.13)	-0.050 (0.23)
Disasters	0.043 (0.00)***	--	--	0.086 (0.00)***	-0.007 (0.00)***	--	--	-0.004 (0.07)*
Ln(1+MA_POL)	--	0.016 (0.03)**	--	0.015 (0.00)***	--	-0.017 (0.00)***	--	0.007 (0.27)
Ln(1+GSVI_POL)	--	--	0.015 (0.04)**	0.031 (0.00)***	--	--	-0.014 (0.00)***	-0.018 (0.02)**
RM	0.917 (0.00)***	0.947 (0.00)***	0.938 (0.00)***	0.876 (0.00)***	0.996 (0.00)***	0.990 (0.00)***	0.993 (0.00)***	0.995 (0.00)***
SMB	-0.188 (0.00)***	-0.170 (0.00)***	-0.174 (0.00)***	-0.169 (0.00)***	-0.137 (0.00)***	-0.136 (0.00)***	-0.137 (0.00)***	-0.137 (0.00)***
HML	-0.017 (0.00)***	-0.015 (0.00)***	-0.030 (0.00)***	-0.021 (0.00)***	-0.012 (0.00)***	-0.019 (0.00)***	-0.014 (0.00)***	-0.011 (0.00)***
MOM	-0.054 (0.00)***	-0.043 (0.00)***	-0.038 (0.00)***	-0.010 (0.10)	0.004 (0.00)***	-0.005 (0.00)***	-0.019 (0.00)***	-0.007 (0.00)***
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\sqrt{h_t}$	0.340 (0.00)***	0.196 (0.02)**	0.275 (0.09)*	0.096 (0.00)***	0.234 (0.00)***	0.294 (0.00)***	0.016 (0.07)*	0.158 (0.09)*
Variance equation								
Constant	0.408 (0.00)***	0.102 (0.01)**	0.111 (0.02)**	0.439 (0.01)**	0.015 (0.00)***	0.034 (0.00)***	0.026 (0.00)***	0.020 (0.00)***
η_{t-1}^2	0.024 (0.44)	0.250 (0.00)***	0.153 (0.03)**	0.687 (0.00)***	0.066 (0.00)***	0.204 (0.00)***	0.782 (0.00)***	0.514 (0.00)***
h_{t-1}	0.440 (0.00)***	0.481 (0.00)***	0.509 0.00)***	0.446 (0.00)***	0.520 (0.00)***	0.040 (0.03)**	0.040 (0.12)	0.031 (0.27)
Adjusted R^2	0.947	0.944	0.945	0.943	0.973	0.973	0.973	0.973

Note: The basis of the estimation results in this table are data for T = 756 weeks from January 2004 to June 2018. While the estimation results in the left part of the table refer to the returns on the DJSI US, the estimation results in the right part refer to the returns on the S&P 500 Index. Besides the four risk factors according to Carhart (1997), the time dummy variables, and the GARCH factors, Model 1 only includes the dummy variable for the global climate-related natural weather disasters, respectively. In contrast, Model 2 only includes media attention to pollution and Model 3 only includes the GSVI for pollution as main explanatory variables. Model 4 includes the dummy variable for the global climate-related natural weather disasters and both indicators for public attention to pollution, respectively. While the upper part of the table reports the parameter estimates from the return equation, the lower part reports the parameter estimates from the variance equation. The corresponding p-values are in parentheses. * (**, ***) means that the estimated parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 8: ML estimation results in four-factor models with a GARCH(1,1)-M process, dependent variables: weekly returns on the FTSE4Good USA Index and the FTSE USA Index, main explanatory variables: public attention to pollution

Return equation	FTSE4Good USA Index				FTSE USA Index			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Constant	-0.248 (0.00)***	-0.256 (0.00)***	-0.202 (0.00)***	-0.208 (0.00)***	-0.124 (0.00)***	-0.144 (0.09)*	-0.062 (0.00)***	-0.082 (0.06)*
Disasters	0.057 (0.00)***	--	--	0.028 (0.00)***	-0.023 (0.00)***	--	--	-0.017 (0.05)*
Ln(1+MA_POL)	--	0.014 (0.00)***	--	0.032 (0.00)***	--	-0.002 (0.07)*	--	-0.001 (0.00)***
Ln(1+GSVI_POL)	--	--	0.014 (0.07)*	0.031 (0.00)***	--	--	-0.016 (0.00)***	-0.039 (0.00)***
RM	0.987 (0.00)***	0.979 (0.00)***	0.981 (0.00)***	0.989 (0.00)***	1.002 (0.00)***	1.004 (0.00)***	1.001 (0.00)***	0.993 (0.00)***
SMB	-0.174 (0.00)***	-0.138 (0.00)***	-0.159 (0.00)***	-0.166 (0.00)***	-0.012 (0.00)***	-0.014 (0.00)***	-0.011 (0.00)***	-0.014 (0.00)***
HML	-0.018 (0.00)***	-0.059 (0.00)***	-0.066 (0.00)***	-0.017 (0.00)***	-0.001 (0.00)***	-0.006 (0.00)***	0.000 (0.57)	-0.001 (0.00)***
MOM	-0.014 (0.00)***	-0.045 (0.00)***	-0.015 (0.00)***	-0.017 (0.00)***	-0.012 (0.00)***	-0.010 (0.00)***	0.003 (0.00)***	-0.010 (0.00)***
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\sqrt{h_t}$	0.235 (0.00)***	0.242 (0.00)***	0.099 (0.08)*	0.350 (0.00)***	0.242 (0.00)***	0.044 (0.09)*	0.240 (0.00)***	0.342 (0.00)***
Variance equation								
Constant	0.183 (0.00)***	0.189 (0.00)***	0.110 (0.00)***	0.170 (0.00)***	0.014 (0.00)***	0.022 (0.00)***	0.018 (0.00)***	0.086 (0.00)***
η_{t-1}^2	0.192 (0.00)***	0.192 (0.00)***	0.382 (0.00)***	0.122 (0.00)***	0.148 (0.00)***	0.895 (0.00)***	0.147 (0.00)***	0.128 (0.00)***
h_{t-1}	0.608 (0.00)***	0.648 (0.00)***	0.498 (0.00)***	0.586 (0.00)***	0.342 (0.00)***	0.002 (0.12)	0.556 (0.00)***	0.599 (0.00)***
Adjusted R^2	0.947	0.946	0.946	0.947	0.974	0.974	0.974	0.974

Note: The basis of the estimation results in this table are data for T = 756 weeks from January 2004 to June 2018. While the estimation results in the left part of the table refer to the returns on the FTSE4Good USA Index, the estimation results in the right part refer to the returns on the FTSE USA Index. Besides the four risk factors according to Carhart (1997), the time dummy variables, and the GARCH factors, Model 1 only includes the dummy variable for the global climate-related natural weather disasters, respectively. In contrast, Model 2 only includes media attention to pollution and Model 3 only includes the GSVI for pollution as main explanatory variables. Model 4 includes the dummy variable for the global climate-related natural weather disasters and both indicators for public attention to pollution, respectively. While the upper part of the table reports the parameter estimates from the return equation, the lower part reports the parameter estimates from the variance equation. The corresponding p-values are in parentheses. * (**, ***) means that the estimated parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 9: OLS estimation results in pooled linear panel models, dependent variables: weekly returns on sustainability and conventional stock indices, main explanatory variables: public attention to climate change and pollution

	Model 1	Public attention to climate change		Public attention to pollution	
		Model 2	Model 3	Model 2	Model 3
Constant	-0.039 (0.00)***	-0.020 (0.11)	-0.003 (0.22)	-0.042 (0.01)**	0.008 (0.69)
SSI	-0.032 (0.00)***	-0.075 (0.00)***	-0.070 (0.00)***	-0.108 (0.00)***	-0.139 (0.00)***
Disasters	-0.004 (0.60)	--	--	--	--
Ln(1+MA)	--	-0.005 (0.00)***	--	0.003 (0.53)	--
Ln(1+GSVI)	--	--	-0.008 (0.00)***	--	-0.011 (0.13)
SSI x Disasters	0.018 (0.03)**	--	--	--	--
SSI x Ln(1+MA)	--	0.020 (0.00)***	--	0.039 (0.00)***	--
SSI x Ln(1+GSVI)	--	--	0.011 (0.00)***	--	0.029 (0.00)***
RM	0.980 (0.00)***	0.979 (0.00)***	0.979 (0.00)***	0.981 (0.00)***	0.979 (0.00)***
SMB	-0.120 (0.00)***	-0.120 (0.00)***	-0.119 (0.00)***	-0.120 (0.00)***	-0.119 (0.00)***
HML	-0.018 (0.00)***	-0.018 (0.00)***	-0.019 (0.00)***	-0.018 (0.00)***	-0.019 (0.00)***
MOM	-0.016 (0.00)***	-0.015 (0.00)***	-0.015 (0.00)***	-0.014 (0.00)***	-0.015 (0.00)***
DJ	-0.014 (0.00)***	-0.016 (0.00)***	-0.013 (0.00)***	-0.016 (0.00)***	-0.015 (0.00)***
Time dummies	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.991	0.991	0.991	0.991	0.992

Note: The basis of the estimation results in this table are data for T = 3024 observations (i.e. four stock indices for 756 weeks) from January 2004 to June 2018. Besides the four risk factors according to Carhart (1997), the dummy variable *DJ* for Dow Jones indices that takes the value one if the index is the DJSI US or the S&P 500, and the time dummy variables, Model 1 only includes the dummy variable for the global climate-related natural weather disasters and the corresponding interaction term with the dummy variable *SSI* that takes the value one if the index is a sustainability stock index. While the first Model 2 only includes media attention to climate change, the first Model 3 only includes the GSVI for climate change as main explanatory variables. Similarly, the second Model 2 only includes media attention to pollution and the second Model 3 only includes the GSVI for pollution as main explanatory variables. The p-values are in parentheses. * (**, ***) means that the estimated parameter is different from zero at the 10% (5%, 1%) significance level, respectively.

Table 10: OLS estimation results in pooled linear panel models, dependent variables: differences in the weekly returns between sustainability and conventional stock indices, main explanatory variables: public attention to climate change and pollution

	Model 1	Public attention to climate change		Public attention to pollution	
		Model 2	Model 3	Model 2	Model 3
Constant	0.229 (0.00)***	0.238 (0.00)***	0.091 (0.00)***	0.227 (0.00)***	0.041 (0.00)***
Disasters	0.0071 (0.00)***				
Ln(1+MA)		0.024 (0.00)***		0.049 (0.00)***	
Ln(1+GSVI)			0.038 (0.00)***		0.046 (0.00)***
RM	-0.003 (0.00)***	-0.004 (0.00)***	-0.003 (0.00)***	-0.005 (0.00)***	-0.003 (0.00)***
SMB	0.002 (0.00)***	0.004 (0.00)***	0.003 (0.00)***	0.002 (0.00)***	0.004 (0.00)***
HML	0.009 (0.00)***	0.008 (0.00)***	0.008 (0.00)***	0.010 (0.00)***	0.009 (0.00)***
MOM	-0.011 (0.00)***	-0.011 (0.00)***	-0.012 (0.00)***	-0.010 (0.00)***	-0.011 (0.00)***
DJ	-0.046 (0.00)***	-0.035 (0.00)***	-0.046 (0.00)***	-0.035 (0.00)***	-0.047 (0.00)***
Time dummies	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.326	0.300	0.393	0.361	0.379

Note: The basis of the estimation results in this table are data for T = 1512 observations (i.e. two differences in the weekly returns for 756 weeks) from January 2004 to June 2018. Besides the four risk factors according to Carhart (1997), the dummy variable *DJ* for Dow Jones indices that takes the value one if the index is the DJSI US or the S&P 500, and the time dummy variables, Model 1 only includes the dummy variable for the global climate-related natural weather disasters. While the first Model 2 only includes media attention to climate change, the first Model 3 only includes the GSVI for climate change as main explanatory variables. Similarly, the second Model 2 only includes media attention to pollution and the second Model 3 only includes the GSVI for pollution as main explanatory variables. The p-values are in parentheses. * (**, ***) means that the estimated parameter is different from zero at the 10% (5%, 1%) significance level, respectively.