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Event Study Conducted in the Oil and Gas Industry

Is it worth it to be green?

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Abstract

In this paper I examine one of the most pressing questions in sustainable corporate governance, trying to find empirical evidence that it can be profitable to incorporate ESG values into a company's management decisions. In the research carried out below I look at the development of stock returns of American oil and gas companies using a Fama-French three-factor model and testing abnormal stock returns according to the event study methodology around important sustainability-related events between 2010 and 2019. I also examine whether the market considers the suitability of this sector – widely deemed to be unsustainable – for investment to be significantly different before, during and after the designated events, and whether there is a difference between the stock performance of ESG-wise well-performing and ill-performing companies during the events.

My results show that the only event having a (statistically) significant effect is the announcement of the Green New Deal, a regulation-wise ambitious package proposed by progressive Democratic congressional representatives and senators in 2019. This leads one to conclude that the market only behaves unfavorably towards the oil and gas industry and significant divestment only occurs when there are serious government regulations in sight signaling a change in the investment climate. In such cases however the market begins to value good ESG performance and penalize unsustainable corporate governance with a decrease in stock value. Based on additional robustness tests performed to confirm the results, it is reasonable to conclude that the significant negative market movements regarding abnormal returns around the announcement of the Green New Deal are credible.

This research helps in unveiling the type of investment environment and the ways in which the market values companies' ethical and sustainable corporate governance attitudes. The results suggest that in an age of increasingly strict environmental regulations it is worthwhile to integrate ESG-values into company strategy.

Key words: ESG, sustainable corporate governance, event study, Fama-French three-factor model, Green New Deal, oil and gas industry, fossil fuels
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1 Introduction

In the past ten years, discussions about sustainable development, mitigation of climate change and consequently, sustainable corporate governance and the role of markets in protecting our environment have become more and more prevalent in public discourse. One of the long-argued questions of corporate ethics is the extent to which – if at all – corporations should take into account the effects of company operations on our societies, environment in company management. The discourse regarding shareholder and stakeholder corporate governance theories or views has recently been extended to the area of ESG (meaning environmental, social and governance) indicators and their gradual spread throughout company performance evaluation and the corresponding rise of a more environmentally conscious consumer class. Many boycotts and activist movements have garnered media attention in the past ten years, trying to encourage market participants to consider ethical and sustainable company operation as an aspect to be considered during investment. These developments raise the possibility of the stakeholder corporate governance theory becoming an equally profitable way to manage a company if the market begins to value such attitudes.

In this research I try to bring forth empirical evidence that ESG-wise well-performing American oil and gas companies are valued more favorably by the market during events such as industrial disasters related to fossil fuels, environmental regulations or international environmental or climate accords being in sight, or when there is activism present in the markets – all events that can theoretically decrease the value of companies in the oil and gas industry. This work can contribute to a deeper understanding of market reactions to sustainable corporate governance actions and in doing so assist future leaders in management decisions.

In the execution of the following event study, I utilized the Fama-French three-factor model, investigated abnormal returns of 128 American oil and gas industry companies by downloading daily stock returns and yearly ESG-performance indicators using Thomson Reuters Eikon software and selecting eight events I suspected could have had significant impact on stock returns in the industry. To execute the statistical analysis and robustness checks, I downloaded the three-factor model components and an industry index (on a daily frequency) from Professor Kenneth French's website. I estimated expected returns around the events using the collected data and used them to calculate abnormal returns, which I tested using different statistical procedures. The reliability of these tests differs under certain special conditions to be discussed later, therefore comparing these can prove useful in judging the credibility of empirical event studies.

The questions proposed in this research are the following:

> Is there evidence in the oil and gas industry markets that increasingly strict and common environmental regulations meant to mitigate climate change negatively affect polluting companies and their value?
> Does the market recognize ESG-wise well-performing and ill-performing companies as being different regarding investment profitability and consequently could it be advantageous to introduce ESG values into corporate management, "could it be worth it to be green"?

In the second chapter I explore the questions of shareholder and stakeholder corporate governance and aim to highlight the fact that if sustainable company management turns out to be profitable due to investors preferring such viewpoints being integrated into the business strategy, then the two theories begin to parallel one another. In the third chapter I analyze the prospects of the oil and gas industry in the light of environmental regulatory tendencies, discuss the concept of long-term investment risk, and provide details of various ESG indices and measurement methods with a focus on the index used in the following empirical analysis downloaded using Thomson Reuters Eikon. In the fourth chapter I discuss the methodology of event studies and corresponding variations, specification problems associated with the methodology and controlling for or mitigating these issues. Results and interpretations of them are discussed in the fifth and sixth chapters. The seventh chapter examines robustness of the results and the paper concludes with a brief recapitulation of the main points.

2 The stakeholder-shareholder dilemma

One of the large debates of business ethics relates to the two concepts of corporate governance, shareholder and stakeholder theory, specifically, in accordance with which theory should corporations be run.
Both theories are in essence normative stances, as they seek to describe the correct way of managing a company (Smith (2003)). Friedman (1970), perhaps the most cited advocate of the shareholder theory, argued in one of his publications in The New York Times that there are no social obligations or responsibilities that bound a company as those can exist only for natural persons. Furthermore, if we want to discuss responsibility regarding a company, we can only do this in the context of the individuals in management who are themselves employees of the owners of the company, and therefore have an employee duty to put the interests of the owners above all else – the interest being the maximization of profits.

Shareholder theory is often misunderstood and misinterpreted in public discourse, as Smith (2003) points out, because corporate profit maximization is portrayed as a goal that overrides all else. As early as 1970, Friedman explained that from a corporate governance stance, the accumulation of maximum profit is only allowed – from a legal and ethical point of view – within the framework of basic social norms. He pointed out that for any company leader to encourage corporate social responsibility actions – no matter how noble – that have no hopes of making a return on costs, by its very nature cannot be ethical. In such cases, the leader or manager who leads the company as an agent, does not spend his own money, but that of his employers.

On the other side of the isle, stakeholders see the collective benefit of groups (stakeholders) either affected by or capable of influencing company activity as the entity to be maximized, not monetary profits. Stakeholder groups include among others, consumers, corporate workers, communities in the company's area of operation and suppliers. Freeman and Phillips (2002), like Friedman, approached the same issue not primarily from an economic, but from an ethical and philosophical point of view, arguing that business owners, like any other members of society, cannot use their property, or in this case, their company in a manner that harms others by violating their individual rights. For this reason, the persons responsible for the management of companies, if they recognize this principle that is morally binding to them as well as the owners, have to take into account the interests of stakeholder communities.

Assuming that existing legislation identifies any corporate activity that violates the freedom of those affected by its operation as illegal, there would not be significant contradictions between the two theories, since Friedman also emphasized the importance of maintaining corporate governance within legal boundaries. However, if we find that the negative effects of certain corporate activities, such effective infringement upon workers' rights or more relevant in this paper, pollution and environmental erosion, are not sufficiently regulated in the existing legal framework, though undoubtedly violate the freedom of the stakeholders, we can understand the gap between the two normative corporate governance theories.

When it comes to pollution and unsustainable operations, the two theories can begin to parallel each other if it can be shown that in some cases a socially responsible way of managing a company is in the interests and so must be the implicit wishes of business owners. In this paper, I aim to find evidence of the fact that the value of a company is increased by socially responsible management compared to its competitors who do not take these aspects into account.

3 Is it worth it to be green?

In this chapter, I explain two different reasons behind possible future declines in investment in oil and gas companies: a rational system of reasoning based on the problem of stranded assets, and an altruistic system of reasoning based on political activism. Afterwards, I briefly present the ESG indicators, which measure the sustainability performance of companies and which can influence the actions of both divestment groups.

3.1 Stranded assets in the oil and gas industry

The Paris Climate Agreement set out the now internationally accepted environmental policy goal of global temperatures not exceeding 2°C by the end of the century.

In a report from HSBC, Paun, Knight and Chan (2015) outlined investor risks regarding fossil fuel reserves, analyzing the phenomenon of "stranded assets". In the research, such assets embody investments that become worthless or very risky before the end of their economic life, such as investments in fossil fuels, which, for a number of reasons, are more likely to undergo significant decreases in value. This is not surprising when one considers the research of McGlade (2015), in which the authors estimated that if we want to keep global warming under 2°C, as outlined in the Paris Climate Agreement, a third of all oil reserves, nearly half of all natural gas reserves, and more than 80% of all coal reserves could not be burned for energy.

The research from HSBS assessed investments in the fossil fuel industry as risky due to stranding for the following reasons:

> compliance with international climate agreements and treaties is expected to increase the number and strictness of national-level environmental regulations, impacting the fossil fuel industry both through CO_2 emissions regulation and increasingly tight health hazard and environmental regulations (e.g. water and air purity)
>
> innovation in the energy sector increases stranding both through efficient energy use and storage, and through a widening array of alternative energy sources; renewable energy sources and nuclear energy increase competition in the energy market, while at the same time pushing down fossil fuel prices, reducing the value of companies in the fossil fuel industry.

Pham et al. (2019) examined the German stock market to look for evidence that the Paris Climate Agreement has had a negative impact on industries emitting large amounts of carbon dioxide. Utilizing the CAPM model methodology within the event study framework and dummy variables to account for the impact of the agreement-related news, they examined the effects of 20 Paris Climate Agreement events and announcements on 17 different industries, represented by industry indices, and found that, in terms of both risk and returns, polluting industries such as the extractive and processing industries reacted negatively news related to the Agreement. This is important evidence for the claim made in the HSBC report (Paun, Knight and Chan (2015)) that progressively stricter and increasing amounts of international environmental and climate accords make investments in polluting industries risky. It is important to note, however, that although Pham and his colleagues used several different tests to support the robustness of their results, they did not test the performance and results of different event study models and examined the reactions of industry indices in only one country, so while the study is thought-provoking, it cannot be considered conclusive evidence regarding the impact of international climate agreements on the fossil fuel industry.

3.2 Divestment: activism or rational investment strategy

In addition to the long-term investment risks discussed above, the already weakening stock market performance of fossil fuel companies has received increasing attention in recent years. The Institute for Energy Economics and Financial Analysis (IEEFA (2019)) pointed out that while in 1980 the energy sector could hold a 29% weight in the S&P 500 index, by 2019 this decreased to only around 5%, while the oil and gas stocks index underperformed throughout almost the entire year of 2019 compared to both the renewable energy index and the S&P 500 index (Copley and Holland (2020)).

Because of these developments, a form of divestment has emerged that leaves the fossil fuel industry behind not on ethical grounds, but for financial reasons. Both the IEEFA (2019) and HSBC (Paun, Knight and Chan (2015)) study mention the possibility of divestment as a step towards risk reduction, but it is important to point out that neither analyses encourage a complete abandonment of the industry, only point out that in the light of current trends there is no reason to be overly optimistic about future prospects in the sector, and that it is worth considering a long-term industry decline as a possible event.

The other type of divestment that was mentioned previously is not based on rational investment strategies, but on environmental activism and ethical investor attitudes. The divestment movement has become more and more directed against the fossil fuel industry in recent years, but in the past there have been several similar movements, including a consumer and corporate boycott of South Africa in the 1980s progressing to a national level boycott in multiple countries (Grossman and Sharpe (1970)), and a boycott of the tobacco industry that began in the 1990s (Wander and Malone (2006)). Dordi and Weber (2019) examined the impact of divestment announcements on stock prices of fossil fuel companies, focusing on 24 announcements between 2012 and 2015. In their research, using BMP-tests on abnormal returns and the CAPM model for calculating expected returns, they were able to detect negative abnormal returns when prominent investors announced plans for divestment and found that the effects were more significant towards 2015, which the authors suggested could indicate a gradual strengthening of the divestment movement and changes in investor attitudes.

Recently, several universities, the Rockefeller Brothers Fund (Smith (2014)), countries such as Ireland (Carrington (2018)) and cities (New York) have announced that they are pulling their investments made through certain funds from the fossil fuel industry. In recent months, three public pension funds in New York City have announced that they will withdraw $4 billion in capital from their investments in the oil and gas industry

(Wittenberg (2021)).

In the following analysis, I also examine the effects of such announcements, trying to decipher whether investors distinguish between oil and gas companies based on their ESG performance when divestment events are happening.

3.3 ESG values and the measuring of sustainable corporate governance

In business, corporate governance and investment, ESG (Environmental, Social, Governance) principles are gradually emerging as relevant factors in decision-making. The integration of ESG principles into business strategy planning allows for the deliberation of issues that are socially important and reflect long-term thinking and sustainability and move beyond the criteria of short-term profit maximization (Tapaszti (2018)). Several indices have been developed over the years to measure ESG performance, one of the first being in the Council on Economic Priorities' (CEP) Shopping for a Better World annual publications and the Green – Oatmeal – Brown categorization. In my research, I used the Thomson Reuters ESG assessment available in the Thomson Reuters Eikon system, so I will briefly describe the structure of that index.

The Thomson Reuters ESG index is based on information provided willingly by companies. The ESG value is calibrated to fall between 0 and 1. Based on this value, the ESG Grade criteria classifies the company's ESG performance from grade D (worst) to grade A (best). The three main criteria are Environmental, Social and Governance sections, which include aspects such as company emissions, resource use, respect for human rights and CSR (Corporate Social Responsibility) activity (Thomson Reuters Eikon (2017)). The ESG result considers performance in the three areas with roughly equal weight, and the result is adjusted downwards by all events summarized by Thomson Reuters as "ESG Controversy".

4 Event study methodology

In this chapter I introduce the methodology used in the empirical section of the paper, the event study methodology conducted on company abnormal returns, which is utilized to answer the main research questions posed above. In the following subsections I first discuss the efficient-market hypothesis – a necessity for event studies to be sensible tools –, then continue to discuss the basics of event studies, the Fama-French three-factor model, time series OLS and the favorable qualities of log-returns in this context, and finally the common specification issues of event studies and their treatment.

4.1 Basics of event studies, the efficient-market hypothesis

As Binder (1998) states in his paper on the methodological developments of event studies, the empirical analysis published by Fama, Fischer, Jensen and Roll (1969) on the effects of company announcements of stock splits on stock prices has started a methodological revolution in the disciplines of finance and economics. This study presented the basics of the practical applications of event studies. The two large areas of application are identified by Binder (1998) as (1) testing the hypothesis of effective information pricing in the markets and (2) assuming the validity of this hypothesis, measuring how events affect company stock prices and how new information is incorporated into the market pricing mechanism. I shall discuss the cases where assumptions of efficient markets hold shortly.

In their study, Fama, Fischer, Jensen and Roll (1969) measured the impact of the above-mentioned company stock split announcements on stock prices using the following linear regression model to separate the event's impact on prices from price effects caused by the general market environment:

$$log_e R_{jt} = \alpha_j + \beta_j * log_e L_t + u_{jt}, \tag{1}$$

where R_{jt} is the stock return of company j at period t, L_t is the representation of general market conditions (in this case the market return calculated from the returns of all securities on the NYSE), parameters α_j and β_j are the constant values characteristic of company j, and u_{jt} is a random error component. The parameters of the equation were estimated using OLS and the authors found that if the estimation period is correctly chosen then the OLS assumptions and specifically assumptions about the estimated error term (having zero mean and time-independent variance, being unautocorrelated and having a distribution independent of logLt) are met, so the model can be considered well specified. The correct selection of the estimation period refers to the fact that the event and – if it is not completely unexpected, – the anticipation period before it is not to be included in the in sample regression, because during this period we have good reason to believe that the error terms do not have a distribution with a zero mean, which would bias our parameter estimates. The regression does not include stock prices directly, but log returns adjusted for dividends (there are important statistical reasons and positive implications for this, which will also be discussed shortly).

As the authors note, the model does not contain all the variables that can potentially affect the returns of a given security, and these effects are thus contained in the error term. When we examine the effect of a mostly unexpected event, this is precisely what we exploit and will refer to later as abnormal returns. However, before proceeding with the presentation of the methodology, it is important to discuss the circumstances in which we can even talk about the incorporation of the effects of news and unexpected events into stock prices.

Fama (1970) expanded the theory of the existing Efficient Market Hypothesis by defining weak, medium, and strong forms of market efficiency. Up until his work, the literature described market environments as efficient if all available information was always fully integrated into prices immediately. Fama (1970) listed the following sufficient but not necessary conditions for the efficient market hypothesis to hold:

(1) there are no transaction costs for trading securities in the market
(2) All relevant information is available to all market participants without cost
(3) all market participants share the same view of the effects of a news story on stock prices and on the distribution of future prices (it is important to note that future prices are random variables, so they do not have a realized value at time t, only a probability distribution).

However, markets can be considered efficient even if these conditions are not fully met, although their non-fulfilment may be rooted in inefficient market functioning. Fama defined the different degrees of market efficiency as follows:

(1) weak market efficiency describes the functioning of market where the set of information incorporated into future prices contains only past and present prices, this is the only information affecting future emerging prices
(2) semi-strong market efficiency describes the functioning of a market where the set of information incorporated into future prices contains all freely available relevant information (e.g. company announcements, market regulations, news)
(3) strong market efficiency describes the functioning of market where all relevant information is incorporated into future prices, i.e. there is no interest group that has a monopoly over relevant insider information.

For the following empirical analyses to be relevant, it is impervious that the market for U.S. oil and gas companies trading on the NYSE be at least describable as semi-efficient. In my research, I proceed by making this assumption (as do all other event studies I have encountered that examine the effects of specific events), but this can be justified based on the study of Fama (1970), who after summarizing the relevant literature states that in most American markets there is hardly any evidence against the hypothesis of efficient market functioning.

4.2 Event study methodology, standard model assumptions

In describing the exact course of event analysis, similar to Dordi and Weber (2019), I rely on what was described in MacKinlay's (MacKinlay (1997)) paper as a seven-step breakdown of the methodology. The first step is to define the events of interest, the event windows during which one wants to examine the impact of the news (events) on company stock prices. The event window may consist of only one day, the day the news is released, but it is more expedient to extend it a few days before and after the event to examine whether the market anticipated the news, what the market's expectations were regarding the effects, whether it overreacted to the news or not, and how long it took to for the news to be accurately factored into the price, all of which we can learn from the market price movements after the event. The second step is to select the company or companies one wants to investigate. As a third step, we need to select the model which we will want to utilize in estimating the expected returns: the two fundamental models are the economic model and different statistical models, such as the market model or the factor models. We will calculate abnormal returns by first estimating the expected returns. As a fourth step, we need to select the estimation period, that is, the time interval over which we can estimate the coefficients necessary to calculate the expected returns. In a market model, this time interval is a set number of sufficiently many days prior to the event window, where we regress a selected market index capable of encapsulating market conditions relevant for the companies of interest on stock returns, and then extrapolate these estimates over the duration of the event window, estimating the expected returns using the market index and the estimated coefficients. As a fifth step, we calculate abnormal returns during the event window using expected and realized returns, and we test their significance (notable deviations from zero, indicating that the news had an impact on company stock prices) using statistical methods. In the sixth step we summarize the empirical results, and in the seventh step we interpret them.

To formalize these steps according to the paper of MacKinlay (1997), abnormal returns can be calculated using the following formula, if we choose the market model among the statistical models:

$$AR_{it} = R_{it} - (\alpha_i + \beta_i * R_{mt}), \tag{2}$$

where $AR_{it}, R_{it}, \alpha_i, \beta_i$ és R_{mt} are the abnormal returns, expected returns, intercept of the linear regression used to estimate expected returns, and the coefficient of the market return of company i at time t, as well as the market market return itself respectively. The model parameters are estimated during the estimation period (*L1*), and during the event window the expected returns are estimated in an "out-of-sample" way. According to the null hypothesis, for each company, the joint conditional distribution of abnormal returns during the event window is normal (provided that $R_{mt} = r_{mt}$, where t represents the time contained in the event window) with zero conditional mean and the following conditional error term variance (MacKinlay (1997)):

$$\sigma^2(AR_{it}) = \sigma^2_{e_i} + \frac{1}{L_1}\left[1 + \frac{R_{m_t} - \hat{\mu}_m}{\hat{\sigma}^2_m}\right]^2, \tag{3}$$

where the second term is the variance caused by parameter fluctuation due to the sampling error, which, however, tends to zero as the time interval of the estimation period increases. In my research, I assume that I have chosen a sufficiently large estimation window to ignore the variance correction factor without any meaningful distortion.

When examining several companies, the overall effect of the news at time t is calculated with the AAR (Average Abnormal Returns):

$$AAR_{it} = \frac{1}{N}\sum_{i=1}^{N} AR_{it}. \tag{4}$$

In our empirical analysis, we want to find out whether the news in question has a significant effect on the returns of companies. Abnormal returns follow a normal distribution of 0 mean with a given standard deviation if H_0 holds. In order to carry out the statistical examination, it is necessary for the cross-section of abnormal returns to be normally distributed, which is why it is important to use samples of the largest possible size in accordance with the central limit theorem. To test H_0, MacKinlay (1997) calculates the following variance:

$$Var(AAR_{it}) = \frac{1}{N^2}\sum_{i=1}^{N} \sigma^2_{\epsilon_i}. \tag{5}$$

For this cross-sectional aggregation of the variances to be correct and for the variance estimator described in equation (5) to not be biased, covariances between abnormal returns of different securities need to be zero – for this to be true, it would be sufficient for the events and estimation intervals for each company to be at a considerably different time, as this would result in independence. This can easily be arranged in the case of company stock split announcements, as they often happen in different years, but can obviously not be the case in the current study, as I am examining the impact of certain "historical" events on stock returns. Therefore, possible non-zero covariances between abnormal returns need to be accounted for.

If we want to examine the effect of the news on a given company's returns during the whole event window, we can use the cumulative abnormal returns:

$$CAR(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}, \tag{6}$$

The use of log returns are very convenient for cumulative abnormal returns, since addition of these log returns gives us exactly the log returns over several periods, while in the case of simple returns one would need to multiply several numbers – which are effectively percentages and thus close to zero –, computationally less convenient. If we want to summarize this cumulative effect over several companies, we calculate the Cumulative Average Abnormal Returns (CAAR), similar to AARs:

$$CAAR = \frac{1}{N} \sum_{i=1}^{N} CAR(t_1, t_2). \tag{7}$$

The following subsections will include a detailed analysis of this methodology, a discussion about its possible misspecifications and an appropriate variation for the analysis I intend to carry out.

4.3 The Fama-French three-factor model

The market model described in subsection 4.2 is essentially a single-factor model. The purpose of such statistical models is to filter out as accurately as possible the variance not related to the examined event from the time series of the stock returns. The market model filters out the variance in returns due to the general market environment. However, in their study Fama and French (1993) identified additional factors that capture other components of the variance in stock returns. The authors looked for general risk factors and proxy variables that could explain differences in returns between companies with different characteristics. The two metrics, which according to Fama and French capture such general risk factors, are BE/ME (book-to-market value) and size (market capitalization). The Fama-French three-factor model is constructed as follows:

$$R_{it} = \alpha_{it} + \beta_1(R_{mt} - R_{ft}) + \beta_2 SMB_t + \beta_3 HML_t + \epsilon_{it}, \tag{8}$$

where R_{ft} is the risk-free return at time t, SMB_t is the excess returns of companies with small market capitalization compared to companies with a large market capitalization, HML_t is the excess returns of companies with a high BE/ME ratio compared to companies with a low BE/ME ratio, $R_{mt} - R_{ft}$ is the market portfolio's excess return over risk-free investments (similar to the market index used in the market model).

High BE/ME value, i.e. low stock price compared to book value and lower market capitalization are all risk factors that cause investors to expect higher returns on their investment in shares, so these factors are suitable for capturing variance beyond what is caused by the market environment factor in the time series of stock returns. (All the data on the right side of the regression equation are available on Professor Kenneth French's website.)

King (1966) found that movements in the prices of NYSE-listed company shares can be divided into two components: a market component and an industry component. The latter statement is sufficiently intuitive: in the case of companies operating in the same sector, investors can value or judge certain events and changes in the market environment similarly across all companies. This, in turn, means that if I were to not address minor or large co-movements of oil and gas company stock prices, the test statistics would be biased.

4.4 Time series and OLS

As Fama (1970) writes, the previous efficient market hypotheses suggested that the efficiency in the markets leads to an assumption that successive returns are independently identically distributed, which means that price developments are stochastic process in which the current price is the function of the price in the previous period and the realization of a white noise process in the current period, mathematically described:

$$p_t = p_{t-1} + u_t. \tag{9}$$

In the book of Kirchgässner, Wolters and Hassler (2012), one can read up on this non-stationary stochastic process called a random walk. In the case of econometric time series, it is common to use the concept of weak stationarity instead of strong stationarity. A stochastic process is weakly stationary if it is stationary in both its mean and covariance, meaning that the expected value of the process is time-independent and constant, and that the covariance between the past values of the process depends only on the length of the interval between the two values, independent of the dates themselves. From the latter assumption follows stationary variance, which means that the variance of the stochastic process is time-independent, finite and constant. The white noise process is a special case of stationary stochastic processes, its mean is zero and its covariance between all t and s time periods is zero where t $\neq$ s. The process in equation (9) is not stationary. If the process is rewritten as $\sum_{t=1}^{t} u_t$, it is evident that its expected value is the sum of the expected values of each independent u_t term, which is naturally zero, but its variance is $t\sigma^2$ and its covariance is min $min(t, s)\sigma^2$, so the time-independent covariance and variance conditions are not met.

The work of Granger and Newbold (1974) highlighted the problem of spurious regressions in the case of non-stationary time series, for which the simultaneous appearance of a high R^2 and low Durbin-Watson indicators (i.e. significant primary autocorrelation) is a telltale sign. The reason for such spurious regressions is that, for example, in the case of two independently generated random walk processes, the remaining term of their linear combination is still a random walk (this means a first-order autocorrelation in the error term). This serious error, which contradicts OLS assumptions, results in test statistics with different distributions from what was assumed for their estimates, which makes R^2 values that are merely coincidentally higher than zero appear significant when they are not. The solution to this can be to free the time series from stochastic trends by differentiation, that is, in the case of a y_t process, with the transformation $y_t - y_{t-1}$. In the case of equation (9), this would mean that the transformed process is merely white noise, which can no longer be modeled with its own past values. If differencing once can make a time series stationary, the original process is said to be integrated of order one (Kirchgässner, Wolters and Hassler (2012)).

The intuitive explanation of Granger and Newbold (1974) for why it is appropriate to continue with a time series OLS after performing the differentiation for stationarity follows from this: a time series to be predicted has two components, one that can be explained by the past behavior of the time series, and one that cannot. It is only necessary to collect additional information for prediction in case of the latter component, for example, in the form of another time series.

It can be observed that the OLS regression on the log returns of shares with other time series (described in the Fama-French three-factor model section) follows the exact logic just described. It is easy to see that the logarithmized transformation of the stock prices and portfolio prices once differentiated is the time series of the log returns.

$$ln(p_t) - ln(p_{t-1}) = ln\left(\frac{p_t}{p_{t-1}}\right) = ln(r_t). \tag{10}$$

If the random walk theory, or a similar one (which does not assume white noise process for the stationary component) is appropriate for describing the price generating process of stocks, for example:

$$p_t = \delta + p_{t-1} + x_t, \tag{11}$$

where δ is a fixed constant and x_t is a weakly stationary process, then differentiation results in a stationary time series. This is another convenient reason for the use of log returns, since with such a transformation we have good reason to believe that our time series to be regressed are stationary, so we can avoid spurious regressions and models that are poorly specified. By removing the non-stationary component from the time series, we can search for information outside the time series to explain their evolution.

The assumptions of time series OLS regressions are similar to the model assumptions of cross-sectional OLS regressions, but due to the fundamentally different nature of time series samples, it is important to properly specify them.

(1) Linearity: the stochastic process follows a linear model

(2) No exact multicollinearity: explanatory variables are not linear combinations of each other and not constant

(3) Strict exogeneity: the mean value of the error term is zero and independent of every explanatory variable

(4) Homoscedasticity: the variance of the error term is constant and independent of all explanatory variables

(5) No autocorrelation: the error term is not correlated with its past values conditional on the explanatory variables (Wooldridge (2012)).

If the first three conditions are met, the OLS estimates are unbiased. In addition, if all five conditions are met, the estimates are efficient. The normality of the error term is not a condition for unbiasedness or efficiency, but it is necessary for the normal distribution of the estimates (MacKinlay (1997)), which in turn is necessary for the proper distribution of test statistics carried out during the event study, so we assume that the following assumption also stands:

(6) Normality of the error term: the conditional distribution of the error term is normal with zero mean and given variance.

The following subsection briefly reviews the literature on the specification problems of event studies, and the procedures that may be suitable for dealing with these misspecifications.

4.5 Model specification issues in the event study methodology

4.5.1 Literature of managing model specification issues in event studies

Event study methodology is used to examine the impact of (mostly) unexpected events on a selected group of stock returns. MacKinlay (1997) takes the mean and standard deviation of abnormal returns of different companies during a given event and uses a statistical test to see if the mean is significantly different from zero – if so, the event has an impact on the market and stock returns. However, the test can only be carried out in this form if the abnormal returns of different companies during the period are independent of each other and follow the same distribution.

Binder (1998) describes that often these necessary conditions are not met. His paper raises four problems where the statistical test outlined by MacKinlay (1997) is poorly specified. First, it is important to note that when looking at events on the same day or in periods of close proximity, due to small but existing co-movements between abnormal returns of different companies, the assumption of independence is incorrect, and consequently it is not possible to determine the standard deviation of abnormal returns from either the cross-sectional data or the estimation intervals demonstrated by MacKinlay (1997) by assuming that covariances between returns are zero. Co-movements between abnormal returns can further increase due to companies operating in the same or related sectors (King (1966)). In addition to the assumption of independence, the assumption of the same distribution of abnormal returns is unrealistic, the standard deviation of abnormal returns can vary from company to company. Binder (1998) mentions the autocorrelation of abnormal returns as a third possible problem (which is a model construction error), and the fourth problem is the increase of the variance of the error term generated by the event in abnormal returns.

Patell (1976) standardized abnormal returns with the standard error of the estimate (adjusted to include the error in the forecast for the event window) to solve the problem of abnormal returns with different standard deviations, and thus avoiding outliers and values of a couple of companies distorting the results. However, Patell's procedure did not solve the problems caused by the increase in variance generated by the event and the co-movements of abnormal returns between companies.

Boehmer, Masumeci and Poulsen (1991)) attempted to eliminate the sensitivity of the Patell test to the variance increase generated by the event, combining the use of standardized abnormal returns with the estimation of their standard deviation from cross-sectional values – the statistical test thus no longer assumes that the standard deviation before the event window matches the standard deviation during the event window, but it remains important that the abnormal returns of companies come from the same distribution, thus, the test implicitly requires that if there is an increase in variance during an event, then it be proportionate for all companies. Their method is called the standardized cross-sectional procedure or the BMP test, which does not correct for the co-movements of abnormal returns between companies.

Kolari and Pynnonen (2010) supplemented the BMP test by taking into account the co-movements of abnormal returns between companies, without which the standard deviation estimates would be biased and underestimated in the event of positive co-movements, which means that tests for the mean of abnormal returns would reject the null hypothesis too often, not in proportion to the nominal significance level. The impact of events that are not significant will be considered to be so too often. Kolari and Pynnönen assume that the variance of standardized abnormal returns is the same among companies (σ_A^2). Let the covariance between companies i and j be indicated by σ_{ij}. The variance of the mean of the standardized abnormal returns of the n companies at time t is the following:

$$\sigma_{\bar{A}}^2 = \frac{1}{n} * \sigma_A^2 + \frac{1}{n^2} \sum_{j=1}^{n} \sum_{j \neq i} \sigma_{ij}. \tag{12}$$

Since $\sigma_i^2 = \sigma_j^2 = \sigma_A^2$, covariances can be rewritten as: $\sigma_{ij} = \sigma_i * \sigma_j * \rho_{ij} = \sigma_A^2 * \rho_{ij}$, where ρ_{ij} is the correlation between the abnormal returns of companies i and j. Equation (12) can thus be changed to the following form:

$$\sigma_{\bar{A}}^2 = \frac{\sigma_A^2}{n} * (1 + (n-1) * \bar{\rho}). \tag{13}$$

where $\bar{\rho}$ is the average correlation of abnormal returns.

Since in my research I examine the market of American oil and gas companies, and I choose my companies from this population, it is reasonable to assume that correlation between abnormal returns is, on average, positive. If I did not adjust the standard deviation used for test statistics with the average correlation, the tests would too often reject the null hypothesis. I estimate average correlation from the estimation window, so in my research I assume that abnormal returns correlate with each other to the same extent during the event window as they do in the estimation window.

The ADJ-BMP test statistic of Kolari and Pynnönen can be written as follows:

$$Z_{AB} = \frac{\bar{A}\sqrt{n}}{s} * \sqrt{\frac{1-\bar{r}}{1+(n-1)\bar{r}}}. \tag{14}$$

where s is the standard deviation estimated from the cross-section of abnormal returns and $\bar{r}$ is the average correlation of abnormal returns in the sample estimated from the estimation window. Although this procedure corrects for the correlation between abnormal returns in the test statistic, the authors obtained the best results in simulations when models filtered out as much of the common variance as possible from abnormal returns, meaning that Fama-French three-factor models (sometimes adding an industry index as well) that modeled other risk factors compared to a market model were deemed preferable. The correction term in equation (14) is the same for test statistics for cumulative abnormal returns.

Of the four major problems mentioned by Binder (1998) which require changes to the basic event study methodology, correlations between abnormal returns, the increased variance of abnormal returns during the event, and the different standard deviations of abnormal returns by company are controlled for using the ADJ-BMP test statistic. However, the autocorrelation in abnormal returns is not explicitly addressed with this test, so I examined the extent of this problem during model diagnostics, the results of which can be found in section 10.B of the Appendix.

The literature empirically confirms the presence of other problems such as the non-normal distribution of abnormal returns. Coutts and Mills (1995) also point out that the desired normal distribution of OLS estimates is manipulated by the non-normal distribution of the error term, and in their study they find that deviations from the normal distribution are most pronounced in the scale parameters (excess kurtosis). They add that in such cases, OLS estimates are extremely sensitive to outliers. (I will therefore use outlier filtering techniques when I carry out my analysis.) Brown and Warner (1985) also note this problem, adding that when examining cross-sectional average abnormal returns, this deviation from the normal distribution is less prominent and can be improved by increasing the sample.

4.5.2 Overview of related event studies controlling for misspecifications

In the third chapter I already presented the studies of Pham et al. (2019) and Dordi and Weber (2019) and mentioned their used methodologies as they were particularly relevant to the divestment phenomenon and long-term stranding risks, and now I shall briefly summarize the procedures of two other studies that explicitly deal with event study misspecifications.

White (1996) examined returns differences related to Brown, Oatmeal and Green ESG classifications for six companies. After the Exxon Valdez oil spill in 1989, the Coalition for Environmentally Responsible Economies (CERES), a non-profit group, created the Valdez Principles, which included a range of sustainable corporate governance values. These were signed by six companies, and these events of signings were examined by White. In his study, he found that higher returns were achieved by companies whose ratings were "Green" during the event. In terms of methodology, White standardized his abnormal returns like Patell (1976), used a BMP test to control for variance increases during the event, and used the market model as a benchmark, the parameters of which he estimated by OLS.

Ramiah, Martin and Moosa (2013) examined the Australian market's reactions to the 1997 Kyoto Protocol, the announcement of a proposal to reduce Australia's CO_2 emissions and other green government packages. In their study, they used a CAPM model to estimate daily abnormal returns which were aggregated by industry, and then tested their significance with a standard t-statistic. Instead of estimating returns out-of-sample, the estimation interval was extended to the event window, with dummy variables and interaction variables measuring the effects of news. They did not attempt to eliminate misspecifications by standardizing abnormal returns or using modified test statistics, but rather validated their results with non-parametric tests. Ten industries were found to have significant negative reactions to green government policies, including the oil and gas sector and mining. However, in their research, they also discovered that in the long run, companies in the energy sector did not see a decrease in company value, suggesting that these companies could pass on the financial burden of tightening environmental regulations to consumers.

Both studies are similar to my own work in certain methodological elements. I will standardize my data as White does and use a version of the BMP-test, and I will conduct industry-level analysis similar to Ramiah, Martin and Moosa (2013).

5 Event study conducted in the American oil and gas industry

In order to resolve the shareholder-stakeholder conflict and to examine the threat of investment-related activism and stranded assets, I have chosen events for my analysis that can lead to meaningful findings regarding each of these problems.

The events examined in my research are summarized below:

Event	Event type	Date
Deepwater Horizon (British Petrol) catastrophe	[Industrial disaster]	2010.04.20
Kalamazoo river oil spill	[Industrial disaster]	2010.07.26
Climate Action Plan (Pres. Obama)	[Government regulation]	2013.06.25
Rockefeller Fund fossil fuel divestment announcement	[Activism]	2014.09.22
Paris Climate Agreement	[International agreement]	2015.12.14
US signs the Paris Climate Agreement	[International agreement]	2016.04.22
Green New Deal (unrealized)	[Government regulation]	2019.02.07
UN Climate Action Summit 2019	[International agreement]	2019.09.23

Table 1: Table of events analyzed during the study.
Own construction.

I grouped the eight events into four categories: industrial disasters, government regulations, international agreements and activism.

The data required for the analysis was downloaded from Thomson Reuters Eikon and Professor French's website. Regarding the companies selected to be in my sample, I chose companies in the oil and gas industry (TRBC rating) whose shares are issued in the US and traded in dollar currency on the New York Stock Exchange. I downloaded the daily prices under "Ordinary Shares" for each company and trading volumes between 01.01.2010 and 31.12.2019, and ESG ratings of companies by year. I downloaded the stock prices of a total of 128 companies (subsection 10.C Appendix), but I was only able to include in the analysis those companies that had available ESG ratings in the year of the given event (so there will not be a uniform number of companies at every event in subsequent investigations). The ESG classification ranges from D to A, but as there were too few companies in each group for meaningful statistical testing, I compressed these into three groups, category 1 for the best ESG performers (A, A, B+B), category 2 for those with poor ESG performance (D+, D, D-). The third group thus implicitly includes medium-performing companies.

I standardized abnormal returns as discussed when showing Patell's (1976) work. Data cleansing was conducted using R. I previously discussed the importance of managing outliers before the analysis, and I now present the practical process of this. I found the extreme values with the help of examining the interquartile ranges. Values that were more than one and a half times the interquartile spread smaller than the first quartile and those that were more than one and a half times the interquartile spread greater than the third quartile were treated as outliers and replaced by the lower and upper limits used to identify them. This was necessary because observations cannot be freely removed from the data series in the case of time series. However, this filtering method may distort the sample if many values need to be replaced this way, so subsection 10A of the Appendix contains the average ratio of the values cleaned in such a way by event, as well as the median, minimum and maximum ratio among the time series (so as to see whether any one time series was severely distorted by the process). No red flags appear based on these results. Companies whose returns time series could not be satisfactorily modeled by the Fama-French three-factor model (R^2 smaller than 0.3) were removed from the sample for that event. The effects of this cleansing on sample size are also set out in subsection 10A of the Appendix. For estimation, I created windows of 70 days. The event window started four days before the event and ended three days after it.

6 Empirical results

I divided this chapter on the results into three subsections. The first subsection contains results obtained using the Fama-French three-factor model, discussing abnormal returns on the day of the event, as well as cumulative abnormal returns before and after the event. The second subsection contains the introduction of the only significant event, the Green New Deal, so that one can better understand why this unexpected proposal is likely to have had such an impact on the markets. In the third subsection, I present the results obtained by the ESG-based breakdown.

6.1 Abnormal returns and cumulative abnormal returns results

Table 2 contains all the important data on abnormal returns generated on the day of the events that is needed for calculation of the BMP test statistic modified by Kolari and Pynnonen (2010), i.e. the average correlation, the cross-sectional average of the abnormal returns on the day of the event, as well as the test statistic and the p-value.

	average correlation	**AR average (0)**	**ADJ-BMP**	**p-value**
Deepwater Horizon	0.2568	0.8228	1.5442	0.1225
Kalamazoo River oil spill	0.1858	-0.2754	-0.8077	0.4193
Climate Action Plan	0.2130	-0.1719	-0.3977	0.6909
Rockefeller Fund divestment	0.3748	-0.3910	-0.6555	0.5121
Paris Climate Accords	0.3208	0.1210	0.1172	0.9067
USA signing Paris Accords	0.2703	0.1556	-0.5564	0.5779
Green New Deal	**0.2887**	**-1.0769**	**-1.9911**	**0.0465**
UN Climate Action Summit	0.2839	0.0823	0.1614	0.8718

Table 2: Average correlation, average of the abnormal returns, ADJ-BMP and p-value, day of the event.
Own construction.

At a 5% significance level, with the exception of the announcement of the Green New Deal draft by progressive Democratic members of Congress and the Senate, we can consider the impact of all events on the U.S. oil and gas industry to be insignificant.

	CAR (-4 , -1)	**ADJ-BMP**	**p-value**	**CAR (1 , 3)**	**ADJ-BMP**	**p-value**
Deepwater Horizon	0.7070	0.8223	0.4109	0.6952	0.7630	0.4455
Kalamazoo River spill	-0.5930	-0.4727	0.6364	-0.2769	-0.2610	0.7941
Climate Action Plan	-0.5816	-0.5971	0.5505	-0.9910	-1.1613	0.2455
Rockefeller Fund divestment	-1.7534	-1.4850	0.1375	1.1935	1.1843	0.2363
Paris Climate Accords	0,9726	0,9399	0,3473	-2,2625	-1,3604	0,1737
USA signing Paris Accords	0.3659	0.4407	0.6594	-0.0967	-0.1384	0.8899
Green New Deal	-0.0266	-0.0312	0.9751	0.3789	0.3317	0.7401
UN Climate Action Summit	-0.0185	-0.0210	0.9833	-1.2058	-0.9460	0.3441

Table 3: Average, ADJ-BMP and p-value of cumulative abnormal returns on the (-4,-1) and (1,3) intervals.
Own construction.

The cumulative abnormal returns on the interval (-4,-1) provide a way to examine which events were expected by the market and what these expectations were, and cumulative abnormal returns on the interval (1,3) summarize the effects after the events. The averages of abnormal and cumulative abnormal returns characterize the direction and extent of market movements, which, if significantly different from zero, carry information on whether the market had positive or negative expectations regarding the investment climate affected by the event.

The results are not entirely surprising. Industry co-movements were not negligible in our case, and although we corrected for them in the used test statistic, Kolari and Pynnonen (2010) also found in their research that if this relationship is not particularly weak, it can reduce the power of the tests. In their study, they proposed the use of a fourth, industry index in the event study regarding companies in the same industry, which filters out the common variance from the time series of returns, thereby significantly reducing the average correlation. However, what we gain from this procedure may be lost in the event window, where this index also reacts to the change that has occurred, our abnormal returns may therefore fall below the threshold of significant movement, since the estimated returns tracked part of the market movements caused by the event. The use of this fourth index is analyzed in later robustness tests.

Why were most events insignificant in terms of abnormal returns? The answer should be divided into parts. First, why are most government regulations and international agreements insignificant in terms of effects? Probably because these events are not particularly unexpected by the market, creation of their framework and their implementation take several months or years, so the official date of becoming binding or the announcement is not necessarily the time the market becomes aware of these events. On this basis, we could say that the market is well informed on the activities of regulators. The reason I assumed that some significance could be demonstrated in such events was because during important regulatory milestones such as legislations coming into effect or signing of international accords, the news cycle picks up on these events and by doing so makes sure that a large number of (potential) investors hear about an event at the same time relevant to their investments, and I hoped to showcase this movement. However, if the market is efficient, publicly available news will be incorporated into stock prices and returns, so investors who had not heard of the Paris Climate Agreement or President Obama's environmental regulatory plans before their effective signing or introduction could still be informed by the prices and trade accordingly long before the announcements. These insignificant results around regulation can therefore be looked at as confirmation of the effectiveness of the market if one prefers.

The fact that industrial disasters did not have a significant impact on the market is, in fact, surprising because all these events damaged the position of competitors in the sector, so it would not have been unrealistic to expect, on average, the returns of other companies in the sector to rise. That didn't happen. The effect was not negative and significant, indicating that investors do not consider the environmental destruction caused by a company in their sector as risky for their own investments, nor do they link these events. The Rockefeller Brothers Fund's divestment announcement was probably not significant because there simply isn't an investment player big enough to move the market with similar decisions on its own. Until the investment environment changes, such a decision by a player will have no impact on the sector. If we want to draw far-reaching conclusions from these results, we could also say that the only force capable of diverting the market from investing in pollution-heavy, unsustainable sectors is an ambitious and drastic regulatory path, as the one set out in the Green New Deal. The latter was the event that can be considered significant, so in the next subsection I will present this legislative package proposal in more detail.

6.2 The Green New Deal and its implications for oil and gas industry companies

When the Green New Deal proposal was released, it was a surprise in the United States and internationally, so in the days after its announcement it became part of the news cycle. Although politically speaking, it had little chance of being passed in the then Republican-controlled Senate, it may have signaled to the market the possibility of the extent of regulatory vehemence in the coming years and decades and thus have led investors to view a sector that would presumably be heavily exposed to these types of regulations as less profitable. The insignificance of cumulative abnormal returns before and after the event shows that investors did not expect the draft to be announced nor did they find the negative swing on the day of the event to be an overreaction to which it is appropriate to responded with adjustment.

The Green New Deal combined two progressive policies to create a package of proposals: decarbonizing the U.S. economy by 2030 and drastically reducing economic inequality (Galvin and Healy (2020)).

In the preamble of the proposal presented on 7 February 2019 to Congress, Congresswoman Alexandria Ocasio-Cortez and Senator Edward J. Markey discussed at length the responsibility of the United States for drastic amounts of CO_2 emissions, the consequences of exceeding 1.5°C average temperature increase relative to pre-industrial times, the likely costs of the damage caused by a 2°C average temperature increase and the demographic effects of an unsustainable environment (Green New Deal (2019)). The proposal identified it as the U.S. Federal Government's duty to achieve net-zero greenhouse gas emissions, to invest in sustainable infrastructure and industry, to provide clean water and air to all its citizens, and to create climate-resilient communities and provide a sustainable environment within 10 years (by 2029). An important point in the proposal was the complete reform of the U.S. energy supply system, which would have required 100% sustainable, renewable and zero-emission energy to meet energy demand within 10 years.

The aim of the proposal was not merely to make polluting industries, including oil and gas companies, pay the price of emissions, but rather to ensure that within ten years there would be no demand for these companies' goods in the United States at all. It is no wonder, then, that such an ambitious or aggressive package had a significant impact on the fossil fuel companies examined.

6.3 The valuation of good ESG-performance in the markets

Table 3 shows abnormal returns of companies with good and bad ESG performance on the day of the event. In theory, the reason for the insignificant abnormal and cumulative abnormal returns presented in Tables 2 and 3 could have been due to the two groups moving in the opposite direction with the same intensity, so that the average of their returns is around zero, but looking at the third table we know that this is not the case, at least not in the case of ESG breakdown.

We see that where Tables 2 and 3 showed no significant movements on the day of the event, the same is shown in Table 4, grouped by ESG. However, in the case of the Green New Deal, we see that the test statistic of companies with a good ESG score is not significant, but the negative test statistic of companies with a bad ESG score is negative and significant. This is the phenomenon I have hypothesized about in the beginning of this paper: there exists such a news that makes the market value unsustainable companies more poorly than sustainable ones, even if all of these companies are in a fundamentally pollution-heavy industry.

	Good ESG		Bad ESG	
	ADJ-BMP	**p-value**	**p-value**	**ADJ-BMP**
Deepwater Horizon	1,6366	0,1017	0,3526	0,9295
Kalamazoo River spill	0,0691	0,9449	0,5980	-0,5273
Climate Action Plan	-0,4303	0,6670	0,8257	-0,2202
Rockefeller Fund divestment	-0,6002	0,5484	0,6419	-0,4650
Paris Climate Accords	0,3597	0,7191	0,8814	0,1492
US signing Paris Accords	0,2250	0,8220	0,9321	0,0851
Green New Deal	-1,3661	0,1719	**0,0299**	**-2,1720**
UN Climate Action Summit	-0,3965	0,6918	0,4127	0,8192

Table 4: ADJ-BMP and p-value of abnormal returns by ESG-performance.
Own construction.

Since out of all the examined events only one had a significant negative effect, I was only able to examine this ESG-based reaction difference once, and for this reason no far-reaching conclusion can yet be drawn. It makes the analysis difficult that the regulatory desire for sustainability legislation in the United States is clearly not yet strong enough for there to be sufficiently many similar announcements the impacts of which could be examined. However, the results are encouraging in terms of the effectiveness of regulation proposals, in contrast with market activism, international climate agreements and industrial disasters.

7 Robustness checks, model diagnostics

In the last methodological chapter of this paper, I examine the credibility of my results. First, I briefly discuss the results of the model diagnostics, which confirm that there are no systemic specification problems in my event study. I then show through the results of the unadjusted BMP test that it is extremely important to take into account the co-movements of the abnormal returns across companies, otherwise our tests become unreliable. In the last subsection, I present the results of the Fama-French three-factor model expanded with the industry index. Due to the difference between these results and the results obtained using the traditional Fama-French three-factor model, I confirm my original results by examining the behavior of the oil and gas index itself around the events in question.

7.1 Model diagnostics regarding the Fama-French three-factor model

It is important to say a few words about the empirical usefulness of the Fama-French three-factor model.

For each event, I reached the final group of companies included in the sample as follows: first, I selected those companies from the 128 I downloaded that had stock prices and volume data available during the event, as well as three days after and seventy-four days before (I did not use volume data for other purposes, but companies that have available volume data are more likely to have reliable price data due to regular trading, there is no thin trading issue). Outlier filtering was performed using the interquartile "clipping" method outlined in previous chapters. Subsection 10.A of the Appendix contains a table showing the effects of outlier filtering. The first column contains the ratio of models with an R^2 of 0.3 or greater among all regressions before outlier filtering, the second to fifth columns show the average, median, minimum and maximum ratio (respectively) of outlier observations in the time series, and the sixth column shows the ratio of models with an R^2 of 0.3 or greater after filtering outlier data. After the outliers were treated, the number of regressions with adequate explanatory power increased for each event, and this was achieved with the median of the ratio of filtered observations per time series not exceeding 3%, therefore no significant distortion happened during the filtering. The final sample of companies at each event was created by removing regressions with an R^2 of less than 0.3 even after the outlier filtering because the predictive power of these models was too weak and so I could not have used it to accurately forecast expected returns.

Subsection 10.B of the Appendix contains a table summarizing model diagnostics. In previous chapters I outlined the model assumptions of time series OLS, and in Table 10.B I summarized the results of the model diagnostics carried out on error terms, which support the adequacy of the models used.

Specifically, I examined the rate at which three error term assumptions were met among all regressions. The assumption of error terms without autocorrelation was inspected using the Breusch-Godfrey test, the assumption of normally distributed error terms by using the Pearson test and the Shapiro-Wilk test, and the assumption of homoscedastic error terms by using the Breusch-Pagan and White tests. It is very important to note that these results are merely an indication of general model quality, I did not select the time series included in the study by them because of the increased probability of a type-I error due to multiple hypothesis testing. For each event and assumption, a high ratio of regressions meet the conditions at a 5% significance level, so there is no systemic specification problem for any event.

7.2 Results of the BMP-test not adjusted for cross-correlation

The correlation-adjusted BMP test was only significant on the day of the event for the Green New Deal announcement, and cumulative abnormal returns were not significant for any of the events. To examine the robustness of my results to cross-correlation, I also performed unadjusted BMP tests and results are shown in the following two tables.

	Average AR	**BMP**	**p-value**
Deepwater Horizon	0,8227628	**6,7248**	**0,0000**
Kalamazoo River spill	-0,2754257	**-3,0478**	**0,0023**
Climate Action Plan	-0,171925	-1,5984	0,1099
Rockefeller Fund divestment	-0,3909905	**-3,0734**	**0,0021**
Paris Climate Accords	0,1209527	0,6645	0,5063
US signing Paris Accords	0,1555836	**2,8476**	**0,0044**
Green New Deal	-1,05532	**-11,9754**	**0,0000**
UN Climate Action Summit	0,08232909	0,9450	0,3446

Table 5: Average of abnormal returns, BMP test statistic not adjusted for cross-correlation, p-value.
Own construction.

The results show that ignoring correlation between the returns of companies operating in the same industry results in tests being much more likely to reject the null hypothesis of the average abnormal return being zero on the day of the event. This makes events appear significant when they are not.

This is particularly evident in cumulative abnormal returns where none are significant for any event with the correlation-adjusted test, while for the unadjusted BMP statistic, the periods before and after most events appear to be significant.

	CAR (-4, -1)	BMP	p-value	CAR (1, 3)	BMP	p-value
Deepwater	**0,7070**	**3,5808**	**0,0003**	**0,6952**	**3,3227**	**0,0009**
Kalamazoo	-0,5930	-1,7838	0,0745	-0,2769	-0,9848	0,3247
CAP	**-0,5816**	**-2,3998**	**0,0164**	**-0,9910**	**-4,6675**	**0,0000**
RFD	**-1,7534**	**-6,9625**	**0,0000**	**1,1935**	**5,5527**	**0,0000**
PCA	**0,9726**	**5,3310**	**0,0000**	**-2,2625**	**-7,7166**	**0,0000**
US PCA	**0,3659**	**2,2553**	**0,0241**	-0,0967	-0,7084	0,4787
GND	**-0,0266**	**-0,1614**	**0,8718**	0,3789	2,1540	0,0312
UN CAS	-0,0185	-0,1228	0,9023	**-1,2058**	**-5,5402**	**0,0000**

Table 6: Average of cumulative abnormal returns, BMP test statistic not adjusted for cross-correlation, p-value. Own construction.

7.3 Fama-French factor model supplemented with an industry index

Although the test statistics presented in Table 2 are adjusted, the relatively high average correlation makes the power of the test lower than what it could be (Kolari and Pynnonen (2010)). Therefore, while examining the robustness of my results, I tried a model based on the Fama-French three-factor model, but expanded the regression with an oil industry index, similar to what was described in the paper of Kolari and Pynnonen (2010). (I downloaded this data from Professor Kenneth French's website, like the other explanatory variables.) The reason for my doing this lies in the results of King's (1966) study, which found that the two main explainable components of corporate returns are the market environment and the industry environment. My expectation was that the returns of an oil index could account for the industry environment, thus reducing the average correlation between abnormal returns of companies. This assumption proved to be undoubtedly true, as can be seen in the second column of Table 7: compared to the data in the second table, the average correlation was significantly reduced for each event.

Interesting results are produced by the application of the new model. The Green New Deal, which proved to be significant in the case of the traditional Fama-French three-factor model and reported negative average abnormal returns, no longer appears to be significant for a model with an industry index. In contrast, two events that did not have a significant effect in our traditional model produced on average positive, significant abnormal returns according to the extended model.

I did not apply the industry index-expanded model in the main part of my research because, firstly, the relevant literature has not yet shown convincing simulations on the effectiveness of its application, and secondly, it can be intuitively understood that if the industry index itself reacts to the given event which we assume affects at least some of the companies within the industry, then the actual abnormal returns are masked by the fact that the movement of the index tracks the movement of returns and forecasts some of that abnormal movement as "expected". It is true, however, that the procedure significantly reduced the average correlation between the abnormal returns of the companies, which may have increased the strength of the tests, but a tradeoff occurs: the power of the test is increased at the cost of "masking" some of the actual abnormal returns.

	Avg. correlation	Average of AR	ADJ-BMP	p-value
Deepwater	0,0703	0,5602	1,8048	0,0711
Kalamazoo	0,0581	-0,2035	-0,9784	0,3279
CAP	0,0626	-0,0743	-0,2889	0,7726
RFD	**0,0949**	**0,7423**	**2,0446**	**0,0409**
PCA	0,1110	0,2972	0,4556	0,6487
US PCA	**0,0857**	**0,3620**	**2,1305**	**0,0331**
GND	0,0537	-0,3812	-1,5903	0,1118
UN CAS	0,0767	0,3366	1,2028	0,2291

Table 7: Average cross-correlation, average of abnormal returns, ADJ-BMP test statistic and p-value for Fama-French three-factor model with industry index.
Own construction.

The cumulative abnormal returns in Table 8 still show no significance at any traditional level for the new procedure, so the fact that there were no meaningful market movements before and after the events has not been contradicted.

	CAR (-4, -1)	ADJ-BMP	p-value	CAR (1, 3)	BMP	p-value
Deepwater	0,5886	1,2215	0,2219	1,0499	1,9447	0,0518
Kalamazoo	-0,9966	-1,2835	0,1993	-0,0531	-0,0810	0,9355
CAP	0,1487	0,2496	0,8029	-0,0725	-0,1417	0,8873
RFD	-0,4051	-0,5730	0,5666	0,4278	0,7648	0,4444
PCA	0,3874	0,5957	0,5514	-1,4517	-1,4664	0,1425
US PCA	0,2155	0,4218	0,6731	-0,2131	-0,5168	0,6053
GND	-0,1223	-0,3058	0,7597	0,5055	0,9244	0,3553
UN CAS	-0,0334	-0,0653	0,9480	-0,2503	-0,3905	0,6962

Table 8: Average of cumulative abnormal returns, ADJ-BMP test statistic and p-value for Fama-French three-factor model with industry index.
Own construction.

There are three events that I considered important to examine further due to the results of the Fama-French three-factor model supplemented by an industry index. These are the Rockefeller Fund divestment announcement, the day the Paris Climate Agreement was signed by the US, and the announcement of the Green New Deal proposal. In the six figures below (two figures per event), the actual returns of the industry index and its excess market return-estimated counterparts are plotted before, during and after the event, as well as histograms of the standardized abnormal returns of the estimation window, and plotted on the same histograms are the abnormal returns generated on the day of the event. The following reason was behind the procedure: Jaffe (1974) and Mandelker (1974) eliminated the correlation between abnormal returns of companies by grouping the companies into portfolios and examining significant deviations in the abnormal returns of these portfolios from zero. The oil industry index I used was produced according to the same principle by Professor French. Therefore, if this index produces significant abnormal returns around events then we have found somewhat informal but useful evidence to confirm (or disprove) the results of our parametric tests. In the time series figures, I marked the index's market returns estimates in red, the index's actual returns in blue, and the vertical gray lines represent the end of the estimation window (day -4) and the day of the event (day 0).

Figure 1: The oil and gas industry index (blue), index estimated by the market index (red) around the Rockefeller Fund divestment.
Own construction.

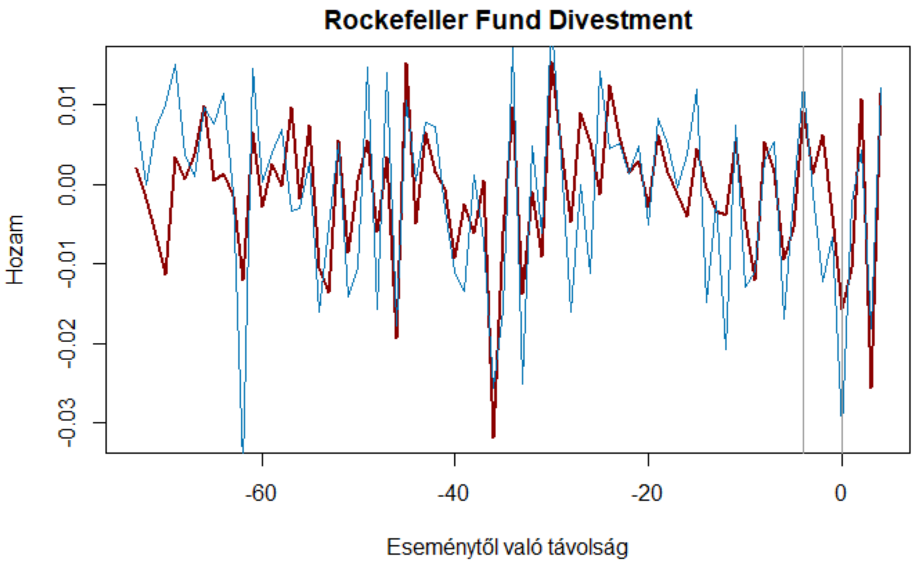
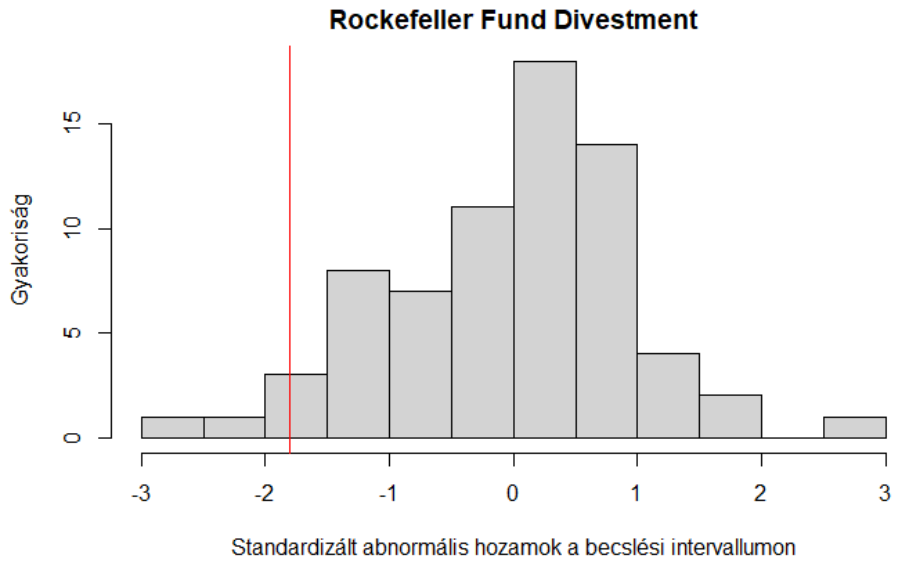


Figure 1 shows that the Rockefeller Fund's divestment announcement produced negative returns, and with the market model this movement was underestimated, so the abnormal return is therefore necessarily negative. The oil industry index compiled by Professor French does not include the exact same companies that my sample for this event does, so it is not inconceivable that the average abnormal returns of the latter are positive and significant, but based on this analysis the industry-expanded model-provided result does not seem to be credible from which the overall reaction of the industry can be judged.

Figure 2: Histogram of the abnormal returns of the industry index during the estimation window, event day abnormal return (red line) Rockefeller Fund divestment. Own construction.



This can be further confirmed by Figure 2, which shows where the abnormal return generated on the day of the event would be located in the distribution of the abnormal returns from the estimation window if a similar distribution was assumed for both. The value falls on the edge of the negative range, a relatively rare value, so it can be assumed that a significant positive abnormal movement, as indicated by the results of the extended model presented in Table 7, did not happen in general.

We examine the other two events in question in a similar way.

Figure 3: The oil and gas industry index (blue), index estimated by the market index (red) around the US signing of the Paris Climate Agreement.
Own construction.

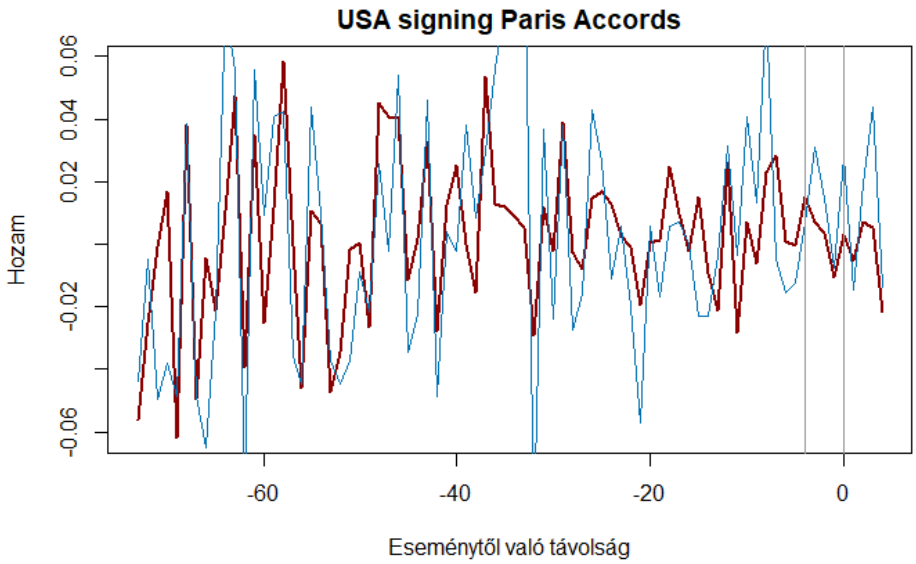
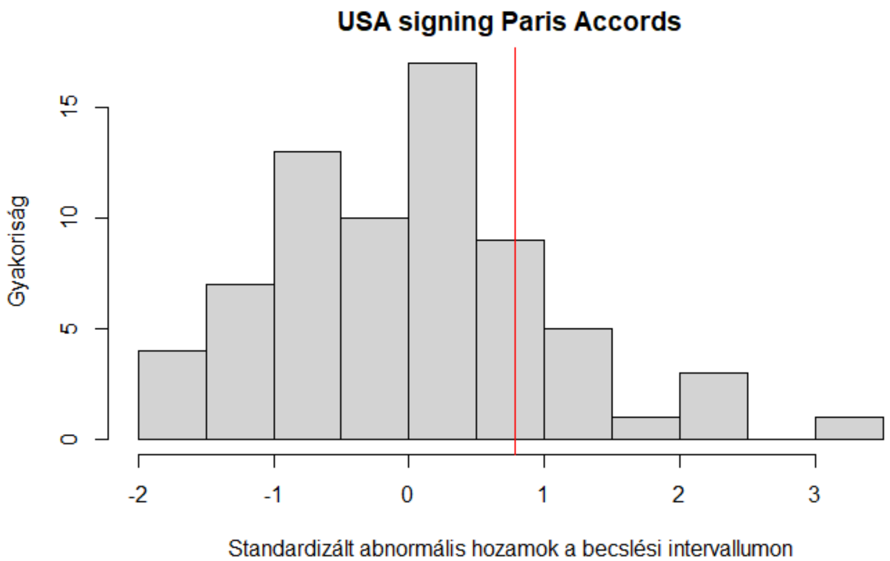
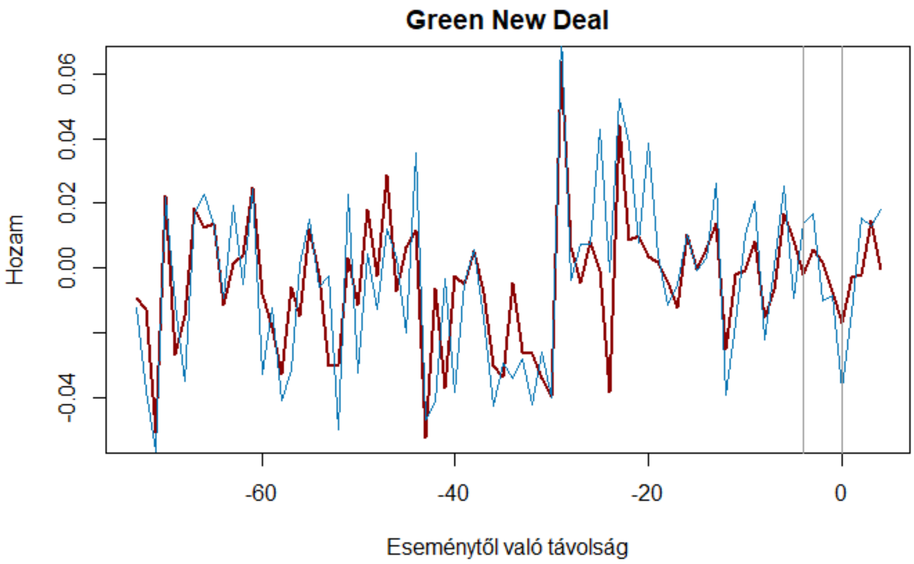


Figure 4: Histogram of the abnormal returns of the industry index during the estimation window, event day abnormal return (red line) US signing of the Paris Climate Agreement.
Own construction.



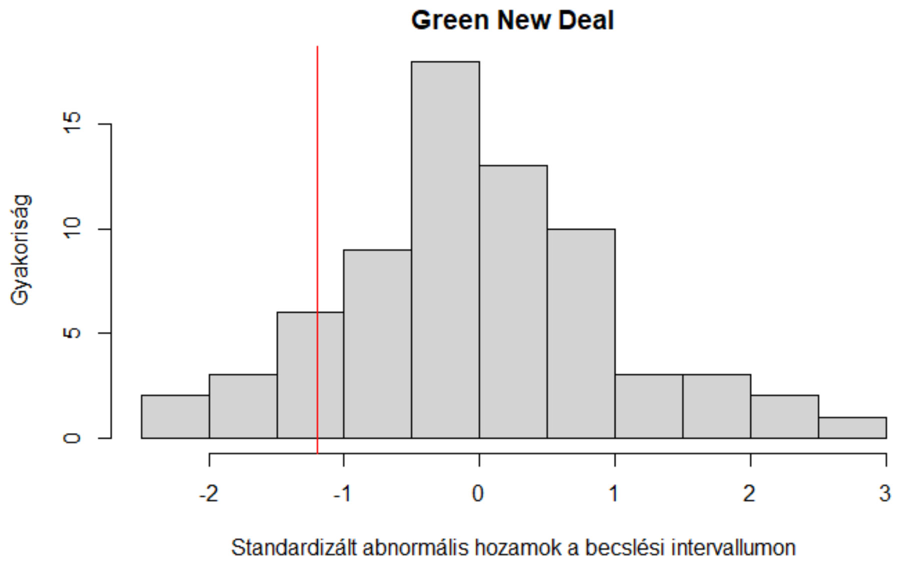
In Figures 3 and 4, we can indeed see positive abnormal returns for the index, but both its value and its location on the histogram suggest that this value should not be significant, as it is neither too large nor too rare compared to the estimation window. Again, the results of the industry index-expanded model do not seem credible based on these results.

Figure 5: The oil and gas industry index (blue), index estimated by the market index (red) around the Green New Deal announcement.
Own construction.



When the Green New Deal proposal was announced, the return on the index was strongly negative, which is still underestimated using the market return, and the histogram shows that the value of the abnormal return is rare compared to the values in the estimation period. Based on these results, the test statistic calculated from the estimates provided by the original Fama-French three-factor model, according to which the Green New Deal announcement resulted in significant negative abnormal returns in the industry, can be characterized as credible.

Figure 6: Histogram of the abnormal returns of the industry index during the estimation window, event day abnormal return (red line) Green New Deal.
Own construction.



8 Conclusion

The fossil fuel industry is at risk of long-term financial risks. The problem of stranded assets, the source of which is growing competition from sustainable and clean energy sources, is a rising concern for the industry. Divestment announcements resulting from more prevalent activism and expectations of future environmental regulations which reduce the value of companies in the industry are also sources of concern for fossil fuel companies.

In the current environment, it is possible for investors to begin to value sustainable investments more, either for financial reasons or for altruism. If the market and investors start to see financial value in sustainable corporate governance and in company decision-making that takes into account the interests and rights of a wide range of stakeholders, a long corporate ethics debate could come to an end. If the shareholder and stakeholder views come to the same conclusion due to ethical management becoming important to the investors themselves, major changes can be made to transform the economy in a more sustainable image. The rise of sustainability evaluation in recent years has led to the development of ESG indicators, which measure the impact a company has on its social and natural environment.

In this paper it was my aim to show empirical evidence for the existence of implicit ethical expectations from the market regarding the management of businesses. My task was to prove with data that it is worthwhile for companies to show a good ESG performance, even in highly polluting industries, because the market will reward the long-term financial security that comes with such behavior.

I discussed the methodology of event studies, the advantages of using log returns for the time series regressions, the importance of using factor models instead of the simple market model, and the importance of adjusting test statistics with average cross-correlation because of within-industry co-movements. I also briefly summarized the fundamental conditions of efficient markets that need to be met to be able to use the event study methodology. During the examinations of robustness, I demonstrated that my procedures, such as the Fama-French three-factor model and the use of log returns are compatible with time series OLS, where error terms have the appropriate properties. I also showed the consequences of not adjusting correlation across corporate abnormal returns when using statistical tests. I examined the results of a Fama-French three-factor model with an industry index but found that although this procedure reduces the correlation between corporate abnormal returns, it does more harm than good, and if we are particularly concerned about the specification problems arising from correlation, it may be useful to examine the behavior of industry indices separately to confirm our results.

Results show that only unexpected, large-scale, highly publicized announcements like the Green New Deal resulted in significant abnormal returns on the day of the announcement. In the case of the Green New Deal, it is also clear that after the event, oil and gas companies with good ESG performance were rated as bad investments to a lesser extent by the market than their ESG-wise ill-performing counterparts. From this one can draw conclusions that may not be surprising but have nonetheless serious implications. Investment attitudes are not deterred by climate agreements where incompliance is hard to sanction, nor by market divestment activism, nor by industrial disasters. The only real change is brought about by legislative packages that propose to fundamentally change the investment environment and make sustainable corporate governance the more profitable option. This could be an incentive for future environmental regulations. Nevertheless, I cannot say that I managed to present conclusive evidence regarding the profitability of being "green" in the oil and gas sector, as there is only one significant event based on my results; but in that case all my hypotheses have been fulfilled: the news had a negative impact on abnormal returns on the day of the announcement, which was not adjusted for in the following days by the market, and investors valued companies with good ESG performance differently from the other companies.

Over the past ten years, climate change and the protection of the environment have become a priority to an unprecedented extent, which may have fundamentally transformed investor behavior between 2010 and 2019, so it is possible that trends such as those closer to 2019 will appear in markets in the future, increasing the value of good ESG performance. It is therefore important to further examine future divestment news and the effects of new environmental regulations. In addition, an interesting further research topic could be to examine specifically the impact of ESG valuation announcements on corporate value, which can serve as direct evidence of the way in which markets price sustainable corporate governance.

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Appendix

10A. Outlier filtering results (Fama-French three-factor model)

	R2 >0.3 before outlier filtering	Avg. ratio of outliers	Median ratio of outliers	Min. of ratio of outliers	Max. of ratio of outliers	R2 >0.3 after outlier filtering
Deepwater	0,8197	0,0328	0,0286	0,0000	0,1571	0,8548
Kalamazoo	0,9516	0,0375	0,0286	0,0000	0,1429	0,9524
CAP	0,7397	0,0342	0,0286	0,0000	0,3571	0,7703
RFD	0,3333	0,0347	0,0286	0,0000	0,3429	0,4390
PCA	0,7470	0,0293	0,0143	0,0000	0,1714	0,7976
US PCA	0,7976	0,0304	0,0214	0,0000	0,2571	0,8118
GND	0,7748	0,0263	0,0143	0,0000	0,1000	0,8214
UN CAS	0,6930	0,0399	0,0286	0,0000	0,1364	0,7391

10B. Model diagnostics (Fama-French three-factor model)

	Number of comp. after R2 filtering	Ratio of time series with unautocorrelated error term (Breusch-Godfrey test)	Ratio of time series with normally distributed error term (Pearson test)	Ratio of time series with normally distributed error term (Shapiro-Wilk test)	Ratio of time series with homoscedastic error term (Breusch-Pagan test)	Ratio of time series with homoscedastic error term (White test)
Deepwater	52	0,9808	0,9038	0,8654	0,9615	0,9615
Kalamazoo	58	0,9483	0,8793	0,7241	0,9828	0,9655
CAP	56	0,9107	0,9464	0,8571	0,9643	0,9821
RFD	35	0,9714	0,9429	0,8286	1,0000	1,0000
PCA	66	0,9394	0,8788	0,8182	0,9394	0,9545
USA PCA	68	0,9412	0,9559	0,8529	0,9706	0,9265
GND	91	0,8791	0,9121	0,8462	0,9560	0,9341
UN CAS	84	0,9286	0,9524	0,8571	0,8929	0,8571

10C. List of oil and gas companies

Name	Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8
AE.N	0	0	0	0	0	0	0	0
AM.N	0	0	0	0	0	0	0	1
AMPY.N	0	0	0	0	0	0	0	0
APA.N	1	1	0	0	1	1	1	1
AR.N	0	0	0	0	0	0	1	1
AROC.N	1	1	1	0	1	1	1	1
BCEI.N	0	0	1	0	1	1	1	1

BKR.N	1	1	1	1	1	1	1	0
BRN.N	0	0	0	0	0	0	0	0
CEI.N	0	0	0	0	0	0	0	0
CHAP.N	0	0	0	0	0	0	0	1
CHK.N	1	1	1	0	1	1	1	1
CKH.N	0	1	1	1	1	1	1	1
CLR.N	1	1	1	1	1	1	1	1
CNX.N	1	1	0	1	1	1	1	1
COG.N	1	1	1	0	0	0	0	0
COP.N	1	1	1	1	1	1	1	1
CPE.N	0	1	0	1	0	1	1	1
CRC.N	0	0	0	0	1	1	1	1
CRK.N	1	1	0	0	0	0	1	0
CVI.N	0	1	1	0	1	1	1	0
CVX.N	1	1	1	1	1	1	1	1
CXO.N	1	1	0	0	1	1	1	1
DEN.N	0	0	0	0	0	0	0	0
DK.N	1	1	1	0	1	1	1	1
DNR.N	1	1	1	1	1	1	1	1
DRQ.N	1	1	1	0	1	1	1	1
DSSI.N	0	0	0	0	0	0	0	1
DVN.N	1	1	1	1	1	1	1	1
EGY.N	0	1	1	0	1	0	0	0
ENSV.N	0	0	0	0	0	0	0	0
EOG.N	1	1	1	1	1	1	1	1
EPM.N	0	0	0	0	0	0	1	0
EQT.N	1	1	1	0	1	0	0	1
ESTE.N	0	0	0	0	0	0	1	1
ETRN.N	0	0	0	0	0	0	0	1
EXTN.N	0	0	0	0	0	1	1	1
FET.N	0	0	0	1	1	1	1	1
FTK.N	0	1	1	1	0	1	0	0
FTSI.N	0	0	0	0	0	0	1	1
GBR.N	0	0	0	0	0	0	0	0
GDP.N	0	0	0	0	0	0	0	0
HAL.N	1	1	1	1	1	1	1	1

HES.N	1	1	1	1	1	1	1	1
HESM.N	0	0	0	0	0	0	0	0
HFC.N	1	1	0	0	1	1	1	1
HLX.N	1	1	1	0	1	1	1	1
HP.N	1	1	1	1	1	1	1	1
HPR.N	1	1	1	1	1	1	1	0
HUSA.N	0	0	0	0	0	0	0	0
ICD.N	0	0	0	0	1	1	1	0
INSW.N	0	0	0	0	0	0	1	1
INT.N	1	1	1	1	1	1	1	1
IO.N	1	1	1	0	0	1	0	1
KMI.N	0	0	1	1	1	1	1	1
KOS.N	0	0	0	0	1	1	1	0
LBRT.N	0	0	0	0	0	0	1	1
LLEX.N	0	0	0	0	0	0	0	0
LNG.N	0	0	0	0	0	0	1	1
LPG.N	0	0	0	0	1	1	1	0
LPI.N	0	0	1	1	1	1	1	1
MCF.N	0	0	0	0	0	0	0	0
MG.N	0	1	0	1	1	0	0	1
MGY.N	0	0	0	0	0	0	1	1
MNRL.N	0	0	0	0	0	0	0	1
MPC.N	0	0	1	0	1	1	1	1
MRO.N	1	1	1	1	1	1	1	1
MTDR.N	0	0	1	1	1	1	1	1
MTR.N	0	0	0	0	0	0	0	0
MUR.N	1	1	1	1	1	1	1	1
MUSA.N	0	0	0	0	1	0	1	0
MXC.N	0	0	0	0	0	0	0	0
NES.N	0	0	0	0	0	0	0	0
NEX.N	0	0	0	0	0	0	1	1
NGS.N	1	1	1	0	1	1	1	1
NINE.N	0	0	0	0	0	0	1	1
NOG.N	0	0	0	0	0	0	1	0
NOV.N	1	1	1	1	1	1	1	1
NR.N	1	1	1	1	1	1	1	1

OII.N	1	1	1	1	1	1	1	1
OIS.N	1	1	0	0	1	1	1	1
OKE.N	1	1	1	1	1	1	1	1
OSG.N	0	0	0	0	0	0	1	0
OVV.N	1	1	0	0	1	1	1	1
OXY.N	1	1	1	0	1	1	1	0
PAGP.N	0	0	0	0	0	1	1	1
PARR.N	0	0	0	0	0	0	0	0
PBF.N	0	0	0	0	0	1	1	1
PE.N	0	0	0	0	1	0	1	1
PED.N	0	0	0	0	0	0	0	0
PHX.N	1	1	1	0	1	1	1	1
PSX.N	0	0	1	1	1	1	1	1
PUMP.N	0	0	0	0	0	0	1	1
PXD.N	1	1	1	0	1	1	1	1
QEP.N	0	0	1	1	1	1	1	1
QES.N	0	0	0	0	0	0	1	0
REI.N	0	0	0	0	0	0	1	0
RES.N	1	1	0	1	1	1	1	0
RNGR.N	0	0	0	0	0	0	0	0
RRC.N	1	1	1	0	0	1	1	1
SBOW.N	0	0	0	0	0	0	0	1
SD.N	0	0	0	0	0	0	1	1
SDPI.N	0	0	0	0	0	0	0	0
SLB.N	1	1	1	0	1	1	1	1
SM.N	1	1	1	0	1	1	1	1
SMHI.N	0	0	0	0	0	0	0	1
SOI.N	0	0	0	0	0	0	1	1
SPN.N	1	1	1	1	1	1	1	0
SWN.N	1	1	1	0	0	0	1	1
TALO.N	0	0	0	0	0	0	1	1
TAT.N	0	0	0	0	0	0	0	0
TDW.N	1	1	1	0	1	0	1	1
TGC.N	0	0	0	0	0	0	0	0
TPL.N	0	0	0	0	0	0	0	0
TRGP.N	0	0	1	0	0	1	1	1

TTI.N	1	1	1	1	1	1	1	1
UNT.N	1	1	1	1	1	1	1	1
VLO.N	1	1	1	0	1	1	1	1
WHD.N	0	0	0	0	0	0	1	1
WLL.N	1	1	1	0	1	1	1	1
WMB.N	1	1	0	0	1	1	1	0
WPX.N	0	0	1	0	1	1	1	1
WTI.N	1	1	1	0	1	1	1	1
WTTR.N	0	0	0	0	0	0	1	1
XEC.N	1	1	1	1	1	1	1	1
XOM.N	1	1	1	1	1	1	1	1