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How the European Union's Renewable Energy Directives Impact the Global Energy Industry

Evidence from Global Stock Markets

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Abstract

This thesis investigates the impact of renewable energy regulations imposed by the European Union on the energy industry. By employing an event study methodology on three directives dating from 2007 to 2018; The Renewable Energy Directive (2009/28/EC), The Indirect Land Usage Change Directive (2015/1513) and the Renewable Energy Directive II (2018/2001/EU); on a sample of 75 firms, consisting of 30 fossil fuel and 45 renewable energy firms from the regions Europe, North America and Asia-Pacific. An abnormal return is estimated for each company at the time of introduction of the three different directives. The results show significant positive abnormal returns for the energy industry with the introduction of the Renewable Energy Directive.

Furthermore, the results show a significant difference between the fossil fuel segment and the renewable energy segment, with positive returns for renewable energy firms, while fossil fuel firms show weak adverse effects. There is no significant impact from the Indirect Land Usage Change Directive, as well as the Renewable Energy Directive II. Finally, there is weak evidence for a difference between regions with the introduction of the Renewable Energy Directive. However, when controlling for additional variables under the regression analysis, the significant effect disappears. This suggests that the regions react similarly to the introduction of renewable energy directives proposed and passed by the European Union.

Preface

This thesis is written as a concluding work of the Master of Science in Economics and Business Administration at the Norwegian School of Economics (NHH) and marks the end of two challenging and educational years.

First and foremost, we would like to thank our supervisor, Dr Tzu-Ting Chiu, for her invaluable guidance and insights throughout the process. Furthermore, we would like to thank PhD candidate David Ogudugu for assisting with the technicalities of the thesis as well as being available for ideas and discussion.

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1. Introduction

The climate is rapidly changing, and the effects of climate change are becoming more apparent. To keep the world below the two-degree Celsius scenario, one estimate suggests it will require an investment into renewable energy of $12 trillion over the next 25 years, equivalent to an increase in yearly investments of $208 billion (BNEF, 2015). To reach these levels, governments across the world must, through regulations and directives, make investing in renewable energy more attractive. On January 23rd, 2008, the European Union (EU) proposed a directive to achieve this: The Renewable Energy Directive (RED). Its purpose was to establish an overall policy for the production and promotion of renewable energy sources and set the ambitious goal demanding the EU to fulfil at least 20% of its total energy needs with renewables by 2020. Since then, two additional directives have been introduced to assist, guide and further the requirements set in RED: The Indirect Land Usage Change (ILUC) Directive and the Renewable Energy Directive II (RED II).

The purpose of this study is to see whether such regulatory changes influence financial markets and investors' decisions when investing in the energy industry. Fama (1970) argues that if markets are semi-strong efficient, prices of securities should efficiently and accurately reflect all public relevant information. This suggests that the introduction of new regulatory changes affecting specific industries, or companies, should be accurately reflected in the stock price of companies. The approach used in this thesis to measure the effect of the three mentioned directives is to analyse the stock returns of companies in the energy industry. If investors believe these regulatory changes are impactful, an increase should be observed in the value of renewable energy firms, similarly a decrease in the value of fossil fuel firms.

To measure the effect of the directives, abnormal returns are estimated for a sample of firms within the energy industry, based on the multi-factor model. The sample is divided into two segments: the fossil fuel segment and the renewable energy segment. The abnormal returns are tested for the energy industry and segments, as well as the difference between segments. Furthermore, the sample is divided into three regions: North America, Europe and Asia-Pacific. The differences between the regions are tested. Furthermore, a regression analysis, including firm-specific control variables, dummies for the directives and the local exchange rate relative to the US dollar, is conducted. Additionally, the regression is run using the fixed effects model to control for firm-specific fixed effects.

The thesis contributes to different topics; firstly, it provides to the research on the effect of green regulatory changes. As the results indicate, the renewable energy segment shows significant positive abnormal returns with the introduction of new regulatory changes. Secondly, the thesis contributes to the research on climate risk premiums in financial markets. The findings show that there are weak negative effects on the fossil fuel segment with the introduction of the RED. A possible reason could be that investors, in recent years, demand a higher climate risk premium when investing in fossil fuel firms.

1.1 The European Union’s Renewable Energy Directives

The European Union’s renewable directives establish a comprehensive policy framework to facilitate the transition from fossil fuel towards renewable energy. The three major directives that have been implemented between 2007 and 2018 are introduced in the following sections.

1.1.1 Renewable Energy Directive (2009/28/EC)

The 23rd of April 2009, the EU’s Renewable Energy Directive was passed. The directive establishes an overall policy for the production and promotion of energy from renewable sources consumed in the EU. The main targets of RED are 20% greenhouse gases (GHG) emission reduction and that renewables should cover 20% of the EU's total energy needs. This target was previously 12%. Moreover, members of the EU must also ensure that at least 10% of fuels consumed in transport comes from renewable sources by 2020 (EU, 2019). The directive entered into force on the 26th of June 2009.

1.1.2 Indirect Land Usage Change Directive (2015/1513)

The RED promotes the use of biofuels in the EU, and the purpose is to reduce GHG emissions from the transport industry. However, it was discovered that not all biofuels were contributing to this goal, which is due to the issue of indirect land-usage change. Indirect land-usage changes occur when the cultivation of crops for biofuels displaces the traditional production of crops for food and feed purposes (EU, 2012). Moreover, the criteria for biofuels in the RED did not include estimates to account for the effect of indirect land-use changes (EU, 2015). To address this issue, the European Commission published a proposal for the ILUC directive.

The ILUC directive limited the maximum contribution of biofuels made from food and energy crops to 7% (T&E, 2019). The ILUC directive also shields already made investments up until

2020, which suggests that the proposed provisions should have little impact on today's use and demand for biofuels.

The directive addresses the production of biofuels and specifically food-based biofuels of agricultural origin that have considerable adverse effects, e.g. occupying land that could be used to produce food, destruction of biodiversity and eco-systems. An environmental issue caused by the production of biofuels was the displacement of existing agricultural activities, leading to unsustainable indirect land-usage change, consequently leading to significant emissions of GHG (Pavlovskaia, 2015).

1.1.3 The Renewable Energy Directive II (2018/2001/EU)

On the 30th of November 2016, the European Commission introduced a proposal to revise the RED. The RED II was passed in December 2018 and is part of the "clean energy for all Europeans package", which aims to maintain the EU as a global leader in renewables and to help towards the EU's emissions reduction requirements set in RED and commitments that were made under the Paris Agreement. The revision sets a new binding renewable energy requirement for the EU for 2030 of at least 32%. EU members are required to draft 10-year national energy & climate plans for 2021-2030, which establishes the framework on how EU members will meet the new 2030 targets (EU, 2019). Moreover, 'High-ILUC risk' biofuels will no longer be counted towards its 2030 renewable energy target. In other words, the proposal showed a willingness to move away from crop-based biofuels and towards more advanced biofuels. The significant changes brought by this proposal is categorised within the transport industry, heating and cooling industry, sustainability and GHG emissions-saving criteria for biofuels, bioliquids and biomass and financial schemes (European Union, 2018).

1.2 The Energy Industry

The energy industry consists of all companies related to the production and distribution of energy. The energy industry is driven by the worldwide supply and demand for energy consumption. As one of the larger industries in the world, the supply and demand for energy is affected by a variety of factors, such as weather forecasts, gas storage, financial speculation, and national and international regulations. The energy industry has experienced steady growth in worldwide demand over the last decades. Although the increase in demand in developed countries is expected to stagnate over the next 10-15 years (Marketline, 2018).

However, as demand for more expensive energy, such as renewable energy and demand for fossil fuel in developing countries, is increasing, the energy market value is expected to continue its increase (Marketline, 2018).

1.2.1 Fossil fuel

The fossil fuel industry consists of companies involved in the production and supply of oil, natural gas, and coal. The industry is defined as the total consumption of oil products and natural gas by end-users. The market for oil and gas has declined in value in recent years, which is due primarily to the significant decrease in the price of crude oil (Marketline, 2018).

Consumption levels in Europe have been slowing down in recent years, as improvements in fuel-efficient technology have been developed. A large part of European countries, such as France, the Netherlands, and Germany, have placed restrictions on fracking, consequently shutting down a section of the market. In other words, consumption levels in Europe have been unstable, especially as producers of renewable energy have increasingly taken importance in its power mix. In North America and Asia-Pacific, however, fracking has been encouraged by governments, to reduce their dependence on imported oil and gas (Marketline, 2018).

1.2.2 Renewable Energy

Renewable energy is becoming increasingly important due to the growing environmental issues caused by the consumption of fossil fuel. Renewable energy comes from natural sources or processes that are constantly replenished. Renewable energy sources are in general beyond humanity in duration but limited in the supply of energy that is available per unit of time (EIA, 2019). The renewable energy market is divided into six sections - hydroelectricity; wind energy; solar, tide and wave energy; electricity generated through biomass, waste and geothermal energy (Marketline, 2018). Due to the nature of the directives in the thesis, there is also made a distinction between biofuel and the rest of the renewable energy segment.

1.2.2.1 Biofuel

Biofuel is produced through biological processes, such as agriculture and anaerobic digestion, rather than fossil fuel that are provided by geological processes. It can be acquired directly from plants, agricultural, commercial, and industrial wastes (Marketwatch, 2019). Biofuels have been around longer than cars, but cheap gasoline and diesel have been preferred due to it being a very dense energy carrier. Volatile oil prices and efforts to counter the increasing climate change have paved the way for clean, renewable fuels.

Transportation today remains heavily reliant on fossil fuel and stands for 23% of the world's GHG emissions (IEA, 2017). Biofuel is supposed to replace fossil fuel, with those made from renewable plant material or other feedstock.

1.3 Hypotheses

With the introduction of RED and the requirements of achieving 20% energy consumption from renewable sources in the EU, there should be an increase in European demand for renewable energy; consequently, a reduction in the need for fossil fuel produced energy. However, as the energy industry is affected by world-wide demand, the introduction of the directives could influence the global energy industry. This is the foundation for the first research questions.

Hypothesis 1**:** *The energy industry is affected by the introduction of the European Union's renewable directives.*

Hypothesis 2A: *The fossil fuel segment is negatively affected by the introduction of the European Union's renewable energy directives.*

Hypothesis 2B**:** *The renewable energy segment is positively affected by the introduction of the European Union's renewable energy directives.*

Hypotheses 1, 2A and 2B aims to answer the question of whether the energy industry and each segment experiences abnormal returns with the introduction of renewable energy directives from the EU. Furthermore, hypothesis 2A and 2B seek to answer the question of whether there is any significant difference between the two segments. As the revision made in the ILUC directive only targets the renewable energy segment, more specifically biofuel firms, the effect from RED and RED II should have a more significant effect on the fossil fuel segment. Furthermore, the effects on the biofuel industry from the ILUC directive is expected to be limited, as investments that are already made are shielded until 2020.

Secondly, the thesis investigates how the introduction of green directives affect firms differently across regions. As the European Union introduces the directives, the European region could experience a more substantial effect from the directives than the other regions. Besides, firms in North America and Asia-Pacific are expected to be less affected due to the reluctance to embrace renewable energy by governments. However, as the energy market is affected by global demand, North America and Asia-Pacific should be impacted as well. Resulting in the following hypothesis:

Hypothesis 3: *There is a difference between the regions (Europe, North America and Asia-pacific) in the energy industry with the introduction of the European Union's renewable energy directives.*

2. Literature review

In this section, previous studies on how environmental concerns are reflected in financial markets and the market efficiency hypothesis is introduced. Additionally, the challenges related to multi-country event studies are discussed.

2.1 The Efficient Market Hypothesis

The Efficient Market Hypothesis, introduced by Fama (1970), is the theory that the value of a stock reflects all relevant available information in the market, making it impossible to have an edge. An efficient market is defined as a market where investors are trying to maximise their profits, and where relevant information is available to all participants. This competition leads to a situation where actual prices of individual securities already reflect the effects of information about events that have taken place, and events that the market expects will take place in the future (Szylar, 2014, pp. 31-33).

Fama defined three different strengths of market efficiency: weak-form, semi-strong form, and strong-form market efficiency. At its weakest form, the market efficiency states that historical prices and values cannot predict future prices. The semi-strong form describes that a market is efficient if all relevant publicly available information is quickly reflected in the market price. In its strongest form, the efficient market hypothesis suggests that a market is efficient if all relevant information to the value of a security, including inside information, is quickly and accurately included in the price of the security (Szylar, 2014, pp. 31-33). If the markets are semi-strong efficient, the regulatory change should be quickly and accurately reflected in the price of stocks when the regulatory change becomes public information.

2.2 Value of Corporate Social Responsibility

With an increased global focus on corporate sustainability, there have been numerous studies on how Environmental Social Governance (ESG) and Corporate Social Responsibility (CSR) affect firms. Taehyun & Yongjun (2019) investigates how ESG actions affect firms' values, by analysing how Supreme Court rulings that award broader regulatory authority to the U.S. Environmental Protection Agency increases the value of sustainable firms. The results indicate that green firms outperform more toxic firms, in terms of positive earnings surprises, higher revenue, and profitability, and receive more capital inflow from institutional investors with longer horizons, suggesting that firms gain value when going green.

Additional research has shown similar results. Flammer (2015) studies the effect on shareholder value when CSR proposals narrowly pass vs narrowly fails. The proposals are divided into social issues and environmental issues (e.g. the reduction of CO_2 emissions). The results show that narrowly passed CSR proposals yield abnormal returns of 0.009, and the implementation of a narrowly passed proposal increases shareholder value with 0.018. Similarly, Dimson, Karakaş, & Li (2018) show that positive abnormal returns follow successful engagements related to environmental, social and governance concerns. However, despite the increased research on whether CSR and ESG actions create shareholder value, there is only weak evidence that it does. This is consistent with Friedman's (1970) theory that a corporation’s only purpose is to maximise profits for its shareholders. Research has also shown that some CSR activities could be value-destroying and driven by manager entrenchment (Di Giuli & Kostovetsky, 2014); (Krüger, 2015); (Cheng, Hong, & Shue, 2013).

2.3 Climate risk

Climate risk has an increasing position in financial markets around the globe and has potentially significant effects on companies. Either through the increased costs from direct climate changes, such as extreme weather or the general rise in sea levels, alternatively, costs due to increased governmental regulations based on environmental concerns. Research has shown that institutional investors believe climate risks should be considered in their investment decisions. Krueger, Sautner, & Starks (2019) show that institutional investors believe climate risks have financial implications for their portfolio firms and that these risks already have started to materialise, particularly regulatory risks. The results also show that long-term institutional investors believe that risk management and engagement is a better approach for addressing climate risks instead of divesting. However, some institutional investors believe that climate risks are under-priced in equity markets and suggests that investors should operate with a higher climate risk premium (Ilhan, Krueger, Sautner, & Starks, 2019).

After 2015, fossil fuel firms that are significantly exposed to climate policy risks are charged a higher spread on their loans. This suggests that banks consider fossil fuel firms to be riskier than comparable firms (Delis, de Greiff, & Ongena, 2019). Furthermore, companies with higher CO_2 emissions earn higher returns, after controlling for size, book-to-market, momentum and other factors that predict returns. These results show that investors are demanding compensation for their exposure to carbon risk through a higher cost of capital, implying that investors do incorporate climate risks into their investment decisions (Bolton & Kacperczyk, 2019).

With these results in mind, investors clearly incorporate environmental concerns in their investment decisions. However, as some institutional investors believe that climate risks are under-priced in equity markets, relevant governmental change concerning environmental concerns should affect the prices of firms. In semi-strong efficient markets, these changes should be quickly and effectively reflected in the stock prices of the affected firms. Moreover, if regulatory changes do not have an impact on related firms, it could be evidence that the climate risk incorporated by investors in their investment decisions accounts for governmental regulation.

2.4 Valuation of intangibles

Further research has shown that investors have a pattern of under-reacting to relevant intangible assets. Edmans (2011) finds that equity markets do not fully value intangibles. Additional research has found similar results (Tetlock, 2010; Hirschey & Richardson, 2003). If regulatory changes are considered as intangible assets, and financial markets show similar inconsistency valuing the impact of regulatory changes, the study might not capture the stock market reaction, as the reaction happens later, outside the event window.

2.5 Measuring the effects of regulations with stock returns

Schwert (1981) suggests using asset prices to measure the impact of regulation on producer profits. He argues that financial data, such as the stock price, is a better indicator than accounting data. Accounting data is only updated a few times each year, through quarterly reports, while stock data provides daily observations. As a result of this, stock data might give more accurate and efficient results. Additionally, daily observations make it possible to isolate single company-specific events.

However, Binder (1985) argues that there are problems related to the use of stock data when testing the effects of regulations. Firstly, for many regulations, it is not known when expectations change, as events such as debates, discussions and votes could affect investors differently. Secondly, because of extensive negotiations between interest groups and regulators, the outcome of votes is likely to be known ahead of time, making it difficult to measure the effects of the result. Lastly, it is not guaranteed that a regulatory change is strictly positive or negative, as firms will likely be affected differently. Because of this, it might be difficult to measure any positive or negative effects on a market level.

2.5.1 Event study methods in multi-country settings

Most event studies over the last two decades published in management journals have analysed the financial implications of announcements in a single country. The main explanation for the lack of multi-country event studies is the assumption that financial markets are not integrated across countries and used the typical market model as a valid representation of stock returns for foreign countries (Lee, 1997; Seth, A; Song, KP; Pettit, RR, 2002).

Nonetheless, studies conducted in the 1970s identified international stock market movements to be a contributor on stock returns due to active international trade and foreign direct investments. This shows that stock returns for firms highly involved in international business can be measured using global capital asset pricing models (Agmon & Lessard, 1977; Lessard, 1974; Solnik, 1974). Given this, it might be problematic to apply the same market model used for a single-country event study, to multi-country studies, as it is likely to give biased results (Park, 2004). One way to solve this problem is to use international versions of the market model when investigating how environmental incidents affect firm value (Lundgren & Olsson, 2010; Park, 2004). Furthermore, selecting events in a multi-country study requires more caution as institutional environments of stock exchanges differ across countries (Park, 2004). This is especially relevant for North America and Asia-Pacific, as there are significant differences in time zones.

3. Event study methodology

In this chapter, the principles of the event study methodology applied in the thesis are presented. The framework attempts to measure the effect of news related to environmental regulatory changes made by the EU on firms operating in the global energy industry. When studying how an announcement or event affects security prices, the event study methodology has become the standard method of measurement. The analysis is divided into two main parts; event study analysis and a following regression analysis, based on the event study.

First, to control for outliers, the data is adjusted by standard winsorisation – changing the values of outliers, so they are closer to other values in the set (Hasting, Mosteller, Tukey, & Winsor, 1947). For the event study, abnormal returns for every observation i is estimated and aggregated across the entire sample. The abnormal returns are then tested to see if they are significantly different from zero. For the regression analysis, the cumulative abnormal returns for the directives are regressed on event-specific and company-specific variables.

3.1 Choice of method

Fama (1991) argues that event studies are *"the cleanest evidence we have on efficiency".* By using stock price data, an event study tries to measure the impact of an event on the value of a firm, or a portfolio of firms. Given efficient markets, the effects on stock prices should be reflected immediately after the release of new information (MacKinlay, 1997). Hence, by using the event study methodology, the economic impact of regulatory changes on firm value is measured. In previous studies, such as by Fama (1970), event studies' purpose was to test the market for semi-strong efficiency - *how swiftly stock prices would reflect new public information.*

Based on Mackinlay (1997) and Binder (1998), an event study with the following analysis is conducted:

- Definition of the event window
- Estimating normal returns
    - Definition of the estimation window
    - Choice of the estimation model
- Estimating abnormal returns

3.2 Defining events and periods

The first step would be to define events of interest and to identify the period over which one may look for a stock price reaction on the firms that are included in the event. For an event such as a merger or earnings announcement, there is a single event and thereby a unique and short event window (MacKinlay, 1997). For a regulatory change, the event window is not as concise. A regulatory change was at some point proposed, then debated, and finally adopted. The event window would thus include this entire period, consequently having multiple event periods.

For regulatory changes, it may be challenging to identify unanticipated event periods. Misplaced events can obscure the detection of abnormal returns. Furthermore, if the news is released continuously over an extended period, it would make it challenging to distinguish the abnormal returns from the market noise. If an event was fully anticipated, the event might be priced out. In conclusion, uncertainty about the event periods may lead to less powerful tests in rejecting the null hypothesis of no regulatory effects (Lamdin, 2001). According to Mackinlay (1997, p.37) *"In cases where the event date is difficult to identify, or the event date is partially anticipated, studies have been less useful"*. However, the European Union has a detailed overview of important dates where information was made public, for each directive. This overview clearly states the date of proposal, debate and final decision.

3.2.1 Timeline for an event study

The first step to establishing the event study timeline would be to define the events and identify the event period. This period, as specified by Mackinlay (1997), involves the estimation window and event window:

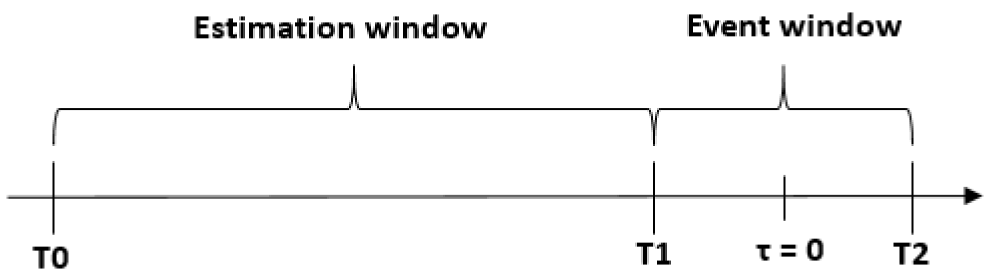

Figure 1. Timeline for an event study

Where,

- $\tau = 0\ (event\ date)$
- $T_0\ to\ T_1\ (estimation\ window)$
- $T_1\ to\ T_2\ (event\ window)$

With,

- $L_1\ = T_1 - T_0\ (length\ of\ estimation\ window)$
- $L_2 = T_2 - T_1\ (length\ of\ event\ window)$

The event and the estimation window should not overlap. Including the event in the estimation window could give the event returns a considerable influence on the normal return measure, to address this problem, a buffer window of two days is added. Moreover, even if the event in question is applicable for one specific date, it is reasonable to set the event window length larger than a single day (MacKinlay, 1997).

The event window is set to three days [-1, 1], the event date (0), one day before (-1) and one day after (1). The day before is to account for the price effect from potential insider trading. The day after is included to capture cases, where information about regulatory changes come just before or after the stock exchange, has closed. This also allows to account for the time difference between regions.

The estimation window length should be long enough to lower the variance of the daily returns to a minimum, and at the same time, short enough to include only the most recent price movement to avoid changes in systematic risk (Strong, 1992). MacKinlay (1997) suggests using a 120-day estimation window, but recent event studies have been around 200-500 days, depending on which data is used.

3.3 Estimating returns

Abnormal returns are defined in the literature as;

$$AR_{i,t} = R_{i,t} - E(R_{i,t}|X_t) \tag{1}$$

Where $R_{i,t}$ is the actual ex-post return and $E(R_{i,t}|X_t)$ is the expected return conditioned to the information X of period t, which is unrelated to the event. To estimate the normal return, there are different models. The most used are the constant mean return model, market model and multi-factor model (MacKinlay, 1997). The constant mean return model is the most basic and assumes that average returns are constant. The market model is based on the market return and is derived from the Capital Asset Pricing Model (CAPM).

Similar to the market model, the multi-factor model is derived from the CAPM but can be based on different factors, such as in this case, the oil price. The rationale behind using factor models is to reduce the variance of the abnormal return by explaining more of the variation on the normal return (MacKinlay, 1997). Like Sadorsky (2001), the multi-factor model is chosen to estimate abnormal returns, based on the market and the returns of crude WTI oil, following the equation;

$$E\left(R_{i,t}\middle|X_t\right) = \alpha_i + \sum_{K=1}^{K} \beta_{i,k} F_{k,t} + \varepsilon_{i,t} \tag{2}$$

Where,

- $E\left(R_{i,t}\middle|X_t\right) = expected\ return\ for\ stock\ i$
- $\alpha_i = \ constant\ term$
- $\beta_{i,k} = exposure\ of\ stock\ i\ to\ factor\ k$
- $F_{k,t} = factor\ k\ return\ value\ in\ period\ t$
- $K = number\ of\ factors$
- $\varepsilon_{i,t} = noise\ for\ stock\ i\ in\ period\ t, i.e. return\ that\ is\ not\ explained\ by\ the\ model$

The above parameters are determined through ordinary least square regression analysis. To use the multi-factor model, an estimation window is defined. The estimation window is the basis for estimating the expected normal returns $E\left(R_{i,t}\middle|X_t\right)$, β and $var\left(\varepsilon_{i,t}\right)$. From equation 1 and 2, the estimated abnormal return in the event window can be rewritten as;

$$\widehat{AR} = R_{i,t} - \widehat{\alpha_i} - \sum_{K=1}^{K} \hat{\beta}_{i,k} F_{k,t} \tag{3}$$

Where $\widehat{AR}$ is the estimated abnormal return and $R_{i,t}$ is the actual return. $\widehat{\alpha_i}$ and $\hat{\beta}_i$ are estimated through the multi-factor model, equation (2).

The variance for the abnormal returns is defined as:

$$\sigma^2\left(\widehat{AR}\right) = \sigma_{\varepsilon_i}^2 + \frac{1}{L_1}\left[1 + \frac{\sum_{K=1}^{K}(F_{k,t} - \hat{\mu}_k)^2}{\sigma_{fk}^2}\right] \quad (4)$$

Where,

$$\widehat{\alpha_\iota} = \hat{\mu}_i - \hat{\beta}_i\hat{\mu}_k \quad (5)$$

$$\hat{\mu}_i = \frac{1}{L_1}\sum_{t=T_0+1}^{T_1} R_{i,t} \quad (6)$$

$$\hat{\mu}_k = \frac{1}{L_1}\sum_{t=T_0+1}^{T_1} F_{k,t} \quad (7)$$

$$\hat{\beta}_i = \frac{\sum_{t=T_{0+1}}^{T_1}(R_{i,t} - \hat{\mu}_i)(F_{k,t} - \hat{\mu}_k)}{\sum_{t=T_0+1}^{T_1}(F_{k,t-}\ \hat{\mu}_k)^2} \quad (8)$$

From equation (4) the variance consists of two parts: the disturbance variance $\sigma_{\varepsilon_i}^2$ and variance from sampling error in the factor model. As mentioned, L_1 is the length of the estimation window and has been defined as $L_1 = (T_1 - T_0)$. By increasing L_1, the second term in the equation will go towards zero, consequently making the variance of the abnormal return closer to $\sigma_{\varepsilon_i}^2$, therefore;

$$\sigma^2\left(AR_{i,t}\right) \approx \sigma_{\varepsilon_i}^2 \quad (9)$$

To have a sufficiently large L_1, the estimation window is set to 250 days, which is approximately a year in terms of trading days.

3.3.1 Aggregation of abnormal returns

Once normal returns are computed, the abnormal returns can be obtained. When the goal is to estimate the impact of one event for each security i, the abnormal returns are found by applying equation (1). However, in this study there is a multi-day period; hence it becomes necessary to aggregate the abnormal returns, consequently obtaining the Cumulative Abnormal Returns (CARs) for security i from T_1 to T_2 as described in the equation;

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t} \tag{10}$$

Where $t_1 < t_2$ and $t_1, t_2 \epsilon$ (event window).

By increasing L_1 the variance and distribution of CAR are:

$$\sigma_i^2(t_1, t_2) = (t_2 - t_1 + 1)\sigma_{\varepsilon_i}^2 \qquad \widehat{CAR_i}(t_1, t_2) \sim N(0, \sigma_i^2(t_1, t_2))$$

Moreover, to assess and test the impact on a pool of firms, a cross-section aggregation is needed (Pacicco, Vena, & Venegoni, 2017). By testing only one event sample, it would be tough to draw any conclusions about the overall effect of the event. Therefore, the Average Abnormal Returns are estimated;

$$AAR_t = \frac{1}{N}\sum_{t=1}^{N} AR_{i,t} \tag{11}$$

For a sufficiently large L_1 the variance for AAR is;

$$\sigma^2(AAR_t) = \frac{1}{N^2}\sum_{t=1}^{N} \sigma_{\varepsilon_i}^2 \tag{12}$$

Finally, by analysing the average effect over multiple days, it is necessary to compute both aggregations shown above and the Cumulative Average Abnormal Returns (CAARs);

$$CAAR(t_1, t_2) = \sum_{t=t_1}^{t_2} \mathrm{AAR}_t \tag{13}$$

Where the variance for CAAR is:

$$\sigma^2(CAAR(t_1, t_2)) = \sum_{t=t_1}^{t_2} \sigma^2(AAR_t) \tag{14}$$

3.4 Cross-sectional analysis

For the second part of the analysis, a cross-sectional analysis based on the CARs is conducted, in order to test for interference between the CARs and firm-specific variables. These variables are the logarithmic value of market cap (ln Equity), book-to-market ratio (BM), debt-to-asset ratio (Debt) and the average local exchange rate (FXrate). Dummy variables are included for the directives and regions. The variables are explained more in detail under chapter 4. The CARs are aggregated for the three directives based on each company. In other words, if a company is listed for the entire event study timeline, there will be three CARs for that specific company. The standard errors for each company are made robust by clustering after tickers. For the main analysis, the coefficients are estimated through OLS for the following models:

$$(1)\quad CAR_{i,t} = \alpha + \beta_1 \ln(Equity)_{i,t} + \beta_2 BM_{i,t} + \beta_3 Debt_{i,t} + \beta_4 \overline{FXrate_{i,t}} + \sum Event + \varepsilon_{i,t}$$

$$(2)\quad CAR_{i,t} = \alpha + \beta_1 \ln(Equity)_{i,t} + \beta_2 BM_{i,t} + \beta_3 Debt_{i,t} + \beta_4 \overline{FXrate_{i,t}} + \sum Region + \varepsilon_{i,t}$$

In an additional analysis, chapter 5.4, the model is controlled for firm-specific fixed effects. Moreover, another regression based on the same variables is run, where differences between renewable energy companies and biofuel companies under the ILUC Directive are tested.

4. Data collection

In this chapter, the method and structure of the data collection process is described. The source of data on which the analysis is based and the motivation behind the selection of the different variables.

4.1 Data source

The daily stock prices from the companies along with the daily index prices, oil prices, exchange rates, and firm-specific effects are collected from Datastream. The final sample represents firms from three different regions: Europe, North America and Asia-Pacific (see table 4.5).

As previously mentioned, the multifactor model is employed on companies globally, and it is, therefore, appropriate to use different market indices when calculating abnormal returns - e.g. for a European company; an index that represents the European stock market is used. These indices are:

- STOXX Europe 600
- STOXX North America 600
- STOXX Asia/Pacific 600

The indices are reviewed quarterly and are weighted by free-float market cap. All the regional indices consist of a fixed number of 600 components, which include large, mid and small-cap companies across different industries (STOXX, 2019). The risk-free rate used to calculate excess returns is the one-month US Treasury bill rate, collected from Datastream.

The data collected on each firm is the daily adjusted stock returns for the period of the timeline. When deciding whether to use daily, weekly or monthly stock returns, there is a trade-off between reducing noise by using daily stock returns, vs the problem of misplacing events. As it is possible to place the event periods on one or more specific days, the use of daily stock returns is preferred (Lamdin, 2001).

4.2 Sample selection

To be able to measure the effectiveness of the directives on the two segments, the sample is divided into fossil fuel and renewable energy firms. For the primary analyses, these will be the main segments. A further distinction between biofuel companies and the rest of the renewable segment is made, as there might be a difference between biofuel companies and renewable energy companies with the introduction of the ILUC Directive. This is tested under chapter 5.4.

Table 4.1: Company sample

	Fossil fuel	Renewable Energy	Biofuel
Initial sample	50	75	80
Companies that are not publicly traded/OTC stocks	(13)	(24)	(49)
Companies not publicly traded for the entire event period	(5)	(16)*	(5)*
Companies that were delisted during the event period	-	(5)	(16)
Companies where revenues from the segment are less than 70%	-	(4)	(2)
Firm-specific confounding events	(2)	(6)	(4)
Final sample	30	36	9

* Included in the final sample

4.2.1 Fossil fuel companies

First, the 50 largest fossil fuel companies based on 2017 revenue were identified. Companies that were not publicly traded and became publicly listed after the first event date were excluded. This is done in order to achieve a balanced panel which makes the dataset more efficient.

4.2.2 Renewable energy companies

When identifying companies operating in the renewable energy industry, the sample is limited to firms operating with solar power, wind power or hydropower. As these are the three largest sources of global renewable energy. Companies within each category were identified. However, as there is a limited amount of renewable energy companies that have been publicly traded for the duration of the event timeline, the sample was expanded by including companies that became listed during the event timeline. The consequence of this is that the panel data set becomes unbalanced and may be less efficient. To avoid biased results, companies that had less than 70 % of their total revenues obtained from renewable sources were also excluded.

Furthermore, biofuel firms were included in the renewable energy segment, as it is expected that they would experience similar effects of RED and RED II. This is done because there is a limited number of firms operating in the biofuel industry, and most of them that do are either not publicly listed or are mainly engaged in other energy segments (e.g. fossil fuel). As with renewable energy companies, biofuel firms that were publicly listed later in the event timeline is included, to increase the sample size. Similarly, companies that are low-ILUC risk and those that are high-ILUC risk have been separated, as defined by the EU (European Commission, 2019). In the initial sample, only one high-ILUC risk company was identified; this company was removed from the sample.

4.3 Factor selection

4.3.1 Oil price

Other macro-economic factors such as inflation, interest rates, oil price, consumption and industry production have been investigated to measure their effect on stock returns (Chang, 1991; Chen, Roll, & Ross, 1986; Dumas & Solnik, 1993; Ferson & Harvey, 1994; Flannery, Hameed, & Harjes, 1997; Wasserfallen, 1989); only insignificant effects on stock returns have been found. Park (2004) therefore, suggests excluding them from the multi-factor model. However, as this thesis studies the impact on companies in the energy industry, the oil price is included in the model, as studies have shown the oil price and the value of oil companies to be correlated (Jones & Kaul, 1996; Manning, 1991; Sadorsky, 2001; Lanza, Matteo, Margherita, & Giovannini, 2003). Moreover, studies have suggested that oil price returns are a better predictor for explaining share returns than the dollar change (Jones & Kaul 1996;

Sadorsky 2001; Lanza Matteo, Margherita & Giovannini 2003). To avoid the problem of perfect collinearity with the event dummies in the regression analysis, the returns on the crude WTI oil is included when estimating abnormal returns.

4.3.2 Exchange rates

Studies have shown that foreign currency exchange rates have a significant and stable impact on stock returns (Bartov & Bodnar, 1994; Bodnar & Gentry, 1993; Darbar & Deb, 1997; Dumas & Solnik, 1993; Roll, 1992). Specifically, Roll (1992) found that nominal exchange rates could explain a significant amount of national index returns. Additionally, Bodnar & Gentry (1993) show that the impact of exchange rate movements on stock returns is significant. Therefore, foreign exchange rates for each firm is included as a control variable in the regression analysis.

4.3.3 Firm-specific effects

To control for firm-specific effects, three different control variables are included in the regression model: book/market-ratio, debt/asset-ratio and equity value. The book-to-market-ratio is found by dividing the book value of equity with the market value of equity; this is to control for growth. To control for the difference in debt, the debt-to-asset ratio is included; this is found by dividing total liabilities with total assets. Equity value is included to control for size and is considered not normally distributed and is therefore transformed to the logarithmic value of equity.

4.4 Events

From the start of the timeline, from 2008 until 2019, there have been three major directives; The Renewable Energy Directive, Indirect Land Usage Change Directive and Renewable Energy Directive II. The directives facilitate the transition away from fossil fuel towards cleaner energy and contribute to reducing GHG emissions.

The official EU website has a detailed overview of all relevant dates. The dates are categorised into three main groups: proposal, discussion and decision. These have been included in the analysis (see table 4.2-4.4).

4.4.1 Renewable Energy Directive

Table 4.2: Events for Renewable Energy Directive

No.	Date	Event
1	*21-Jan-08*	The first proposal for the Renewable Energy Directive.
2	*28-Feb-08*	Policy debate in the European Council on the energy package, focusing on the proposal for a directive on the promotion of the use of energy from renewable sources.
3	*05-Jun-08*	Discussions in the Council on the main aspects of the RED.
4	*17-Sep-08*	Opinion from the Economic and Social Committee on the proposal of the RED the Committee votes in favour 105 to 38.
5	*08-Oct-08*	Committee of Regions gives their opinion the RED.
6	*10-Oct-08*	The Council discusses the RED – No notable changes or agreements.
7	*20-Oct-08*	The council notes information from the Presidency on the main aspects of the RED.
8	*04-Dec-08*	Ministers discuss the RED informally. – No notable changes or agreements.
9	*17-Dec-08*	The Parliament approves the Commission's proposal as amended. Instructs its President to forward its position to the Council and the Commission.
10	*06-Apr-09*	The Council formally adopts the various legal acts configuring the RED.
11	*23-Apr-09*	Signature by the Presidents of the EP and Council.
12	*26-Jun-09*	The Renewable Energy Directive begins.

Source: Official Journal of the European Union

4.4.2 Indirect Land Usage Change Directive

Table 4.3: Events for ILUC Directive

No.	Date	Event
1	*17-Oct-12*	Proposal for a directive concerning Indirect Land Usage Change with the production of biofuels.
2	*17-Apr-13*	Economic and Social Committee opinion votes in favour of the proposal 146 votes to 26.
3	*11-Sep-13*	Parliament first reading of the proposal.
4	*13-Jun-14*	1st reading Council – Close to an agreement.
5	*28-Apr-15*	Agreement in the Parliament on new amendments.
6	*02-Jun-15*	Agreement in the Council and the Commission.
7	*17-Jun-15*	The Commission accepts amendments adopted by the Parliament.
8	*13-Jul-15*	The Council approves the amendments adopted by the Parliament and accepted by the Commission.
9	*09-sep-15*	The Presidents of the Parliament and the Council sings the proposal

Source: Official Journal of the European Union

4.4.3 Renewable Energy Directive II

Table 4.4: Events for Renewable Energy Directive II

No.	Date	Event
1	*30-Nov-16*	The proposal by the European Commission of a revised Renewable Energy Directive (RED II).
2	*26-Apr-17*	The European Economic and Social Committee welcomes the publication of the revised directive on the promotion of renewable energy sources.
3	*13-Jul-17*	European Committee of Regions suggests amendments to the directive.
4	*17-Jan-18*	The Parliament calls on the Commission to refer the matter to Parliament again if it replaces its proposal based on the Committee of regions proposals.
5	*13-Nov-18*	The Parliament agrees to the amendments made by the Commission. Instructs its President to forward its position to the Council
6	*04-Dec-18*	Council approves the proposal with 24 votes to one.
7	*11-Dec-18*	Signature by the Presidents of the Parliament and Council

Source: Official Journal of the European Union

4.5 Confounding events

There are some confounding events under RED and RED II:

RED:

- Event 5 (08.10.08): Global markets went significantly down; S&P fell 23.7% from 02.10-09.10 and fell 14.5% during the 3-day event window. The fossil fuel and the renewable energy segment experience significant abnormal returns of -7.8% and -11.6%, respectively.
- Event 7 (20.10.08): OPEC (Organisation of the Petroleum Exporting Countries) announces they will cut supply to inflate the oil prices, the fossil fuel segment experience significant abnormal returns of 7.2%.
- Event 9 (17.12.08): OPEC announces they will cut supply to inflate the oil prices, consequently leading to the abnormal returns in the oil segment of 5.8% that are significant on the 1% level. This event is the day where RED is first agreed upon between all member states; in other words, an essential date for RED. The renewable segment also has a return of 13.8% that is significant on the 1% level.

RED II:

- Event 1 (30.11.16): OPEC announces they will cut supply to inflate the oil prices, the fossil fuel segment experience significant abnormal returns.

Event 5 will be removed from any further analysis, as the significant fall in the market prices, could lead to biased results (see appendix, table 8.1 for results including event 5). The remaining events will be presented under the event-study analysis when comparing the fossil fuel and the renewable energy segment.

Moreover, future oil prices were used in order to control for the OPEC announcements, as this could be a better explanatory variable when estimating abnormal returns. However, the results remained similar (See appendix, table 8.2). Consequently, for the regression analysis, CARs for event 7 under RED and event 1 under RED II, will be excluded from the oil companies. These events are removed because there is no significant change to the directives on these dates. Event 9 will be included in both, as this is an essential date for RED.

4.6 Descriptive statistics

Table 4.5: Sample Distribution partitioned by regions, countries and segments

Region	Oil & Gas		Renewable		Total	
	N	%	N	%	N	%
North America	7	23.3 %	19	42.2 %	26	34.7 %
USA	6	20.0 %	17	37.8 %	23	30.7 %
Canada	1	3.3 %	2	4.4 %	3	4.0 %
Europe	13	43.3 %	16	35.6 %	29	38.7 %
Switzerland	-	-	1	2.2 %	1	1.3 %
Norway	1	3.3 %	1	2.2 %	2	2.7 %
Italy	1	3.3 %	1	2.2 %	2	2.7 %
France	2	6.7 %	1	2.2 %	3	4.0 %
England	2	6.7 %	2	4.4 %	4	5.3 %
Denmark	-	-	2	4.4 %	2	2.7 %
Spain	1	3.3 %	3	6.7 %	4	5.3 %
Germany	-	-	4	8.9 %	4	5.3 %
Poland	1	3.3 %	-	-	1	1.3 %
Austria	1	3.3 %	-	-	1	1.3 %
Hungary	1	3.3 %	-	-	1	1.3 %
Greece	2	6.7 %	1	2.2 %	3	4.0 %
Holland	1	3.3 %	-	-	1	1.3 %
Asia-Pacific	10	33.3 %	10	22.2 %	20	26.7 %
China	1	3.3 %	3	6.7 %	4	5.3 %
Hong Kong	-	-	1	2.2 %	1	1.3 %
Japan	-	-	1	2.2 %	1	1.3 %
Israel	-	-	1	2.2 %	1	1.3 %
New Z	-	-	1	2.2 %	1	1.3 %
Australia	-	-	2	4.4 %	2	2.7 %
India	5	16.7 %	1	2.2 %	6	8.0 %
Russia	3	10.0 %	-	-	3	4.0 %
Thailand	1	3.3 %	-	-	1	1.3 %
Total	30	100.0 %	45	100.0 %	75	100.0 %

Complete list of companies in appendix 8.5, table 8.13-8.15

Table 4.6: Descriptive statistics and Correlation for Variables used in Regression Analysis

Panel A: Summary Statistics

Variables	Mean	Std. Dev	Q1	Median	Q3
CAR	.086	.544	-.16	.003	.214
Debt	.574	.236	.45	.564	.701
BM	.86	.974	.449	.719	1.17
Equity	31,564	65,282	563	4,164	36,110
FX rate	.988	.522	.702	1.152	1.31

Panel B: Matrix of Correlations for control variables

Variables	(1)	(2)	(3)	(4)	(5)
(1) CAR	1.000				
(2) Debt	-0.217	1.000			
(3) BM	-0.003	-0.426	1.000		
(4) Equity	-0.099	-0.130	-0.078	1.000	
(5) FX rate	-0.191	0.106	0.003	0.001	1.000

All continuous variables have been winsorised at the 1st and 99th percentiles by replacing observations outside these parameters with the 1st and 99th percentiles to limit extreme values (Hasting, Mosteller, Tukey, & Winsor, 1947). Equity is reported before log transformation, and their logarithm values are used in the regression. The number of observations is 207.

Panel C: Matrix of Correlation for dummy variables

Variables		Variables	
(1) CAR	1.000	(1) CAR	1.000
(2) RED	0.188	(2) NA	0.097
(3) ILUC	-0.025	(3) EU	-0.047
(4) RED II	-0.154	(4) AP	-0.050

Variable definitions:
CAR = Cumulative Abnormal Return from one day before to one day after the events for each event
Debt = Debt-to-asset ratio for company i during the event periods
BM = Book-to-market ratio for company i during the event periods
Equity = The market cap for company i during the event periods (in millions)
FX rate = Average local exchange rate of company i relative to the US dollar.
RED = Dummy for the Renewable Energy Directive (2009/28/EC)
ILUC = Dummy Indirect Land Usage Change Directive (2015/1513)
RED II = Dummy for Renewable Energy Directive II (2018/2001/EU)
NA = Dummy for the region of North America
EU = Dummy for the region of Europe
AP = Dummy for the region of Asia-Pacific

Descriptive statistics

Table 4.6, Panel A is the descriptive statistics for the variables used in the regression model. The sample of 75 firms experiences a mean cumulative abnormal return of 0.086 during event periods. The sample firms, on average, has a debt-to-asset ratio of 0.574, the book-to-market ratio of 0.86, equity of 31,564 million and an exchange ratio of 0.988. Equity is higher than the median, suggesting skewness of the distribution, the variable is, therefore, log-transformed in the regression analysis. The first and third quartiles of book-to-market values are 0.449 and 1.17, respectively, which implies that there is considerable cross-sectional variation among the sample in terms of future growth prospects.

Matrix of Correlations

Table 4.6, Panel B reports the correlation for the variables used in the regression. The CAR is negatively correlated with all control variables. The remaining variables have, in general, low correlations, except debt and book-to-market value, where there is a negative correlation of 0.426. Table 4.6, Panel C reports the correlation for the dummy variables used in the regression. For the directives, the CAR is positively correlated with RED, and negatively with ILUC and RED II. For the regions, the CAR is positively correlated with North America and negatively with Europe and Asia-Pacific.

5. Analysis

This chapter consists of two parts. First, the results from the event-study analysis is presented, where the abnormal returns are tested under each event and for differences between regions and the two segments. The total effect on the abnormal returns of the three directives is also tested. Secondly, the findings from the following regression analysis are presented.

5.1 Event-study analysis

5.1.1 Mean CARs for the energy industry

Table 5.1: Mean CARs for the energy industry from One Trading Day before, to One Trading Day after the Events for RED

Event: RED	N	Mean CAR Industry	N	Mean CAR Fossil Fuel	N	Mean CAR Renewable	Difference Fossil fuel-Renewable
1	*54*	0.012*	*30*	0.000	*24*	0.026**	-0.026
		(0.073)		*(-0.968)*		*(0.039)*	*(0.141)*
2	*54*	-0.026***	*30*	-0.018***	*24*	-0.035***	0.017
		(0.000)		*(-0.002)*		*(0.006)*	*(0.103)*
3	*56*	-0.039***	*30*	-0.044***	*26*	-0.033***	-0.011
		(0.000)		*(0.000)*		*(0.009)*	*(0.391)*
4	*56*	-0.025***	*30*	-0.038***	*26*	-0.010	-0.028
		(0.000)		*(0.000)*		*(0.421)*	*(0.168)*
6	*56*	0.055***	*30*	0.031***	*26*	0.083***	-0.052**
		(0.000)		*(0.000)*		*(0.000)*	*(0.040)*
7	*56*	0.049***	*30*	0.072***	*26*	0.023	0.049**
		(0.000)		*(0.000)*		*(0.103)*	*(0.035)*
8	*57*	0.022***	*30*	-0.006	*27*	0.052***	-0.058***
		(0.009)		*(0.510)*		*(0.000)*	*(0.008)*
9	*59*	0.089***	*30*	0.058***	*29*	0.121***	-0.062***
		(0.000)		*(0.000)*		*(0.000)*	*(0.008)*
10	*59*	-0.009	*30*	-0.006	*29*	-0.013	0.007
		(0.275)		*(0.534)*		*(0.370)*	*(0.574)*
11	*59*	0.019**	*30*	0.020**	*29*	0.017	0.002
		(0.033)		*(0.034)*		*(0.245)*	*(0.845)*
12	*61*	0.005	*30*	0.007	*31*	0.002	0.004
		(0.604)		*(0.473)*		*(0.871)*	*(0.773)*
Total	*61*	0.014***	*30*	0.007**	*31*	0.022***	-0.015**
		(0.000)		*(0.036)*		*(0.000)*	*(0.016)*

P-values are in parenthesis: *** p<0.01, ** p<0.05, * p<0.1 – based on standard t-test.
Event 5 is not included in the analysis due to reasons explained in chapter 4.5.
Results are obtained from N listed fossil fuel and renewable energy firms. Mean CAR Industry is the Average Cumulative return for sample companies in the energy industry (full sample). Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

Table 5.1 shows a strong relationship between the introduction of RED and the abnormal returns in the energy industry. This is consistent with hypothesis 1 that the energy industry is significantly affected by the introduction of renewable energy regulations, with both segments showing abnormal returns. The positive returns of the fossil fuel segment are conflicting with hypothesis 2B, that the fossil fuel segment should react negatively to the introduction of renewable energy regulations. However, when controlling for the OPEC events, the fossil fuel segment yields significant negative abnormal returns (see appendix 8.3). Additionally, there is a significant difference between the two segments under RED.

Table 5.2: Mean CARs for the energy industry from One Trading Day before to One Trading Day after the Events for ILUC.

Event ILUC	N	Mean CAR Industry	N	Mean CAR Fossil fuel	N	Mean CAR Renewable	Difference Fossil fuel-Renewable
1	*57*	-0.001	*30*	0.000	*37*	-0.002	0.002
		(0.862)		*(-0.950)*		*(0.832)*	*(0.804)*
2	*69*	0.008	*30*	0.005	*39*	0.010	-0.005
		(0.165)		*(0.247)*		*(0.292)*	*(0.603)*
3	*69*	0.000	*30*	-0.002	*39*	0.002	-0.003
		(0.966)		*(0.715)*		*(0.849)*	*(0.740)*
4	*69*	0.007	*30*	0.001	*39*	0.012	-0.011
		(0.178)		*(0.852)*		*(0.165)*	*(0.266)*
5	*71*	0.000	*30*	0.013**	*41*	-0.010	0.023
		(0.961)		*(0.012)*		*(0.203)*	*(0.110)*
6	*71*	-0.005	*30*	-0.009*	*41*	-0.001	-0.008
		(0.356)		*(0.070)*		*(0.879)*	*(0.393)*
7	*71*	-0.017***	*30*	-0.008	*41*	-0.025***	0.017
		(0.001)		*(0.150)*		*(0.001)*	*(0.117)*
8	*71*	0.007	*30*	-0.004	*41*	0.016*	-0.020
		(0.170)		*(0.409)*		*(0.053)*	*(0.104)*
9	*71*	0.006	*30*	-0.006	*41*	0.014	-0.020
		(0.312)		*(0.287)*		*(0.102)*	*(0.160)*
Total	*71*	0.000	*30*	-0.001	*41*	0.002	-0.003
		(0.831)		*(0.595)*		*(0.616)*	*(0.476)*

P-values are in parenthesis: *** p<0.01, ** p<0.05, * p<0.1 – based on standard t-test.
Results are obtained from N listed fossil fuel and renewable energy firms. Mean CAR Industry is the Average Cumulative return for sample companies in the energy industry (full sample). Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

The ILUC Directive, from table 5.2 is insignificant for the energy industry, as explained previously, it is aimed at the biofuel industry, and where certain types of biofuels no longer count towards the renewable target set by RED. This is also the case for the segments. The directive also shields investments made, until 2020, which suggests that the proposed provisions should have little impact on today's use and demand for biofuels. Companies that are in the biofuel industry are also tested; these results are insignificant as well, see section 5.4.2.

Table 5.3: Mean CARs for the energy industry from One Trading Day before to One Trading Day after the Events for RED II.

Event	N	Mean CAR Industry	N	Mean CAR Fossil fuel	N	Mean CAR Renewable	Difference Fossil fuel-Renewable
1	*74*	0.001	*30*	0.011**	*44*	-0.006	0.017*
		(0.849)		*(0.023)*		*(0.495)*	*(0.056)*
2	*74*	-0.008	*30*	-0.007	*44*	-0.009	0.002
		(0.116)		*(0.101)*		*(0.269)*	*(0.821)*
3	*75*	0.003	*30*	0.001	*45*	0.004	-0.002
		(0.564)		*(0.719)*		*(0.626)*	*(0.765)*
4	*75*	-0.010**	*30*	-0.009**	*45*	-0.011	0.001
		(0.037)		*(0.016)*		*(0.165)*	*(0.900)*
5	*75*	0.003	*30*	0.004	*45*	0.003	0.001
		(0.613)		*(0.407)*		*(0.791)*	*(0.902)*
6	*75*	0.008	*30*	0.014***	*45*	0.003	0.011*
		(0.209)		*(0.002)*		*(0.740)*	*(0.093)*
7	*75*	-0.007	*30*	-0.006	*45*	-0.007	0.001
		(0.279)		*(0.197)*		*(0.473)*	*(0.921)*
Total	*75*	-0.001	*30*	0.001	*45*	-0.003	0.004
		(0.448)		*(0.502)*		*(0.273)*	*(0.199)*

P-values are in parenthesis: *** p<0.01, ** p<0.05, * p<0.1 – based on standard t-test.
Results are obtained from N listed fossil fuel and renewable energy firms. Mean CAR Industry is the Average Cumulative return for sample companies in the energy industry (full sample). Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

From table 5.3, the RED II directive is insignificant for the energy industry. The significant dates are few and conflicting, which leads to an insignificant total. This is, to some extent, unexpected, as there were similar expectations for RED II and RED. This could be an indication that the market already has priced this in, RED II is, after all only a revision of RED. Another explanation could be that investors have included climate risk in their investment decisions. This explanation would be consistent with the results found by (Krueger, Sautner, & Starks, 2019).

5.1.2 Regions for the energy industry

Table 5.4: Mean CARs for regions in the energy industry from One Trading Day before to One Trading Day after the Events for RED

Event	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR AP	Difference EU-NA	Difference EU-AP	Difference NA-AP
1	*22*	0.040***	*16*	0.017	*16*	-0.032**	0.023	0.073***	0.050***
		(0.000)		*(0.198)*		*(0.010)*	*(0.174)*	*(0.000)*	*(0.006)*
2	*22*	-0.027***	*16*	-0.032**	*16*	-0.018	0.006	-0.009	-0.015
		(0.002)		*(0.015)*		*(0.178)*	*(0.583)*	*(0.485)*	*(0.263)*
3	*23*	-0.040***	*17*	-0.043***	*16*	-0.031**	0.003	-0.009	-0.011
		(0.000)		*(0.002)*		*(0.018)*	*(0.803)*	*(0.672)*	*(0.605)*
4	*23*	-0.050***	*17*	0.021	*16*	-0.039***	0.071***	-0.011	0.060**
		(0.000)		*(0.132)*		*(0.004)*	*(0.001)*	*(0.674)*	*(0.028)*
6	*23*	0.044***	*17*	0.090***	*16*	0.036***	-0.047	0.008	0.054*
		(0.000)		*(0.000)*		*(0.009)*	*(0.162)*	*(0.742)*	*(0.082)*
7	*23*	0.064***	*17*	0.059***	*16*	0.016	0.005	0.048*	0.042*
		(0.000)		*(0.000)*		*(0.254)*	*(0.858)*	*(0.071)*	*(0.058)*
8	*24*	-0.003	*17*	0.060***	*16*	0.017	-0.064**	-0.021	0.043
		(0.761)		*(0.001)*		*(0.256)*	*(0.035)*	*(0.312)*	*(0.182)*
9	*24*	0.098***	*18*	0.113***	*16*	0.051***	-0.015	0.047**	0.062*
		(0.000)		*(0.000)*		*(0.001)*	*(0.643)*	*(0.047)*	*(0.075)*
10	*24*	-0.016	*18*	-0.035*	*17*	0.026*	0.018	0.042***	0.061***
		(0.194)		*(0.057)*		*(0.076)*	*(0.204)*	*(0.005)*	*(0.001)*
11	*24*	0.032**	*18*	0.000	*17*	0.018	0.032**	0.014	-0.018
		(0.011)		*(0.984)*		*(0.220)*	*(0.017)*	*(0.390)*	*(0.197)*
12	*26*	-0.006	*18*	0.027	*17*	-0.001	-0.034	-0.005	0.029
		(0.606)		*(0.142)*		*(0.928)*	*(0.156)*	*(0.622)*	*(0.200)*
Total	*26*	0.012***	*18*	0.026***	*17*	0.004	-0.013*	0.008	0.021***
		(0.009)		*(0.000)*		*(0.355)*	*(0.097)*	*(0.234)*	*(0.008)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on standard t-test
Event 5 is not included in the analysis due to reasons explained in chapter 4.5.
Results are obtained from N listed fossil fuel and renewable energy firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

From table 5.4, the North American region is experiencing the most considerable abnormal returns. An explanation for this could be that European fossil fuel companies are more negatively affected by RED than North American companies; when conducting tests for differences between the regions within the segments (see appendix, table 8.3-8.9), results show that European firms in the fossil fuel segment are significantly negatively affected compared to the North American segments.

Table 5.5: Mean CARs for regions in the energy industry from One Trading Day before to One Trading Day after the Events for ILUC.

Event	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR Asia	Difference EU-NA	Difference EU-AS	Difference NA-AS
1	*28*	0.003	*20*	0.004	*19*	0.007	-0.001	-0.005	-0.004
		(0.760)		*(0.744)*		*(0.391)*	*(0.958)*	*(0.707)*	*(0.701)*
2	*28*	-0.004	*22*	0.016	*19*	0.000	-0.020*	-0.004	0.016*
		(0.640)		*(0.119)*		*(0.997)*	*(0.073)*	*(0.708)*	*(0.061)*
3	*28*	0.022**	*22*	-0.015	*19*	0.000	0.037***	0.022	-0.016
		(0.013)		*(0.124)*		*(0.966)*	*(0.001)*	*(0.130)*	*(0.210)*
4	*28*	-0.003	*22*	0.033***	*19*	-0.010	0.036***	0.006	0.043***
		(0.700)		*(0.000)*		*(0.304)*	*(0.002)*	*(0.599)*	*(0.004)*
5	*28*	0.006	*23*	-0.008	*20*	0.004	0.013	0.002	-0.012
		(0.462)		*(0.447)*		*(0.638)*	*(0.355)*	*(0.936)*	*(0.532)*
6	*28*	-0.005	*23*	0.013	*20*	-0.013	-0.019	0.008	0.027
		(0.493)		*(0.180)*		*(0.128)*	*(0.114)*	*(0.549)*	*(0.102)*
7	*28*	-0.015*	*23*	-0.023**	*20*	-0.013	0.008	-0.002	-0.010
		(0.052)		*(0.025)*		*(0.142)*	*(0.522)*	*(0.891)*	*(0.479)*
8	*28*	0.017**	*23*	-0.004	*20*	0.028***	0.022*	-0.011	-0.033*
		(0.024)		*(0.676)*		*(0.002)*	*(0.095)*	*(0.590)*	*(0.092)*
9	*28*	0.017	*23*	0.015	*20*	0.014	-0.015	-0.014*	0.001
		(0.024)		*(0.167)*		*(0.160)*	*(0.547)*	*(0.099)*	*(0.975)*
Total	*28*	0.002	*23*	0.003	*20*	0.002	-0.001	0.000	0.001
		(0.439)		*(0.386)*		*(0.589)*	*(0.825)*	*(0.973)*	*(0.822)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on standard t-test
Results are obtained from N listed fossil fuel and renewable energy firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

From table 5.5, the results for the ILUC Directive when comparing regions are consistent with the overall industry. There is no significant effect from the directive, even when comparing across regions. There are significant abnormal returns on some event days; however, they are mostly conflicting, which leads to an insignificant total.

Table 5.6: Mean CARs for Regions in the energy industry from One Trading Day before to One Trading Day after the Events for RED II

Event	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR Asia	Difference EU-NA	Difference EU-AS	Difference NA-AS
1	*28*	0.001	*26*	-0.005	*20*	0.012	0.006	-0.011	-0.018
		(0.866)		*(0.654)*		*(0.130)*	*(0.577)*	*(0.297)*	*(0.135)*
2	*28*	-0.006	*26*	-0.007	*20*	-0.011	0.001	0.005	0.004
		(0.369)		*(0.541)*		*(0.131)*	*(0.972)*	*(0.583)*	*(0.823)*
3	*29*	0.011	*26*	0.002	*20*	0.001	0.009	0.011	0.001
		(0.104)		*(0.850)*		*(0.927)*	*(0.406)*	*(0.340)*	*(0.902)*
4	*29*	-0.003	*26*	-0.026**	*20*	-0.004	0.022	0.001	-0.021*
		(0.638)		*(0.011)*		*(0.512)*	*(0.117)*	*(0.950)*	*(0.054)*
5	*29*	-0.012	*26*	0.004	*20*	0.020**	-0.016	-0.032*	-0.016
		(0.236)		*(0.728)*		*(0.012)*	*(0.168)*	*(0.061)*	*(0.318)*
6	*29*	0.005	*26*	0.003	*20*	0.015*	0.002	-0.010	-0.012
		(0.644)		*(0.796)*		*(0.076)*	*(0.839)*	*(0.270)*	*(0.149)*
7	*29*	0.002	*26*	-0.006	*20*	-0.015*	0.009	0.017	0.008
		(0.812)		*(0.592)*		*(0.082)*	*(0.361)*	*(0.187)*	*(0.535)*
Total	*29*	0.002	*26*	0.003	*20*	0.002	-0.001	0.000	0.001
		(0.439)		*(0.386)*		*(0.589)*	*(0.825)*	*(0.973)*	*(0.822)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on standard t-test
Results are obtained from N listed fossil fuel and renewable energy firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

Table 5.6 shows the test results for the regions under RED II. These results are consistent with the discussion under section 5.3, that investors have priced in the effects of RED, and that the changes from RED are not considered to have a significant impact on the industry.

5.2 Regression Analysis

In this section, the results from the event-study analysis are investigated to see if they stay consistent, when controlling for additional independent variables.

Panel A: Regression Results – RED II as baseline

	(1) Industry	(2) Fossil fuel	(3) Renewable
Constant	0.586**	0.761***	-0.015
	(2.278)	(2.999)	(-0.048)
RED	0.236**	-0.183**	0.570***
	(2.112)	(-2.540)	(3.199)
ILUC	0.093	0.002	0.184*
	(1.481)	(0.032)	(1.944)
FX rate	-0.195***	-0.109	-0.097
	(-2.761)	(-1.531)	(-0.843)
Debt	-0.490	-0.414*	-0.473
	(-1.484)	(-1.931)	(-1.322)
BM	-0.048	-0.072	-0.052
	(-0.729)	(-1.510)	(-0.984)
ln Equity	-0.013	-0.033	0.059**
	(-0.898)	(-1.558)	(2.408)
Obs.	207	90	117
Adj. R-squared	0.090	0.158	0.209

T-values are in parenthesis: *** *p<0.01*, ** *p<0.05*, * *p<0.1*
The CARs are aggregated for the three directives based on each company. In other words, if a company is listed for the entire timeline, there will be three CARs for that specific company. The standard errors for each company are made robust by clustering after tickers. CARs from event 5 in RED and event 1 in RED II are not included due to reasons explained in section 4.5. CARs from event 7 for RED is not included for the fossil fuel companies due to reasons explained in section 4.5. RED II is included as the baseline for the regression. See table 4.6 for variable definitions.

The findings from the regression analysis in panel A are consistent with the previous findings. The CARs for the industry are significantly positive with the introduction of RED when compared to RED II, while it is significantly negative for the fossil fuel segment, and positive for the renewable energy segment. When testing the difference in CARs between the fossil fuel segment and renewable energy segment for RED, there is a significant difference on the 1% level. The results also show weak evidence that the renewable energy segment experiences significant positive abnormal returns under the ILUC directive compared to RED II.

Some of the included control variables are significant. First, exchange rates are significantly negative for the industry, suggesting that when the dollar depreciates relative to the home currency, companies within the energy industry experience lower returns. Additionally, there is a negative relationship between size and the introduction of RED for the fossil fuel segment shown by the coefficient on ln Equity and a positive relationship between size and the introduction of RED for the renewable segment. This indicates that investors value the effect of RED higher for established renewable firms. Furthermore, when testing the difference between ln Equity between the segments, results show a significant difference on the 1% level.

Panel B: Regression results – North America (NA) as the baseline

	(1) Industry	(2) Fossil fuel	(3) Renewable
Constant	0.730***	0.804**	0.350
	(2.778)	(2.570)	(0.970)
EU	-0.029	-0.049	-0.039
	(-0.407)	(-0.619)	(-0.337)
AP	-0.088	-0.114	-0.070
	(-0.954)	(-1.154)	(-0.492)
FX rate	-0.187***	-0.126	-0.152
	(-2.656)	(-1.669)	(-0.874)
Debt	-0.562	-0.381	-0.687*
	(-1.599)	(-1.604)	(-1.788)
BM	-0.059	0.005	-0.078
	(-0.923)	(0.095)	(-1.593)
ln Equity	-0.009	-0.043*	0.071***
	(-0.628)	(-1.821)	(2.893)
Obs.	207	90	117
Adj. R-squared	0.064	0.087	0.099

T-values are in parenthesis: *** *p<0.01*, ** *p<0.05*, * *p<0.1*
The CARs are aggregated for the three directives based on each company; in other words, if a company is listed for the entire timeline, there will be three CARs for that specific company. The standard errors for each company are made robust by clustering after tickers. CARs from event 5 in RED and event 1 in RED II are not included due to reasons explained in section 4.5. CARs from event 7 for RED is not included for the fossil fuel companies due to reasons explained in section 4.5. North America (NA) is included as a baseline for the regression. See table 4.6 for variable definitions.

From panel B, results show that, when controlling for additional factors, the regional differences are no longer significant — indicating that the directives have a similar effect for all regions. As with the regression from panel A, the constant term is significant, which can be explained by the fact that all control variables are negatively correlated with the CARs. The regression in Panel B also shows a significant debt variable for the renewable segment. This suggests that firms with lower debt-to-asset ratios experience higher abnormal returns. The debt variable is also significant for the fossil fuel segment from panel A. These results indicate that investors value less risky firms in the form of low debt-to-asset ratios.

5.3 Additional analysis

5.3.1 Regression analysis using fixed effects

To control for firm-specific fixed effects, a further regression analysis using the fixed effects model is presented. An additional regression with fixed effects for Panel B is not run, because the estimator takes out all the variance at the group level. Thus, there is nothing left for the region dummies to explain.

Panel C: Regression results – RED II as the baseline with fixed effects.

	(1) Industry	(2) Fossil fuel	(3) Renewable
Constant	-0.864	1.092	-0.932
	(-0.660)	(0.719)	(-0.708)
RED	0.240**	-0.022	0.469**
	(2.197)	(-0.379)	(2.485)
ILUC	0.143	0.044	0.233
	(1.664)	(0.670)	(1.605)
FX rate	-1.215***	-0.732***	-1.139
	(-3.648)	(-2.978)	(-1.195)
Debt	-0.384	0.181	-0.238
	(-0.695)	(0.166)	(-0.397)
BM	0.043	0.045	0.037
	(0.306)	(0.344)	(0.260)
ln Equity	0.255**	-0.054	0.297**
	(2.069)	(-0.486)	(2.049)
Fixed Effects	Included	Included	Included
Obs.	207	90	117
Adj. R-squared	0.258	0.284	0.314

T-values are in parenthesis: *** *p<0.01*, ** *p<0.05*, * *p<0.1*
After conducting a Hausman test between Random Effects and Fixed Effects, the null hypothesis is rejected that there is no systematic difference between the coefficients; therefore, the Fixed Effects model is used (see appendix, table 8.10-8.12 for results). The CARs are aggregated for the three directives based on each company. In other words, if a company is listed for the entire timeline, there will be three CARs for that specific company. The standard errors for each company are made robust by clustering after tickers. CARs from event 5 in RED and event 1 in RED II are not included due to reasons explained in section 4.5. CARs from event 7 for RED is not included for the fossil fuel companies due to reasons explained in section 4.5. RED II is included as a baseline for the regression. See table 4.6 for variable definitions.

From Panel C, with fixed effects, RED still has a significant effect on CARs compared to RED II, while ILUC is still insignificant. However, the constant term is no longer significant, as the fixed effect constant has no trivial interpretation anymore. The effect of exchange rate becomes more significant, suggesting a more substantial impact on the CARs for the fossil fuel segment, in other words, the segment seems to be negatively affected by the depreciation in their local currency. The variable for size (ln Equity) is now positively significant for the industry, as well as the renewable segment.

5.3.2 Testing renewable energy and biofuel companies under ILUC

As explained, there might be a difference in CARs between biofuel companies and renewable energy companies with the introduction of the ILUC Directive, as the directive promotes low-ILUC risk biofuel companies, additional analysis is conducted.

Table 5.7: Mean CARs for Renewable and Biofuel companies from One Trading Day before to One Trading Day after the Events for ILUC

Event	N	Mean CAR Renewable	N	Mean CAR Biofuel	Difference Renewable-Biofuel
1	*30*	0.004	*7*	-0.030	0.034***
		(0.715)		*(0.188)*	*(0.003)*
2	*31*	0.010	*8*	0.009	0.001
		(0.353)		*(0.684)*	*(0.958)*
3	*31*	0.007	*8*	-0.020	0.027
		(0.482)		*(0.272)*	*(0.158)*
4	*31*	0.010	*8*	0.017	-0.007
		(0.297)		*(0.343)*	*(0.562)*
5	*33*	-0.011	*8*	-0.007	-0.003
		(0.204)		*(0.742)*	*(0.901)*
6	*33*	-0.008	*8*	0.026	-0.035
		(0.325)		*(0.350)*	*(0.252)*
7	*33*	-0.026***	*8*	-0.021	-0.005
		(0.002)		*(0.467)*	*(0.701)*
8	*33*	0.022***	*8*	-0.015	0.037*
		(0.008)		*(0.612)*	*(0.073)*
9	*33*	0.020**	*8*	-0.014	0.034
		(0.029)		*(0.634)*	*(0.119)*
Total	*33*	0.003	*8*	-0.006	0.009
		(0.402)		*(0.310)*	*(0.191)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on t-test.
Results are obtained from N listed renewable and biofuel firms. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

The first part of the analysis, from table 5.7, shows no total significant abnormal returns for either renewables or biofuel companies for the ILUC Directive. Furthermore, in total, there is no significant difference. In other words, the ILUC Directive seems to have no impact on the two segments. This is consistent with the findings from the primary analysis.

Panel D: Regressions results for Renewable and Biofuel companies for ILUC – North America as the baseline.

	(1) Full Sample CAR	(2) Renewable CAR	(3) Biofuel CAR
Constant	0.167	0.689	-2.456
	(0.225)	(0.832)	(-1.880)
EU	0.003	-0.022	0.815
	(0.021)	(-0.147)	(1.644)
FX rate	0.109	0.137	0.282
	(0.396)	(0.500)	(0.479)
Debt	0.036	-0.355	-0.981
	(0.064)	(-0.490)	(-1.285)
BM	-0.120	-0.179	0.277*
	(-1.136)	(-1.129)	(1.910)
ln Equity	-0.004	-0.027	0.363*
	(-0.094)	(-0.603)	(1.926)
Obs.	31	23	8
Adj. R-squared	0.066	0.193	0.097

T-values are in parenthesis: *** *p<0.01*, ** *p<0.05*, * *p<0.1*
The CARs are aggregated for the three directives based on each company. In other words, if a company is listed for the entire timeline, there will be three CARs for that specific company. The standard errors for each company are made robust by clustering after tickers. CARs from event 5 in RED and event 1 in RED II are not included due to reasons explained in section 4.5. CARs from event 7 for RED is not included for the oil and gas companies due to reasons explained in section 4.5. There are no biofuel companies for Asia; thus, the dummy is not included. North America (NA) is included as a baseline for the regression. See table 4.6 for variable definitions.

From Panel D, when controlling for other variables, the results show no significant results for the renewable segment. As mentioned, the ILUC Directive shields investments made into high-ILUC risk companies until 2020. If investors anticipated the ILUC Directive before it was made public, and the decision to shield investments was proposed during the event period, it makes sense that low-ILUC companies will react negatively. Another explanation could be the low sample size of biofuel companies. As previously stated, it is challenging to identify publicly listed biofuel companies for the period.

6. Discussion and conclusion

6.1 Discussion

In this chapter, the results from chapter 5 will be discussed. As the thesis title states, the main objective is to investigate the effect of renewable energy regulations, proposed and introduced by the European Union, on the energy industry. Resulting in the main hypothesis:

Hypothesis 1**:** *The energy industry is affected by the introduction of the European Union's renewable energy directives.*

The first part of the analysis and the following regression results, from table 5.1 and panel A show similar results regarding the effect on the energy industry. Indicating that the introduction of the Renewable Energy Directive had a significant impact on abnormal returns for the industry, even when controlling for confounding events, additional independent variables and firm-specific fixed effects. However, no significant effect from the ILUC Directive and RED II were found, also when controlling for other variables and firm-specific fixed effects. As mentioned in chapter 5, this implies that investors may consider the additions and changes made with the introduction of the ILUC and RED II to be priced in before the directives were made public. As well as the fact that investors, in recent years and to a higher degree, incorporate climate risks into their investment decisions. This is consistent with the findings of both Bolton & Kacperczyk (2019) and Krueger, Sautner, & Starks (2019). In addition, the non-significant effect from ILUC and RED II on renewable could be explained by the findings of Edmans (2011), that investors do not fully value intangibles.

Additionally, another point of interest is how the introduction of the EU's renewable energy regulations affect fossil fuel firms and renewable energy firms separately and how they differ.

Hypothesis 2A: *The fossil fuel segment is negatively affected by the introduction of the European Union's renewable energy directives.*

The event-study method results from table 5.1 show total significant mean CARs for the fossil fuel segment of 0.007 during RED. However, when controlling for the confounding OPEC statements (appendix 8.1), the fossil fuel segment has a total significant mean CAR of

-0.006. Moreover, the regression analysis shows a significant negative coefficient of RED when using RED II as the baseline, for the fossil fuel segment. However, when controlling for firm-specific fixed effects, RED is no longer significant. Based on these results, there is weak evidence that the fossil fuel segment is negatively affected by the introduction of the EU's renewable regulations. No significant effects were found for the ILUC Directive and RED II.

Hypothesis 2B**:** *The renewable energy segment is positively affected by the introduction of the European Union's renewable energy directives.*

From the first part of the analysis, there is a total significant mean CAR of 0.022 for the renewable energy segment during RED. Similar results are found in the regression analysis when comparing RED against RED II. Furthermore, when using the fixed effects model, the results remain consistent, with a significant positive coefficient for RED. The results indicate strong evidence that the renewable energy segment was positively affected by the introduction of RED. This suggests that renewable energy companies experience positive abnormal returns with the introduction of EU's renewable energy regulations, which is consistent with the findings of previous studies conducted on green firms, such as Flammer (2015) and Dimson, Karakaş & Li (2018).

Also, the tests from the first part of the analysis indicate no significant effect of the ILUC Directive. However, the coefficient of ILUC in the regression model is significant on the 10% level, which suggests weak evidence that renewable energy companies were positively affected by the ILUC Directive compared to RED II.

When comparing the two segments, there is a significant difference of 0.015 on the 5% level, with the introduction of RED. These results stay consistent when controlling for additional variables and the fixed effects model. When testing the difference between coefficients under RED for the segments, the findings show a significant difference on the 1% level — suggesting strong evidence that the two segments were affected differently with the introduction of RED. This is consistent with the findings of Taehyun & Yongjun (2019), that green firms outperform more toxic firms with the introduction of green regulatory changes. There is no evidence of differences between segments for the two other directives.

Hypothesis 3: *There is a difference between the regions (Europe, North America and Asia-pacific) in the energy industry with the introduction of the European Union's renewable energy directives.*

From table 5.4, the findings show a significant difference between Europe and North America and a significant difference between North America and Asia-Pacific. However, the regression analysis shows no significant effects between the regions, indicating that the significant difference found in the initial analysis was due to other factors than the specific region.

6.2 Conclusion

The findings of the thesis show that regulatory changes regarding the use and promotion of renewable energy have a significant effect on the abnormal returns of firms within the energy industry. This indicates that investors value regulatory changes regarding the promotion of renewable energy usage. However, the results for the ILUC Directive and RED II show no significant effect on abnormal returns for the industry. The reason for the non-significant impact could be because changes and additions to the EU's Renewable Energy Directive are insignificant in the eyes of investors. The fact that investors in recent years are more concerned with incorporating climate risk in their investment decisions also plays a role.

Furthermore, when differentiating between the fossil fuel and the renewable energy segment within the industry, the renewable energy segment outperforms the fossil fuel segment with the introduction of EU's renewable energy regulations. Finally, the first part of the analysis shows a significant difference between Europe and North America, and North America and Asia-Pacific. However, with additional control variables in the regression model, the significant difference disappears.

6.3 Limitations

The event study method relies on the fact that one can determine the time when information can be described as public information. For older events, it can be challenging to determine the event window with certainty. Despite having access to specific dates when the information was made public, one cannot say with absolute certainty that, or to which extent, the information was withheld from the public beforehand. In other words, it is assumed that news is not known until the EU publishes it. This may not be the case. It is also assumed that the relevant markets are semi-strong efficient. Criticism of the efficient market hypothesis is the distribution of asymmetric information, which means that changes in the stock price may occur before the information was made public.

This study is also based on a multi-country setting and is limited to the energy industry, between 2007 and 2018 — the data collection accumulated is limited to 75 companies, with 30 fossil fuel companies and 45 renewable energy companies. Limitations in terms of listed renewable energy companies have resulted in a relatively small sample selection, consequently leaving us with only 26 renewable energy companies at the start of the timeline. Additionally, there might exist some bias in the fossil fuel segment, due to the selections of the 50 largest companies; however, the companies included represents a large portion of the industry market value.

Under the Additional Analyses, section 5.4, differences in the renewable energy segment by separating biofuel companies from the rest under the ILUC Directive are tested. However, there are only nine listed biofuel companies in the sample, consequently making it difficult to find any significant results, assuming there are any.

6.4 Suggestions for further research

We have not found any similar studies, such as ours, that examines the impact of RED and its revisions, and thus there is great potential for further research on the topic. This thesis tries to answer the question of how financial markets react to the EU's regulatory changes. With the introduction of RED, there are financial schemes and numerous regulations that try to facilitate increased investment and more favourable conditions for renewable energy firms. Suggestions for further research can be to focus more on how firms adapt to these regulatory changes, for example:

1. Whether fossil fuel companies' budget for carbon risk.
2. Whether companies in the energy industry restructure their financial policies, such as the debt-to-asset ratio.
3. If the financial schemes set by the European Union facilitates increased investments.

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8. Appendix

8.1 Controlling for futures of Crude oil prices

Table 8.1: Controlling for futures of Crude oil prices

Event	N	Mean CAR Spot Price	Mean CAR Five-month future	Mean CAR Three-month future
Red 7	*30*	0.072***	0.066***	0.067***
		(0.000)	*(0.000)*	*(0.000)*
Red 9	*30*	0.058***	0.044***	0.050***
		(0.000)	*(0.000)*	*(0.000)*
RED II 1	*30*	0.011**	0.006	0.006
		(0.023)	*(0.190)*	*(0.239)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test.
Results are obtained from N listed fossil fuel firms. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date

8.2 Results for RED with event 5

Table 8.2: Results for RED with event 5 and the total

Event	N	Mean CAR Fossil fuel	N	Mean CAR Renewable
5	*30*	-0.078***	*26*	-0.171***
		(0.000)		*(0.000)*
Total	*30*	0.000	*26*	0.011**
		(0.964)		*(0.043)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test.
Results are obtained from N listed fossil fuel and renewable energy firms. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date

8.3 Controlling for confounding events

To control for the OPEC announcements, we have conducted an additional analysis, where event 5, 7 and 9 are removed from the fossil fuel segment, see table 8.3.

Table 8.3: Mean CARs for the fossil fuel segment under RED, controlled for confounding events

Event RED	N	CAAR Fossil fuel
1	*30*	0.000
		(0.968)
2	*30*	-0.018***
		(0.002)
3	*30*	0.044****
		(0.000)
4	*30*	-0.038***
		(0.000)
6	*30*	0.031***
		(0.000)
8	*30*	-0.006
		(0.510)
10	*30*	-0.006
		(0.534)
11	*30*	0.020**
		(0.034)
12	*30*	0.007
		(0.473)
Total	*30*	-0.006**
		(0.049)

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test. Results are obtained from N listed fossil fuel and renewable energy firms. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date

When these events are removed from the sample, results change. From table 8.3, we see that the total abnormal return for the fossil fuel segment is now -0.006 and is significant on a 5% level. We do not test for a difference here because of the inconsistency of events used. However, we have already seen that there is a significant difference when including all events.

8.4 Regions for segments

8.4.1 Regions for the fossil fuel segment

Table 8.4: Mean CARs for the fossil fuel segment partitioned by regions from One Trading Day before to One Trading Day after the Events for RED

Event RED	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR AP	Difference EU-NA	Difference EU-AS	Difference NA-AS
1	*13*	0.019***	*7*	0.017*	*10*	0.036***	-0.019	0.017***	0.002***
		(0.008)		*(0.082)*		*(0.002)*	*(0.836)*	*(0.005)*	*(0.006)*
2	*13*	-0.016**	*7*	0.029***	*10*	-0.014	0.016	0.029	0.012
		(0.038)		*(0.005)*		*(0.271)*	*(0.298)*	*(0.839)*	*(0.253)*
3	*13*	0.038***	*7*	0.034***	*10*	0.058***	0.038	0.034	-0.004
		(0.000)		*(0.002)*		*(0.000)*	*(0.827)*	*(0.489)*	*(0.468)*
4	*13*	0.047***	*7*	0.010	*10*	0.060***	0.047**	-0.010	-0.057*
		(0.000)		*(0.435)*		*(0.000)*	*(0.031)*	*(0.724)*	*(0.057)*
6	*13*	0.023**	*7*	0.036**	*10*	0.041***	-0.023	-0.036	-0.013
		(0.014)		*(0.011)*		*(0.007)*	*(0.678)*	*(0.417)*	*(0.883)*
8	*13*	-0.029**	*7*	0.007	*10*	0.015	0.029**	-0.007**	-0.036
		(0.012)		*(0.701)*		*(0.370)*	*(0.036)*	*(0.031)*	*(0.695)*
10	*13*	-0.022*	*7*	-0.006	*10*	0.015	0.022	0.006***	-0.015*
		(0.088)		*(0.757)*		*(0.372)*	*(0.113)*	*(0.006)*	*(0.071)*
11	*13*	0.030**	*7*	0.018	*10*	0.007	-0.030	-0.018	0.012
		(0.017)		*(0.378)*		*(0.702)*	*(0.359)*	*(0.136)*	*(0.461)*
12	*13*	0.004	*7*	0.019	*10*	0.003	-0.004**	-0.019	-0.016
		(0.786)		*(0.354)*		*(0.866)*	*(0.018)*	*(0.933)*	*(0.046)*
Total	*13*	-0.009**	*7*	0.004	*10*	-0.010	0.009**	-0.004	-0.013*
		(0.034)		*(0.406)*		*(0.143)*	*(0.050)*	*(0.881)*	*(0.095)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test.
Event 5, 7 and 9 are not included in the analysis due to reasons explained in chapter 5.1.
Results are obtained from N listed fossil fuel firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

Table 8.5: Mean CARs for the fossil fuel segment partitioned by regions from One Trading Day before to One Trading Day after the Events for ILUC

Event ILUC	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR Asia	Difference EU-NA	Difference EU-AS	Difference NA-AS
1	*13*	0.001	*7*	0.013*	*10*	0.004	-0.001	-0.013	-0.012
		(0.905)		*(0.072)*		*(0.635)*	*(0.261)*	*(0.783)*	*(0.279)*
2	*13*	-0.004	*7*	0.011*	*10*	0.002	0.004*	-0.011	-0.016
		(0.553)		*(0.097)*		*(0.800)*	*(0.097)*	*(0.542)*	*(0.370)*
3	*13*	0.013*	*7*	-0.010	*10*	-0.005	-0.013*	0.010	0.023
		(0.069)		*(0.111)*		*(0.568)*	*(0.053)*	*(0.129)*	*(0.705)*
4	*13*	0.002	*7*	0.017***	*10*	-0.013	-0.002	-0.017	-0.015**
		(0.775)		*(0.006)*		*(0.207)*	*(0.152)*	*(0.204)*	*(0.012)*
5	*13*	0.021***	*7*	0.002	*10*	0.013	-0.021	-0.002	0.019
		(0.008)		*(0.788)*		*(0.228)*	*(0.270)*	*(0.819)*	*(0.742)*
6	*13*	-0.003	*7*	-0.008	*10*	-0.010	0.003	0.008	0.005
		(0.740)		*(0.292)*		*(0.354)*	*(0.418)*	*(0.554)*	*(0.882)*
7	*13*	-0.019**	*7*	-0.014*	*10*	0.015	0.019	0.014*	-0.005**
		(0.020)		*(0.058)*		*(0.171)*	*(0.759)*	*(0.080)*	*(0.045)*
8	*13*	-0.001	*7*	-0.001	*10*	0.007	0.001	0.001	0.000
		(0.951)		*(0.914)*		*(0.546)*	*(0.961)*	*(0.564)*	*(0.539)*
9	*13*	-0.008	*7*	-0.003	*10*	0.003	0.008	0.003	-0.005
		(0.391)		*(0.731)*		*(0.778)*	*(0.716)*	*(0.212)*	*(0.618)*
Total	*13*	0.000	*7*	0.001	*10*	0.002	0.000	-0.001	0.000
		(0.936)		*(0.785)*		*(0.708)*	*(0.912)*	*(0.792)*	*(0.848)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test, described in chapter 3.3.3
Results are obtained from N listed fossil fuel firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

Table 8.6: Mean CARs for the fossil fuel segment partitioned by regions from One Trading Day before to One Trading Day after the Events for RED II

Event RED II	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR Asia	Difference EU-NA	Difference EU-AS	Difference NA-AS
2	*13*	-0.011*	*7*	-0.012*	*10*	0.003	0.011	0.012	0.001
		(0.075)		*(0.079)*		*(0.668)*	*(0.905)*	*(0.128)*	*(0.131)*
3	*13*	0.008	*7*	-0.007	*10*	0.006	-0.008	0.007	0.015
		(0.214)		*(0.299)*		*(0.441)*	*(0.014)*	*(0.921)*	*(0.412)*
4	*13*	-0.009	*7*	-0.010*	*10*	-0.012	0.009	0.010	0.001
		(0.131)		*(0.079)*		*(0.126)*	*(0.791)*	*(0.819)*	*(0.904)*
5	*13*	0.003	*7*	-0.002	*10*	0.005	-0.003	0.002	0.004
		(0.705)		*(0.838)*		*(0.612)*	*(0.647)*	*(0.882)*	*(0.688)*
6	*13*	0.010	*7*	0.007	*10*	0.020**	-0.010	-0.007	0.004
		(0.134)		*(0.366)*		*(0.036)*	*(0.716)*	*(0.402)*	*(0.212)*
7	*13*	0.003	*7*	-0.013	*10*	-0.009	-0.003*	0.013	0.016
		(0.642)		*(0.086)*		*(0.366)*	*(0.053)*	*(0.326)*	*(0.706)*
Total	*13*	0.001	*7*	0.006**	*10*	0.002	-0.001**	0.006	0.007
		(0.784)		*(0.010)*		*(0.614)*	*(0.021)*	*(0.751)*	*(0.206)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test, described in chapter 3.3.3
Event 1 is not included in the analysis due to reasons explained in chapter 5.1.
Results are obtained from N listed fossil fuel firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date

8.4.2 Regions for the renewable energy segment

Table 8.7: Mean CARs for the renewable energy segment partitioned by regions from One Trading Day before to One Trading Day after the Events for RED

Event RED	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR AP	Difference EU-NA	Difference EU-AP	Difference NA-AP
1	*9*	0.071***	*9*	0.017	*6*	-0.027	0.054	0.098**	0.044
		(0.000)		*(0.443)*		*(0.325)*	*(0.133)*	*(0.028)*	*(0.209)*
2	*9*	-0.042**	*9*	-0.035	*6*	-0.024	-0.007	-0.018	-0.011
		(0.022)		*(0.114)*		*(0.393)*	*(0.716)*	*(0.556)*	*(0.699)*
3	*10*	-0.043**	*10*	-0.049**	*6*	0.012	0.006	-0.055**	-0.061**
		(0.015)		*(0.027)*		*(0.661)*	*(0.669)*	*(0.015)*	*(0.010)*
4	*10*	-0.053	*10*	0.029***	*6*	0.005**	0.082**	-0.048	0.034
		(0.000)		*(0.000)*		*(0.040)*	*(0.016)*	*(0.191)*	*(0.359)*
6	*10*	0.071***	*10*	0.129***	*6*	0.029	-0.058	0.042	0.100
		(0.000)		*(0.000)*		*(0.287)*	*(0.302)*	*(0.352)*	*(0.034)*
7	*10*	0.023	*10*	0.042*	*6*	-0.011	-0.019	0.034	0.053*
		(0.253)		*(0.088)*		*(0.693)*	*(0.679)*	*(0.420)*	*(0.099)*
8	*11*	0.027	*10*	0.098***	*6*	0.021	-0.071	0.006	0.077
		(0.194)		*(0.000)*		*(0.476)*	*(0.130)*	*(0.895)*	*(0.203)*
9	*11*	0.128***	*11*	0.147***	*7*	0.069**	-0.019	0.058	0.078
		(0.000)		*(0.000)*		*(0.011)*	*(0.694)*	*(0.190)*	*(0.156)*
10	*11*	-0.010	*11*	-0.052**	*7*	0.042	0.042*	-0.052	-0.094**
		(0.663)		*(0.048)*		*(0.113)*	*(0.072)*	*(0.103)*	*(0.010)*
11	*11*	0.034	*11*	-0.011	*7*	0.035	0.045*	-0.001	-0.046*
		(0.142)		*(0.676)*		*(0.190)*	*(0.073)*	*(0.976)*	*(0.080)*
12	*13*	-0.016	*11*	0.032	*7*	-0.007	-0.049	-0.009	0.040
		(0.442)		*(0.238)*		*(0.782)*	*(0.234)*	*(0.638)*	*(0.288)*
Total	*13*	0.017**	*11*	0.032***	*7*	0.014*	-0.015	0.004	0.019
		(0.042)		*(0.001)*		*(0.086)*	*(0.266)*	*(0.736)*	*(0.146)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test, described in chapter 3.3.3
Event 5 is not included in the analysis due to reasons explained in chapter 5.1.
Results are obtained from N listed renewable energy firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

Table 8.8: Mean CARs for the renewable energy segment partitioned by regions from One Trading Day before to One Trading Day after the Events for ILUC

Event ILUC	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR AP	Difference EU-NA	Difference EU-AP	Difference NA-AP
1	*15*	0.005	*13*	-0.001	*9*	0.011	0.006	-0.006	-0.012
		(0.778)		*(0.938)*		*(0.474)*	*(0.764)*	*(0.763)*	*(0.477)*
2	*15*	-0.004	*15*	0.018	*9*	-0.002	-0.023	-0.002	0.021
		(0.793)		*(0.214)*		*(0.888)*	*(0.246)*	*(0.924)*	*(0.123)*
3	*15*	0.030*	*15*	-0.018	*9*	0.007	0.048	0.023	-0.024
		(0.050)		*(0.217)*		*(0.678)*	*(0.016)*	*(0.380)*	*(0.290)*
4	*15*	-0.008	*15*	0.041***	*9*	-0.006	-0.048	-0.002	0.046*
		(0.598)		*(0.001)*		*(0.726)*	*(0.004)*	*(0.926)*	*(0.074)*
5	*15*	-0.008	*15*	-0.012	*9*	-0.005	0.004	-0.003	-0.007
		(0.546)		*(0.397)*		*(0.733)*	*(0.832)*	*(0.865)*	*(0.658)*
6	*15*	-0.007	*16*	0.023	*10*	-0.017	-0.030	0.009	0.040
		(0.549)		*(0.103)*		*(0.227)*	*(0.084)*	*(0.709)*	*(0.156)*
7	*15*	-0.011	*16*	-0.027	*10*	0.040***	0.015	0.029	0.014
		(0.357)		*(0.061)*		*(0.004)*	*(0.373)*	*(0.160)*	*(0.487)*
8	*15*	0.033***	*16*	-0.006	*10*	0.050***	0.039	-0.017	-0.056
		(0.007)		*(0.686)*		*(0.001)*	*(0.080)*	*(0.648)*	*(0.124)*
9	*15*	0.007	*16*	0.023	*10*	0.025	-0.016	-0.018	-0.002
		(0.600)		*(0.133)*		*(0.130)*	*(0.655)*	*(0.188)*	*(0.946)*
Total	*15*	0.004	*16*	0.005	*10*	0.003	-0.001	0.001	0.002
		(0.402)		*(0.408)*		*(0.694)*	*(0.943)*	*(0.858)*	*(0.817)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test, described in chapter 3.3.3
Results are obtained from N listed renewable energy firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model and is based on regional indices and the price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

Table 8.9: Mean CARs for the renewable energy segment partitioned by regions from One Trading Day before to One Trading Day after the Events for RED II

Event RED II	N	Mean CAR EU	N	Mean CAR NA	N	Mean CAR AP	Difference EU-NA	Difference EU-AP	Difference NA-AP
1	*15*	-0.017	*19*	-0.010	*10*	0.024*	-0.006	0.040***	-0.034**
		(0.191)		*(0.512)*		*(0.075)*	*(0.688)*	*(0.007)*	*(0.021)*
2	*15*	-0.002	*19*	-0.005	*10*	0.026**	0.003	0.024*	0.021
		(0.853)		*(0.738)*		*(0.036)*	*(0.901)*	*(0.098)*	*(0.433)*
3	*16*	0.014	*19*	0.005	*10*	0.005	0.009	0.019	0.010
		(0.216)		*(0.716)*		*(0.694)*	*(0.611)*	*(0.229)*	*(0.458)*
4	*16*	0.001	*19*	0.031**	*10*	0.003	0.032	-0.002	-0.034**
		(0.927)		*(0.021)*		*(0.783)*	*(0.188)*	*(0.943)*	*(0.044)*
5	*16*	-0.024	*19*	0.006	*10*	0.036***	-0.030	-0.059*	-0.029
		(0.172)		*(0.697)*		*(0.006)*	*(0.109)*	*(0.056)*	*(0.286)*
6	*16*	0.000	*19*	0.002	*10*	0.009	-0.002	-0.009	-0.008
		(0.999)		*(0.916)*		*(0.487)*	*(0.878)*	*(0.506)*	*(0.520)*
7	*16*	0.002	*19*	-0.004	*10*	0.009	0.006	-0.008	-0.013
		(0.923)		*(0.809)*		*(0.137)*	*(0.696)*	*(0.340)*	*(0.467)*
Total	*16*	-0.004	*19*	-0.005	*10*	0.003	0.002	-0.006	-0.008
		(0.482)		*(0.260)*		*(0.623)*	*(0.800)*	*(0.406)*	*(0.278)*

P-values are in parenthesis: *** p<0.01. ** p<0.05. * p<0.1 – based on the t-test, described in chapter 3.3.3
Results are obtained from N listed renewable energy firms partitioned by regions, where EU = Europe, NA = North America and AP = Asia-Pacific. Cumulative abnormal return is computed using the multi-factor model based on regional indices and price return of crude oil described in the thesis. The estimation window to compute market parameters extends from 252 days before to two days before each event date.

8.5 Random Effects vs Fixed Effects

Table 8.10: Random Effects and Fixed Effects: Full sample

	Random Effects CAR	Fixed Effects CAR
Constant	0.586***	-0.864
	(2.986)	(-1.099)
RED	0.236**	0.240**
	(2.558)	(2.397)
ILUC	0.093	0.143
	(1.070)	(1.611)
FX rate	-0.195***	-1.215***
	(-2.659)	(-3.792)
Debt	-0.490***	-0.384
	(-2.755)	(-1.197)
BM	-0.048	0.043
	(-1.119)	(0.615)
ln Equity	-0.013	0.255***
	(-0.946)	(3.470)
Obs.	207	207
R-squared	.z	0.280

Z-values are in parenthesis for Random effects.
T-values are in parenthesis for Fixed Effects.
*** *p<0.01*, ** *p<0.05*, * *p<0.1*

Hausman (1978) specification test

	Coef.
Chi-square test value	36.436
P-value	0.000

Table 8.11: Random Effects and Fixed Effects: Fossil fuel sample

	Random Effects CAR	Fixed Effects CAR
Constant	0.747**	1.092
	(2.066)	(0.636)
RED	-0.182***	-0.022
	(-2.625)	(-0.275)
ILUC	0.003	0.044
	(0.039)	(0.701)
FX rate	-0.113**	-0.732***
	(-2.082)	(-3.558)
Debt	-0.393	0.181
	(-1.334)	(0.276)
BM	-0.069	0.045
	(-1.068)	(0.277)
ln Equity	-0.033	-0.054
	(-1.416)	(-0.399)
Obs.	90	90
R-squared	.z	0.332

Z-values are in parenthesis for Random effects.
T-values are in parenthesis for Fixed Effects.
*** *p<0.01*, ** *p<0.05*, * *p<0.1*

Hausman (1978) specification test

	Coef.
Chi-square test value	17.209
P-value	.009

Table 8.12: Random Effects and Fixed Effects: Renewable energy sample

	Random Effects CAR	Fixed Effects CAR
Constant	-0.015	-0.932
	(-0.050)	(-0.951)
RED	0.570***	0.469***
	(3.941)	(2.704)
ILUC	0.184	0.233
	(1.399)	(1.560)
FX rate	-0.097	-1.139
	(-0.644)	(-1.530)
Debt	-0.473**	-0.238
	(-2.130)	(-0.563)
BM	-0.052	0.037
	(-0.979)	(0.399)
ln Equity	0.059**	0.297***
	(2.163)	(3.021)
Obs.	117	117
R-squared	.z	0.350

Z-values are in parenthesis for Random effects.
T-values are in parenthesis for Fixed Effects.
*** *p<0.01*, ** *p<0.05*, * *p<0.1*

Hausman (1978) specification test

	Coef.
Chi-square test value	9.804
P-value	.133

Table 8.13: Fossil fuel companies

#	Company name	Country	STOXX Index
1	Exxon Mobil (XOM)	USA	North America 600
2	Chevron Corporation (CVX)	USA	North America 600
3	Valero Energy (VLO)	USA	North America 600
4	ConocoPhillips (COP)	USA	North America 600
5	Enterprise Products (EPD)	USA	North America 600
6	Schlumberger (SLB)	USA	North America 600
7	Suncor Energy (SU)	Canada	North America 600
8	Sinopec Group (SPO)	China	Asia/Pacific 600
9	ONGC (ONG)	India	Asia/Pacific 600
10	Indian Oil Corporation (IO)	India	Asia/Pacific 600
11	Reliance Industries (REL)	India	Asia/Pacific 600
12	Bharat Petroleum (BHP)	India	Asia/Pacific 600
13	Hindustan Petroleum (HPT)	India	Asia/Pacific 600
14	Lukoil (LKO)	Russia	Asia/Pacific 600
15	Gazprom (GAZ)	Russia	Asia/Pacific 600
16	Rosneft (RSF)	Russia	Asia/Pacific 600
17	PTT (PTTB)	Thailand	Asia/Pacific 600
18	Royal Dutch Shell (RDSA)	Holland	Europe 600
19	BP (BP)	UK	Europe 600
20	Centrica (CNA)	UK	Europe 600
21	Total (TAL)	France	Europe 600
22	Engie (ENGI)	France	Europe 600
23	Eni (ENI)	Italy	Europe 600
24	Equinor (EQNR)	Norway	Europe 600
25	Repsol (REP)	Spain	Europe 600
26	OMV Group (OMV)	Austria	Europe 600
27	PKN Orlen (PLK)	Polen	Europe 600
28	MOL (MMG)	Hungary	Europe 600
29	Motor Oil Hellas (MOH)	Greece	Europe 600
30	Hellenic (HPI)	Greece	Europe 600

Table 8.14: Renewable Energy Companies

#	Company name	Country	STOXX Index
1	First Solar (FSLR)	USA	North America 600
2	Enphase Energy (ENPH)	USA	North America 600
3	SolarEdge Tech (SEDG)	USA	North America 600
4	Sunpower Corporation (SPWR)	USA	North America 600
5	Sunrun (RUN)	USA	North America 600
6	Ascent Solar Technologies (ASTI)	USA	North America 600
7	Canadian Solar (CSIQ)	USA	North America 600
8	Ormat Technologies (ORA)	USA	North America 600
9	Pattern Energy Group (PEGI)	USA	North America 600
10	Renewable Energy Group (REGI)	USA	North America 600
11	Enviva Partners (EVA)	USA	North America 600
12	Clean Energy Fuels (CLNE)	USA	North America 600
13	Futurefuel (FF)	USA	North America 600
14	Gevo (GEVO)	USA	North America 600
15	Green Plains (GPRE)	USA	North America 600
16	Rex American Resources (REX)	USA	North America 600
17	Darling Ingredients (DAR)	USA	North America 600
18	Bookfield Renewable (BEP.UN)	Canada	North America 600
19	Innergex Renewable (INE)	Canada	North America 600
20	Longyuan Power Group (CLYU)	China	Asia/Pacific 600
21	Goldwind (GWS)	China	Asia/Pacific 600
22	Sinovel (OVA)	China	Asia/Pacific 600
23	Dongfang Electric (DEM)	Hong Kong	Asia/Pacific 600
24	Electric Power Development Company	Japan	Asia/Pacific 600
25	Enlight Renewable Energy (ENLT)	Israel	Asia/Pacific 600
26	Meridian Energy (MELZ)	New Z	Asia/Pacific 600
27	Carnegie Energy Group (CCEX)	Australia	Asia/Pacific 600
28	Infigen Energy (IFNX)	Australia	Asia/Pacific 600
29	Suzlon Energy (SZE)	India	Asia/Pacific 600
30	EQTEC (EQT)	England	Europe 600
31	PV Crystolax Solar (PVCS)	England	Europe 600
32	Vestas Wind Systems (VEW)	Denmark	Europe 600
33	Ørsted (DEN)	Denmark	Europe 600
34	EDP Renovaveis (EDPR)	Spain	Europe 600
35	Acciona Energy (ANA)	Spain	Europe 600
36	Siemens Gamesa Renewable Energy (GAM)	Spain	Europe 600
37	Phoenix Solar (PS4)	Germany	Europe 600
38	EnergieKontor AG (EKT)	Germany	Europe 600
39	Nordex AG (NDX1)	Germany	Europe 600
40	SMA Solar Technologies (S92)	Germany	Europe 600
41	Terna Energy (TEN)	Greece	Europe 600
42	Enel Green Power (ENEL)	Italy	Europe 600
43	Hexagon Composites (HEX)	Norway	Europe 600
44	ETRION (ETX)	Switzerland	Europe 600
45	Deinove (DEIN)	France	Europe 600

Table 8.15: Biofuel Companies (only low ILUC-risk)

#	Company name	Country	STOXX Index
1	Renewable Energy Group (REGI)	USA	North America 600
2	Enviva Partners (EVA)	USA	North America 600
3	Clean Energy Fuels (CLNE)	USA	North America 600
4	Futurefuel (FF)	USA	North America 600
5	Gevo (GEVO)	USA	North America 600
6	Green Plains (GPRE)	USA	North America 600
7	Rex American Resources (REX)	USA	North America 600
8	Darling Ingredients (DAR)	USA	North America 600
9	Deinove (DEIN)	France	Europe 600