How the European Union Renewable Energy Directive Impacts the Global Energy Industry

Evidence from Global Stock Markets

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Dissertation written under the supervision of Professor Zoë Venter

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Abstract

This thesis investigates the impact of the European Union's Renewable Energy Directive (RED) on global energy markets, assessing investor response and its implications for the energy industry. The study analyses cumulative abnormal returns of 409 firms, including fossil fuel and renewable energy sectors across Europe, North America, and Asia. An event study methodology is employed to capture market reactions from the proposal to the approval of RED. The findings suggest that the implementation of RED has resulted in significant positive cumulative abnormal returns. This highlights that investors take regulatory changes into account when evaluating climate risks. It is worth noting that, contrary to expectations, the fossil fuel industry experienced a paradoxical positive response after the implementation of RED. This implies that the market recognizes the need for transitioning towards more environmentally friendly practices. The thesis explores the regional impacts of RED, revealing that its effects extend beyond the EU and influence energy firms globally. This research contributes to the discourse on climate risk premiums and the financial implications of green regulation, offering fresh insights into how environmental policies are shaping investment decisions in the energy industry.

Title: How the European Union Renewable Energy Directive Impacts the Global Energy Industry

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Resumo

Esta tese investiga o impacto da Diretiva da União Europeia relativa às Energias Renováveis (RED) nos mercados globais de energia, avaliando a reação dos investidores e as suas implicações para a indústria energética. O estudo analisa os retornos anormais cumulativos de 409 empresas, incluindo os sectores dos combustíveis fósseis e das energias renováveis na Europa, América do Norte e Ásia. É utilizada uma metodologia de estudo de eventos para captar as reações do mercado desde a proposta até à aprovação da RED. Os resultados sugerem que a implementação da RED resultou em retornos anormais cumulativos positivos e significativos. Este facto evidencia que os investidores têm em conta as alterações regulamentares ao avaliarem os riscos climáticos. É de notar que, contrariamente às expectativas, a indústria dos combustíveis fósseis registou uma resposta positiva paradoxal após a implementação da RED. Este facto implica que o mercado reconhece a necessidade de transição para práticas mais respeitadoras do ambiente. A tese explora os impactos regionais da RED, revelando que os seus efeitos se estendem para além da UE e influenciam as empresas de energia a nível global. Esta investigação contribui para o discurso sobre os prémios de risco climático e as implicações financeiras da regulamentação verde, oferecendo novas perspetivas sobre a forma como as políticas ambientais estão a moldar as decisões de investimento na indústria energética.

Título: O impacto da diretiva da União Europeia relativa às energias renováveis na indústria energética mundial

Autor: Ana Alves

Palavras-chave: Diretiva relativa às energias renováveis (RED), Risco Climático, Impacto, Retornos Anormais Cumulativos

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List of Abbreviations

Abbreviation	Description
CAPM	Capital Asset Pricing Model
CO2	Carbon Dioxide
CSR	Corporate Social Responsibility
EMH	Efficient Market Hypothesis
ESG	Environmental, Social, Governance
EU	European Union
FF	Fossil Fuels
GDP	Gross Domestic Product
GHG	Greenhouse Gas
OLS	Ordinary Least Square
RE	Renewable Energy
RED	Renewable Energy Directive
U.S.	United States of America
UK	United Kingdom

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1. Introduction

In the context of the urgent need to combat climate change, the imperative for a transition to sustainable energy sources has been highlighted, requiring an examination of the critical role of government policies and regulations in driving investment in the renewable energy sector. Governments worldwide are responsible for implementing policies that incentivize cleaner alternatives, recognizing the energy industry as a significant contributor to carbon emissions. By directing investments towards renewable energy initiatives, governments can address environmental concerns and stimulate economic growth in the emerging green energy sector. The 2009 Renewable Energy Directive (RED) is an example of how regulations can shape the present towards a more sustainable future. The European Union (EU) committed to mandatory targets and subsequently increased the share of renewable energy in EU consumption from 12.5% in 2010 to 23% in 2022 (EU, 2009), surpassing the goal established in the RED. This progress is in line with the EU's global leadership in renewables, as demonstrated by its technological advancements and the integration of renewable energy as a pillar of initiatives, contributing to a cost-effective, self-sufficient, and resilient energy ecosystem that reduces dependence on external suppliers.

This thesis aims to investigate the influence of the RED on financial markets and investor decisions. Fama (1970) argues that if markets are semi-strong efficient, security prices should accurately reflect all public relevant information. Therefore, the introduction of new regulatory changes should be reflected in the prices of securities. Changes in regulations affecting specific industries or companies should be accurately reflected in the stock prices of those companies. This research seeks to provide a comprehensive understanding of how the RED not only contributes to environmental sustainability but also influences financial dynamics in the energy industry. If investors believe that this regulatory change is effective and that climate risks are being incorporated into their investment decisions, there should be an increase in the value of renewable energy firms and a decrease in the value of fossil fuel firms.

To measure the effect of the RED, abnormal returns are estimated for a sample of firms within the energy industry, based on the Capital Asset Pricing Model (CAPM) model. The sample is divided into two sectors: the fossil fuel sector and the renewable energy sector. The cumulative abnormal returns are tested for the energy industry and sectors, as well as the difference between sectors. Furthermore, the sample is divided into three regions: North

America, Europe, and Asia. The differences between regions are tested. Additionally, a regression analysis including firm-specific control variables is conducted.

This thesis makes significant contributions to several topics. Firstly, it provides empirical research on the financial implications of environmental regulation, specifically the RED. As the results indicate, the energy industry shows positive cumulative abnormal returns with the introduction of the RED. The results support the idea that financial markets are increasingly taking climate risks into account. Secondly, this work contributes to the discussion on climate risk premiums in financial studies. It reveals a paradoxical positive response from the fossil fuel sector following the implementation of the RED. This could be interpreted as the market's recognition of the need for these traditionally non-renewable companies to transition towards greener operations. Such a transition may be considered ultimately value-enhancing in the context of a carbon-constrained world.

The rest of this paper is structured as follows: Section 2 discloses awareness background information. Section 3 reviews the existing literature, summarizing the scholarly work on the subject. Section 4 discusses the hypotheses that will be tested in this paper. Section 5 describes the data used, while section 6 provides clarity on the methodology employed. In section 7 the study presents the results, some of which are subjected to robustness tests in section 8. Subsequently, section 9 provides a main discussion of the results regarding the main hypotheses. Lastly, Section 10 outlines the study’s limitations, proposes areas for further research and provides a conclusion.

2. Framework and Background

2.1. Renewable Energy Directive (2009/28/EC)

To reduce greenhouse gas (GHG) emissions and decrease energy import reliance in the European Community, renewable energy sources should be closely linked to increased energy efficiency. The European Union's adoption of the RED on April 23, 2009, established the following mandatory national targets: achieve a 20% share of renewable energy in overall energy consumption and a 10% share in the transport sector by 2020, surpassing the previous target of 12%. The directive officially came into force on June 26, 2009. The main aim of these compulsory national targets is to establish a stable framework for investors, promoting certainty and encouraging the ongoing development of technologies across all renewable energy sources within the 27 member countries (EU, 2009).

2.2. Energy Industry

The energy industry includes all companies involved in producing and distributing energy resources. The energy industry is driven by the worldwide supply and demand for energy consumption. As one of the largest industries in the world, the supply and demand for energy are affected by a variety of factors, such as weather forecasts, gas storage, financial speculation, and national and international regulations.

Although energy demand has been increasing in recent years due to technological advancements and the growing electrification of the economy, consumers and firms have been attempting to reduce their energy consumption for environmental reasons by improving energy efficiency.

To have a global perspective of energy consumption, oil accounted for the highest share of the global Energy Consumption sector in 2021, with 30.5% of the sector's overall volume. In comparison, coal accounted for 27.7% of the sector's total. The industry has been significantly impacted by the issue of climate change in recent years. Renewable energy sources have experienced the highest growth in output in recent years, reaching 12.5% in 2021 (Marketline, 2022).

2.2.1. Fossil Fuel

The fossil fuel sector consists of companies involved in the production and supply of oil, natural gas, and coal, which plays a critical role in global energy consumption. The global oil and gas market experienced a strong recovery in 2021 and 2022 after a contraction in 2020. This was due to the lifting of pandemic restrictions and price escalations resulting from geopolitical events. The market is expected to experience moderate growth going forward, supported by key macroeconomic drivers such as rising GDP, in line with industrialization, and inflation.

Economic growth plays a significant role as expanding economies lead to increased business growth in end-use industries, driving demand for the oil and gas market. The sector achieved a compound annual growth rate of 8.4% between 2017 and 2022 (Marketline, 2023).

The fossil fuel sector, which is responsible for two-thirds of global GHG emissions, is facing an increasing number of risks due to advancements in climate change mitigation. The coal industry is expected to face higher risks, while oil businesses are expected to face lower risks due to the lack of substitutes. It is concluded that there is a trade-off: any gain for the climate could signify a loss for the fossil fuel industry, unless innovative technologies can separate carbon emissions from energy production, thus breaking the zero-sum dynamic currently at play (Krane, 2017).

The primary reason is that governments, corporations, and stakeholders are increasingly demanding more transparent and ambitious emissions reduction targets. Emissions from oil and gas activities are being subjected to greater scrutiny, which aligns with the growing consensus on the necessity of a global transition to clean energy. It is highly recommended to strategically decrease the consumption of coal, oil, and natural gas to combat global warming (Achakulwisut, et al., 2023).

2.2.2. Renewable Energy

The renewable energy market consists of the net generation of electricity through renewable sources. It is divided into five segments, these being hydroelectricity, wind, solar, biomass and geothermal energy.

The importance of renewable energy is increasing due to the environmental issues caused by the consumption of fossil fuels. The global renewable energy market has been growing at a compounded annual growth rate of 11.1% from 2011 to 2022. Hydroelectricity is the largest segment of the global renewable energy market, accounting for 48.7% of the market's total volume, followed by wind energy (Marketline, 2023).

Sustainable transition strategies in the energy sector are based on three key technological shifts: increasing energy efficiency on the demand side, improving generation efficiency at the production level, and replacing fossil fuels with a combination of renewable energy sources and low-carbon nuclear options (Kabeyi & Olanrewaju, 2022). These shifts are essential for achieving the decarbonization of global energy systems, which is a critical challenge of the 21st century. Additionally, the expansion of renewable energy is recognized as a crucial factor in reducing carbon dioxide (CO2) emissions and plays a dominant role in achieving the targets set by the Net Zero Emissions (NZE)[1] scenario by 2030.

[1] Developed by the International Energy Agency (IEA).

3. Literature Review

3.1. The Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH), introduced by Fama (1970), states that the value of a stock reflects all relevant information available in the market, making it impossible to be outperformed. An efficient market is characterized by investors seeking to maximize profits and universal access to relevant information, fostering competition that results in securities' actual prices which reflect both past and anticipated future events.

Fama (1970) delineated three levels of market efficiency – weak, semi-strong, and strong. Weak-form efficiency asserts that historical prices cannot predict future prices; semi-strong form describes that a market is efficient when all publicly available information is quickly reflected in prices, while strong-form contends that a market is efficient if all relevant information, including insider information, is promptly and precisely incorporated into security prices. If the markets are semi-strong efficient, any regulatory change made by a government, such as the RED, should be reflected quickly and accurately in the stock prices when it becomes public information.

In contrast, Țițan (2015) examines the phenomenon of delayed price responses to event announcements in financial markets, which is often attributed to investor inattention. This delay indicates that prices do not always adjust instantaneously to new information, which contradicts the semi-strong form of the EMH. The paper reviews and analyzes the literature on EMH by examining the speed at which financial markets incorporate new information. Empirical evidence suggests that there is a noticeable delay in market reaction times, which may indicate inefficiencies in the market's processing of events. This evidence challenges the established notions of the EMH theory.

3.2. Corporate Social Responsibility

The relationship between the RED, corporate social responsibility (CSR), and financial markets suggests a significant intersection. Compliance with directives such as the RED is becoming critical for investors, given the growing importance of CSR criteria in investment decisions. This concept is explained in more detail by Pratoomsuwan and Chiaravutthi (2023). Their empirical study shows that investment preferences tend to favour companies whose CSR initiatives are integrated into their core business functions. A positive approach to CSR, particularly when it is materially related to a company's primary activities, can significantly influence investment decisions.

Similarly, Christensen et al. (2021) found that the introduction of mandated CSR and sustainability reporting not only has effects on capital markets, influencing investor decisions and stock prices but also leads to changes in firm behavior. Companies may adjust their practices to align with CSR and sustainability standards, reflecting a broader shift in the purpose of corporations. This shift places a growing emphasis on serving stakeholders beyond just shareholders.

Furthermore, it is crucial to disclose CSR activities to stakeholders. Gao et al. (2022) examine the influence of CSR performance quality and disclosure clarity on investors' earnings projections. Additionally, the study highlights the importance of CSR report readability in investment decision-making. The results indicate that positive CSR performance leads to more favorable earnings estimates by investors. Clear and comprehensible CSR reports enhance the positive impact of CSR performance on investors' earnings expectations. It is important not only to engage in CSR activities but also to effectively communicate these efforts to stakeholders, thereby improving their understanding and appreciation of the company's CSR efforts.

3.3. Climate Risk

The intersection of climate change and finance is a developing field of study, particularly focusing on how climate change affects stock returns. This topic is crucial given the divergent views among institutional investors on the impact of climate change on financial assets. A key area of research is whether the risks associated with carbon emissions are accurately reflected in asset prices.

Bolton and Kacperczyk (2021) investigate the relationship between CO_2 emissions and the performance of U.S. stocks. The study highlights the need for further research into the impact of carbon emissions on stock performance. The study analyses whether investors demand a carbon risk premium by observing variations in stock returns relative to CO_2 emissions across different firms and industries. The results reveal that companies with higher CO_2 emissions tend to yield higher returns. The study suggests that investors are seeking compensation for the risks associated with higher emissions. It concludes that there is substantial evidence to support the notion that CO_2 emissions have a positive and meaningful impact on stock returns. This implies that investors are pricing in carbon risk. Furthermore, the observed carbon premium does not align with the sin stock divestment effect, highlighting the distinct nature of carbon risk in investment decision-making processes. This emphasizes the critical understanding that, while divestment based on emission intensity exists, it is limited to a certain number of industries.

Climate risk is being reflected in the investment strategies of institutional investors, who are now giving priority to integrating these risks into their decision-making choices. As addressed by Krueger et al. (2019), investors are highly aware of the financial impact of climate risks, particularly regulatory risks, on their portfolios. The study also finds that institutional investors prefer to engage with companies on climate issues over divestment. However, some institutional investors argue that current equity markets are underestimating climate risks, suggesting that investors should demand a higher climate risk premium.

Cohen et al. (2023) examine the correlation between institutional investors' need for climate-related information and corporate response in terms of disclosure and action, as well as the resulting impact on CO_2 emissions. The analysis of the world's leading platform of corporate climate risk disclosures provides evidence that companies with significant ownership by Carbon Disclosure Project signatories are more likely to disclose climate information. This disclosure is associated with lower CO_2 emissions, highlighting the crucial role of institutional investors in promoting corporate environmental transparency and accountability. The findings also reflect a strategic shift in the incorporation of climate risk into investment decisions.

3.4. Measuring the Effects of Regulations on Stock Returns

Schwert (1981) proposes using asset prices, in particular stock prices, to measure the impact of regulation on the profitability of affected firms. This is because stock prices offer more frequent and timely data compared to quarterly accounting reports. In addition, they provide more accurate data and a larger number of observations. The author acknowledges that although stock prices can reflect the impact of a particular regulation with more precise and current insights, they cannot answer all the pertinent questions regarding its effects. This exemplifies the challenge of isolating the impact of a particular regulation when the price of a security rises.

Binder (1985) highlights challenges in using stock data to evaluate regulatory effects. This can lead to challenges in accurately evaluating the effects of regulations. Regulatory announcements are often anticipated and involve extensive negotiations before voting, making outcomes predictable. Secondly, it is not immediately evident whether regulation has consistently positive or negative effects. In the same industry, some firms may benefit while others may suffer. As an example, Stigler (1974) discusses collective action and argues that the interests of large firms differ significantly from those of small firms. Additionally, unlike other commonly studied events, regulation often impacts multiple firms in the same industry during the same period. Therefore, when significant excess returns are discovered, it is uncertain whether they are due to regulation or some other industry-specific shock. The author highlights the unpredictability of changes in investor expectations resulting from regulatory discussions or votes, the prior knowledge of vote outcomes due to negotiations, and the differential impact of regulatory changes on different firms. This complicates the assessment of uniform market effects.

3.5. Valuation of Intangibles

Edmans (2011) reveals that equity markets undervalue intangibles such as intellectual property and brand equity, and investors systematically underreact to their value. This phenomenon is supported by studies conducted by Tetlock (2010) and Hirshey & Richardson (2003), indicating a broader market inefficiency in pricing intangibles. Recognizing regulatory changes as an intangible asset implies that their true effect may be underestimated or delayed in financial markets.

4. Hypotheses

With the introduction of the RED and its mandate to achieve a 20% share of energy consumption from renewable sources within the EU, the demand for renewable energy in Europe was expected to rise, while at the same time reducing dependence on energy derived from fossil fuels. Note that implementing such directives can have a significant impact on the global energy industry due to its interconnected nature. As the directive is introduced by the EU, the region may experience a more substantial effect from it. However, other regions, such as North America and Asia, are also expected to be impacted. To assess the effectiveness of this directive in reducing GHG emissions across EU member countries, a comprehensive case study has been conducted. The following hypotheses are tested in this context:

Hypothesis 1: *The European Union's Renewable Energy Directives of 2009 have had an impact on the energy industry.*

Hypothesis 2: *The fossil fuel (renewable energy) segment experiences a negative (positive) impact after the directive.*

Hypothesis 3: *There is an impact of the Renewable Energy Directives (RED) that extends beyond the borders of the European Union, not only affecting companies within the EU but also in the North America and Asia regions.*

5. Data Collection

This section outlines the methodology and framework used in the data collection process. It describes the selection of the data source and the rationale behind choosing specific variables, which serve as the basis for my analysis.

5.1. Data Source and Sample Selection

The process started with the extraction of company listings from each energy industry – Fossil Fuel and Renewable Energy sectors – across three distinct regions: Europe, North America, and Asia, using Refinitiv Eikon as the primary data source. Following this initial step, daily index prices and firm-specific variables were collected from Datastream for each company, covering the period of January 1, 2007, to December 31, 2009. To ensure accurate company identification, the tickers between Refinitiv and Datastream were matched. Entities that were inactive or delisted during the specified period were then removed from the dataset. The refined sample was then matched with quarterly data on firm-specific variables. The final sample comprises 409 different companies.

To measure the effectiveness of the RED on the two energy sectors, the sample is divided into Fossil Fuels and Renewable Energy firms. The analysis focuses primarily on these categories, with an additional layer of distinction based on geographical regions. This approach assumes that the RED has effects beyond Europe, requiring a region-specific analysis to fully comprehend its impact on the energy sector.

Table 1 Sample Size by Energy Segment and Region

	Fossil Fuels	Renewable Energy	Energy Industry
Europe	101	21	122
NA	101	24	125
Asia	134	28	162
Final Sample	336	73	409

The CAPM model, which is used globally by companies, is employed to estimate abnormal returns. An explanation of the model is provided in the following section. For a comprehensive global perspective, it is suitable to use a general index that covers the regions explored in this study: Europe, North America, and Asia. The STOXX Global 1800 index, frequently employed in recent research, serves as an effective benchmark for this purpose (Gavrilakis & Floros, 2024). Therefore, it is extracted the STOXX Global 1800 Index from Refinitiv Eikon. This index contains 600 European, 600 North American, and 600 Asia/Pacific stocks. The STOXX Europe 600 Index, the STOXX North America 600 Index, and the STOXX Asia/Pacific 600 Index represent a total of 600 stocks from each of the respective regions. The indices are reviewed quarterly and weighted by free-float market cap. Each regional index comprises 600 components, including large, mid, and small-cap companies from various industries (STOXX, 2019).

The risk-free rate used to compute the excess returns refers to the one-month US Treasury bill rate, which has been collected from Kenneth R. French Data Library.

5.2. Firm Control Variables

To account for firm-specific effects, the regression models used include five different control variables: book-to-market value (BTMV), debt-to-assets ratio (D/A), total assets (SIZE), return on assets (ROA) and debt-to-equity (D/E) ratio. The BTMV, which is calculated as the inverse of the market-to-book value, adjusts for growth differentials. The D/A, which is determined by the ratio of total liabilities and total assets, serves as a measure to control for varying debt levels. SIZE is determined by a logarithmic transformation applied to normalize the total assets values, which are included in the model to address size variations. The models also include ROA, which is calculated by dividing net income by total assets to adjust for profitability variations. Lastly, the D/E is used to regulate leverage differences, which is computed by dividing total liabilities by total shareholder equity. All these variables were extracted from the DataStream and winsorized at the 1% and 99% levels.

5.3. Events

The RED is a measure aimed at promoting the use of renewable energy sources and reducing GHG emissions in the EU. The official EU website organizes the dates into three categories: proposal, discussion, and decision phases, which are reflected in the table below. It is important to note that regulatory announcements, such as those related to the RED, are typically preceded by thorough negotiations and discussions. This extensive preparatory process often makes the outcomes of these announcements somewhat predictable. In this context, it is analyzed 12 significant events, to observe how markets responded over time to the adoption of regulatory measures in the field of renewable energy and environmental policy in the EU.

Table 2 Events for the RED

Event	Date	Event Description
1	21/01/2008	The first proposal for the RED.
2	28/02/2008	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	05/06/2008	Discussions in the Council on the main aspects of the RED.
4	17/09/2008	Opinion from the Economic and Social Committee on the proposal of the RED the Committee votes in favour 105 to 38.
5	08/10/2008	Committee of Regions gives their opinion the RED.
6	10/10/2008	The Council discusses the RED – No notable changes or agreements.
7	20/10/2008	The council notes information from the Presidency on the main aspects of the RED.
8	04/12/2008	Ministers discuss the RED informally. – No notable changes or agreements.
9	17/12/2008	The Parliament approves the Commission’s proposal as amended. Instructs its President to forward its position to the Council and the Commission.
10	06/04/2009	The Council formally adopts the various legal acts configuring the RED.
11	23/04/2009	Signature by the Presidents of the EP and Council.
12	26/06/2009	The RED begins.

Source: Official Journal of the European Union

5.4. Descriptive Statistics

This section provides an overview of the variables used in this research.

Table 3 Variable Description, Summary Statistics and Variables Correlation

Panel A: Overview of variables

Variable	Description	Calculation	Type	Source
CAR	Cumulative Abnormal Return from one day before to one day after the events for each event	Detailed in Section 4.4.	Dependent	Datastream; Kenneth R. French Data Library
A_CAR	The average of the CAR within each company is calculated to aggregate all events analyzed.	Detailed in Section 4.4.	Dependent	Datastream; Kenneth R. French Data Library
BTMV	Book-to-market value for company i during the event periods	1/ Market-to-Book value	Control	Datastream (Eikon)
D/A	Debt-to-asset ratio for company i during the event periods	Total liabilities/Total assets	Control	Datastream (Eikon)
SIZE	The total assets for company i during the event periods (in millions)	Natural logarithm of the number of total assets	Control	Datastream (Eikon)
D/E	Debt-to-Equity for company i during the event periods	Total Liabilities/Total Shareholder Equity	Control	Datastream (Eikon)
ROA	Return on Assets for company i during the event periods	Net income/Total Assets	Control	Datastream (Eikon)
RED	Dummy for the Renewable Energy Directive (2009/28/EC)	Dummy variable equal to 1 if the firm is subject to the RED (is from the EU)	Independent	Official Journal of the European Union
NA	Dummy for the region of North America	Dummy variable equal to 1 if the firm is from NA and 0 otherwise	Independent	Datastream (Eikon)
Europe	Dummy for the region of Europe	Dummy variable equal to 1 if the firm is from EU and 0 otherwise	Independent	Datastream (Eikon)
Asia	Dummy for the region of Asia	Dummy variable equal to 1 if the firm is from AP and 0 otherwise	Independent	Datastream (Eikon)
FF	Dummy for fossil fuel companies	Dummy variable equal to 1 if the firm is from Fossil Fuel sector and 0 otherwise	Independent	Datastream (Eikon)
RE	Dummy for renewable energy companies	Dummy variable equal to 1 if the firm is from Renewable Energy Sector and 0 otherwise	Independent	Datastream (Eikon)

Panel B: Descriptive statistics

	N	Mean	SD	Median	Min	Max
CAR	14,724	-0.014	0.087	-0.007	-0.872	0.745
A_CAR	1,227	-0.014	0.025	-0.011	-0.140	0.109
BTMV	4,908	0.901	1.153	0.641	-3.125	6.250
D/A	4,908	0.812	2.630	0.461	0.011	23.260
Size	4,908	13.397	3.812	13.722	3.892	22.513
ROA	4,908	-0.210	1.815	0.018	-14.400	5.744
D/E	4,908	1.220	2.200	0.772	-3.564	14.361

Panel C: Matrix of Correlation table for control variables

	A_CAR	CAR	BTMV	D/A	SIZE	ROA	D/E
A_CAR	1.000						
CAR	0.468 [2]	1.000					
BTMV	-0.086	-0.033	1.000				
D/A	-0.040	-0.005	-0.311	1.000			
SIZE	0.079	0.023	0.185	-0.307	1.000		
ROA	0.064	0.013	0.132	-0.584	0.297	1.000	
D/E	0.032	-0.003	-0.020	-0.102	0.249	0.172	1.000

Panel D: Matrix of Correlation for dummy variables

CAR	1.000	A_CAR	1,000	CAR	1.000	A_CAR	1.000
FF	-0.004	FF	-0.013	Europe	-0.014	Europe	-0.032
RE	0.004	RE	0.013	NA	0.048	NA	0.153
				Asia	-0.032	Asia	-0.114

All continuous variables have been winsorized 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). Total Assets are reported before log transformation, and their logarithm values are used in the regression. The observations correspond to 409 companies.

Table 3 describes the variables used (Panel A), presents key statistics (Panel B), and the coefficients of correlation between the variables (Panels C and D). Considering all 409 firms, on average, both the cumulative abnormal return (CAR) and the average of the cumulative abnormal return (A_CAR) are -0.014 during the event periods studied. This means that there was a consistent decrease in stock returns for all firms in the sample during the RED, with an average underperformance of 1.4% relative to expected returns.

The firms, on average, have a book-to-market value of 0.901, a debt-to-asset ratio of 0.812, size of 14,724 million, returns on equity of -0.210 and a debt-to-equity of 1.220. The average book-to-market value suggests that, on average, companies may be undervalued. This indicates that the market believes they hold more book value than market value. It may indicate that investors are willing to pay more for a company than its net assets are worth, suggesting that companies have healthy future profit projections, and investors are willing to pay a premium for that possibility. However, as in the sample, the mean CAR is negative while the mean BTMV is positive, this could suggest that, although there might be a potential undervaluation, the market's expectations about the future cash flows or risk profile of these companies have led to negative CAR. On average, debt levels are high, but there is significant variation within the sample. Some companies have almost no debt, while others have debt that far exceeds their assets. The median debt-to-asset ratio is lower than the mean, indicating a skew towards

[2] The correlation between these two variables is insignificant as no analysis was conducted.

companies with lower levels of debt. The size of the companies in the sample varies widely, with most being smaller companies. The firm profitability within the sample is not favorable since companies show, on average, a negative ROA, and a high cross-section variation. This may be due to sector volatility or operational inefficiencies. Finally, on average, the D/E ratio is high, and presents a wide dispersion, highlighting a significant variance in financial structures and possibly differing financial strategies or risk tolerances across the companies. The variability in most of these measures also shows that the companies across the sample are quite diverse in their financial characteristics.

Panel C presents the correlation between the variables used in the regressions. The CAR exhibits a negative correlation with most of the control variables, except for size and debt-to-equity ratio. All variables have weak correlations with CAR indicating that the more independent the variables the less risk of collinearity between explanatory variables, leading to more reliable results. The control variables, in general, exhibit low correlations within themselves, except for ROA, which has higher values.

Panel D presents the correlation between the dummy variables used. While the renewable energy sector shows a positive correlation with CAR, the fossil fuels sector shows a negative one. In terms of regions, CAR is positively correlated with North America and negatively correlated with Europe and Asia. It appears that investors do not distinguish between sectors or regions in terms of expected returns during the event window, as it does not significantly impact the firm's cumulative abnormal returns. The expected performance change in response to the RED seems to be similar between sectors and regions.

6. Methodology

The purpose of this section is to explain the process used to assess the impact of the EU's RED on companies operating in the global energy industry. An event study, the standard method for measuring the impact of events or announcements on security prices, was applied.

6.1. Choice of the Method

Fama (1991) proposed the use of stock price data in event studies to measure the impact of specific events on a firm's valuation, assuming the efficient market theory where stock prices adjust instantaneously to new information, a perspective reinforced by MacKinlay in 1997. According to MacKinlay (1997), the elaboration of the methodology highlights several critical steps that significantly influence the results, emphasizing the importance of selecting an appropriate event window length, identifying a precise sample for analysis, calculating abnormal returns using an appropriate model, establishing a benchmark estimation window, and conducting significance tests to confirm the reliability of the results. Hence, by using the event study methodology, the economic impact of regulatory changes on firm value is measured.

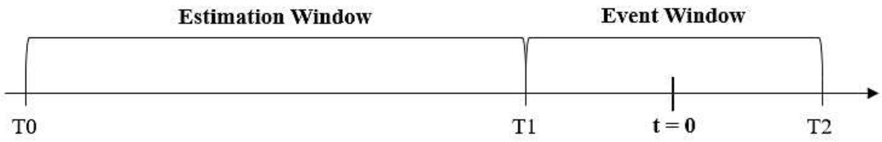
6.2. Defining the Event Timeline

The first step in the methodology was to define the event of interest and identify the period over which to look for a price reaction of the firms involved in such an event (the event window). The event analyzed is the RED, a regulatory change adopted on April 23rd, 2009. According to MacKinlay (1997), in event studies such as mergers or earnings announcements, there is a single event and, therefore, a unique and short event window. However, in the case of regulatory changes, such as the RED, this is not the case. All stages of the process, from proposal to adoption, are acknowledged by the public. Thus, my event window covers all the dates since the proposal to the adoption, therefore ending up testing multiple subsequent connected events.

Determining the exact timing of those succeeding events in a regulatory change analysis is complex and often obscures the detection of abnormal returns. This complexity is compounded when regulatory announcements occur gradually, making it difficult to separate significant returns from market noise. If an event is anticipated it may be priced out, reducing the power of tests to disprove the hypothesis of no regulatory impact (Lamdin, 2001). Mackinlay (1997) states that studies struggle to find meaningful conclusions when event dates are unclear or partially anticipated. To overcome this, it is resorted to the EU's detailed record of all the dates of the RED – from the initial proposal to the final decision.

In the event study timeline, it is important to define which events to study and identify the event period for each of them, which includes the estimation of the event windows. Note that the event and estimation windows should not overlap, as including the event in the estimation window could significantly influence the normal returns measure. To avoid this, even if the event in question applies to a specific date, it is reasonable to set an event window length greater than the respective day of the event date (MacKinlay, 1997).

Figure 1 Timeline for an Event Study



Where t = 0 ($event\ date$), $T0\ to\ T1$ ($estimation\ window$), and $T1\ to\ T2$ ($event\ window$).

For the event window, I followed the Mackinlay (1997) study where the event window includes three days [-1,1], encompassing the day before the event [-1], the event day [0], and the day after the event [+1]. Including the previous day aims at capturing the impact of possible insider trading on prices. In addition, including the day after ensures that the analysis captures instances where news of regulatory adjustments are released just before or after the markets close, thereby also considering time differences between regions.

The estimation windows are set to 252 days, which is approximately a year in terms of trading days. This length is chosen because the estimation window should be long enough to minimize the variance of daily returns, but short enough to include only the most recent price movements and, thus, avoid changes in systematic risk (Strong, 1992).

6.3. Abnormal Returns

Abnormal returns (ARs) are computed throughout the event windows defined to measure the impact and strength of the respective events under consideration. The literature defines abnormal returns as:

$$AR_i = r_i - E(r_i) \quad (1)$$

Where AR_i is the abnormal return, r_i is the actual return and $E(r_i)$ is the expected return. Various models can be used to estimate the expected return. The most widely recognized model is the CAPM which follows the following formula:

$$E(r_i) = r_f + \beta_i \times (r_m - r_f) \quad (2)$$

Where r_f is the risk-free return, β_i is the sensitivity of the stock price movement to the market portfolio return and r_m is the market return.

CAPM, introduced by Sharpe (1964) and Lintner (1965), is an equilibrium model where the expected return of a given asset is determined by its covariance with the market portfolio. According to MacKinlay (1997), the application of this method has been common since 1970 due to its simple intuition. However, deviations from the CAPM have been discovered, implying that the validity of the restrictions imposed by the CAPM on the market model is questionable (Fama & French, 2004). The restrictions mentioned are based on: 1. All investors are risk-averse, i.e. they expect higher expected returns for higher risk; 2. Markets are perfect (there are no transaction costs and taxes, information is available to all, there is a risk-free interest rate that is the same for all, and assets are infinitely allocable); 3. All investment participants have the same investment opportunities; 4. All investors have the same judgments about expected return, dispersion and covariance.

All the steps followed to calculate the expected return are explained in the following subsection.

6.3.1. Computations and Beta estimation

The CAPM model was used to estimate the beta, which is an important variable in the model, as it assesses the stock's sensitivity to market movements. The risk-free rate used to calculate excess returns was obtained from the one-month US Treasury bill rate. The daily market return was measured using the STOXX Global 1800 Index, which provides a comprehensive representation of general market performance.

As mentioned before, the estimation window is set to 252 days, which is approximately a year of trading days. As a first step, I calculate the risk premium (RP) of each company using the equation:

$$RP_i = r_i - r_f, \quad (3)$$

and the market portfolio risk premium, for the same analyzed time series, using the equation:

$$RP_m = r_m - r_f, \quad (4)$$

where r_i is the actual return, r_m is the market return and r_f is the risk-free return.

Then, I calculate the variance and covariance for each stock and the market, to obtain the beta for each stock using the following formula:

$$\beta_i = \frac{COV(RP_i, RP_m)}{VAR(RP_m)}. \quad (5)$$

Once all the betas were computed, the expected return of each stock was calculated for each day in the dataset, applying equation (2).

With all the expected returns and actual returns available, I computed the abnormal returns by subtracting the expected stock price movements from the actual stock price movements.

6.4. Cumulative Abnormal Returns

To evaluate the impact of a specific event on security i, abnormal returns are calculated using equation (1). However, since this study covers multiple days, we need to aggregate the abnormal returns. I use those to compute the cumulative abnormal return for security i (CAR_i) from T_1 to T_2 as described below:

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

To aggregate all the events for each company, I used the average CAR per company, described in the following formula:

$$A\_CAR_i(t_1, t_2) = \frac{1}{E}\sum_{t=1}^{E} CAR_{it} \tag{7}$$

Where $t_1 < t_2$ and $t_1, t_2 \epsilon$ (event window), and E is the number of events studied.

Following the calculation of the CARs, the subsequent phase of the analysis involved a detailed investigation of the effect of the directive on the CARs. A series of t-tests are used following the event-study analysis to test the significance of the ARs following each event. Additionally, I also test for the significance of the differences between segments and regions.

6.5. Cross-Sectional Analysis

A regression analysis was then conducted to test the relationship between the RED and the CARs, controlling for firm-specific variables. All coefficients are estimated through OLS regressions and robust standard errors are taken into consideration.

The following regression was estimated to assess the relationship between each (individual) RED event and the CARs of firms in the energy industry:

$$CAR_{i,t} = \alpha + \beta_1 RED_{i,t} + \beta_2 BTMV_{i,t} + \beta_3 D/A_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 ROA_{i,t} + \beta_6 D/E_{i,t} + \varepsilon_{i,t} \tag{A}$$

To provide an overview of all events, the average of the 12 cumulative abnormal returns (A_CAR) was used to assess the significance of the overall RED in the energy industry. The analysis is performed by running progressive regressions (firm controls are added progressively). The primary reason for using this process is to enhance the interpretability and relevance of the model by methodically integrating firm-specific variables, which allows for a sophisticated understanding of each variable's impact on the model's predictive accuracy.

$$A\_CAR_i = \alpha + \beta_1 RED_i + \beta_2 BTMV_i + \beta_3 D/A_i + \beta_4 SIZE_i + \beta_5 ROA_i + \beta_6 D/E_i + \varepsilon_i \quad \text{(B)}$$

The last regression used aims to determine if there are regional differences in the impact of the RED on the average cumulative abnormal returns, beyond the borders of the EU. The Dummy NA is used as a baseline to avoid the situation of multicollinearity.

$$A\_CAR_i = \alpha + \beta_1 Europe_i + B_2 Asia_i + \beta_3 BTMV_i + \beta_4 D/A_i + \beta_5 SIZE_i + \beta_6 ROA_i + \beta_7 D/E_i + \varepsilon_i \quad \text{(C)}$$

7. Results

This section consists of two parts. Firstly, it presents the results of the event-study analysis, where a series of t-tests were conducted to test the significance under each event and for the differences between the two segments and regions. It also tests the total effect of the RED on the abnormal return, by using the A_CAR. Secondly, it presents the results of the regressions analysis.

7.1. Event-study Analysis

7.1.1. Mean CARs for the Energy Industry

Table 4 Mean CARs for the Energy Industry from One Trading Day before to One Trading after the Events for RED

Event	Mean CAR Industry	Mean CAR FF	Mean CAR RE	Difference FF-RE
1	-0.0396***	-0.0412***	-0.0322***	0.0090
	(0.0000)	*(0.0000)*	*(0.0006)*	*(0.1646)*
2	0.0001	0.0004	0.0014	0.0042
	(0.9457)	*(0.8065)*	*(0.1818)*	*(0.6706)*
3	-0.0119***	-0.0112***	-0.0151***	-0.0045
	(0.0000)	*(0.0000)*	*(0.0522)*	*(0.3824)*
4	-0,0315***	-0.0332***	-0.0234**	0.0067
	(0.0000)	*(0.0000)*	*(0.0327)*	*(0.1348)*
5	-0.0411***	-0.0401***	-0.0460***	-0.0059
	(0.0000)	*(0.0000)*	*(0.0004)*	*(0.4715)*
6	-0.0161***	-0.0177***	-0.0090	0.0087
	(0.0000)	*(0.0025)*	*(1.3386)*	*(0.3293)*
7	0.0040***	0.0075***	-0.0118	-0.0193**
	(0.1311)	*(0.0119)*	*(0.7733)*	*(0.0054)*
8	-0.0185***	-0.0229***	-0.0014	0.0243***
	(0.0000)	*(0.0000)*	*(0.8410)*	*(0.0003)*
9	-0.0129***	-0.0139***	-0.0085	0.0053
	(0.0000)	*(0.0000)*	*(1.2571)*	*(0.3637)*
10	0.0030	0.0036*	0.0006	-0.0029
	(0.1605)	*(0.0979)*	*(0.9387)*	*(0.5072)*
11	0.0017	0.0405***	-0.0094***	-0.0134**
	(0.4578)	*(0.0000)*	*(0.7045)*	*(0.0207)*
12	-0.0002	-0.0003	0.0001	0.0005
	(0.8982)	*(0.5678)*	*(0.9832)*	*(0.9223)*
Total	-0.0136***	-0.0137***	-0.0129***	0.0009
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.6416)*

The respective p-values are shown in parentheses with the respective corresponding significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1, based on standard t-test.
Results are obtained from the N FF (fossil fuel) companies and RE (renewable energy) companies. FF-RE is the difference between the two sectors. Mean CAR Industry is the Average cumulative abnormal return for sample companies in the energy sector (full sample = 409 companies). Cumulative abnormal return is computed using the CAPM model. The estimation window to compute the market parameters (beta) from 252 days before each event date. The event window around each event is from [-1,1].

Table 4 reveals a relatively strong relationship between all events up to the official introduction of the RED and the cumulative abnormal returns in the energy industry (most values are statistically significant at the 1% level and present an economically relevant magnitude). This is consistent with hypothesis 1 – that the energy industry is significantly affected by the RED, with both sectors showing meaningful CARs. Overall, the market appeared to react unfavorably to the initial proposal of the RED (event 1), particularly within the FF sector. This may indicate that the initial announcement had an adverse impact across the respective industry. As the directive progressed through various stages of approval, the market's reaction fluctuated, indicating a continuous reassessment of the potential impact of the RED on both the FF and RE sectors. From events 10 to 12, most of the values are not statistically significant, suggesting that the market had already previously incorporated the impact of the RED on both sectors.

Note that the FF sector frequently exhibits negative CARs, which may suggest that investors anticipated a potential negative impact on the industry due to the RED's focus on promoting renewable energy, which is consistent with hypothesis 2. On the other hand, the negative returns of the firms from the RE sector contradict hypothesis 2, since it was expected that this sector would react positively to the introduction of the RED.

The comparison between the FF and RE sectors generally indicates that the implementation of the RED would be less favorable for fossil fuel firms, as evidenced by more statistically significant and economically relevant negative values. However, the lack of statistical significance in the total difference across all events (as well as within each event for most of the events) implies that the anticipated negative impact on the FF sector relative to the RE sector was perhaps not as drastic as expected.

7.1.2. Regions for the energy industry

Table 5 Mean CARs for Regions in the Energy Industry from One Trading Day before to One Trading Day after the Events for RED

Event	Mean CAR Europe	Mean CAR NA	Mean CAR Asia	Difference Europe-NA	Difference Europe-Asia	Difference NA-Asia
1	-0.0295***	-0.0174**	-0.0644***	-0.0144***	0.0410***	-0.0320***
	(0.0000)	*(0.0362)*	*(0.0000)*	*(0.0080)*	*(0.0000)*	*(0.0000)*
2	-0.0055	0.0032	0.0021*	0.0080**	-0.0052	-0.0021
	(0.5780)	*(0.4143)*	*(0.0829)*	*(0.0236)*	*(0.1198)*	*(0.5518)*
3	-0.0192***	0.0038	-0.0184***	0.0105***	0.0108***	-0.0225***
	(0.0000)	*(0.3033)*	*(0.0000)*	*(0.0050)*	*(0.0021)*	*(0.0000)*
4	-0.0497***	0.0002	-0.0422***	0.0259***	0.0178***	-0.0456***
	(0.0000)	*(0.9749)*	*(0.0000)*	*(0.0000)*	*(0.0006)*	*(0.0000)*
5	-0.0417***	-0.0416***	-0.0403***	0.0008	0.0013	0.0007
	(0.0000)	*(0.0000)*	*(0.0000)*	*(0.9079)*	*(0.8400)*	*(0.9208)*
6	0.0241***	-0.0348***	-0.0321***	-0.0573***	0.0263***	0.0268***
	(0.0000)	*(0.0056)*	*(0.0000)*	*(0.0000)*	*(0.0002)*	*(0.0003)*
7	-0.0080	0.0355***	-0.0112	0.0171***	0.0252***	-0.0453***
	(0.7129)	*(0.0000)*	*(0.2425)*	*(0.0032)*	*(0.0000)*	*(0.0000)*
8	-0.0300***	-0.0370***	0.0043	0.0163***	-0.0378***	0.0266***
	(0.0000)	*(0.0000)*	*(0.2294)*	*(0.0041)*	*(0.0000)*	*(0.0000)*
9	-0.0194***	-0.0176*	-0.0045	0,0092*	-0.0141***	0.0068***
	(0.0000)	*(0.0880)*	*(0.8965)*	*(0.0629)*	*(0.0024)*	*(0.0000)*
10	0.0035	-0.0015	0.0062*	-0.0007	-0.0052	0.0066
	(0.3166)	*(0.6988)*	*(0.0547)*	*(0.8855)*	*(0.2352)*	*(0.1605)*
11	0.0103***	0.0057	-0.0080	-0.0124**	0.0160***	-0.0058
	(0.0010)	*(0.2633)*	*(0.4751)*	*(0.0107)*	*(0.0004)*	*(0.2325)*
12	-0.0129***	0.0103**	0.0012	0.0181***	-0.0024*	-0.0151***
	(0.0000)	*(0.0202)*	*(0.6137)*	*(0.0000)*	*(0.5099)*	*(0.0000)*
Total	-0.0148***	-0.0084***	-0.0172***	0.0018	-0.0084***	-0.0059***
	(0.0000)	*(0.0003)*	*(0.0000)*	*(0.2594)*	*(0.0000)*	*(0.0001)*

The respective p-values are shown in parentheses with the respective corresponding significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1, based on standard t-test.
Results are obtained from N FF and RE companies partitioned by regions, where Europe (Europe), NA (North America) and Asia (Asia). Europe-NA is the difference between Europe and NA. Europe-Asia is the difference between Europe and Asia. NA-Asia is the difference between NA and Asia. Cumulative abnormal return is computed using the CAPM model. The estimation window to compute the market parameters (beta) from 252 days before each event date. The event window around each event is from [-1,1].

Table 5 presents the t-tests for the mean CARs for regions within the energy industry around the RED events. As expected from the results presented in the previous table, the CARs are mostly negative and significant at the 1% level, and here I find that to be true for all regions (despite the different reactions to each event across those regions). These results support hypothesis 3, indicating that the impact of the EU's RED extended beyond EU borders, affecting the energy industry in North America and Asia as well. The different intensities of investor response to the RED events across the three regions are indicated by the varying magnitudes of the CARs. Europe, being the region where the directive takes effect mandatorily, experienced the most substantial investor reactions, as evidenced by the higher number of CARs that are statistically significant. It is also found that negative CARs were particularly strong in Europe, which is consistent with the expectation of the RED's direct effects on the EU energy industry due to policy changes. Nevertheless, the significant CARs observed in North America and Asia suggest that, around the world, investors also adjusted their valuations of energy companies based on the legislative developments within the EU, indicating an international ripple effect of the RED. The differential impacts, especially the statistically and economically significant negative difference between the mean CARs in Europe and Asia, highlight the broader implications of regional policies on the global energy market. This indicates that although the directive is an EU initiative, its consequences were felt worldwide, demonstrating the interconnected nature of the energy industry and investment ecosystems.

7.2. Regression Analysis

This section analyses the consistency of the event study results using an OLS regression that controls for additional independent variables.

Table 6 Regression Results between each (individual) RED event and the CARs of firms in the energy industry

	Panel A - CAR Event 1			Panel B - CAR Event 2			Panel C - CAR Event 3		
	Industry	FF	RE	Industry	FF	RE	Industry	FF	RE
RED	-0.009	-0.007	-0.026	0.009	0.02***	-0.131***	0.015***	0.012***	0.086***
	(0.009)	*(0.009)*	*(0.016)*	*(0.007)*	*(0.005)*	*(0.034)*	*(0.005)*	*(0.004)*	*(0.021)*
BTMV	0.003	0.003	0.008	-0.01***	-0.008***	-0.011	-0.003	-0.003	-0.004
	(0.002)	*(.002)*	*(.006)*	*(0.002)*	*(0.002)*	*(0.009)*	*(0.003)*	*(0.003)*	*(0.005)*
D/A	-0.004***	0.000	-0.012***	-0.002*	-0.003***	0.000	0.002*	0.003**	-0.001
	(0.002)	*(0.002)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.001)*
SIZE	-0.001	-0.001	-0.005*	0.000	0.000	-0.001	0.000	0.000	-0.002
	(0.001)	*(0.001)*	*(0.003)*	*(0.000)*	*(0.000)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.002)*
ROA	-0.001	0.000	0.001	-0.004**	-0.006***	0.001	0.001	0.001	0.001
	(0.002)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.001)*	*(0.004)*	*(0.002)*	*(0.002)*	*(0.001)*
D/E	0.000	0.000	-0.005	0.001**	0.001**	0.002	-0.001*	-0.002***	0.004
	(0.002)	*(0.002)*	*(0.005)*	*0.000*	*0.000*	*(0.003)*	*(0.001)*	*(0.001)*	*(0.003)*
Constant	-0.011	-0.026	0.065***	-0.003	-0.02**	0.144***	-0.023**	-0.019	-0.077***
	(0.016)	*(0.018)*	*(0.024)*	*(0.011)*	*(0.009)*	*(0.037)*	*(0.011)*	*(0.012)*	*(0.024)*
Observations	1227	1008	219	1227	1008	219	1227	1008	219
R-squared	0.017	0.002	0.223	0.033	0.055	0.083	0.017	0.026	0.043
Adj R^2	0.012	-0.004	0.201	0.028	0.05	0.057	0.012	0.020	0.016

	Panel D - CAR Event 4			Panel E - CAR Event 5			Panel F - CAR Event 6		
	Industry	FF	RE	Industry	FF	RE	Industry	FF	RE
RED	0.088***	0.091***	0.071***	-0.006	-0.004	-0.018	-0.058***	-0.061***	0.044*
	(0.016)	*(0.017)*	*(0.022)*	*(0.012)*	*(0.013)*	*(0.02)*	*(0.013)*	*(0.014)*	*(0.024)*
BTMV	-0.012***	-0.017***	0.002	-0.006	-0.011**	0.011*	0.000	0.002	-0.005
	(0.003)	*(0.004)*	*(0.004)*	*(0.004)*	*(0.005)*	*(0.006)*	*(0.004)*	*(0.005)*	*(0.007)*
D/A	0.001	0.002	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.008***
	(0.001)	*(0.002)*	*(0.002)*	*(0.001)*	*(0.002)*	*(0.003)*	*(0.003)*	*(0.005)*	*(0.002)*
SIZE	0.003***	0.005***	-0.004*	0.001	0.002**	-0.006*	0.005***	0.006***	-0.002
	(0.001)	*(0.001)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.004)*	*(0.001)*	*(0.001)*	*(0.003)*
ROA	0.002	0.003	0.001	0.006***	0.004*	0.013***	0.003	-0.001	0.017***
	(0.002)	*(0.002)*	*(0.003)*	*(0.002)*	*(0.002)*	*(0.005)*	*(0.003)*	*(0.005)*	*(0.004)*
D/E	0.000	0.000	-0.003	-0.002	-0.003	0.01*	-0.002	-0.002	0.001
	(0.001)	*(0.001)*	*(0.005)*	*(0.002)*	*(0.002)*	*(0.005)*	*(0.002)*	*(0.003)*	*(0.006)*
Constant	-0.151***	-0.173***	-0.043	-0.046**	-0.051**	0.033	-0.026	-0.047*	-0.006
	(0.02)	(0.022)	(0.028)	(0.022)	(0.024)	(0.031)	(0.024)	(0.027)	(0.031)
Observations	1227	1008	219	1227	1008	219	1227	1008	219
R-squared	0.068	0.105	0.032	0.014	0.02	0.063	0.051	0.064	0.128
Adj R^2	0.064	0.099	0.005	0.01	0.014	0.037	0.046	0.058	0.103

	Panel G - CAR Event 7			Panel H - CAR Event 8			Panel I - CAR Event 9		
	Industry	FF	RE	Industry	FF	RE	Industry	FF	RE
RED	0.027***	0.034***	0.064***	0.006	0.006	-0.024	0.027***	0.018*	0.032**
	(0.010)	*(0.011)*	*(0.013)*	*(0.007)*	*(0.008)*	*(0.016)*	*(0.008)*	*(0.009)*	*(0.015)*
BTMV	-0.013***	-0.008**	-0.018***	-0.004	-0.002	-0.011	-0.001	-0.004	0.001
	(0.003)	*(0.004)*	*(0.005)*	*(0.003)*	*(0.003)*	*(0.007)*	*(0.003)*	*(0.004)*	*(0.003)*
D/A	0.000	0.002	-0.003**	0.000	-0.001	0.000	0.002*	0.001	0.000
	(0.001)	*(0.002)*	*(0.001)*	*(0.001)*	*(0.002)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.002)*
SIZE	0.002*	0.002**	-0.003	0.002*	0.002**	0.004	0.002**	0.001	0.007***
	(0.001)	*(0.001)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.003)*	*(0.001)*	*(0.001)*	*(0.002)*
ROA	0.003*	0.007***	-0.005***	0.000	-0.002	0.002	0.003*	0.000	0.014***
	(0.002)	*(0.002)*	*(0.002)*	*(0.001)*	*(0.002)*	*(0.004)*	*(0.002)*	*(0.001)*	*(0.005)*
D/E	-0.004***	-0.004***	0.000	0.002*	0.003**	-0.006**	0.001	0.001	-0.006
	(0.001)	*(0.001)*	*(0.005)*	*(0.001)*	*(0.001)*	*(0.003)*	*(0.001)*	*(0.001)*	*(0.005)*
Constant	-0.024	-0.040**	-0.020	-0.043***	-0.054***	-0.002	-0.061***	-0.037**	-0.114***
	(0.017)	*(0.019)*	*(0.021)*	*(0.015)*	*(0.017)*	*(0.026)*	*(0.013)*	*(0.014)*	*(0.022)*
Observations	1227	1008	219	1227	1008	219	1227	1008	219
R-squared	0.032	0.032	0.148	0.011	0.015	0.049	0.016	0.013	0.184
Adj R^2	0.027	0.026	0.123	0.006	0.009	0.022	0.011	0.008	0.161

	Panel J - CAR Event 10			Panel K - CAR Event 11			Panel L - CAR Event 12		
	Industry	FF	RE	Industry	FF	RE	Industry	FF	RE
RED	-0.014**	-0.012*	-0.008	-0.037***	-0.039***	-0.024*	0.014**	0.014**	0.038***
	(0.006)	*(0.007)*	*(0.013)*	*(0.006)*	*(0.007)*	*(0.012)*	*(0.006)*	*(0.006)*	*(0.015)*
BTMV	-0.005**	-0.003	-0.009*	-0.001	-0.002	0.002	0.000	-0.003	0.010*
	(0.002)	*(0.003)*	*(0.006)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.006)*
D/A	-0.002	0.003	-0.023***	-0.003*	-0.002	-0.009**	0.002	0.002	0.000
	(0.003)	*(0.002)*	*(0.006)*	*(0.002)*	*(0.002)*	*(0.004)*	*(0.002)*	*(0.002)*	*(0.004)*
SIZE	0.000	0.001	-0.002	-0.004***	-0.004***	-0.001	-0.001	0.000	-0.005**
	(0.001)	*(0.001)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.002)*
ROA	-0.001	0.002	-0.017	-0.005**	-0.003	-0.016**	-0.001	-0.001	-0.003
	(0.003)	*(0.003)*	*(0.011)*	*(0.002)*	*(0.002)*	*(0.006)*	*(0.001)*	*(0.001)*	*(0.007)*
D/E	-0.003***	-0.003**	-0.007	-0.001	0.000	-0.007**	0.002**	0.001	0.007**
	(0.001)	*(0.001)*	*(0.004)*	*(0.002)*	*(0.002)*	*(0.003)*	*(0.001)*	*(0.001)*	*(0.004)*
Constant	0.027**	0.011	0.064***	0.088***	0.099***	0.037*	-0.008	-0.012	0.007
	(0.013)	*(0.015)*	*(0.020)*	*(0.017)*	*(0.021)*	*(0.022)*	*(0.011)*	*(0.011)*	*(0.022)*
Observations	1227	1008	219	1227	1008	219	1227	1008	219
R-squared	0.019	0.020	0.188	0.045	0.045	0.167	0.021	0.029	0.055
Adj R^2	0.014	0.014	0.165	0.040	0.039	0.144	0.016	0.023	0.028

The respective robust standard errors are shown in parentheses with the respective corresponding significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1.

The findings from Table 6 are somehow consistent with the previous findings. Here, the RED also has a statistically significant impact on the energy industry (sometimes reaching significance at the 1% level), which is in line with hypothesis 1. Moreover, the impact of the RED events on CARs seems to also have fluctuated over time when considering this regressions' results, which reiterates the fact that the market was continuously reassessing the potential effects of the RED as the directive progressed through its legislative stages.

However, bear in mind that the regression analyses related to the European RED events reveal a nuanced market response. By looking at the critical legislative milestone, Event 1, it showed a negative but insignificant RED coefficient, suggesting that the market did not react strongly to the initial proposal of the directive. This could mean that the market either did not view this event as immediately impactful or was waiting for more concrete developments. The market's unfavorable reaction to the initial proposal is consistent with the previous negative coefficients. Event 4, related to the committee votes, represented a crucial phase where the proposal gained formal support within the EU's legislative bodies. The significant RED coefficient for both sectors respecting this event suggests a clear market response to the increasing likelihood of the directive's enactment. For the final approvals, from Event 9 to 12, there is high statistical significance, but the signs of RED coefficients vary. This could reflect the market's mixed interpretations of the directive's final terms and their different anticipated impacts on various segments of the energy industry. The statistically insignificant energy industry CARs from events 10 to 12 in Table 4 could indicate that the market had already incorporated the impact of the RED into prices, which is not directly observable in the regression analysis because it still shows significance for the RED variable during these events when controlling for other factors, reflecting more subtle market adjustments.

The negative coefficients on the RED variable in the FF sector in specific, which are in line with expectations, together with the surprisingly negative reactions in the RE sector, suggest a complex market assessment that sees potential challenges for both sectors with the implementation of the RED. Although there are still negative values in some of the events for the RE sector, these regression results are more in line with hypothesis 2, compared with the results from the event-study analysis.

As shown in Table 6, the control variables appear to have varying impacts on CARs, but generally, they seem to exhibit small coefficients that are not consistently significant across all panels. This implies that the control variables do not consistently explain the variation in CAR values across the different events.

Table 7 Progressive Regression Results of the RED on A_CAR [-1,1]

	A_CAR				A_CAR				A_CAR			
	Industry				FF				RE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RED	0.003	0.005**	0.005**	0.005*	0.003	0.006***	0.006***	0.006***	-0.005	-0.001	0.001	0.001
	(0.002)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.005)*	*(0.005)*	*(0.005)*	*(0.005)*
BTMV	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002	-0.001	-0.001	-0.001
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*
D/A	-0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	-0.003***	-0.004***	-0.002	-0.002
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*
SIZE		0.001***	0.001***	0.001***		0.001***	0.001***	0.001***		-0.001**	-0.002***	-0.001**
		(0.000)	*(0.000)*	*(0.000)*		*(0.000)*	*(0.000)*	*(0.000)*		*(0.001)*	*(0.001)*	*(0.001)*
ROA			0.001	0.001			0.001	0.001			0.004*	0.004*
			(0.001)	*(0.001)*			*(0.001)*	*(0.001)*			*(0.002)*	*(0.002)*
D/E				0.000				0.000				0.000
				(0.000)				*(0.000)*				*(0.001)*
Constant	-0.014***	-0.023***	-0.023***	-0.023***	-0.014***	-0.032***	-0.031***	-0.031***	-0.003	0.009	0.010	0.009
	(0.002)	*(0.005)*	*(0.005)*	*(0.004)*	*(0.002)*	*(0.005)*	*(0.005)*	*(0.005)*	*(0.006)*	*(0.008)*	*(0.008)*	*(0.009)*
Observations	1227	1227	1227	1227	1008	1008	1008	1008	219	219	219	219
R-squared	0.012	0.019	0.021	0.021	0.012	0.032	0.033	0.033	0.097	0.120	0.131	0.131
Adj R^2	0.010	0.016	0.017	0.016	0.009	0.028	0.029	0.028	0.085	0.104	0.110	0.106

The respective robust standard errors are shown in parentheses with the respective corresponding significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table 7 shows the results of the regression analysis that aggregates the CARs over the 12 events that compose the RED for the energy industry and each of its two sectors. The results reveal nuanced insights into the market's reaction to the RED (the variable of interest). The RED variable has consistently positive and statistically significant coefficients for the energy industry and the FF sector (this holds for most specifications of the model, meaning from column 2-4 and 6-8), indicating a slightly positive adjustment in stock values in response to the RED events. This runs counter to the expected negative impact on the FF sector and the respective previous results, suggesting a potential market perception of aggregated adaptability or strategic pivoting in these firms towards the shifting energy paradigm. This contrasts with the near to neutral effect observed in the RE sector. For the RE sector, the RED variable shows an insignificant positive effect, indicating that while the market may already account for some intangible benefits aligned with renewable energy firms, it might still struggle (undervalue or delay) in recognizing the additional intangible assets these firms gain from regulatory compliance and leadership in sustainability, as suggested by Edmans (2011). The positive and significant response observed in CARs to the RED, particularly within the FF sector, suggests that the market recognizes these firms' potential to address and adapt to climate risk and highlights the aspect that investors prefer dealing with this transitioning challenge over divesting, as underscored by Krueger et al. (2019). Control variables, such as BTMV, have a consistent negative and significant association with the CARs for the energy industry overall and the FF sector. On the other hand, the SIZE is a positive factor for the energy industry and the FF sector's CARs, highlighting the advantage of larger entities, while it has an inverse impact on the CARs of the RE sector, possibly reflecting the agility of smaller firms of this sector in adapting to policy shifts. It is also important to note that with the introduction of the variable SIZE, the variable RED became significant in the energy industry and in the FF sector, meaning that SIZE is an important aspect of how companies are valued in the context of regulatory policies. Debt levels (D/A) have a notable impact on RE firms, correlating with lower CARs. This correlation could imply concerns about the financial robustness of leveraged firms in a changing regulatory landscape, as if a firm is already highly leveraged, it may have less flexibility to adapt to these changes and investors may view this as a risk, resulting in lower CARs. ROA is only significant for the RE sector, which may indicate that profitability can enhance these firms' ability to capitalize on opportunities from the directive. Despite the observed trends, the modest R-squared values across the models indicate that there are still numerous factors affecting CARs that have not been accounted for by the variables included in the analysis. Even still, the R-squared values increase as more control variables are added, which shows that including these variables does improve the model's explanatory power.

Table 8 Regression Results of Regional Differences in the A_CAR during RED

	A_CAR		
	Industry	FF	RE
Europe	-0.008***	-0.008***	-0.015***
	(0.002)	*(0.002)*	*(0.005)*
Asia	-0.012***	-0.011***	-0.021***
	(0.002)	*(0.002)*	*(0.005)*
BTMV	-0.002***	-0.002***	0.000
	(0.001)	*(0.001)*	*(0.002)*
D/A	0.000	0.001	-0.002
	(0.001)	*(0.001)*	*(0.001)*
SIZE	0.001***	0.001***	-0.001
	(0.000)	*(0.000)*	*(0.001)*
ROA	0.000	0.000	0.004*
	(0.001)	*(0.001)*	*(0.002)*
D/E	0.000	0.000	0.001
	(0.000)	*(0.000)*	*(0.001)*
Constant	-0.017***	-0.023***	0.010
	(0.003)	*(0.004)*	*(0.009)*
Observations	1227	1008	219
R-squared	0.055	0.061	0.203
Adj R^2	0.050	0.054	0.176

The respective robust standard errors are shown in parentheses with the respective corresponding significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1.

Table 8 demonstrates that, compared to Table 5, the results remain consistent when controlling for firm-specific variables in addition to regions, suggesting that the directive has a wide-ranging impact, affecting firms across Europe and Asia. The analysis reveals that CARs are negative in Europe and Asia around the time of the event studied, particularly in the RE sector, which experiences the steepest decline compared to North America. This suggests that the directive had a pervasive impact on investor response across global energy markets, highlighting the directive's extraterritorial effects, in accordance with hypothesis 3.

8. Robustness Tests

In this section, two robustness tests are implemented to ensure the stability and reliability of the results. Firstly, the event window is expanded from [-1,1] to [-2,2] to assess the if the results remain consistent. Secondly, the Fama-French Five-Factor (5FF) model is applied to confirm that the conclusions hold under a different return estimation model. This test is performed on the analysis of the impact of the overall event of the RED on the A_CAR, which provides the most comprehensive information.

8.1. Extension of the Event Window

The previous analysis examined the significant events of the RED from proposal to final approval, with the goal of capturing a comprehensive view of market reactions. In this section, the event window has been extended from [-1,1] to [-2,2] days to include both immediate and potentially minor delayed market responses.

Table 9 Progressive Regression Results of the RED on A_CAR [-2,2]

	A_CAR				A_CAR				A_CAR			
	Industry				FF				RE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RED	0.023**	0.030***	0.029***	0.0270**	0.023**	0.034***	0.034***	0.033***	0.004	0.018	0.025	0.018
	(0.010)	*(0.011)*	*(0.011)*	*(0.011)*	*(0.011)*	*(0.011)*	*(0.011)*	*(0.011)*	*(0.020)*	*(0.020)*	*(0.020)*	*(0.020)*
BTMV	-0.002	-0.003	-0.002	-0.002	-0.005**	-0.005**	-0.005*	-0.005*	0.005	0.008	0.010	0.011
	(0.003)	*(0.003)*	*(0.003)*	*(0.003)*	*(0.002)*	*(0.002)*	*(0.003)*	*(0.003)*	*(0.008)*	*(0.007)*	*(0.008)*	*(0.008)*
D/A	-0.002	-0.001	0.001	0.001	0.000	0.001	0.003*	0.003*	-0.008*	-0.010**	-0.001	-0.001
	(0.002)	*(0.002)*	*(0.002)*	*(0.002)*	*(0.001)*	*(0.001)*	*(0.002)*	*(0.002)*	*(0.004)*	*(0.004)*	*(0.005)*	*(0.005)*
SIZE		0.002**	0.002**	0.002**		0.003***	0.003***	0.003***		-0.004**	-0.005***	-0.008***
		(0.001)	*(0.001)*	*(0.001)*		*(0.001)*	*(0.001)*	*(0.001)*		*(0.002)*	*(0.002)*	*(0.002)*
ROA			0.003*	0.003			0.003*	0.002			0.016*	0.016*
			(0.002)	*(0.002)*			*(0.002)*	*(0.002)*			*(0.009)*	*(0.009)*
D/E				0.002				0.001				0.011
				(0.001)				*(0.001)*				*(0.007)*
Constant	-0.075***	-0.107***	-0.106***	-0.103***	-0.073***	-0.126***	-0.125***	-0.124***	-0.055*	-0.017	-0.015	0.010
	(0.011)	*(0.018)*	*(0.018)*	*(0.017)*	*(0.011)*	*(0.018)*	*(0.018)*	*(0.018)*	*(0.028)*	*(0.037)*	*(0.037)*	*(0.031)*
Observations	2045	2045	2045	2045	1680	1680	1680	1680	365	365	365	365
R-squared	0.003	0.007	0.008	0.009	0.005	0.016	0.017	0.017	0.028	0.036	0.043	0.059
Adj R^2	0.002	0.005	0.005	0.006	0.004	0.014	0.014	0.013	0.020	0.025	0.029	0.044

*The respective robust standard errors are shown in parentheses with the respective corresponding significance levels indicated by *** $p<0.01$, ** $p<0.05$, * $p<0.1$.*

Table 9 shows that the consistency of the results did not change, confirming the initial findings. The significance of the RED variable, which proves positive and statistically significant for the energy industry and, in particular for the FF sector (this holds for most specifications of the model, meaning from column 1-4 and 5-8), remained and even strengthened for the energy industry in the broader window. This indicates a persistent recognition of the RED's impact on these sectors across more days, which suggests an amplified market acknowledgment of the directive's impact. Additionally, the variable RED gains statistical significance when only controlling for the first two firm-specific variables.

8.2. Five Factor Model

In the robustness checks section of this thesis, the analysis extends to employing the 5FF model. This aims to validate the findings obtained from the CAPM and provide a comprehensive assessment of asset pricing dynamics by incorporating additional risk factors. The 5FF model incorporates five key factors to explain stock returns more comprehensively.

Table 10 Progressive Regression Results of the RED on A_CAR applying the 5FF model

	A_CAR				A_CAR				A_CAR			
	Industry				FF				RE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
RED	0.001	0.001	0.001	0.000	0.001	0.003	0.003	0.002	-0.011**	-0.003	-0.002	-0.001
	(0.003)	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.003)*	*(0.005)*	*(0.005)*	*(0.005)*	*(0.005)*
BTMV	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	0.000	0.000
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.002)*	*(0.002)*	*(0.002)*	*(0.002)*
DA	0.000	0.000	0.000	0.000	0.001*	0.001**	0.001**	0.001*	-0.003**	-0.004***	-0.002*	-0.002*
	(0.001)	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*
SIZE		0.000	0.000	0.000		0.001*	0.001*	0.000		-0.002***	-0.003***	-0.002***
		(0.000)	*(0.000)*	*(0.000)*		*(0.000)*	*(0.000)*	*(0.000)*		*(0.001)*	*(0.001)*	*(0.001)*
ROA			0.000	0.000			0.000	0.000			0.003	0.003
			(0.001)	*(0.001)*			*(0.001)*	*(0.001)*			*(0.002)*	*(0.002)*
DE				0.000				0.001				-0.001
				(0.000)				*(0.000)*				*(0.001)*
Constant	-0.014***	-0.015**	-0.015**	-0.014**	-0.016***	-0.025***	-0.025***	-0.024***	0.002	0.024***	0.025***	0.023***
	(0.003)	*(0.006)*	*(0.006)*	*(0.006)*	*(0.003)*	*(0.007)*	*(0.007)*	*(0.007)*	*(0.006)*	*(0.008)*	*(0.008)*	*(0.008)*
Observations	1227	1227	1227	1227	1008	1008	1008	1008	219	219	219	219
R-squared	0.003	0.003	0.003	0.004	0.010	0.014	0.014	0.016	0.079	0.144	0.150	0.152
Adj R^2	0.000	0.000	-0.001	-0.001	0.007	0.010	0.009	0.010	0.066	0.128	0.130	0.128

*The respective robust standard errors are shown in parentheses with the respective corresponding significance levels indicated by *** p<0.01, ** p<0.05, * p<0.1.*

Using the 5FF to compute the ARs and looking at the subsequent analysis results, presented in Table 10, it is found that the results prove less robustness when compared to the ones derived from the CARs calculated using the CAPM (in Table 7). Although the direction of the RED's impact remains the same, its statistical significance on the energy industry and fossil fuel sector diminishes. In comparison to the CAPM, the 5FF model considers additional factors such as size, value, profitability, and investment. These factors may overlap with the influence previously attributed solely to the RED in the CAPM analysis. It is possible that these factors absorb elements of market behavior or risk that the RED variable might have been proxying, leading to a dilution of its previously observed statistical significance. Moreover, this may also derive from the fact that these factors are not only included in the 5FF when computing ARs, but also controlled for in the regression, meaning that they are being considered twice. Conversely, regarding the RE sector, the RED is only statistically significant in column 9. This may indicate that the specific variables included are particularly relevant to capturing the effect of the RED on the RE sector. The limited set of controls could be the most salient form of explaining the variance in returns for the RE sector, suggesting that they directly relate to the way regulatory changes impact these firms. It might also imply that the inclusion of additional variables in the model could introduce noise or multicollinearity, which dilutes the observable impact of the RED on the RE sector. This phenomenon highlights the importance of model specification and the potential for overfitting, as well as the possibility that some variables could be acting as proxies for unobserved or omitted factors that are more directly affected by the RED.

9. Discussion

This section discusses the results from section 7. As the thesis title states, the main objective is to investigate the effect of the RED on the energy industry. This leads to the main hypothesis:

Hypothesis 1: *The European Union's Renewable Energy Directives of 2009 have had an impact on the energy industry.*

The first part of the analysis and the following regression results, from Table 4 to Table 6 and 7, show similar results regarding the effect on the energy industry. Indicating that the introduction of the RED had a significant impact on CAR for the industry, even when controlling for firm-specific variables. As found by Krueger et al. (2019), investors are highly aware of the financial impact of climate risks, particularly regulatory risks, on their portfolios. Investors believe that after this directive firms will adapt their strategies to greener ones.

Additionally, another point of interest is how the introduction of the RED affects FF companies and RE companies differently.

Hypothesis 2: *The fossil fuel (renewable energy) segment experiences a negative (positive) impact after the directive.*

The event-study method results from Table 4 show a total statistically significant mean CAR for the FF sector of -0.0137 during the RED. However, when controlling for firm-specific variables in the regression analysis, this sector shows a positive and significant value of 0.006 for the variable of interest, suggesting a potential market perception of aggregated adaptability or strategic pivoting in these firms towards the shifting energy paradigm. Even when testing for robustness, the results for FF remain positive for both tests. Based on these results, there is weak evidence that the FF segment is negatively affected by the RED.

For the RE sector, from the first part of the analysis, there is a total statistically significant mean CAR of -0.0129 during the RED. Contradictory results are found in the regression analysis where the sector shows insignificant and positive results, indicating that while the market may already account for some intangible benefits aligned with RE firms, it might still struggle (undervalue or delay) in recognizing the additional intangible assets these firms gain from regulatory compliance and leadership in sustainability, as suggested by Edmans (2011).

When comparing the two sectors, there is a statistically insignificant difference of 0.0009 with the introduction of the RED, suggesting that the difference between the two sectors is not meaningful (similar impact in both sectors).

Hypothesis 3: *There is an impact of the Renewable Energy Directives (RED) that extends beyond the borders of the European Union, not only affecting companies within the EU but also in the North America and Asia regions.*

From both analysis (Table 5 and Table 8), the results remain consistent (negative and statistically significant) even when controlling for firm-specific variables in addition to regions, suggesting that the directive has a wide-ranging impact, affecting firms across Europe and Asia.

10. Conclusion

As in any other paper, this thesis comes with a number of limitations that are important to be addressed. The event study technique relies on accurately identifying the point at which information becomes publicly available. For past events, it can be difficult to determine the exact time of public disclosure. Even with known publication dates, there is no guarantee that the information was not already partially leaked or known to certain market participants. The assumption is that information remains private until officially released by the EU, which may not always be the case. Furthermore, this method assumes that markets are semi-strong form efficient, processing all publicly available information. However, critics argue that asymmetric information is prevalent, which may cause stock prices to reflect new information before it is publicly acknowledged.

Another limitation of this study is the potential presence of confounding effects, which may have not been accounted for. These effects arise when external events or information coincide with the study period, influencing stock prices and potentially obscuring the true impact of the RED on firm valuations. This oversight may challenge the attribution of observed market reactions directly to the RED events.

A last limitation has to do with this study's relatively low R-squared values that are observed in the regressions. This indicates that the models only explain a small portion of the variability in the firms' cumulative abnormal returns, leaving a substantial amount of variance unaccounted for by the specified factors.

Regarding further research, note that the focus of this study has been solely the impact of the 2009 Renewable Energy Directive, as it was the pioneering initiative in the EU's renewable energy policy. Given the evolving and increasingly urgent challenges posed by global warming, subsequent directives have emerged with revisions and updates that address these growing concerns. With this context in mind and focusing on how firms adapt to these regulatory changes, the following suggestions for further research are proposed:

1. Comparative Analysis of Subsequent Revised Directives, such as the Renewable Energy Directive II (2018/2001/EU) or the Renewable Energy Directive III (EU/2023/2413).
2. Longitudinal Impact Study.
3. Whether companies in the energy industry restructure their financial policies, such as the debt-to-asset ratio.

To conclude this thesis, the results demonstrate that regulatory measures aimed at promoting renewable energy usage significantly affect the cumulative abnormal returns in the energy industry, highlighting the attention that financial markets are placing on regulatory shifts in energy policy. This highlights the financial markets' sensitivity to regulatory changes in energy policies and suggests that investors are increasingly prioritising climate risk considerations in their investment strategies. The analysis shows that the fossil fuel sector outperformed the renewable energy sector after the implementation of the Renewable Energy Directive (RED). This finding may reflect a nuanced investor outlook on the adaptability of traditional energy companies in the evolving energy market context. Furthermore, the data confirm the global impact of the RED, highlighting the interconnectivity of energy markets and regulatory influence across borders.

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