



# The Impact of European Environmental Policies on Equity Markets: An Econometric Analysis

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## Abstract

This thesis investigates the impact of European environmental policies on equity markets, utilizing an event study methodology complemented by regression analysis to measure market reactions to policy announcements. Specifically, it examines whether such announcements generate abnormal stock returns and how these returns vary based on firm characteristics, such as environmental exposure and environmental performance. The dataset comprises European publicly traded firms from 2010 to 2023, focusing on the major EU policy initiatives such as the Paris Climate Agreement and the European Green Deal.

The findings indicate that the events generally lead to significant abnormal returns, highlighting the market's sensitivity to regulatory changes. The results also show that firms with low emissions typically experience superior returns around the event date compared to high-emission firms, driven by their lower transition risks. Furthermore, firms with strong environmental management practices experience inferior returns around the event date compared to firms with weak practices. This counterintuitive result is attributable to the immediate compliance costs incurred by environmentally proactive companies, which negatively impact their short-term financial performance. However, over the long term, lagging firms may face greater challenges and experience the opposite effect. Additionally, the study reveals sector-specific variations in short-term systematic risk following policy announcements, with high-impact sectors like industrials showing greater volatility. Overall, the research contributes to the ongoing debate on the economic implications of environmental regulation, providing valuable insights for policymakers, investors, and corporations alike.

**Title:** The Impact of European Environmental Policies on Equity Markets: An Econometric Analysis

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**Keywords:** Event Study, Regression Analysis, European Union, Environmental Policies

## Resumo

Esta tese investiga o impacto das políticas ambientais europeias nos mercados de ações, utilizando um estudo de eventos complementado por análise de regressão para medir as reações do mercado aos anúncios de políticas. Examina-se se tais anúncios geram retornos anormais de ações e como esses retornos variam conforme as características das empresas, como exposição e desempenho ambiental. O conjunto de dados abrange empresas públicas europeias de 2010 a 2023, focando em iniciativas políticas da UE, como o Acordo de Paris e o Acordo Verde Europeu.

Os resultados indicam que os eventos geralmente levam a retornos anormais significativos, destacando a sensibilidade do mercado às mudanças regulatórias. Empresas com baixas emissões geralmente experimentam retornos superiores em torno da data do evento, em comparação com empresas de altas emissões, devido aos menores riscos de transição. Além disso, empresas com fortes práticas de gestão ambiental tendem a experimentar retornos inferiores em comparação com aquelas com práticas fracas. Este resultado pode ser atribuído aos custos imediatos de conformidade incorridos por empresas ambientalmente proativas, que impactam negativamente seu desempenho financeiro de curto prazo. No entanto, a longo prazo, as empresas menos proativas podem enfrentar maiores desafios e experimentar o efeito oposto.

O estudo também revela variações específicas de setores no risco sistemático de curto prazo após os anúncios de políticas, com setores de alto impacto, como o industrial, mostrando maior volatilidade. No geral, a pesquisa contribui para o debate sobre as implicações econômicas da regulamentação ambiental, fornecendo insights valiosos para formuladores de políticas, investidores e corporações.

**Título:** O impacto das políticas ambientais europeias nos mercados de ações: Uma Análise Econométrica

**Autor:** Tim Raymund Quint

**Palavras-chave:** Estudo de Eventos, Análise de Regressão, União Europeia, Políticas Ambientais

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**List of Abbreviations**

AR	Abnormal Return
CAR	Cumulative Abnormal Return
CSR	Corporate Social Responsibility
EMH	Efficient Market Hypothesis
EU	European Union
GHG	Greenhouse Gas Emissions
GSign Test	Generalized Sign Significance Test
IEA	International Energy Agency
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NOAA	National Oceanic and Atmospheric Administration
UK	United Kingdom

## 1. Introduction

In the beginning of 2024, a critical moment in our understanding of climate change was marked by the joint publication from NASA's Goddard Institute for Space Studies and NOAA's National Centers for Environmental Information (NCEI, 2024). Their comprehensive report delivered an alarming revelation: 2023 was officially the warmest year on record, surpassing previous temperatures by significant margins. This milestone highlights an escalation in the planet's climate crisis as UN Secretary-General António Guterres, starkly proclaimed the transition from an era of global warming to what he termed "global boiling" (Guterres, 2023).

The recent findings point out the need for immediate and decisive action to tackle climate change which puts the issue at the top of the global political agenda (Zhang, 2022). Governments are called upon to enact laws on environmental regulation that outline concrete steps towards a more sustainable future. For instance, the Paris Climate Agreement, which entered into force in 2016 and has been adopted by almost 200 countries, aims to reduce global GHG emissions and limit the rise in global temperatures below 2 degrees Celsius (UN, 2024).

Driven by the surge in public awareness of climate change, there has also been a growing academic interest in exploring the effects of environmental news on stock market dynamics. Within this field of study, a particularly novel and unexplored area has emerged, focusing on the stock market reaction to the announcement of environmental policies. Environmental policies typically aim to shape market dynamics and compel polluting companies to internalize the cost of negative externalities.<sup>1</sup> Therefore, they can significantly influence a company's prospects, capable of triggering shifts in investor sentiment towards its stock.

This study measures the market's reaction to the announcement of environmental legislation in the form of abnormal stock returns. They can then be used to infer whether policies create or destroy shareholder value. Additionally, a company's environmental exposure and performance is used to assess whether green policies achieve their desired effect in the sense that they promote sustainability and penalize pollution. Building on this, the study also examines short-term systematic risk across different sectors, comparing high environmental impact industries, such as industrials, with low impact sectors like healthcare.

This approach is supported by several studies which confirm that a growing number of investors incorporate environmental concerns into their decision-making processes (Krueger et al., 2018;

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<sup>1</sup> Negative externalities are unintended and often overlooked consequences of economic activities that cause harm or disadvantage to others without those responsible bearing the costs.

Bolton & Kacperczyk, 2022). If the marginal investor considers climate change related factors, then this will hurt the share price for less climate-conscious companies and nudge them towards more climate-sensitive business practices (Heinkel et al., 2001). In this case, market forces will help to accelerate the transition to a low-carbon economy (Ramelli et al., 2018). Consequently, the study of environmental policies' impact on stock markets is not just an academic exercise; it is a critical inquiry into how the financial ecosystem adapts and supports global sustainability goals. It provides valuable feedback for policymakers, investors, and companies trying to navigate the complexities of environmental compliance while pursuing economic objectives.

The European Union serves as a prime example to study this relationship between legislation, sustainability and financial markets because of its leading role in the global initiative against climate change. For a long time, the EU has been spearheading legislative measures to promote eco-friendly practices and reduce pollution. Particularly in the last 15 years, the EU has passed a large number of new environmental policy measures, such as the Paris Climate Agreement, the Green Deal and the 2030 Climate Target Plan.

In short, this study focuses on evaluating the impact of the EU's legislative framework on investor sentiment and market trends. It investigates whether the EU's regulatory efforts are making a difference in directing the economy towards a greener future. In doing so, this analysis provides a deeper understanding of policy effectiveness. More specifically, this thesis aims to accomplish three main objectives: (i) it examines whether EU environmental regulation announcements trigger significant abnormal returns; (ii) it explores how stock returns vary between firms with high and low pollution levels, as well as strong and weak environmental performance and lastly; (iii) it examines how these policy announcements influence short-term systematic risk in the market, highlighting sector-by-sector differences.

This thesis is structured to address these objectives as follows: Chapter 2 establishes the theoretical groundwork required for a comprehensive and in-depth understanding of the issue. This chapter reviews the relevant literature and outlines the contribution of this study to the current literature. The next chapter formulates the hypotheses for this study. Chapter 4 details the research methodology and describes the data as well as the events utilized in the empirical analysis. Chapter 5 presents the empirical findings, discussing and interpreting the results and pointing out limitations. Finally, Chapter 6 concludes the thesis by summarizing the main findings, discussing their practical implications, and providing an academic outlook for future research.

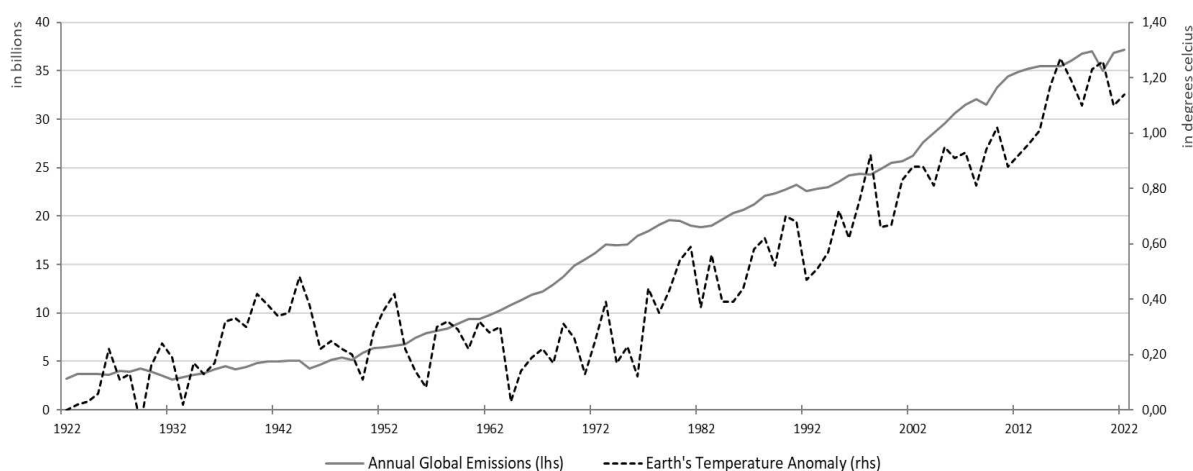
## 2. Literature Review

### 2.1. The Evolution of Climate Science and Global Awareness

We live in an era where climate change is becoming increasingly self-evident, representing one of the most pressing challenges of our time. The escalating consequences of extreme weather events, melting polar ice and rising sea levels not only pose a threat to the health of our planet but also have profound implications for economic stability, public health, and social justice worldwide (IPCC, 2023). For this reason public awareness has significantly increased regarding the urgent need for governmental intervention to combat anthropogenic climate change (OECD, 2023). Although presently, the overwhelming majority of climate scientists (estimated at 97%) concur that human actions are the primary driver of climate change, this widespread agreement has emerged gradually over time (NASA, 2024).

The idea that human activities are changing our planet's climate developed from a marginal notion in the 19<sup>th</sup> and early 20<sup>th</sup> centuries, to universal scientific consensus by the 21<sup>st</sup> century. One of the earliest contributions to this field came from scientists like Joseph Fourier in the 1820s and John Tyndall in the 1850s who discovered the greenhouse effect (Weart, 2004). The first quantitative link between carbon dioxide levels and the Earth's temperature was made by Swedish scientist in 1896 (Arrhenius, 1896). However, the modern debate around anthropogenic climate change first began to emerge in the scientific community in the mid-20th century. The issue reached a pivotal moment with the First World Climate Conference of 1979 acknowledging climate change on a global stage and initiating widespread international discourse and action (DGVN, 1979).

**Figure 1: Global Annual Emissions and Temperature Anomalies**



Source: Ritchie et al., 2023

Since the discovery of the greenhouse gas effect global GHG emissions have amassed to more than 3175 Gigatons from 1850 until today (World Data Lab, 2024). During this period, annual emissions have continuously increased with the IEA reporting that in 2023 alone, CO<sub>2</sub> emissions have surged by 1.1 percent to a record 37.4 billion tons (IEA, 2023). At the same time however, the IEA observed a structural slowdown in global GHG emissions due to successful countermeasures and policies. According to current projections 2023 might go down in history as the year that global carbon emissions peaked if countries deliver on the promises made in their Nationally Determined Contributions (United Nations, 2023).

## **2.2. Influence of Environmental Regulation on Firms' Competitiveness**

The growing empirical evidence and scientific research behind climate change has prompted governments worldwide to enact environmental legislation to mitigate its adverse effects, reduce greenhouse gas emissions, and transition towards a sustainable economy. For instance, the Kyoto Protocol was one of the first international treaties in which 192 countries agreed to reduce their emissions. By implementing policies such as carbon pricing, renewable energy incentives, and stringent emissions standards, nations are striving to meet international climate targets (European Council, 2024). While these regulations serve a crucial societal and ecological purpose, they have sparked a debate about balancing environmental stewardship and economic growth. In literature the impact environmental stringency has on companies is generally comprised of two opposing views. Both revolve around how environmental regulation affects a firm's competitiveness (Testa et al., 2015).

The first perspective is based on the pollution haven hypothesis and argues that environmental regulation and economic activity are negatively correlated because they impose additional costs for companies (Meadows et al., 1972). According to this view, environmental regulation addresses market failure by forcing companies to internalize the costs of negative externalities, posing a substantial transition risk for companies and leading to large-scale structural change (Semieniuk, 2021).<sup>2</sup> Transition risk reflects the uncertainty of adjusting toward carbon neutrality and includes legal, technological, market and reputational risks (Bolton & Kacperczyk, 2022; EPA, 2024). It is an important factor because several studies found evidence of a widespread, significant premium attributable to transition risks, where companies with higher carbon emissions experience higher stock returns (Bolton & Kacperczyk, 2021, 2023).

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<sup>2</sup> There are two categories of climate risks: (i) transition risks related to the transition to a lower-carbon economy; (ii) physical risks related to the physical impacts of climate change (e.g. flood or hurricane damage)

According to the pollution haven hypothesis shareholder value may be negatively impacted through three main mechanisms: (i) firms in areas with strict regulations face higher costs compared to those in less regulated areas because of fines, liabilities and administrative or legal action against polluters (Gray & Shadbegian, 1995; Stewart, 1993); (ii) new policies require significant investment which can divert resources from other productive activities (Berman 2001; Dufour 1998; Haveman & Christiansen 1981); (iii) lastly, regulations could lead to stranded assets, restricting companies from leveraging assets like heavy machinery, due to environmental constraints (Iraldo et al., 2011; Korten 1995). As a result, firms in countries with stricter environmental regulations (i.e. developed markets) may find themselves at a competitive disadvantage compared to their international rivals. This could reduce their competitiveness and profitability, potentially leading to firms relocating their operations to countries with more lenient environmental rules (i.e. emerging markets) (Scholtens, 2008).

The second perspective follows the Porter hypothesis, which argues that strict environmental regulation can stimulate technological and process innovations. These innovations may lead to higher efficiency and competitiveness for firms, more than offsetting the costs of regulatory compliance (Porter & Linde 1995). However, this theory is based on the assumption that environmental regulations are well designed. In this case, a "win-win" scenario can be created: promoting sustainability while increasing business competitiveness.

The Porter hypothesis challenges the conventional belief that environmental regulations are solely an economic burden for businesses and is supported by five key arguments (Dowell et al., 2000): (i) cost savings of lower environmental standards may not result in actual cost savings, as firms often incur remediation costs due to pressure from international organizations such as Green Peace or the WWF (Ibeanu et al., 2023); (ii) adhering to a single, stringent environmental standard globally can streamline operations and reduce monitoring costs across subsidiaries (Bartlett & Ghoshal, 1998); (iii) adopting stricter standards than legally required positions firms ahead of the curve as regulation and enforcement intensifies over time (Grossman & Krueger, 1995); (iv) firms gain a competitive edge by pushing for stricter environmental regulations and adopting advanced technologies to operate more efficiently (OECD, 2018); (v) some additional benefits may arise by embracing environmental compliance such as heightened employee morale and corporate reputation.

The opposing views suggest that environmental regulations might either negatively or positively influence shareholder value, highlighting the need for empirical research to quantify their effect on firm performance.

### 2.3. Empirical Evidence

Examining the impact environmental stringency can have on companies is multifaceted. This complexity arises from the diverse ways in which regulations affect various aspects of the firm. Therefore, the inquiry can be approached with different research methodologies, each with its own strengths and limitations. Hence, there is a growing body of literature with different strands of research on this topic.

Numerous studies examine the effects of environmental news on stock markets, with notable contributions from Hamilton (1995), White (1995), Klassen and McLaughlin (1996), Bosch, Edward, and Lee (1998), Lanoie et al. (1998) and Lorraine et al. (2004). Generally, they find that unfavorable environmental news tends to produce negative abnormal returns and vice versa. Additionally, the findings suggest that firms with good environmental management practices produce higher stock returns than firms with poor practices around these events. Studies dealing with the effect of environmental regulation on corporate profitability have been conducted by Cohen et al. (1995), Shane (1995), Hart and Ahuja (1996), Nehrt (1996), Russo & Fouts (1997), Dowell et al. (2000). What these studies find is that environmental regulation can have a significant impact on a company's profitability. Also, the research indicates that the business performance in response to new regulations is dependent on the firm's sustainability characteristics (e.g. environmental disclosures, ESG rating). This study builds on these findings but focuses on examining the immediate announcement effect of environmental regulations.

**Table 1: Overview of Empirical Studies**

Study	Time Period	Region	Events
Blacconiere & Northcut (1997)	1985-1986	USA	26
Ramiah et al. (2013)	2004-2011	Australia	19
Ramiah et al. (2015)	1997-2011	USA	133
Jiang & Luo (2018)	2009-2011	China	8
Pham et al. (2019)	2014-2016	Germany	20
Pham et al. (2019)	2006-2018	Singapore	10
Pham et al. (2020)	2005-2010	France	16
Birindelli & Chiappini (2020)	2013-2018	EU	8
Guo et al. (2020)	2014-2017	China	10
Diaz-Rainey et al. (2021)	2015-2017	USA	4
Bauer et al. (2023)	2021-2022	USA	8

Source: Own Analysis

The current empirical evidence analyzing how the announcement of environmental policy measures impacts equity markets is still in its infancy and points to mixed results. An overview of the current empirical results from different event studies can be found in table 1.

In an early study, Blacconiere and Northcut (1997) found that chemical firms had an overall negative reaction to announcements of stricter legislation because of increased regulatory costs. More recently, Ramiah et al. (2013) examined the Australian stock market reaction to 19 announcements associated with environmental regulation and showed that green policies have a mixed effect on abnormal returns, with apparent sector-by-sector differences. They found that environmental policies do not always achieve the desired effect in the sense that some heavy polluters (i.e., energy sector) are not affected negatively. Also, they showed that announcements appear to influence the systematic risk of industries, leading to a diamond risk phenomenon.

In a later US study, Ramiah et al. (2015) demonstrated that announcements could achieve the desired effects and documented negative abnormal returns for the biggest polluters, whereas environmentally friendly businesses were less affected. The same results were obtained by Bauer et al. (2023), who analyzed several events related to the Inflation Reduction Act in the US. Furthermore, the results were replicated by Jiang & Lou (2018) for the Chinese market, as well as for the German and Singaporean markets by Pham et al. (2019). However, for France, Pham et al. (2019) found contradicting results.

Additionally, a study done by Guo et al. (2020) found similar results but also pointed out that the effect of environmental regulation is contingent on firm characteristics, such as size, profitability, and industry. On the European market, there is only one study from Birindelli & Chiappini (2020) who found that market reactions to climate policies were more pronounced after the Paris Climate Agreement. However, they found that the company's sector was more influential than its environmental characteristics in determining market reactions toward climate policies. Similar to this, Diaz-Rainey et al. (2021) conducted a sector-specific study focusing on the oil and gas industry as heavy polluters and found a large negative impact from the Paris Climate Agreement.

Lastly, Ramiah et al. (2013) also analyzed the impact of green policy announcements on systematic risk and found that the biggest polluters experienced more dramatic changes in systematic risk than low polluters. These results for systematic risk were later replicated in a study by Pham et al. (2019).

In summary, the empirical evidence from the current literature points to three important findings: i) equity markets respond to the announcement of environmental policies with abnormal stock returns around the event date, ii) the response differs by firm-specific characteristics such as environmental exposure and environmental performance and iii) environmental legislation has an impact on the systematic risk of equity markets.

#### **2.4. Contribution to Existing Empirical Literature**

This thesis contributes to the existing literature in several ways: (i) it adds to the ongoing debate concerning how environmental regulations impact the valuation of equities; (ii) it examines the European Union (EU) as a leader in climate change policy, which, until this point, has been analyzed only in one other study by Birindelli & Chiappini (2020); (iii) it complements inconclusive results of prior research on how a firm's environmental exposure and performance, influence the impact of green policies on firm valuation; (iv) it considers a wider and more recent timeframe and thus provides a contemporary perspective of market dynamics; (v) it analyzes not just a single policy but incorporates the most significant policy events in the EU's recent history; (vi) it builds upon the pioneering work of Ramiah et al., studying the impact on systematic risk.

The empirical analysis of the formulated hypotheses points to three main results. First, the results show that green policy announcements lead to significant stock market reactions as measured by abnormal returns, emphasizing that these events introduce new and meaningful information. Secondly, the individual characteristics of a company, in particular its environmental exposure and performance influence the stock price reaction in response to these events both in terms of magnitude and direction. More specifically, the results show that firms with low GHG emissions experience superior returns in the event window compared to high polluters. This is explained by the lower transition risks and compliance costs faced by these firms (Bolton & Kacperczyk, 2021, 2023). Companies with lower emissions are better positioned to adapt to new regulations without incurring significant expenses, thereby reassuring investors and leading to more favorable market reactions. Moreover, the analysis reveals that firms with strong environmental performance experience inferior returns compared to those with weaker performance. This counterintuitive result suggests that, bad performers fare better in the short term. The explanation lies in the immediate compliance costs that firms with robust environmental practices incur (Jiang & Luo, 2018). While these companies are proactive in adopting sustainable measures, the upfront expenses associated with compliance can negatively impact their

short-term financial performance. In contrast, firms with poorer environmental performance may initially avoid these costs, resulting in better short-term returns. However, this advantage is likely temporary. Over the long term, as regulatory enforcement tightens and societal demands for sustainability increase, these lagging firms may face greater challenges and higher costs to catch up with compliance requirements, potentially leading to diminished returns (Ramiah et al., 2013). Hence, the analysis highlights the tension between the short-term financial impacts and long-term developments. Good environmental performers may bear early costs but are better positioned for future resilience and competitiveness, whereas poor performers may enjoy short-term gains but risk long-term financial stability and market position. Lastly the results of this study show that green policy events do not only impact stock returns but also cause changes in the short-term systematic risk of equity markets depending on the stock's sector classification. Lastly, the study shows that green policy events impact not only stock returns but also short-term systematic risk, varying by sector classification (Pham et al., 2019). High-impact sectors like industrials and materials experience greater volatility due to greater exposure to transition risks. Conversely, low-impact sectors such as information technology and healthcare, with lower exposure, remain more stable with less pronounced risk changes in response to these events.

Overall, the results have relevant implications for policy makers, investors and corporations. Investor can gain a better understanding of how environmental regulations influence equity valuations, supporting their sustainable investment strategies. Policy makers can learn about the effectiveness of environmental legislation, guiding the creation of more impactful policies that balance environmental and economic goals. Companies gain insights into the importance of environmental conduct in mitigating the impact of policy changes on their market valuation.

### 3. Hypothesis Development

Based on the above mentioned findings of previous research, it is now possible to formulate the hypotheses that build the foundation of the research question, providing a structured approach.

#### 3.1. Relevancy of Environmental Legislation

The review of prior studies highlights the critical role of environmental legislation as a significant driver of change in the financial markets, influencing the allocation of capital towards more sustainable investments. Research has consistently shown that legislative announcements are highly relevant as they can lead to abnormal stock returns and shifts in market valuations. Such market movements, either positive or negative, are indicative of the market's interpretation of the potential benefits or costs these regulations impose on the operational and financial outlook of the firm. A positive response may be driven by the perception that regulations will lead to innovation, higher efficiency, or enhance a company's reputation, thus improving its profitability. Conversely, a negative market reaction could result from concerns over increased costs, stringent compliance requirements, or restrictions that may impede business operations and profitability. As a result, investors realign their investment strategies based on the new information. Correspondingly, this study examines the extent to which the announcement of environmental regulations is associated with abnormal stock returns, signaling the market's perception of the regulation's impact on a firm's future prospects. Given this, I posit that:

**H1:** Environmental legislative announcements are associated with significant abnormal stock returns, reflecting the market's assessment of the regulation's financial impact on firms.

#### 3.2. The Importance of Firm Characteristics

Building on the assumption that markets respond to environmental legislative announcements, literature has shown that the nature of this response appears to be influenced by specific firm characteristics, especially (i) its environmental exposure and (ii) its environmental performance.

(i) The research indicates that the effect of environmental regulation is heterogenous among firms with high to low environmental exposure (Ramiah et al., 2013, 2015, 2016). This is intuitive as environmental regulation is usually aimed at forcing polluting companies to internalize the costs of negative externalities. As a result, highly polluting firms (e.g. oil & gas industry)

are most vulnerable to transition risks and are likely to face the most severe negative consequences for shareholder wealth (Diaz-Rainey et al., 2021). In contrast, firms that do not contribute to pollution may not be affected by heightened environmental regulations as they have a lower environmental exposure. In summary, this means that the stock market reaction to environmental regulation is dependent on the firm's level of pollution.

However, a flaw of previous research results from inadequately identifying high and low polluting firms. This issue primarily arises from categorizing firms based on broad sector or industry codes, which can consolidate diverse sub-sectors under a single umbrella (Birindelli & Chiappini, 2020). Although the industry might be broadly labeled as major polluters, such generalization does not accurately reflect the environmental footprint of every sub-sector within that industry. This problem highlights the need for a more nuanced approach in categorizing firms based on their pollution level (e.g. GHG emissions), to quantify the difference in abnormal stock returns. Given this, I posit that:

**H2a:** Following environmental legislative announcements, abnormal stock returns differ according to the firm's level of GHG emissions.

(ii) A company's environmental performance as a component of corporate social responsibility (CSR) is increasingly recognized not just as a moral imperative but as a strategic asset that positively influences shareholder value (Beal, 2014). Companies that proactively engage in environmentally sustainable practices position themselves favorably in the eyes of investors and stakeholders (Godfrey et al., 2018). Moreover, a strong commitment to environmental performance builds up goodwill and acts as an insurance-like buffer against various transition risks. For instance in case of environmental misconduct, this moral capital may lead investors to react less severely. Correspondingly, a US study from Flammer (2013) found that around the announcement date of negative corporate environmental news, firms behaving responsibly towards the environment experienced better stock returns compared to firms behaving irresponsibly. Consequently, good environmental performance serves as a pragmatic approach to ensuring greater stability for shareholders and thus protects the company against unforeseen transition risks. This insurance like effect of environmental performance against eco-harmful events was also proven to be true by studies from Heflin & Wallace (2017) as well as Blacconiere & Patten (1994).

It is therefore reasonable to assume that environmental performance, measured through ratings/scores also plays a role in the market response to environmental regulations. On the one

hand firms exhibiting a lower environmental commitment should find it more difficult to adopt new regulations and therefore experience higher costs than others. On the other hand, well-prepared firms face fewer transition risks and may even be able to capitalize on the opportunities by efficiently meeting new standards, thus gaining competitive advantages. Following this logic firms with higher environmental performance would experience an insurance like effect when new policies are announced. Furthermore, Ramelli et al. (2018) found that companies with responsible climate change strategies did not lose value following the rollback of climate policies by Trump. The study suggested that this "climate responsibility premium" can be attributed to the strategic behavior of long-horizon investors who acknowledge the firms' efforts due to the overarching, long term trend of sustainability. By contrast, Birinidelli & Chiappini (2020) found the opposite when the EU introduced new environmental policies. They suggested that high performers will immediately shoulder the costs of compliance, while low performers will not address the issues directly, especially if there is a delay in the enforcement of green policies (Jiang & Luo, 2018). Therefore, high performers may experience no mitigating or even worse negative effects during announcements. Given this, I posit that:

**H2b:** Following environmental legislative announcements, abnormal stock returns differ according to the firm's environmental management practices.

### 3.3. Impact on Systematic Risk

Systematic risk (also "aggregate risk") is defined as the risk inherent to the entire market, as opposed to unsystematic risk which only impacts a specific sector or company (Hull, 2023). It is often referred to as "market risk" and includes risks related to macroeconomic events, such as geopolitics, natural disasters as well as fiscal and monetary policy. Systematic risk is non-diversifiable, meaning it cannot be mitigated via portfolio diversification across different asset classes because it impacts the entire financial system (Zopounidis et al., 2021). The Capital Asset Pricing Model (CAPM) is often used to understand and measure systematic risk, using beta as proxy to assess the sensitivity of an asset to the market portfolio (Hull, 2023).

The research of Ramiah et al. (2013, 2015) indicates that policy announcements may influence firms' systematic risk. Employing the Capital Asset Pricing Model (CAPM), their research revealed sector-specific changes in systematic risk following these announcements. Broadly, they observed a rise in risk within polluting sectors and a decline in risk within environmentally friendly sectors. However, they do not provide a theoretical explanation for the observations

they made. As noted by Zhang (2022), investors face considerable uncertainty in valuing climate change related risks in the stock market, most notably transition risk. Drawing upon the theoretical concepts from Hull (2023) policy announcements introduce uncertainty to the market stemming from transition risks. As a result investors recalibrate their portfolio based on their subjective views about the policies' impact on financial markets. This increases market volatility which is reflected in the firm's beta. This process highlights the sensitivity of financial markets to economic policy news and the complex interplay between investor sentiment and market valuations. Given this, I posit that:

**H3:** Following environmental legislative announcements, firms experience a change in systematic risk which depends upon the sector classification.

## 4. Methodology

To examine the hypotheses outlined in the previous chapter, this study will utilize an event study methodology complemented by a regression analysis. The event study is a well-established tool to assess the market response to specific occurrences, such as policy announcements. This approach allows to isolate the stock market response from other market fluctuations, thus providing a clear picture of investor sentiment. Regression analysis is used to identify the relevant factors driving Cumulative Abnormal Returns (CARs).

The methodology chapter is organized into four main sections: The first section describes the process of identifying and selecting the relevant policy events. The second chapter details the data collection process. The next two chapters elaborate on the variables and the modeling approach used in the event study and regression analyses. Following this, I explain the approach in evaluating systematic risk.

### 4.1. Events

Choosing the right events is crucial because it impacts the validity, reliability, and interpretability of the event study's outcome (Cohen et al., (2017)). Hence, the selection process must be objective and systematic. Most importantly, events must be directly related to the research question and introduce substantial and novel information to the market. The events selected must be exogenous, meaning they are unexpected or not anticipated by market participants (Miyajima, 2007). Events that are anticipated are already factored into prices and may thus not provide clear insights into the impact of new information on market valuations. Lastly, data availability and quality is important in order to identify the real “event date”, the initial public announcement. This date can be difficult to pinpoint especially when information is leaked or disseminated over a longer period. Therefore, it was necessary to carefully scrutinize news sources, press releases, and other forms of public disclosure to determine the most accurate event date.

The event selection process of this study differs from Ramiah et al. (2013, 2015) who categorize 19 policy events into three groups: (i) policy announcements, (ii) policy acceptances or rejections, and (iii) policy implementations. However, following the research of Leuz & Wysocki, (2016) I argue that focusing exclusively on the initial announcement of policies is more effective because “the regulation is priced in from the time of the announcement, if not earlier”. The first announcement introduces more novel and significant information than subsequent policy

developments (e.g. ratification) which are often already priced in, diminishing their informational value. Additionally, the events considered in this study, were all accepted without any instances of rejection, further validating the adequacy of this approach.

Generally, environmental policies unfold within the EU as follows: The process begins with the European Commission, who proposes new policies. These proposals then undergo a review from both the European Parliament and the Council. Following this, the policies are formally adopted and implemented across the EU, with ongoing enforcement and evaluation (European Council, 2024).

As a result, the online archive of the European Commission serves as the main repository of information for policy announcements. I limit the observation period to announcements made between 2010 and 2023 aligning with the onset of the European Union's intensified focus on green legislation in the early 2010s. I also exclude policies directed at specific industries, as well as subsequent policies which are part of larger initiatives because they are less relevant in terms of novelty and impact. The focus lies specifically on the announcement effect of the major EU policy packages, with the goal of understanding the general market response.

**Table 2: EU Environmental Policy Announcements**

Nr.	Date	Category	Event Description
1	25/10/2012	EED	EU Commission announces ' <i>Energy Efficiency Directive</i> '
2 <sup>a</sup>	22/01/2014	CEP	EU Commission announces 2030 ' <i>Climate &amp; Energy Policy Framework</i> ' targeting an emission reduction of 40% by 2030
3 <sup>a</sup>	15/07/2015	ETS	EU Commission announces to strengthen ' <i>EU Emission Trading System</i> '
4 <sup>a,b</sup>	12/12/2015	PCA	EU Commission announces ' <i>Paris Climate Agreement</i> '
5 <sup>a</sup>	12/12/2017	PCA	EU Commission announces new ' <i>Action Plan for the Planet</i> ' with ten initiatives
6 <sup>a</sup>	28/11/2018	PCA	EU Commission announces EU 2050 strategic vision: ' <i>A Clean Planet for All</i> '
7	11/12/2019	GREEN	EU Commission announces the ' <i>European Green Deal</i> ': Increasing emission target to 50%
8	04/03/2020	GREEN	EU Commission announces proposal for ' <i>European Climate Law</i> ' to ensure a climate neutral EU by 2050
9 <sup>b</sup>	16/08/2020	GREEN	EU Commission announces ' <i>Climate Goal Plan 2030</i> ': Emission reduction target raised from 50 to 55%.
10	14/07/2021	GREEN	EU Commission announces ' <i>Fit for 55</i> ' package
11 <sup>b</sup>	02/12/2023	GREEN	EU Commission announces ' <i>Global Pledge on Energy Efficiency</i> '

Source: Own Analysis

<sup>a</sup> Previously studied by Pham et al. (2019) or Birindelli & Chiappini (2020).

<sup>b</sup> If event date falls on a weekend next trading day is used.

The key initiatives since 2010 include: Energy Efficiency Directive (EED), Climate & Energy Policy Framework (CEP), Emission Trading System (ETS), Paris Climate Agreement (PCA) and the European Green Deal (GREEN). These policy measures are crucial because they bring about fundamental change for every aspect of business by setting new sustainability standards. All these policy events primarily focus on reducing carbon emissions which is not arbitrary but a reflection of the European Union's overarching environmental objectives. The EU has strategically prioritized combating climate change through carbon reduction because carbon can be precisely measured. This aspect is crucial for setting clear targets, monitoring advancement, and implementing adjustments to ensure that policy objectives align with the EU's commitment to zero carbon emission by 2050 (European Council, 2024).

## 4.2. Data

The data sample used in the analysis is comprised of European publicly traded firms ranging from small to large market sizes. A stock must satisfy four essential criteria to be included in this selection: (i) the company's headquarters must be located within an EU member state; (ii) the company must have a minimum market capitalization of 2.5 billion EUR because firms falling below this threshold are often less monitored by financial analysts and thus exhibit lower liquidity, and more inefficient market responses to events (Schwert, 2002); (iii) the company must have had its initial public offering (IPO) prior to 2012 and continued to be listed up until 2023; (iv) the company's ESG and fundamental data must be available.

**Table 3: Overview of Variables**

Variable.	Quantification	Data Source
Stock Returns	Time Series of Stock Prices	Datastream
Environmental Performance	Environmental Pillar Score	Datastream
Emissions	GHG Emissions to Revenue	Datastream
Firm Size	Log of Total Assets	Compustat
Leverage	Long Term Debt to Total Assets	Compustat
Profitability	ROA: EBIT to Total Assets	Compustat
Sector	GICS Code	Compustat
Systematic Risk	BETA	Datastream
Market Return	Euro STOXX 600	Datastream
Risk Free Rate	1-month US Treasury Rate	Kenneth French Data Library

Source: Own Analysis

Daily stock returns as well as the Euro STOXX 600 as proxy for market returns were sourced from Datastream, while the risk-free rate was obtained from the Kenneth French Data Library for European factors. Environmental scores as well as total emissions and yearly stock betas were collected using Datastream. For the control variables such as size, leverage, profitability and sector, the necessary financial data was collected from Compustat.

It is important to note that the United Kingdom (UK) decided to leave the European Union (EU) following a referendum on June 23, 2016, declaring its intention to diverge from EU environmental regulations and standards. Consequently, EU policies may not directly influence British companies. However, these firms might still react to EU directives due to indirect spill-over effects, justifying the inclusion of UK firms in the study sample. Similarly, Croatia joined the EU on July 1, 2013. Given that Croatia was part of the EU for the majority of the study's observation period, Croatian companies were also incorporated into the sample. Upon refining the dataset by eliminating inconsistencies, missing, and incorrect data, the process resulted in a total of 572 time-series of stock returns.

**Table 4: Descriptive Statistics**

<b>Variable.</b>	<b>Mean</b>	<b>STD</b>	<b>P25</b>	<b>P50</b>	<b>P75</b>
Market Cap (in € b)	21.80	43.22	4.22	7.18	20.19
Environmental Score	0.68	0.20	0.51	0.72	0.83
Emissions to Revenues (in m)	141.48	532.98	4.45	13.65	50.76
Log Total Emissions	4.99	1.24	3.56	4.07	4.73
Log Total Assets (in € b)	4.15	0.83	3.65	11.87	53.45
Leverage	0.19	0.21	0.06	0.16	0.27
Profitability	0.08	0.12	0.03	0.07	0.11

Source: Own Analysis

### 4.3. Event Study Methodology

The event study methodology is rooted in the Efficient Market Hypothesis which states that stock prices fully reflect all available information, implying that stocks always trade at their fair value. EMH can be categorized into three forms: weak, semi-strong, and strong. Each form reflects a different level of market efficiency based on the types of information (historical prices, all public information, or all information including insider information) considered to be reflected in stock prices (Fama, 1970). If EMH holds, stock prices are expected to immediately respond to new information; this process forms the foundational principle of event studies

(Kliger & Gurevich, 2014). Accordingly, the event study methodology hinges on three central methodological assumptions (Brown & Warner, 1980).

- (i) Markets react efficiently and changes in the stock price accurately reflect the economic impact of the event
- (ii) The event is unexpected and has not yet been factored into the stock price
- (iii) There are no other confounding events during the event window

To understand how stock prices react to announcements of environmental policies, abnormal returns (AR) must be calculated around the announcement date. This study aims to capture the short-term effects of the events on stock prices as initially proposed by Fama et al. (1969). For longer-term effects, such as M&A transactions, methods like the buy-and-hold approach or the Jensen's alpha approach have been developed which capture the impact over longer periods of time (i.e. months or years).

AR is defined as the difference between the actual (or realized) return and the expected (or normal) return of stock  $i$  on day  $t$ . Expected return ( $Re$ ) is defined as the return that would typically be expected for stock  $i$ , in absence of the event. It serves as a benchmark, calculated based on a chosen model that best predicts the stock's performance under "normal" conditions (MacKinlay, 1997).

$$(1) \quad AR_{it} = R_{it} - Re_{it}$$

$AR_{it}$  = Abnormal stock return

$R_{it}$  = Actual stock return

$Re_{it}$  = Expected stock return

There is a variety of different models that can be used to calculate expected returns. For example Ramiah et al. (2013, 2015, 2016) use four different expected return models: (i) a simple rolling average model; (ii) the market model; (iii) the capital asset pricing model (CAPM) and (iv) the Fama-French (FF) three-factor model. Each expected return model has its own advantages and limitations (Ahern, 2009). The market model is most commonly used for event studies (Holler, 2016). It predicts the expected returns with a regression analysis that regresses stock returns on market returns over the estimation window yielding two parameters resulting from this analysis (i.e., alpha & beta).

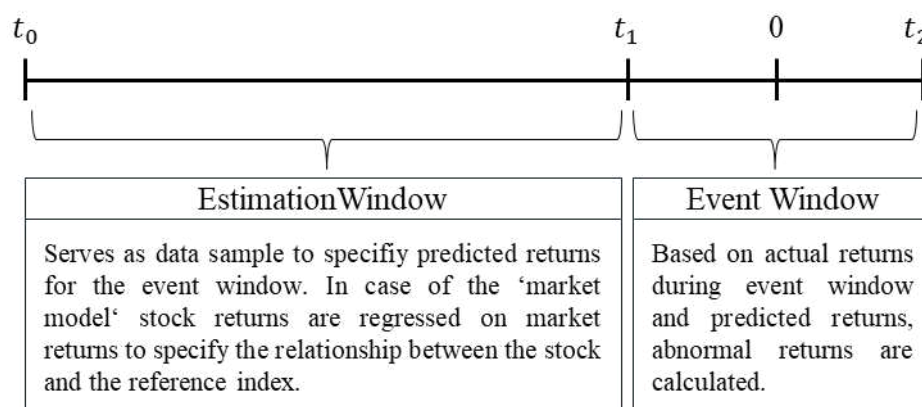
$$(2) \quad Re_{it} = \alpha_i + \beta_i Rm_t + \varepsilon_{it}$$

$\alpha_i$  = Regression's alpha coefficient

$\beta_i$  = Regression's beta coefficient

However, one of the main issues of this approach is to determine the right length of the estimation window. Recent meta-research reviewing 400 event studies finds that estimation window lengths spread out between 30 and 750 days (Holler, 2014).

**Figure 2: Estimation & Event Window**



Source: Own Analysis

Choosing the correct estimation window length is difficult because researchers must balance estimation accuracy and incorrect calculation parameters. The estimation window needs to be long enough to provide a stable estimate of the 'normal' performance but not too long that it includes effects from unrelated past events or changes in the economic environment. Striking this balance can be difficult, especially in volatile markets or industries undergoing rapid change. Longer estimation windows offer higher precision because they mean larger returns samples; however, there is a risk of showing erroneous alpha and beta factors due to confounding events (Brown & Warner, 1985).

CAPM follows a similar logic as the market model but has the advantage that only the event window is necessary as the stocks yearly beta can be sourced directly from Refinitiv (Campbell et al., 1996). However, it is important to note that beta values are backward-looking and may not always reflect the most current market conditions. For the purpose of this analysis the CAPM model will be used. CAPM calculates expected returns based on the risk-free rate, the stock's systematic risk and the market return (Fama, 1970).

$$(3) Re_{it} = r_f + \beta_i(Rm_t - r_f) + \varepsilon_{it}$$

$r_f$  = Risk-free rate of return

$\beta_i$  = Beta as measure of stock's systematic risk

The observations of abnormal returns must be aggregated in order to draw general conclusions from the data. The aggregation can be done along two dimensions - through time and across

securities. When aggregating through time the right event window length must be selected. Typically, before a new policy is announced it goes through various debates and revisions and stimulates uncertainty in the market. Due to information leakage policies may be anticipated a few days before the event date. On the other hand, markets may take a while to adjust for over or underreaction to the new information. Therefore, I follow the suggestion from Ramiah et al. (2015) and choose an event window of five days before and after the event [-5;5]. Event windows typically range in their length between 1 and 11 days and center symmetrically around the event day (Holler, 2014). The returns during the full event window can be aggregated to obtain Cumulative Abnormal Returns (MacKinlay, 1997). The estimation window has a horizon length of  $L_1 = T_1 - T_0 + 1$  and the event window of  $L_2 = T_2 - T_1$ . The CAR starting at time  $T_1$  through time  $T_2$  is defined as:

$$(4) CAR_i = \sum_{t=T_1}^{t=T_2} AR_{it}$$

$CAR_i$  = Cumulative Abnormal Return over event period

$T_1$  &  $T_2$  = First and last day of event window

CARs can be further aggregated across all securities denoted as  $N$  to compute the Cumulative Average Abnormal Returns (MacKinlay, 1997).

$$(5) CAAR = \frac{\sum_{i=1}^{i=N} CAR}{N}$$

$N$  = Number of securities in sample

$CAAR_i$  = Cumulative Average Abnormal Returns over event period

Evaluating the statistical significance of the Cumulative Average Abnormal Return (CAAR) requires the computation of significance tests. Generally, the literature on event-studies covers a wide range of tests. This study follows a similar approach compared to Birindelli & Chiappini (2020) and employs the Patell Z Test (1976) which is based on the Cross-Sectional T-Test.

$$(6) \sigma_{CAAR}^2 = \frac{1}{N-1} \sum_{i=1}^N (CAR_i - CAAR)^2$$

$\sigma_{CAAR}^2$  = Variance

The test statistic for  $H_0: E(CAAR)=0$  can be computed as

$$(7) t = \sqrt{N} \frac{CAAR}{\sigma_{CAAR}}$$

The Patell test overcomes the standard t-test's weakness of event-induced volatility. Event-induced volatility refers to the increase in the volatility of a stock's return that is caused by the event. The event can lead to increased trading activity, which causes stock prices to fluctuate

more than they normally would. This complicates the measurement of statistical significance. The underlying idea of the Patell Test is to standardize each  $AR_{i,t}$  by the so-called forecast-error-corrected standard deviation before calculating the test statistic.

$$(8) SAR = \frac{AR_{it}}{\sigma_{AR_{it}}}$$

$$(9) \sigma_{AR_{it}}^2 = \sigma_{AR_i}^2 \left( 1 + \frac{1}{M} + \frac{(R_{mt} - \bar{R}_m)^2}{\sum_{t=T_0}^{T_1} (R_{mt} - \bar{R}_m)^2} \right)$$

$\sigma_{AR_{it}}$  = Standard deviation of abnormal return of stock i on day t

$\sigma_{AR_i}$  = Standard deviation of abnormal returns of stock i in estimation window

M = Number of returns in estimation window

$R_{mt}$  = Market return on day t

$\bar{R}_m$  = Mean of market returns in the estimation window

The test statistic for  $H_0: E(CAAR)=0$  can be computed as

$$(10) z = \frac{1}{\sqrt{N}} \sum_{i=1}^N \frac{CSAR_i}{\sigma_{CSAR_i}}$$

N = Number of stocks

$CSAR_i$  = Cumulative standardized abnormal returns of stock i

$$(11) CSAR_i = \sum_{t=T_1+1}^{T_2} SAR_{it}$$

Although the Patell test accounts for event-induced volatility, it is sensitive to cross-sectional correlation which is why Boehmer et al. (1991) suggested the BMP and Kolari & Pynnönen (2010) developed an adjusted version of both models called the Adjusted Patell test. However, all of these tests are parametric and thus rely on the assumption that the data follows a specific distribution, (e.g. normal distribution). A non-parametric significance test like the Generalized Sign Test can be used to solve this issue. It compares the proportion of positive ARs around the event date to the proportion from a period unaffected by the event, the estimation window (here 75 days). The test is well suited for event windows of 1 to 11 days (Cowan, 1992).

$$(12) p = \frac{1}{N} * \sum_{i=1}^N \frac{1}{M} * \sum_{T_1}^{T_2} S_{it}$$

$$(13) S_{it} = \begin{cases} 1 & \text{if } AR_{it} > 0 \\ 0 & \text{otherwise} \end{cases}$$

The statistic for the GSign Test for  $H_0: E(CAAR)=0$  is defined as:

$$(14) Z = \frac{w - N * p}{\sqrt{N * p * (1 - p)}}$$

$w$  = Number of positive  $CAR_i$  during the event window

$p$  = Fraction of positive  $AR_{i,t}$  during the estimation window (across both securities  $i$  and time  $t$ )

Significance tests for each event are carried out individually, determining the statistical significance of abnormal returns based on the absolute value of the test statistic. Should this value surpass the two-tailed critical values of 1.645, 1.96, or 2.576, abnormal returns are identified as significant at the 90%, 95%, and 99% confidence levels, respectively. Furthermore, the analysis includes portfolio sorts to differentiate between firms with high and low emissions and those with good versus poor environmental management practice.

#### 4.4. Regression Methodology

Building upon the findings from the event study analysis, the study explores the impact of the environmental score and the firm's emissions on the Cumulative Abnormal Return (CAR) by conducting a regression analysis following the approach of Miyajima & Yafeh (2007). The regression equation is formulated as follows:

$$(15) \text{CAR}_{i,t,e} = \alpha_t + \beta_1 * \text{Env. Performance} + \beta_2 * \text{Emissions} + \beta_3 * \text{Size} + \beta_4 * \text{Leverage} + \beta_5 * \text{Profitability} + \gamma_j + \delta_k + \epsilon_{it}$$

$CAR_{i,t,e}$  = Cumulative abnormal returns for firm  $i$  at time  $t$  and event  $e$

$\alpha$  = Intercept

$\beta$  = Coefficient for the explanatory variables

$\gamma_j$  = Sector fixed effects

$\delta_k$  = Event fixed effects

$\epsilon_{it}$  = Error term for firm  $i$  at time  $t$

The equation outlines a fixed effects panel regression model and follows the approach of Birindelli & Chiappini (2020). The dependent variable of all model specifications is represented by CAR. CAR is regressed on environmental performance and emissions. To consider alternative explanations for the abnormal returns, multiple control variables are included, following Flammer (2013), such as profitability, size, and leverage. These characteristics are lagged by one year to ensure they are known to investors on the announcement date. Furthermore, prior research indicates that stock responses can vary by sector, leading to the inclusion of sector fixed effects in the regression (Pham, 2019). Event fixed effects are incorporated as well to address any potential influence from unobserved time-varying differences.

#### 4.5. Systematic Risk Methodology

The implementation of strict environmental regulations presents a significant transition risk to high polluting firms. Conversely, the lax environmental policies introduce a degree of uncertainty for businesses committed to environmental sustainability. The business environment can change substantially following the introduction of such regulations, the impacts of which on systematic risk remain largely unexplored (Pham et al., 2019). Addressing hypothesis 3, this chapter aims to quantify the short-term fluctuations in systematic market risk following the announcement of green legislation, utilizing the methodology employed by Ramiah et al. (2013). Their research extends the CAPM asset pricing model by incorporating interaction variables to estimate the change in beta as a proxy for systematic risk. The first interaction term involves multiplying beta by an aggregate dummy variable (AD) representing a value of one on event dates and zero otherwise. The second interaction term multiplies the intercept by the aggregate dummy variable. The equation estimates the aggregate effect of the announcements on the stock market.

$$(16) R_{It} - R_{ft} = \alpha_I + \beta'_I(R_{mt} - R_{ft}) + \beta''_I(R_{mt} - R_{ft}) * AD_t + \beta'''_I * AD_t + \epsilon_{it}$$

$\alpha_I$  = Intercept

$\beta'_I$  = Average short-term systematic risk of the industry

$\beta''_I$  = Change in the industry risk

$\beta'''_I$  = Change in intercept

$R_{It}$  = Daily return on the industry portfolio

$R_{ft}$  = Risk-free rate

$R_{mt}$  = Market return at time t

$AD_t$  = Aggregate dummy variable with 1 on event dates, 0 otherwise

$\epsilon_{it}$  = Error term

However, with this aggregate model, effects of opposite outcomes from different announcements may cancel each other out. Therefore, another variation of this model was developed by Graham et al. (2012) to disaggregate the effects into individual announcements. This allows to identify the exact contribution of each green policy announcement by using a series of individual dummy variables (Pham et al., 2019). The authors propose a model specification where the individual dummy variable either takes the value of one for the first 15 days and zero otherwise or takes the value of one solely on the event date itself. To mitigate potential multicollinearity issues arising from correlated event dummies, the intercept interaction term ( $\beta'''_I$ ) is dropped.

$$(17) R_{It} - R_{ft} = \alpha_I + \beta_I'(R_{mt} - R_{ft}) + \sum_{g=1}^N \beta_I''(R_{mt} - R_{ft}) * ID_{gt} + \epsilon_{it}$$

$ID_{gt}$  = Individual dummy variable per event with 1 on event dates, 0 otherwise

g = Event number

For the analysis the EURO STOXX 600 will be used as a proxy for the market return, and the risk-free rate was retrieved from the Kenneth French European data library. The industry returns are calculated by aggregating the stock returns from the data sample based on their industry classification.

## 5. Analysis & Results

### 5.1. Event Study Analysis

The analysis starts by testing the first hypothesis through an event study analysis. To briefly recite, the goal is to identify whether the announcement of European environmental legislation leads to any market response as measured by significant cumulative abnormal returns in the event window [-5:+5] around the announcement date.

Table 5 displays the descriptive statistics for CARs across all event dates, corresponding to the announcement of different European environmental legislation. The average CARs (Mean) on these dates hint at the market's reaction to each legislative event within the specified event window of eleven days (spanning from five days before to five days after the announcement). For instance, a negative mean CAR might suggest general concern among investors regarding the impact of new regulations, whereas a positive mean CAR may indicate investor optimism about the potential benefits of these regulations. The standard deviation (STD) provides insights into the volatility of CARs, while the percentiles (P25, P50, P75) as well as the minimum (Min) and maximum (Max) values provide a deeper understanding of the distribution of CARs.

**Table 5: CARs Descriptive Statistics for all Events**

<b>Nr.</b>	<b>Date</b>	<b>Mean</b>	<b>STD</b>	<b>P25</b>	<b>P50</b>	<b>P75</b>	<b>Min</b>	<b>Max</b>
1	25/10/2012	0.0034	0.0026	-0.0225	0.0064	0.0317	-0.31	0.18
2	22/01/2014	0.0093	0.0028	-0.0218	0.0096	0.0413	-0.23	0.18
3	15/07/2015	-0.0027	0.0038	-0.0399	0.0007	0.0396	-0.26	0.18
4	12/12/2015	0.0075	0.0041	-0.0236	0.0053	0.0383	-0.54	0.42
5	12/12/2017	0.0069	0.0017	-0.0155	0.0047	0.0257	-0.15	0.26
6	28/11/2018	0.0124	0.0030	-0.0178	0.0065	0.0380	-0.19	0.26
7	11/12/2019	0.0011	0.0020	-0.0255	-0.0020	0.0259	-0.21	0.29
8	04/03/2020	-0.0015	0.0323	-0.1236	-0.0040	0.1145	-0.58	1.05
9	16/08/2020	0.0001	0.0019	-0.0244	-0.0007	0.0238	-0.19	0.26
10	14/07/2021	0.0052	0.0020	-0.0187	0.0052	0.0282	-0.32	0.19
11	02/12/2023	-0.0012	0.0032	-0.0264	-0.0007	0.0253	-0.28	0.75

Source: Own Analysis

Note: Table illustrates the descriptive statistics for all CARs over the event window of [-5:+5] of all firms (N=572).

Table 6 presents a comprehensive overview of the Cumulative Average Abnormal Returns (CAAR) related to all events, accompanied by the results from corresponding T-Tests, Patell Z, and Generalized Sign Z Tests. The CAAR values, some of which are notably positive, imply that certain events elicited a positive market reaction, as seen for instance on 28/11/2018 with a significant CAAR of 2,50%. Conversely, a negative CAAR such as on 15/07/2015 with -0.48% suggests an overall negative market response to the announcement. Out of 11 events 6 exhibited statistical significance for the CAAR values across all significance tests, clearly demonstrating significant market activity. In contrast, the events that did not elicit a significant reaction likely introduced less new or less meaningful information, were poorly timed, lacked clarity, or were viewed as less credible, resulting in muted market reactions. This supports the idea of investigating the impact of European environmental legislation on equity markets.

**Table 6: CAAR for all Events**

Nr.	Date	CAAR	T-Test	Patell Z	GSign Z
1	25/10/2012	0.69%	2.28**	1.68*	3.71***
2	22/01/2014	1.62%	5.24***	3.54***	3.96***
3	15/07/2015	-0.48%	-1.33	-0.92	-0.63
4	12/12/2015	1.51%	3.97***	2.34**	4.05**
5	12/12/2017	1.38%	5.57***	2.54**	3.84***
6	28/11/2018	2.50%	7.53***	4.13***	3.55***
7	11/12/2019	0.21%	0.79	1.01	1.18
8	04/03/2020	-0.30%	-0.28	-0.23	-0.50
9	16/08/2020	-0.07%	-0.28	-0.09	-0.37
10	14/07/2021	1.05%	3.92***	2.85***	3.95***
11	02/12/2023	-0.24%	-0.70	-0.24	-0.89

Source: Own Analysis

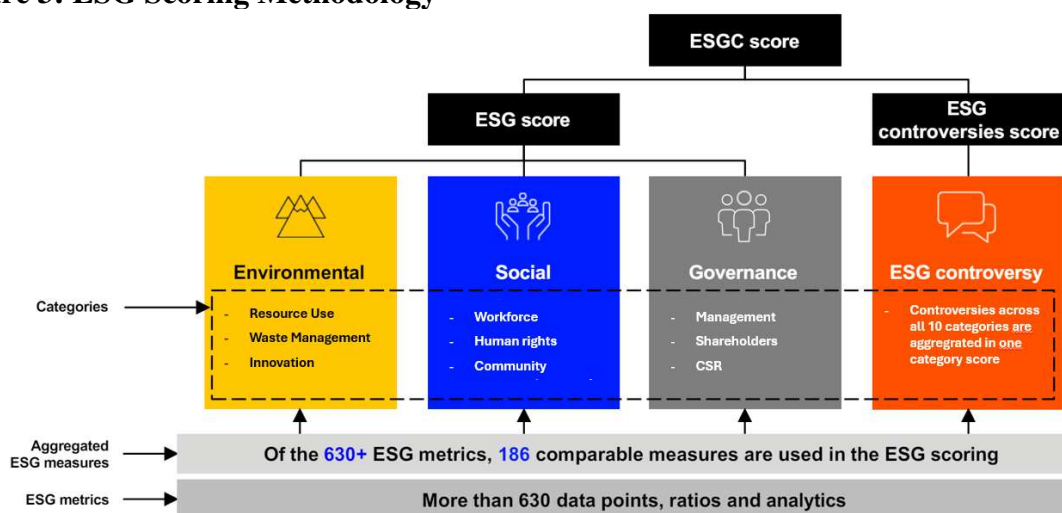
Note: The table illustrates the cumulative average abnormal returns (CAARs) over the event window of [-5:+5] of all firms (N=572). The statistical significance is tested through T-Test, Patell Z Test (1991) and Cowan's Generalized Sign Test (1992). The asterisks denote levels of statistical significance, at the 10%, 5% and 1% level.

To test the second hypothesis, the methodology involves segmenting the data sample into distinct groups through portfolio sorting. This process begins by assigning a rank to each firm,

numbering from 1 to 572 based on their emissions and on their environmental score. With these rankings established, the firms are then categorized into groups for comparative analysis.

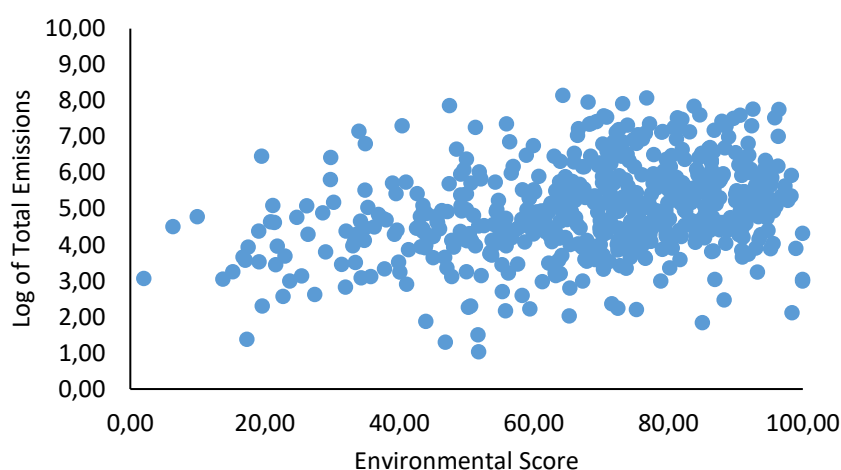
Initially, firms are separated based on their greenhouse gas (GHG) emissions, adjusted for revenue, to distinguish between high and low polluting firms. Additionally, firms are evaluated based on their environmental management practices, separating them into groups of good or bad.. This classification is determined by the environmental pillar score, which is a quantifiable metric that gauges the quality of a firm's environmental standards and practices. The environmental pillar score incorporates various factors, including resource use, waste management, and environmental innovation, thus serving as a comprehensive indicator.

**Figure 3: ESG Scoring Methodology**



Source: LSEG ESG User Guide (2023)

The data sample used for the portfolio sorting is expressed in figure 4. The scatterplot shows that there is no linear relationship between a firm's emissions and its environmental pillar score. This means, contrary to expectation, higher GHG emission do not necessarily equate to lower environmental scores, pointing to the complexity of ESG performance metrics and further validating the approach of sorting firms on both criteria. Additionally, a scatterplot was created for size and emissions to check for any size-related correlation, but it showed only a weak relationship.

**Figure 4: Scatterplot of Firm's Pollution Level and Environmental Pillar Score**

Source: Own Analysis

The subsequent tables showcase the outcomes of the Cumulative Average Abnormal Returns (CAAR) analysis from the previously mentioned event studies, which were conducted using a portfolio sorting methodology. The insights contribute to the understanding of how a firm's sustainability characteristics, are factored into market valuations.

**Table 7: CAAR for all Events sorted by Environmental Mngmt. Practices**

Nr.	Date	Bad Practices Portfolio (N=286)				Good Practices Portfolio (N=286)			
		CAAR	T-Test	Patell Z	GSign Z	CAAR	T-Test	Patell Z	GSign Z
1	25/10/2012	0.38%	1.25	1.11	1.93*	0.30%	1.02	1.05	1.80*
2	22/01/2014	0.80%	2.43**	2.73***	2.80***	0.81%	2.90***	3.54***	2.86***
3	15/07/2015	0.50%	1.30	1.61	1.92*	-0.99%	-2.88***	-1.95*	-2.11**
4	12/12/2015	1.25%	3.14***	3.23***	3.31***	0.26%	0.70	0.43	0.36
5	12/12/2017	0.55%	2.11**	1.92*	2.01**	0.83%	3.62***	3.21***	2.17**
6	28/11/2018	2.15%	5.42***	5.62***	3.88***	0.33%	0.99	1.24	1.34
7	11/12/2019	0.54%	1.88*	1.93*	1.77*	-0.33%	-1.31	-1.76*	-1.68*
8	04/03/2020	1.08%	1.94*	2.11**	2.40**	-1.38%	-2.40**	-2.48***	-3.31***
9	16/08/2020	0.53%	1.77*	1.32	2.16**	-0.60%	-2.64***	-1.76*	-2.32**
10	14/07/2021	0.45%	1.55	1.56	1.78	0.59%	2.48**	1.88*	1.75*
11	02/12/2023	0.41%	1.07	0.84	1.29	-0.65%	-2.24**	-1.89*	-2.12**

Source: Own Analysis

Note: The table illustrates the cumulative average abnormal returns (CAARs) over the event window of [-5:+5] sorted by firms with good and bad environmental practices based on their environmental pillar score. The statistical significance is tested through T-Test, Patell Z Test (1991) and Cowan's Generalized Sign Test (1992). The asterisks denote levels of statistical significance, at the 10%, 5% and 1% level.

Table 7, similarly to Table 6, offers a detailed presentation of CAARs for all events, alongside results from the accompanying significance tests. However, in this case, the CAAR is specifically calculated for two separate categories of firms: those with substandard environmental practices and those with superior environmental practices.

The Cumulative Average Abnormal Returns (CAAR) and the corresponding significance tests indicate a distinct pattern of market response to firms' environmental performance. The 'Bad Practices Portfolio' displays exclusively positive CAAR values, implying that firms with inadequate environmental practices, on average, yielded positive abnormal returns in response to the events. Conversely, the 'Good Practices Portfolio' exhibits mixed results of positive and negative CAAR values. Furthermore, the significance levels across both portfolios emphasizes that the results are generally not due to chance, which reinforces the relevance of environmental practices in influencing market reaction to the events.

**Table 8: CAAR for all Events sorted by Emissions**

Nr.	Date	High Emissions Portfolio (N=286)				Low Emissions Portfolio (N=286)			
		CAAR	T-Test	Patell Z	GSign Z	CAAR	T-Test	Patell Z	GSign Z
1	25/10/2012	0.13%	0.43	0.41	0.50	0.56%	1.84*	1.80*	2.11**
2	22/01/2014	1.26%	4.11***	2.45**	4.04***	0.35%	1.14	1.31	1.75*
3	15/07/2015	-0.77%	-2.07**	-1.93*	-1.87*	0.29%	0.81	0.93	1.02
4	12/12/2015	0.48%	1.42	1.74*	1.21	1.03%	2.47**	2.24**	2.34**
5	12/12/2017	0.45%	1.92*	1.27	1.28	0.94%	3.61***	2.30**	3.38***
6	28/11/2018	1.06%	3.28***	4.88***	2.55**	1.44%	4.41***	2.99***	2.52**
7	11/12/2019	-0.68%	-2.46**	-1.84*	-1.78*	0.89%	3.34***	1.80*	1.81*
8	04/03/2020	0.17%	0.16	0.29	0.85	-0.47%	-0.80	-0.95	-0.92
9	16/08/2020	-0.51%	-2.00**	1.72*	-1.82*	0.44%	1.62	0.78	0.54
10	14/07/2021	0.62%	2.58***	1.63	1.45	0.42%	1.47	1.41	0.82
11	02/12/2023	-0.74%	-2.38**	-2.5**	-2.57**	0.50%	1.36	1.83*	1.92*

Source: Own Analysis

Note: The table illustrates the cumulative average abnormal returns (CAARs) over the event window of [-5:+5] sorted by the firms' output of GHG emissions scaled by the firms' revenues. The statistical significance is tested through T-Test, Patell Z Test (1991), and Cowan's Generalized Sign Z Test (1992). The asterisks denote levels of statistical significance, at the 10%, 5% and 1% level.

Table 8 categorizes firms into two distinct groups based on emission levels: the 'High Emissions Portfolio' and the 'Low Emissions Portfolio'. The analysis reveals a mixed response in the 'High Emissions' category, with both positive and negative CAARs observed. In contrast, the 'Low Emissions' group primarily exhibits positive values, with a number of events yielding statistically significant positive returns. This pattern indicates a generally favourable market response to events for firms with lower emissions.

Consolidating the findings from Tables 7 and 8, an event is deemed significant when at least two out of the three statistical tests yield significance at the 10% threshold (Birindelli & Chiappini, 2020). Applying this logic leads to the following observations:

**Table 9: Summary of Significance Tests for all Events**

Response	Bad Practices	Good Practices	High Emission	Low Emission
Insignificant	4	3	5	5
Negative	0	5	4	0
Positive	7	3	2	6

Source: Own Analysis

Note: Events are considered to be significant if at least two tests exhibit significance at the 10% level.

For the environmental score analysis, in the 'Bad Practices' group, out of 11 events 4 were found to be insignificant, 0 showed a significant negative reaction, and 7 events had a significant positive reaction. This suggests that firms with poor environmental practices, did either respond positively or did not respond in a statistically significant way. For the 'Good Practices' group, 3 events were deemed insignificant, 5 showed a significant negative reaction, and 3 exhibited a significant positive reaction. This indicates a mixed response among those type of firms.

Moving on to the emissions analysis, the 'High Emissions' group had 5 insignificant events, 4 with a significant negative reaction, and 2 with a significant positive reaction. Meanwhile, the 'Low Emissions' group presented a contrasting picture with 5 insignificant events, no significant negative reactions, and 6 significant positive reactions, suggesting that the market generally rewards firms with lower emissions levels in response to the events.

In short, firms characterized by poor environmental management practices tend to react positively to the events, while those with good practices react either negatively or neutral. Furthermore, firms with higher emissions levels tend to exhibit negative or neutral reactions, whereas firms with lower emissions react positively.

In order to further substantiate these observations, a long-short trading strategy is employed. The strategy involves taking long positions in firms with low emissions and short positions in those with high emissions during the event window (low minus high). Additionally the same approach is applied for the other category taking long positions in firms with poor environmental practices while shorting those with good practices during the event window (bad minus good). The performance of these strategies is then benchmarked against the market returns over the same time period to evaluate their effectiveness.

**Table 10: Portfolio Returns of 10<sup>th</sup> and 90<sup>th</sup> percentiles**

Nr.	Date	Market Portfolio	Low-High Strategy	Bad-Good Strategy
1	25/10/2012	-0.45%	0.95%	2.26%
2	22/01/2014	-3.36%	-0.29%	1.49%
3	15/07/2015	6.63%	2.20%	-1.24%
4	12/12/2015	-4.17%	0.64%	1.87%
5	12/12/2017	0.44%	0.50%	0.31%
6	28/11/2018	-3.29%	0.50%	2.44%
7	11/12/2019	2.93%	-0.88%	-1.22%
8	04/03/2020	-30.37%	0.84%	10.88%
9	16/08/2020	1.44%	1.82%	-0.23%
10	14/07/2021	0.22%	-0.04%	0.56%
11	02/12/2023	3.09%	1.47%	1.27%
<b>Sum</b>		-26.90%	7.72%	18.39%
<b>Sum (ex. Event 8)</b>		3.47%	6.88%	7.51%

Source: Own Analysis

Note: The portfolios for the long-short trading strategy are computed using firms that rank at the 10th and 90th percentiles in terms of their environmental pillar score or their greenhouse gas (GHG) emissions. Portfolio returns do not consider transaction costs and are calculated over the event window [-5:5].

The data from table 10 validates the findings of table 9 indicating that the trading strategies based on sustainability factors can outperform the market under certain conditions. The Low-High Emission Strategy yields a total return of 7.72% whereas the Bad-Good Management Strategy yielded a return of 18.39%. The market return totaled only 3.47% for the same period. These strategies maintain their advantage even when the outlier around event 8 of -30.37% linked to the Covid market crash, is excluded from the analysis. However, it is important to note these results should be considered in light of transaction costs and the risk profile of the strategies, which are not accounted for in this table and could be studied in further research.

In conclusion, evidence was found that supports both hypothesis 2a and 2b. The obtained results are similar to those of Birindelli & Chiappini (2020) in that the market response to environmental policy announcements differs based on the firms' sustainability characteristics. As was to be expected low emission firms profited from the announcement of environmental legislation. This is in line with the findings of Diaz-Rainey et al. (2022) who show that highly polluting firms (e.g. oil & gas industry) are most vulnerable to transition risks and face the most severe negative consequences for shareholder wealth. However, contrary to expectations, firms with good environmental practices underperformed compared to those with bad practices. This supports Jiang & Luo (2018), who state that high performers will immediately shoulder the costs of compliance thus negatively impacting the firm's short-term profitability. Meanwhile low performers will not address the issues directly and initially avoid these costs, especially if there is a delay in the enforcement. Over the long term, as regulatory enforcement tightens and societal demands for sustainability increase, these lagging firms may face greater challenges and higher costs to catch up with compliance requirements, potentially leading to diminished returns.

## 5.2. Regression Analysis

Table 11 displays the results of the regression analysis, which is focused on examining hypotheses 2a and 2b. The objective is to verify the results of the event study analysis presented in Chapter 4.1 and to determine the reliability of the findings. However, before interpreting the results, it is important to discuss regression diagnostics.

Robust and reliable regression results hinge on regression diagnostics to verify the assumptions of the stochastic regression model. If these assumptions are not met, the regression may yield unreliable estimates. Hence, each regression was tested according to the following diagnostics.

The Jarque-Bera Test indicated that the residuals of the regression model do not follow a normal distribution. Nevertheless, this deviation does not necessarily undermine the model's reliability, in the context of a large sample size. According to the Central Limit Theorem the impact of non-normality is diminished as sample size increases, which mitigates concerns regarding the distribution of residuals. Breusch-Pagan test was conducted, revealing issues with heteroskedasticity. Consequently, panels were estimated using heteroskedasticity robust standard errors. The Variance Inflation Factors (VIF) were computed to detect the presence of multicollinearity among predictors. However, with all VIF values below the threshold of 10, there are no concerns of multicollinearity. Lastly, the Durbin-Watson statistic was calculated to test for independence. The results hovered around 2, indicating no substantial first-order autocorrelation

within the residuals. Also, Breusch-Godfrey test showed no issues with higher-order autocorrelation. The four regression models are designed to capture the effect of environmental performance, emissions, profitability, leverage, and size on CARs, accounting for sector and event fixed effects in certain specifications.

**Table 11: Fixed Effects Panel Regression CARs**

Dep. Variable	1 CAR	2 CAR	3 CAR	4 CAR
Constant	0.0514*** (0.0056)	0.0406*** (0.0061)	0.0512*** (0.0065)	0.0404*** (0.0077)
Env. Performance	-0.0127** (0.0053)	-0.0173*** (0.0041)	-0.0156*** (0.0048)	-0.0198*** (0.0051)
Emissions	-0.0024* (0.0014)	0.0011 (0.0012)	-0.0022* (0.0013)	0.0019 (0.0012)
Profitability	0.0118* (0.0070)	0.0146** (0.0063)	0.0212*** (0.0074)	0.0166** (0.0071)
Leverage	-0.0055 (0.0044)	-0.0011 (0.0060)	0.0055 (0.0043)	-0.0016 (-0.0054)
Size	0.0075*** (0.0019)	0.0086*** (0.0020)	0.0099*** (0.0018)	0.0089*** (0.0028)
Sector Fixed Effects	No	Yes	No	Yes
Event Fixed Effects	No	No	Yes	Yes
F-stat	22.92	11.55	9.33	7.96
Observations	6292	6292	6292	6292
R-Squared	0.018	0.027	0.022	0.044
Adj. R-Squared	0.017	0.025	0.019	0.038

Source: Own Analysis

Note: CARs [-5;5] for all events are regressed on independent variables. Env. Perf is measured as environmental score and emissions as log of total GHG equivalents. Profitability is measured as ROA, Leverage as total debt to total assets, Size as the log of total assets, variables are lagged by one year to ensure information was known to investors on announcement date. All estimations are made using white robust standard errors. Standard errors are provided in parenthesis and asterisks denote levels of statistical significance, at the 10%, 5% and 1% level.

Environmental Performance has a consistently negative impact on CARs across all four models, with significance at the 1% level. For instance, in the 4th column the results ( $\beta = -0.0198$   $STD=0.20$ ) suggest that a one standard deviation increase in environmental performance leads to a decrease in CAR of 0.40%. This suggests that higher environmental performance scores are associated with lower CARs, thus proving hypothesis 2b. This reinforces the results from the previous chapter according to which firms with bad environmental management practices benefit in the short term from the announcement effect of green legislation. However, in the long-term this trend might reverse itself.

Moreover, the emissions coefficient is negative in all models although only significant in the first and third model, which do not control for sector fixed effects. This suggests that when not accounting for the sector variation, higher emissions are associated with lower CARs reflecting market penalization for higher emissions output. However, when introducing sector fixed effects the significance of the emissions variable disappears. This change implies that the impact of emissions on CARs that was observed in the first model might be confounded by sector-specific characteristics. In other words, the significance of emissions in the first model may partially be attributable to differences between sectors rather than emissions per se. Overall, these results do not support hypothesis 2a but are similar to the research of Ramiah et al. (2013) who observe that green legislation has a mixed effect on abnormal returns with apparent sector-by-sector differences. In that sense the analysis suggests that the sector classification may serve as a superior measure for future short costs and transition risk rather than emissions. For instance, a firm specializing in computer software may report low emissions levels, yet the consequences of new regulations for such a firm would differ drastically from those for a renewable energy firm. Despite both firms possibly having low emission figures, the renewable energy firm operates within a traditionally high-emission industry, where regulatory changes are likely to have more profound financial and operational impacts. This highlights the need for a more nuanced approach to assess transition risks within the broader context of industry-specific benchmarks and regulatory landscapes, rather than relying solely on emission metrics.

Profitability appears to have a positive and statistically significant effect on CARs. A possible explanation is, that investors believe that firms with robust profitability margins will be more capable to absorb the cost of new policies without detriment to their financial health. In other words, profitable firms are better positioned to drive innovation and enhance efficiency thus actively leveraging new regulation to create competitive advantages (Porter & van der Linde, 1995b). In contrast, leverage is negatively correlated with CARs in all models but not statistically significant and does not appear as a distinguishing characteristic although prior research found some evidence that leverage does indeed influence the market response (Ramiah et al. 2013). Size consistently displays a positive coefficient across all models, hinting that firms with greater assets generally achieve higher CARs, potentially reflecting investor confidence in the stability and capacity of larger firms to manage regulatory compliance costs.

The same regression analysis was conducted for the upper and lower deciles and quartiles of firms, based on environmental performance, to further investigate its effect on CAR. However, no significant results were found, likely due to the small sample size in these subset regressions.

### 5.3. Systematic Risk Analysis

In the previous sections, the immediate impact of green legislation on stock prices has been extensively analysed. However, scholars argue that such events can also affect the systemic risk in the market. Table 12 presents the changes in systematic risk following the announcements of environmental policies, measured by the beta coefficients for each sector during statistically significant events. This analysis aims to understand how markets differentiate between sectors based on their potential vulnerability to transition risks and their ability to adapt to changes in the regulatory landscape.

**Table 12: Impact on Short-Term Systematic Risk**

Sector	Const.	Beta	Event Number / Date				
			(4) 12/12/2015	(6) 28/11/2018	(7) 11/12/2019	(8) 04/03/2020	(11) 02/12/2023
Telecomms	0.00 (1.05)	0.84 (98.30)	-0.05 (-0.31)	-0.60 (-0.24)	-1.06 (-0.74)	<b>0.75**</b> <b>(2.36)</b>	0.58 (0.47)
Financials	0.00* (1.74)	1.07 (119.39)	-0.17 (-0.97)	-0.34 (-0.13)	<b>2.13*</b> <b>(1.77)</b>	0.64 (1.85)	0.37 (0.28)
Utilities	0.00** (2.05)	0.75 (73.07)	<b>6.47***</b> <b>(2.66)</b>	-2.49 (-0.81)	-1.31 (-0.74)	-0.04 (-0.11)	0.79 (0.52)
Consumer Staples	0.00 (3.57)	0.68 (91.37)	0.16 (1.12)	-1.91 (-0.86)	0.40 (0.33)	-0.43 (-1.51)	0.17 (0.15)
Industrials	0.00 (4.98)	1.05 (147.01)	<b>-0.48***</b> <b>(-3.49)</b>	<b>3.14*</b> <b>(1.68)</b>	<b>-3.02**</b> <b>(-2.36)</b>	0.65 (2.35)	0.53 (0.50)
Consumer Discretionary	0.00 (3.57)	1.07 (110.84)	<b>-0.61*</b> <b>(-1.90)</b>	<b>-4.86*</b> <b>(-1.69)</b>	0.35 (0.21)	<b>0.96***</b> <b>(2.60)</b>	0.33 (0.23)
Information Technology	0.00 (5.39)	1.04 (83.80)	0.02 (0.08)	<b>5.28*</b> <b>(1.67)</b>	2.00 (0.95)	0.06 (0.13)	2.53 (1.39)
Real Estate	0.00 (2.46)	0.74 (50.83)	-0.04 (-0.16)	-0.82 (-0.19)	-0.55 (-0.22)	-0.65 (-1.15)	<b>4.02*</b> <b>(1.85)</b>
Health Care	0.00 (4.95)	0.73 (75.30)	0.09 (0.45)	3.65 (1.63)	-1.73 (-1.03)	-0.06 (-0.16)	-0.47 (-0.33)
Materials	0.00 (2.50)	1.06 (113.25)	<b>-0.40*</b> <b>(-1.65)</b>	<b>4.07*</b> <b>(1.86)</b>	<b>2.80*</b> <b>(1.74)</b>	<b>0.56*</b> <b>(1.75)</b>	-1.53 (-1.10)
Energy	0.00 (0.31)	1.03 (60.74)	-0.13 (-0.40)	2.87 (0.57)	1.60 (0.55)	<b>1.25*</b> <b>(1.90)</b>	-1.15 (-0.46)

Source: Own Analysis (based on Ramiah et al. 2013)

Note: Reports the summarized (significant) results of the regression relating to hypotheses 3 with events as individual dummy variables that take the value of 1 on announcement days and zero otherwise. All estimations are made using white robust standard errors. T-values are provided in parenthesis and asterisks denote levels of statistical significance, at the 10%, 5% and 1% level.

The results exhibit a mixed sector-by-sector response, with both positive and negative coefficients, suggesting that there is no uniform reaction to the events across different sectors. Out of the 11 events analysed, only 5 resulted in significant changes in short-term systematic risk across sectors. Notably, events 4, 6, 7, and 8 had a particularly pronounced effect, impacting

three or more sectors. However, event 8 might be an anomaly, as it coincided with the Covid Crash of 2020, potentially obscuring the results. The analysis was also conducted across high and low emission firms as well as firms with good and bad environmental performance, revealing no significant findings except for event 8. This suggests that the changes might cancel each other out, indicating the need to account for sector-specific differences.

Examining the most significant events, event 4 corresponded to the announcement of the Paris Climate Agreement, event 6 introduced the "Clean Planet for All" initiative, and event 7 was linked to the unveiling of the European Green Deal. These three events were clearly perceived by investors as highly impactful. They stood out because the announcements of these regulations marked turning points that signified substantial commitments to environmental sustainability. Moreover, they signaled a paradigm shift towards more decisive action and enhanced corporate accountability.

Out of the 11 sectors that were analyzed almost all were impacted by at least one event. However, it seems that consumer discretionary, materials and industrials sector were affected most. Consumer Discretionary includes firms that sell non-essential goods and services, like luxury goods or entertainment. The industrials sector typically includes companies involved in construction and manufacturing. The materials sector includes firms that engage in the procurement of chemicals, construction materials, metals etc. All of these industries are highly sensitive to economic cycles and global demand. A downturn in the economy or negative consumer sentiment can drastically affect the sales and performance of these businesses. Industries like healthcare or consumer staples are less affected by economic fluctuations due to the essential nature of their products and services. Healthcare, for example, encompasses medical services, pharmaceutical products, and health insurance, areas that consumers prioritize regardless of economic conditions. Similarly, the consumer staples sector includes companies that produce or distribute necessities such as food, beverages, and household products, which maintain steady demand. Therefore, they are less susceptible to changes in the regulatory environment.

The obtained results confirm hypothesis 3, indicating that policy announcements can indeed influence systematic risk, eliciting varied responses across different sectors. This finding aligns with the research conducted by Ramiah et al. (2013, 2015) and Pham et al. (2019).

#### 5.4. Limitations

Conducting scientific research invariably entails dealing with certain limitations. Research is not a perfect representation of reality but rather the attempt to approximate it as closely as possible. This inherent imperfection stems from various constraints such as methodological boundaries, biases, and the availability of resources. Every scientific study must navigate these challenges. Moreover, the very nature of scientific inquiry, which is to isolate variables and test hypotheses under controlled conditions, means that the complexity of real-world scenarios is often reduced. This simplification is necessary for analytical clarity, but it also means that conclusions drawn from research might not fully capture all the nuances of a natural setting

This being said, one key limitation of the event study methodology is the reliance on a single expected return model, such as CAPM, which only considers market risk. For more robust results, it's advisable to explore additional models. For instance the Fama-French Three-Factor model also accounts for other risk factors such as size and value, in addition to market risk.

Moreover, identifying the correct event date is crucial in event studies as information leakage can obscure the actual impact date. To address this issue, the earliest announcement dates were verified through a review of news sources. However, it is important to acknowledge that the exact event date cannot be guaranteed. Also the effects of policies and regulations often unfold gradually, influencing firm value over time as the market adapts making it difficult to choose the right event window. In this study, an event window of [-5:5] days around the event was used, encompassing five days before and five days after the event to capture both anticipatory reactions and subsequent adjustments. However, it would be beneficial to explore other event windows to assess how varying lengths might influence the analysis results.

Another limitation observed in this research is the overlap of policy announcements with confounding macroeconomic events, which can obscure policy effects. This suggests a need for caution in interpreting findings, as broader macroeconomic factors may undermine study robustness. Specifically, the study identified the Covid-19 crash as significant confounding event. Additionally, firm-specific confounding factors like earnings reports were not considered, which, although generally negligible in larger samples, could still bias results to some degree.

Furthermore, in this event study, three different significance tests were utilized: the cross-sectional t-test, the Patell Z Test, and the Generalized Sign Z Test. However, numerous other tests

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could also be employed to evaluate the significance of the Cumulative Average Abnormal Returns (CAARs). Exploring additional tests could enhance the robustness of the findings by providing different perspectives on the statistical significance.

Lastly, a common challenge that many researchers face is the limitation of data quality and availability. While Refinitiv Datastream offers extensive information on environmental firm data, the quality of this data is somewhat problematic. The leading ESG rating agencies are MSCI ESG Research and Sustainalytics. They hold more accurate and more comprehensive datasets that could be highly valuable for this research. However, the high subscription costs associated makes the data less accessible.

## 6. Conclusion and Outlook

In response to climate change the European Union has outlined a stringent pathway to achieve net zero emissions by 2050, recognizing the urgency for climate action and environmental responsibility. Central to this ambitious goal are the EU's environmental policies, which serve as crucial instruments in the transition towards a low-carbon economy. These policies encompass a broad range of measures, with a primary focus on reducing greenhouse gas emissions. They are designed to significantly influence firm operations and business models, pushing companies to adopt more sustainable practices. Consequently, this not only mitigates environmental impacts but also reshapes the economic landscape by setting new standards, fostering innovation and integrating sustainability into corporate strategies. However, it is important to note that while these policies can be a source of competitive advantage, they also pose significant challenges to companies. Adapting to these regulations may require significant upfront investment and operational adjustments, which can be detrimental to some firms.

Correspondingly, this thesis examined the short-term market response to the announcement of environmental policies in the EU over the past decade. More specifically, this study analyzed whether market reactions, in terms of abnormal returns, varied based on a firm's exposure to transition risks. This exposure was quantified by factors such as the firm's total emissions, environmental performance, and sector classification. The aim was to determine whether these characteristics influenced investor preferences following green policy announcements.

The results of this study show that the announcements indeed have a significant impact on equity markets, eliciting measurable price reactions. Moreover, it was observed that firms with lower emissions are less susceptible to transition risks compared to their high-emission counterparts and, thus tend to experience better abnormal returns following such announcements. This phenomenon can be attributed to the fact that high-emission firms are more exposed to transition risks, often facing higher compliance costs and regulatory pressures.

Additionally, the study presents an unexpected trend: firms with less robust environmental management practices tend to exhibit better abnormal returns compared to those with more stringent practices. This counterintuitive result can be explained by the immediate financial burden that compliance places on firms with proactive environmental strategies. In contrast, firms that have been slower to adopt environmental measures avoid these upfront costs. However, this advantage could be short-lived as regulatory enforcement tightens and societal demands for sustainable practices grow. This insight calls for further investigation into the long-term financial

impacts of environmental strategies and their influence on firm valuation in the context of evolving regulatory environments.

The study demonstrated that in addition to short-term reactions in the form of abnormal stock returns, green policy announcements also influenced short-term systematic risk in the market, which varied depending on a firm's industry classification. Specifically, industries traditionally associated with higher environmental impacts, such as industrials and materials, exhibited more pronounced changes in systematic risk compared to sectors with generally lower environmental footprints, like information technology. This variation in risk exposure suggests that the market differentiates between sectors based on their potential vulnerability to new environmental regulations and their ability to adapt to these changes. Firms in high-impact industries might see increased volatility due to potential costs associated with compliance, transitioning processes, and changing consumer preferences. In contrast, firms in industries less directly affected by such policies might experience more stable risk profiles. This result shows the importance of industry classification in predicting and managing the financial impacts of environmental policies. It also suggests that investors should consider these dynamics when assessing risk and making investment decisions in the context of increasing regulatory focus on environmental sustainability.

Understanding the drivers behind the varying impact of environmental policies is crucial for investors, company management and policymakers to accurately assess potential effects on stock prices and the associated risks introduced by such regulatory changes. In short, the key finding of the study is that green policy announcements indeed have a significant short-term effect on stock prices and systematic risk. However, this impact varies based on a firm's individual characteristics, such as emission levels, environmental performance, and sector classification.

This thesis focused on examining the immediate stock price reactions to climate policy announcements. Future research should extend this research by exploring the long-term impacts of green policy announcements. Specifically, it would be beneficial to analyse how these policies influence the performance of listed firms in the long run, considering not only stock prices but also fundamental metrics like for example operational efficiency and market share. This would provide a more comprehensive understanding of the policy measures and their overall effectiveness over longer time horizons.

Additionally, this study utilized emissions as a proxy for environmental exposure and the environmental pillar score as a proxy for environmental performance. Future investigations could expand on this research by employing alternative proxies that might capture different aspects.

Moreover, analysing country-specific differences in response to climate policies could be highly valuable. This could involve a comparative study across various regulatory environments, assessing how different levels of policy stringency and enforcement influence market reactions and firm behaviour. Such research would help identify best practices and suggest policy adjustments tailored to the unique economic and cultural contexts of different regions.

Also, the study found that changes in short-term systematic risk can be either positive or negative. Future research could explore the long-term effects as well as the specific drivers behind these positive and negative changes. This includes examining how different types of environmental policies (e.g., carbon pricing, emissions standards, renewable energy incentives) affect various sectors differently.

Lastly, future research should focus on analysing investor behaviour through sentiment analysis to gain deeper insights into market dynamics in response to environmental policies. Using natural language processing sentiment analysis can interpret and quantify subjective information from financial news, social media, and earnings call transcripts. Tracking changes in sentiment before, during, and after policy announcements reveals how investor perceptions evolve and correlate with market reactions such as stock price volatility and abnormal returns.

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## Appendix

### List of Securities in Data Sample

1U1	BEAN	EDPR	HOLM B	LPP	REY	SZU	ASM	COTN	FRAS	JET2	OCDO	SESG	UMI
III	BWY	EFGN	HWDN	LUKN	REP	SCA B	ASML	CBK	FNTN	BAER	OMV	SVT	UCG
A2A	BKG	FGR	HSBA	MC	RXL	SHB A	ASSA B	SGO	FME	BELA	SNP	SGSN	ULVR
AAK	BIM	EKTA B	BOSS	EMG	RHM	UHR	G	CFR	FRE	JYSK	OPL	SHC	UNI
AALB	BKW	ELI	HUH1V	MAP	RICHTER	SWEC B	ABF	ML	FPE3	KBC	ORA	SHEL	UTG
ABBN	BNP	ELISA	HUSQ B	MKS	RMV	SWED A	AZN	CPG	GALP	KEMIRA	ORNBV	SFZN	UTDI
ABDN	BOL	EMMN	IBE	MBK	RILBA	SOBI	ATCO A	CON	GAW	KER	ORK	SIE	UU.
ANA	BOL	EMSN	ICLR	MB	RIO	SLHN	NDA	KBHL	G1A	KRZ	PKN	SIKA	UPM
AC	EN	ENG	IGG	MELE	ROG	SPSN	AZA	ALB	GEBN	KESKOB	OTP	SIX2	VK
ACE	BP.	EBK	NK	MBG	ROCK B	SREN	AV.	COV	GFC	KGH	PNDORA	SEB A	VIE
ACKB	BPE	ECV	IMI	MRK	RR.	SCMN	AVOL	CWK	GMAB	KIND SDB	PGHN	SKA B	VER
ACS	BRD	ELE	IIA	METSB	ROR	SQN	CS	ACA	GF	KGF	PSON	SKF B	VWS
ADDT B	BRE	ENEL	IMB	MOL	RBREW	SYDB	AXFO	CE	GXI	KRX	RI	SN.	VGP
ADEN	BNR	ENGI	INCH	MNDI	RS1	SY1	AZM	CRH	GETI B	KINV B	PSN	SMIN	VID
ADS	BATS	ENI	IDR	MOR	RTLL	TATE	BAB	CRDA	GIVN	KOMB	PGE	SK3	VIG
ADM	BLND	ENT	ITX	MOH	RUI	TW.	BANB	EVD	GJF	KNEBV	PHNX	SRG	DG
AGS	BT.A	EQNR	INDU A	MOWI	RWE	TECN	BA.	BN	GL9	KCR	TPEIR	BB	VIRP
AF	BUCN	ERG	INDT	MTX	RYA	TEL2 B	BALN	DANSKE	GLEN	KOG	PAH3	FLY	VIS
AIR	BDX	ESB	IFCN	MUV2	SAAB B	TIT	BGN	AM	GN	AD	PKO	GLE	VTY
AIXA	BNZL	EL	IFX	MYCR	SAF	ERIC B	BMPS	DSY	OPAP	KPN	PZU	SW	VIV
AKER	BRBY	RF	ING	MYTIL	SAGA A	TEF	BPSO	CPR	GRG	PHIA	PRP	SOF	VOD
AKRBP	BVI	EUROB	INGA	ETE	SGE	TKA	TLV	DCC	GRF	VPK	PROX	SOW	VOE
ALFA	BZU	ERF	COL	NG.	SPM	TEL	BBVA	DLG	GBLB	KRKG	PRU	SOI	VOW
ALK B	CAI	EURN	ICP	NTGY	SALM	TEP	BCP	DEMANT	GCO	KRN	PRY	SOL	VOLV B
ALV	CABK	EVN	IAG	NWVG	SAMPO	TELIA	SAB	DLN	GSK	KNIN	PSPN	SOON	VONN
ALPHA	CAP	EXPN	ITP	NVG	SMSY	TEMN	SAN	DBK	GIB	LUND B	PPC	SOP	VZN
ALSN	CGCBV	FABG	IP	NEM	SAND	TEN	BHW	DB1	HM B	ROVI	PUB	SRBNK	WCH
ALO	AFX	BALD B	INRN	NESTE	SAN	TRN	MIL	LHA	HLMA	MMB	PUM	SXS	WAWI
ATE	CARL B	FERG	ITRK	NESN	SPL	TSCO	BIRG	DHL	HNR1	LAGR B	QGEN	SPX	WDP
AMS	CA	FIE	ISP	NEX	SAP	HO	PEO	DTE	HL.	AI	RBI	SSAB A	WRT1V
AMBU B	CAST	FLS	LATO B	NXT	DIM	TKA	BKT	DWNI	HEI	LAND	RAND	SSE	WEIR
AMP	CDR	FLU	IPN	NKT	SBMO	TOM	BCVN	DGE	HEIO	LEC	RAA	SGKN	MF
ANDR	CNA	FHZN	IPS	NOKIA	SCHA	TOP	BARC	DIA	HEIA	LGEN	RKT	STJ	WTB
AAL	CEZ	FDR	IRE	NDX1	SU	TTE	BDEV	DIE	HTO	LR	REC	STAN	WIE
ANTO	LISN	FLTR	ITV	NHY	SDR	T2G	BARN	DPLM	HELN	LDO	RED	STMPA	WKL
MAERSK B	CDI	FCC	SBRY	NOVN	SCR	TREL B	BAS	GIL	HEN3	LLOY	RDW	STERV	YNDX
ARCAD	CIE	FNOX	JHX	NOVO B	SK	TRI	BAYN	SMDS	HER	LI	REL	STB	YAR
MT	CLN	FORTUM	DEC	NSIS B	SECT B	TRYG	BMW	DSV	HEXA B	LSEG	RCO	STR	YPSN
AKE	COLO B	FRVIA	JD.	BEKB	SECU B	TUI1	BION	EOAN	HPOL B	LMP	RNO	STMN	ZABA-R-A
AHT	COLR	FRA	JMT	OBS	SGRO	UCB	BESI	EZJ	HIK	LONN	RSW	SAX	ZEAL
BEI	BEIJ B	EDP	HOLN	LOTB	BC8	EDEN	HOT	OR	RTO	SUBC	ZURN		

Note: Tickers as per Refinitiv Datastream Identifier