Is it rewarding to become carbon neutral?

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Summary

The world is on the move towards a carbon-neutral era to reduce the impact of climate change. For companies, it is increasingly relevant to participate in this development. My research therefore examines how the announcement of planned climate neutrality affects companies' share prices in the short term. Using the event study methodology, I study market reactions on 117 corporate climate neutrality announcements by publicly traded U.S. companies between 2020 and March 2022. The analysis shows that the companies' share prices respond significantly positive with a 1.43% cumulative average abnormal return (CAAR) in the five days around the announcement. I have further investigated the stock market reactions by clustering the dataset based on company characteristics. I discover that companies that announce stricter carbon reduction targets have a higher cumulative abnormal return (CAR). In addition, companies that declare their carbon neutrality in association with voluntary membership in the Climate Pledge Initiative experience a higher CAR than the announcement without the membership. Finally, a multivariate regression analysis is used to examine whether agency problems influence the level of market reactions. However, no definitive conclusion can be obtained.

Keywords: carbon neutrality, event study, announcement effects, CSR, stock market reaction, agency problem

Summary

A sociedade atual está direcionada para uma era neutra em carbono de forma a reduzir o seu impacto nas alterações climáticas. É cada vez mais relevante para as empresas participarem nesta tendência. O meu trabalho pretende examinar como o anúncio de neutralidade climática pelas empresas afeta os seus respetivos preços de ações. Usando a metodologia de estudo de eventos, analisei as reações do mercado em 117 anúncios de neutralidade climática de empresas norte-americanas cotadas em bolsa entre 2020 e março de 2022. A análise mostra que os preços das ações das empresas respondem de forma significativamente positiva com um retorno anormal médio acumulado (CAAR) de 1,43%. nos cinco dias após o anúncio. Analisei ainda as reações do mercado de ações agrupando o conjunto de dados com base nas características empresariais. Os resultados mostram que as empresas que anunciam metas de redução de carbono mais rígidas têm um retorno anormal cumulativo (CAR) mais elevado. Para além disso, as empresas que declaram neutralidade carbónica associadas a uma adesão voluntária à Climate Pledge Initiative apresentam um CAR mais alto comparativamente ao anúncio sem a adesão. Adicionalmente, realizei uma análise de regressão multivariada de forma a examinar se os problemas de agência influenciam o nível de reações do mercado. No entanto, não foi possível obter uma conclusão definitiva através dos resultados obtidos.

Palavras-chave: neutradilidade carbónica, estudo de eventos, efeitos de anúncio, CSR, reacção do mercado bolsista, problema de agência

1 Introduction

Decarbonisation is one of the most current and widely discussed topics (IPCC, 2021). Various stakeholders, including politicians, NGOs, customers, and employees increase pressure for more action to achieve carbon reductions. It is therefore increasingly crucial for companies to prioritise climate change. New initiatives like the European Green Deal are forcing companies to adapt their business model to be more sustainable (European Commission, 2019). To meet the climate targets, it is particularly relevant for companies to reduce greenhouse gases, including carbon dioxide. Therefore, increasing number of companies are joining voluntary auditing standards such as the Global Reporting Initiative (GRI) and committing to disclose non-financial information, including carbon emissions. (Yang et al., 2021).

Several researchers have already studied company shareholders' reception of carbon disclosures (Fisher-Vanden and Thorburn, 2011; Griffin and Sun, 2013; Alsaifi et al., 2020). Carbon disclosure refers to the disclosure of the CO2 emissions caused by companies. Fisher-Vanden and Thorburn (2011) and Alsaifi et al. (2020) have observed a negative reaction on stock prices following voluntary carbon disclosure. They justify this with investors' expectations for new carbon abatement investments that increase companies' costs. Griffin & Sun (2013) contrast this and find positive reactions following voluntary carbon disclosure, attributing this to better stakeholder management and the reduction of information asymmetries.

My work builds on voluntary carbon disclosure; however, I am not looking at absolute emissions, but I investigate how announcements of intended carbon neutrality with a stated exit date affect stock prices in the short run. My first Hypothesis states that companies that announce a strategy for planned carbon neutrality and back it up with a precise exit date will experience a positive short-term return. With increasing carbon prices, which negatively impact shareholders' value, investors should welcome companies that have a strategy to become carbon neutral (Matsumura et al., 2014; Refinitiv Eikon 2021). The second hypothesis consists of three assumptions and investigates the emergence of the short-term cumulative abnormal returns (CAR). First, I test whether corporations with a carbon intensive business model benefit more from planned decarbonisation. Next, I investigate whether companies with a full decarbonisation strategy exhibit a higher CAR than companies that only

make parts of the company carbon neutral. As a third distinction, I examine if the commitment to decarbonisation in conjunction with voluntary participation in the Climate Pledge Initiative, whose members commit to be carbon zero at the latest by 2040 positively impacts short-term stock returns (The Climate Pledge, 2021).

For my third hypothesis, I examine the motivation for investing in carbon neutrality and analyse whether companies with a propensity for agency problems benefit less from announcements of carbon neutrality. In this case, the agency conflict is seen as the fact that management does not pursue profit maximisation as the company's primary goal. The theory states that CSR projects enhance the reputation of managers but are detrimental to shareholders as they impose costs. (Krüger, 2015). I follow Jensen and Meckling (1976) and Jensen (1986) and assume that companies with high leverage have less scope for wasteful projects, whereas companies with high cash reserves are more vulnerable to projects that do not generate positive net present values (NPV). Therefore, I expect a more favourable stock market reaction from companies less susceptible to agency concerns.

To test Hypothesis 1 and 2, I apply the event study methodology to compute short-term CAR. This approach is suitable for my research, as the corporate news on climate neutrality is visible and can be assigned to a single day. Yet, all tests are carried out for different periods to capture the direct impact of the news as well as to detect information leakage and longer-lasting reactions. To investigate Hypothesis 3, I conduct several regression analyses using CAR as the dependent variable. As the independent variable, I use accounting data indicating agency problems including book leverage, liquidity, and dividends.

Based on the analyses carried out, I can confirm Hypothesis 1. The event study shows that investors respond positively to announcements of a corporate strategy for decarbonisation. Positive CARs are visible for all periods considered. It is striking that positive returns are already visible in the days before the announcement, as well as in the following days. It can therefore be assumed that investors have information available prior to the event. It also takes investors several days to understand the announcement's magnitude and fully price in the information.

Hypothesis 2, consists of three different sub-theses, testing the following assumptions. The first assumption is, that companies with a carbon intensive business model will benefit more from the announcements of planned decarbonisation. This Hypothesis cannot be confirmed. Although positive CARs are found for this category, they are not significantly higher compared to non-carbon intensive companies or the whole dataset. The second

subdivision, namely that companies that announce a complete withdrawal from climate-damaging activities have a higher short-term CAR compared to companies that only commit themselves to a partial withdrawal, is found to be true. The last sub-hypothesis, which states that companies that announce their planned climate neutrality in connection with a membership in the Climate Pledge Initiative will experience more positive stock market reactions, is confirmed. The highest CAR was found in this case.

The third hypothesis cannot be answered unequivocally. On the one hand, there is a negative correlation between liquidity and the CARs, implying that companies with lower agency problems experience higher CARs following the announcement of the climate targets. On the other hand, the variable book leverage cannot confirm this theory, as negative estimators are also found, which indicates that higher debt levels do not lead to higher CARs as predicted by the hypothesis.

2 Literature Review

The literature review provides an overview of the current state of the academic community on the impact of CO2 disclosure news. In recent years, the environmental performance of companies has become increasingly relevant for various stakeholders including investors, employees, and policymakers. The increasing interest in sustainability has also led to a growing number of scholars in the field of finance showing interest in this area and presenting findings that are partly very contradictory depending on which ESG or CSR indicators were considered. My research differs from other papers since I research the news on planned carbon neutrality, not general ESG or carbon disclosure, as most scholars do. Nevertheless, the conclusions of these studies are highly relevant to my research as they provide information on how investors perceive information on corporate sustainability. There are various methods of measuring the relationship between the environment and stock market performance and I will provide an overview of important conclusions that relate to environmental and especially carbon disclosure events.

2.1 Motivation for CSR

The impact of CSR activity and the associated economic consequences have been researched by a wide range of scholars. (Dimson et al., 2015; Fisher-Vanden and Thorburn, 2011; Hart and Ahuja, 1996; Hong et al., 2012; Krüger, 2015). When analysing the effects, a distinction is often made between the two different schools of thought of Milton Friedman and Edward Freeman. Friedman (1970), sees the "social responsibility of businesses is to increase its profits," and not in spending capital to do social good. Friedman (1970) considers any action that goes beyond the business and regulatory framework as an additional cost. The faster shift to a carbon-neutral economy also belongs to this category, as it is associated with higher costs. Building on Friedman's statement that CSR is not of interest to investors, many scholars consider this to be an agency problem as one can argue that the management is using funds for projects that are not generating positive NPVs. The money spend on the project, leading to an increase in their ESG score, is assumed to have the sole purpose of benefitting their own reputation (Benabou and Tirole, 2010; Cheng et al., 2013; Krüger, 2015).

On the other hand, rich literature exists that argues otherwise. Freeman's (1984) stakeholder theory suggests that companies should not only include shareholders' interests like Friedman proposes, but consider any stakeholders affected, including customers, employees, or the community. Several scholars argue, like Freeman, that CSR reduces the potential for conflict between management and stakeholders through better communication (Jo and Harjoto, 2011). Orlitzky, Schmidt, and Rynes (2003) argue that CSR activity enhances companies' reputation and can lead to higher valuations (Orlitzky et al., 2003). These results are relevant in my context because announcing carbon neutrality reduces information asymmetries with investors about future carbon emissions and furthermore boosts companies' reputations.

2.2 Influence of CSR Activity on Stock Prices

To identify and measure how the environmental efforts impact the financial performance and stock prices of companies, three different methods have been widely used: regression analysis, portfolio analysis as well as the event study, which is also used in my research in combination with regression to evaluate the causes of the outcome.

The regression models address longer-term correlations between environmental performance, such as carbon emissions, and market or accounting-based performance measures. The results vary widely, with both positive and negative outcomes. Brouhle et al. (2009) and Darnall et al. (2008) find a positive correlation between environment and financial performance when the environmental parameters are associated with regulatory risk, liability, or compliance. Lins et al. (2017), who examine both stock price and accounting performance during the 2007-2009 financial crisis, also find favourable results for higher-rated CSR companies. Stock market returns were, on average more than 4% higher during the financial crisis for higher-rated CSR companies compared to their lower-rated peers. In addition, companies with a high CSR rating have higher sales growth, profitability, employee productivity, as well as higher levels of trust (Lins et al., 2017). Research by Matsumura et al. (2014) find a negative dependency between company valuations and greenhouse gas emissions, which becomes even stronger when companies do not disclose sufficiently.

Studies on portfolio analysis also come to very divergent results. The methodology is based on comparing the portfolio performance of environmentally friendly stocks with portfolios based on companies that do not devote much attention to being environmentally active. The studies of Ziegler et al. (2009) reveal a negative portfolio return. In their research, they create a portfolio that includes a short position of companies driving little or no transformation towards lower emissions and a long position of companies successfully reducing their greenhouse gases. Kempf and Osthoff (2007) found positive results, who implement a best-in-class screening approach to build a portfolio. By simultaneously considering different ratings in the trading strategy, a positive abnormal return of 8.7% is achieved. Even higher profits are generated by Liesen et al. (2017), who exploit market inefficiencies in greenhouse gas disclosure. The strategy is based on investments in companies that have a high disclosure quality and can demonstrate high climate stability, generating a positive risk-adjusted abnormal return of more than 13% (Liesen et al., 2017).

Finally, the results of past event studies are particularly relevant to my research, as it covers the same methodology. Similar to the regression and portfolio analyses, ambiguous results are found. Differences arise due to the classification of public information as either positive or negative. Jacobs et al. (2010) and Fisher-Vanden and Thorburn (2011) find negative market reactions when examining voluntary emissions avoidance. Jacobs et al. (2010) attribute the associated costs as an explanation for the negative returns. However, they note positive market reactions in connection with philanthropic environmental gifts that

mainly include cash donations (Jacobs et al., 2010). Fisher-Vanden and Thorburn (2011) find negative reactions when companies voluntarily join organizations and clubs that are committed to reducing emissions. These effects are even more pronounced for companies with weak corporate governance structures. They conclude that voluntary environmentally friendly activities are not in line with the profit maximization of companies (Fisher-Vanden and Thorburn, 2011). Studies by Griffin et al. (2017) and Chapple et al. (2013) also find a negative link between emissions and company values based on their event studies. They explain this relationship by attributing costs to emissions, which they categorize as liabilities that are not included in the balance sheet. Griffin et al. (2017) assign these costs to all companies, including companies that publish their carbon footprint and companies that do not disclose information. The event study conducted by Alsaifi et al. (2020) examines the impact of carbon disclosure on UK companies. It is relevant because they first distinguish between companies that are part of the Carbon Disclosure Program, which is comparable to the Climate Pledge initiative considered in this paper. Second, they use a distinction between carbon intensive and less-intensive industries. Their findings show that market reactions are negative, which is explained by higher costs associated with emission reduction investments, which are not offset by financial benefits. The negative returns were more pronounced for carbon intensive companies (Alsaifi et al., 2020). However, positive values were found for carbon disclosure during the financial crisis from 2007 to 2009, which is important considering that my research overlaps with the Covid-19 pandemic. They find a CAAR of 1.19% in the time window (-1/1) for companies participating in the Carbon Disclosure Program (CDP) and 0.35% for companies not participating in the initiative.

Positive market reactions are observed by Klassen and McLaughlin (1996), these are not directly related to the disclosure of carbon emissions but to awards for good corporate environmental performance. In an event study by Griffin and Sun (2013), the scholars find positive abnormal returns following voluntary carbon disclosure announcements. This effect is particularly strong for smaller firms. In the period from -2 to 2 days around the release date, they find an average return of 2.32%. For large companies, the return is considerably lower, amounting to 0.48%. Lastly, some papers find no correlation between carbon disclosure and a change in firm value (Jacobs et al., 2010; Kim and Lyon, 2011).

In a meta-analysis that examined 73 empirical studies on the relationship between carbon disclosure and corporate financial performance, Velte et al. (2020) identify a positive relationship. They also observe a reduction in information asymmetries for companies that

disclose their greenhouse gas emissions, as well as a positive relationship between carbon emissions performance and carbon reporting.

2.3 Motivations for Climate-Neutral Operations

Since the Paris Climate Agreement in 2015, companies have been required to address the issue of sustainability and emission reduction more thoroughly (Matsumoto et al., 2019). The management of firms is increasingly involved and engaged in addressing the beforementioned issues. In a survey by Deloitte, more than 1,200 European Chief Financial Officers indicate that they are concerned with the subject and see greater relevance in the future (Michela et al., 2019). More and more organizations are established to improve companies' environmental performance and develop strategies for the transformation to a climate-neutral economy. These include the Task Force on Climate-related Financial Disclosures (TCDD), an organization established by the Financial Stability Board (FSB) and has more than 2,600 member companies with a combined market capitalization of 25 trillion U.S. dollars. The organization aims to set guidelines for climate-related financial disclosure as well as to give advice on governance, risk management, and strategy related to disclosure and reporting practice (Task Force on Climate-related Financial Disclosures, 2021). Another notable organization is The Climate Pledge, launched by Amazon and Jeff Bezos in 2019. The members, including more than 300 major multinational companies and organisations, have committed to achieving climate neutrality latest by 2040, i.e., 10 years before the Paris Agreement (The Climate Pledge, 2021). In my event study, I also investigate whether there is a connection between participation in this initiative and a subsequent reaction to the stock markets. I include voluntary environment organisations as the participation in these organisations decreases the information asymmetries with shareholders as the messages of sustainability are more present and more credible compared to internal company guidelines.

3 Background

There are many reasons why companies are making more of an effort to publish their climate footprints, as well as to improve their climate footprints and move more quickly toward a carbon neutral business model. The following catalysts advance the transformation

and are discussed as they provide explanations for stock market reactions following carbon strategy announcements.

3.1 Stricter Environmental Regulation

The number of regulations and laws in the field of environmental protection is increasing and stringent, forcing companies to adapt technologically (Ahmed, 2020). The European Union and several other OECD countries are leading the way and have set targets of 40% carbon reduction and 40% higher energy efficiency compared to 1990 (Ahmed, 2020). American authorities are also tightening their laws and imposing stricter limits on companies (U.S. Environmental Protection Agency, 2021). For my work, it is therefore relevant that investors are already anticipating the company's efforts to save carbon through stricter regulation.

3.2 Shareholder Demand for Climate Action

The subject of sustainable investment is gaining popularity with both private investors and fund managers (Barber et al., 2021; Hartzmark and Sussman, 2019). ESG ratings and sustainability rankings, i.e., provided by Morningstar, are making it much easier for investors to determine how sustainable companies and funds are. With the help of Morningstar sustainability scores, Hartzmark and Sussman (2019) ascertain that investors prefer a higher score and invest greater sums in respective funds compared to poorly ranked funds. Bauer et al. (2021) also find a preference for more sustainability-oriented investment funds in their research. Investors would even sacrifice returns for sustainability, which they consider a fundamental criterion. This becomes clear when looking at sustainable assets under management (AUM) which have increased by an average of 15% per year over the last two years and have reached a total of $35.3 trillion in 2020 in the markets of Europe, USA, Japan, Canada, and Australasia (Global Sustainable Investment Alliance, 2021). Well-known figures from the financial world are also promoting the shift towards a carbon-neutral economy. Larry Fink, the CEO of the largest asset manager Blackrock, addresses in his annual letter to the CEOs of the portfolio companies that Blackrock will sell shares in companies that "present a high sustainability-related risk" (Times. N. Y., 2020). Due to the importance of

ESG factors, which are impacting investors, companies are interested in improving their ranking. Carbon disclosure and good environmental management are therefore of interest to the management.

3.3 Negative Press

Companies' CSR and environmental activities are receiving more attention and are being addressed by the press. Flammer (2013) discovers in his work with the help of the Factiva database that the number of articles on this topic is constantly rising. This is relevant to my work because the increased circulation of information allows more investors to access the knowledge, which should be reflected in the event study. Engle et al. (2020) likewise find that climate and environmental news have risen substantially and steadily since the year 2000. Their analysis is based on news reports from the Wall Street Journal and is therefore very relevant to the capital markets. They also find a correlation between the news and stock market movements and have developed a trading strategy from this. Thus, they show the direct influence of media coverage, especially for negative information (Engle et al., 2020). Climate finance research is also growing in relevance and becoming the subject of scientists' work. Top journals such as The Review of Financial Studies have devoted an entire issue to the topic of climate finance. They have launched a competition in 2017 among scholars to develop research proposals on the subject (Hong et al., 2020).

3.4 Increasing Carbon Price

European companies are directly affected by a CO2 price, the so-called EU emissions allowance price, which acts as a cap-and-trade market to comply with the emissions ceiling set by the European Commission (Bua Giovanna et al., 2021). The price per ton is trading at €80.16 (30th December 2021), representing a price increase of more than 140% for the year 2021 alone (Refinitiv Eikon 2021). As described by Alsaifi et al. (2020) and Jacobs et al. (2010b), investors value higher carbon emissions as costs. Griffin et al. (2017) argue that greenhouse gas emissions reflect an equity discount that must be deducted from the company's valuation. They set the discount per ton at $79 for S&P 500 companies. Matsumura et al. (2014) estimates are considerably higher and calculate a discount of $212

per ton of CO2 that is penalized on the firm value for S&P500 companies. This is highly relevant for evaluating my event study, as decarbonisation should thus reduce costs and increase the company's value. Incorporating this information, the event study should capture a market reaction that reflects the lower future costs in today's firm value.

4 Hypothesis Development & Reasons for Stock Market Effects

In this paper, the main question I am trying to answer is whether there is an impact of the announcement of planned corporate carbon neutrality on the company stock price. The first hypothesis will directly address this question by stating that there is a positive market reaction following decarbonisation announcements. The second hypothesis will be more specific about company characteristics and includes sub-hypotheses to test different influences including carbon intense business models, decarbonisation strategies and membership in a voluntary environmental organisation. Finally, the third hypothesis will center around agency problems.

4.1 Stock Market Reaction Following Carbon Related Announcements

My first hypothesis follows the literature, which states that ESG announcements result in market reactions (Klassen and McLaughlin, 1996; Alsaifi et al., 2020; Chapple et al., 2013; Fisher-Vanden and Thorburn, 2011; Griffin et al., 2017; Griffin and Sun, 2013). Building on this hypothesis, I follow Griffin and Sun (2013) and anticipate that the market reaction will be, on average, favourable. Taking these research findings into account, my first hypothesis is:

H1: Corporate announcements on carbon neutrality result in a positive market response

Building on Hypothesis 1, I will take a closer look at the company's characteristics to identify drivers of the abnormal returns. The factors included pose important firm differentiation in terms of carbon-related performance. A distinction is made between companies that operate in industries with a high carbon footprint, such as construction, manufacturing, energy, etc. and companies that operate in sectors with a lower carbon footprint, such as software or telecommunication companies. More information about the

sorting can be found in Appendix 1. Building on Griffin's et al. (2017) finding that firm value is negatively correlated with the level of emissions, it can be assumed that carbon-intensive companies will be impacted more positively if they announce carbon neutrality. This theory is further supported by Matsumura et al. (2014) studies. Hypothesis H2 a) is therefore:

H2 a): Share prices of carbon-intensive companies benefit to a greater extent from announcements of future carbon neutrality

Furthermore, I examine whether there are differences between companies announcing a complete exit from carbon emissions and firms only announcing a partial exit, such as individual departments or production facilities. If one follows the theory of Griffin et al. (2017) and Matsumura et al. (2014) that CO2 emissions negatively influence company valuations, a complete phase-out should have a greater positive effect.

H2 b): Share prices will react more strongly when companies announce complete carbon neutrality compared to a partial decarbonisation

Following the exit strategy, I investigate companies that are part of the Climate Pledge Initiative and filter them according to their relevance to my dataset regarding the legal entity, size, and location. As discussed in Chapter 3.1 joining the Climate Pledge Initiative is a voluntary organisation, but it positively impacts reputation and message dissemination.

H2 c): Companies that connect climate neutrality with a membership in the Climate Pledge Initiative experience more positive market reactions

4.2 Agency Problems

Based on Friedman's statement that CSR is not of interest to shareholders, many researchers consider it an agency concern (Benabou and Tirole, 2010; Cheng et al., 2013). Agency problems arise if resources spent on CSR do not generate additional revenues nor save costs and are therefore reducing the value of the company (Masulis and Reza, 2015). Krüger (2015) argues that the management implements CSR to improve their personal reputation among stakeholders such as employees, non-governmental organizations, or

politicians. In addition, it can also lead to management focusing less on their task to maximize profits for shareholders and more on CSR issues (Jensen, 2001). The agency concerns can be assessed with the help of liquid assets, including cash and short-term investments, as well as book leverage (Jensen, 1986). The separation of ownership and power makes it possible for managers to use cash reserves more easily to carry out CSR activity for the sake of their own interests (Jensen & Meckling, 1976). Masulis and Reza (2015) therefore, argues that excess cash should be valued at a discount proportionally to a company's governance criteria. High cash reserves enable management to undertake CSR projects that, while helping its reputation, can be wasteful and not generate positive cash flow.

On the other hand, a high leverage ratio may force management to be cautious with cash due to the high debt obligation. Krüger (2015) therefore, argues that low cash reserves and high leverage ratios give management less scope for CSR activity and that these companies are less affected by agency problems and experience more positive stock market reactions following CSR news. I also look at dividends, as high pay-outs reduce agency problems by limiting the funds available for wasteful projects (Jensen, 1986; Jensen and Meckling, 1976).

Whether CSR activities are causing agency problems and thus have a negative impact on the share price, or are simply a sign of good governance, will be tested in the following hypothesis. I am testing the theory in the spirit of Krüger (2015) that for companies with low agency problems, i.e., low cash ratios and higher leverage ratios, the market reactions following corporate announcements for decarbonisation will be more positive. I go beyond Krüger's (2015) work and additionally include dividends and CapEx as measures of agency concerns.

H3: Companies with low agency problems experience better market reactions following climate neutrality announcements compared to high agency concerned companies

5 Methodology & Data

The following section describes the methodology I use to investigate the research question if news regarding corporate initiatives to achieve carbon neutrality trigger a market response. First, I explain the event study methodologies, which is based on the market model and uses daily returns. Thereby, I describe the statistical models used to test for significance.

The second tool used is a basic Ordinary Least Square (OLS) Regression, through which I provide more information about the outcomes of the event study. Subsequently, I describe the variables used for the regressions. Finally, I describe the data sample and provide details and characteristics.

5.1 Methodology

5.1.1 Event Study

The event study methodology is a commonly used approach to measure events' impact on companies' share price (Brown and Warner, 1985; Campbell and Wesley, 1993; MacKinlay, 1997). In line with several other researchers, I use a market-based model to calculate the abnormal returns (Jacobs et al., 2010b; Krüger, 2015; Alsaifi et al., 2020). Abnormal returns reflect the difference to the expected return and thereby show the influence of the event. The market model for any company *i* for a time *t* is:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \quad (1)$$

R_{it} represents the return for company *i* in time *t*. The intercept α_i and the slope β_i represent the relationship of the asset *i* with the market portfolio return R_{mt}. $\beta_i R_{mt}$ reflects the proportion of the return from asset *i* that is attributed to the movements of the market portfolio. The error or zero mean disturbance term is ε_{it} for asset *i* at time *t* and provides information about the return that cannot be explained by the market portfolio (MacKinlay, 1997). To obtain the parameters, I use an estimation window with a time horizon of 100 trading days, including at least 70 valid return observations. The estimation period goes to 50 trading days before the event in order not to include the potential influences of the events. In the following formula, AR_{it} represents the abnormal return for company *i* in time *t*, which are calculated as the difference between the actual daily return in the event period of the company and the expected return of the market portfolio.

$$AR_{it} = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{m,t} \quad (2)$$

The model eliminates the part of the return that is related to the fluctuations of the market return. The variance of the abnormal return is reduced, and the events are more visible, on a risk-adjusted basis (MacKinlay, 1997). This is important for my research, as the Covid-19 pandemic caused high volatility for the stock markets within the time frame used. The model takes the companies' return at the event's time and compares it to the benchmark (Groening and Kanuri, 2018). Like Groening and Kanuri (2018), the event study tool of WRDS was used to access the Daily WRDS World Indices, which is market capitalisation weighted.

5.1.2 Assumptions

The fundamental assumption of event studies is that markets are efficient and that all market participants simultaneously access new information (Fisher-Vanden and Thorburn, 2011). However, the event window usually includes days before and after the event to capture the full effect. The days before the event are included due to potential information leakage, and the days following to capture the full impact of the announcements. If the time window is too large, however, it becomes more difficult to attribute changes in the share price to the event. I therefore consider (-1/1), (-3/3), (-5/5), (-10/10), and (-20/20) trading day periods, which are described in more detail in the following chapter. Furthermore, I assume there is cross-sectional independence for the events, indicating that the company announcements are uncorrelated (Brown and Warner, 1985). Finally, I would like to point out that for my event study, which follows the market model methodology, it is assumed that there is a linear relationship between the company and the market returns. I assume that the average return of the companies in my data set is constant over time and that the return of the market and the included companies follow a linear relationship (MacKinlay, 1997).

Event Window

The event windows of comparable event studies vary greatly. Flammer (2013); Groening and Kanuri (2018); Jacobs et al. (2010) use the day of the event as well as the previous day (-1/0). Fisher-Vanden and Thorburn (2011) uses different time frames, namely (0/1); (-1/1); (-2/2). Alsaifi et al. (2020) use a three-day window of the previous and the following day of the event (-1/1). Lastly, Krüger (2015) uses an extended time frame of 11 and 21 days (-5/5); (-10/10).

For my event study, I use multiple time frames. First, I follow the studies of Klassen and McLaughlin (1996) and use a three-day time window for which I include the previous and the following trading day of the event (-1/1). I also use other time frames as a robustness check, namely (-3/3), (-5/5), (-10/10), and (-20/20). This robustness check helps to understand the impact of the news on share prices for different periods. Furthermore, it accounts for information leakage and lagged information reception, which can account for abnormal returns around the actual event date. The cumulative abnormal returns (CAR) for the given time windows are calculated as follows:

$$CAR_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_{i\tau} \tag{3}$$

The CARs estimate the percentage change in share price associated with the companies' announcement of carbon neutrality. The CAR is the sum of all abnormal returns and thus measures the direct impact of the event and shows how much the share price changed compared to its expected value. To account for all firms' events at all necessary points, I aggregate the CARs to obtain the cumulated average abnormal return CAAR (MacKinlay, 1997).

$$CAAR = \frac{1}{N} \sum_{i=1}^{N} CAR_i(\tau_1, \tau_2) \tag{4}$$

5.1.3 Significance Tests

The statistical significance tests follow the hypothesis testing, where the Null Hypothesis (H_0) implies to have the mean of the abnormal returns inside the event window being equal to zero, while the alternative hypothesis (H_A) states the opposite.

$$(H_0): CAR = 0$$
$$(H_A): CAR \neq 0$$

Cross Sectional t-Test

I use a cross-sectional t-test which is a parametric test that checks if the $H_0: CAR = 0$ is true. For the ordinary cross-section method, I perform a t-test by dividing the average residual of the event period by its standard cross-sectional error over time (Boehmer, 1991).

$$t_{CS} = \frac{\frac{1}{M}\sum_{i=1}^{M} CAR_{i,t}}{\sqrt{\frac{1}{M(M-1)}\sum_{i=1}^{M}\left[CAR_i - \frac{1}{M}\sum_{i=1}^{M} CAR_i\right]^2}} \quad (5)$$

The M denotes the number of returns that are matched or non-missing. The standard cross-sectional test considers the event-induced variance. However, the weakness of the cross-sectional t-test, as for most parametric tests, is that it is sensitive to cross-sectional correlation (Boehmer, 1991).

Patell Z Test

I take the Patell Z to test for $H_0: CAR = 0$. Compared to the cross-sectional t-test, is this robust to how abnormal returns are distributed throughout the event window. Patell's Z uses standardised abnormal returns (SAR) of the event window by the standard deviation of the returns (Patell, 1976).

$$SAR_{i,t} = \frac{AR_{i,t}}{\sqrt{VAR\left(\varepsilon_{AR_i}\right)}} \quad (6)$$

$$t_{Patell} = \frac{\sum_{i=1}^{M} SAR_{i,t}}{\sqrt{\sum_{i=1}^{M}\frac{K_i - 2}{K_i - 4}}} = \frac{mean(SAR_{i,t})}{\left(\sqrt{\sum_{i=1}^{M}\frac{K_i - 2}{K_i - 4}}\right)/M} \quad (7)$$

For this test, M denotes the number of stocks in the event study. K reflects the non-missing returns for company *i*'s estimation window.

Corrado Rank Test

The Corrado rank test is a non-parametric test that considers the estimation period (100 trading days) and the actual event window as a single time series. The test assigns a rank to each daily return for every combination of company and event dates (Corrado and Zivney, 1992). The test is therefore conducted for each trading day and tests H_0: $CAR = 0$. The test was chosen because it does not require the abnormal returns to be normally distributed to achieve a correct specification under the H_0 (Campbell and Wesley, 1993). In addition, it accounts for serial dependence in abnormal returns and is robust to multi-day event periods with clustered events (Campbell and Wesley, 1993).

$$Z_R = d^{\frac{1}{2}} \frac{\overline{K_D} - m_{rank}}{\left[\sum_{t=1}^{T_{total}} (\overline{K_t} - m_{rank})^2 / T_{total}\right]^{\frac{1}{2}}} \tag{8}$$

Within the test, d denotes as days of the event window. $\overline{K_D}$ is the mean rank across companies. The ranking is based on the smallest to largest abnormal return. $\overline{K_T}$ is the average rating for n securities on day *t* of the estimation window period T_{total}. m_{rank} is the average rank.

5.1.4 Regression Analysis

To empirically test which company characteristics are driving the CAR, I run different OLS regressions to measure the influence of independent variables on the dependent variable. Independent variables are accounting values and firm characteristics that are used to provide information which companies are more affected by carbon neutrality announcements. The choice of independent variables is further described following regression equations. The CAR is the dependent variable and reflects the aggregated effect of the event for the different windows (-1/1), (-3/3), (-5/5), (-10/10), and (-20/20). The regression of CAR is a method used by many researchers to better interpret event studies (Fisher-Vanden and Thorburn, 2011; Flammer, 2013). All variables used in the regressions are described in more detail in Appendix 1. I give justifications for how the calculations are made and state the databases I

use to retrieve the variables. Following the individual equations, I provide my reasoning why I included the variables.

The first regression tests Hypothesis 2, namely that carbon intense companies experience a greater stock market movement compared to less carbon intense companies. Furthermore, I included control variables that are firm characteristics and accounting metrics. The first regression contains the following parameter:

$$CAR_i = \alpha + \beta_i Carbon\ Intense_i + \beta_i Carbon\ Neutral_i + \beta_i Climate\ Pledge_i + \beta_i Target\ Year_i + \beta_i Service\ Sector_i + \beta_i Carbon\ Intense\ Sector_i + \beta_i Public\ Sector_i + \beta_i Dividend_i + \beta_i Intangible\ Assets_i + \beta_i ROA_i + \log(Mkt\ Cap)_i + \beta_i Invested\ Capital_i + \varepsilon_i \quad (9)$$

I use the three dummy variables, carbon intense, carbon neutral, and climate pledge to gain a better understanding of how the factors influence the stock market reaction following the events. In addition, these three variables are considered in the regression as robustness tests to confirm the findings from the event study analyses. I follow the idea of Flammer (2013), who uses regressions to validate his event study results.

The variable target year provides information about the time frame of the planned way to become carbon neutral. It is stated in the difference in years between the announcement and the year that the company plans to be carbon neutral. I use this to test whether it makes sense for companies to implement a fast or slower decarbonisation strategy. Considering the results of Matsumura et al. (2014), a quick exit should be viewed positively, as carbon emissions have a negative impact on the company's valuation. On the other hand, an earlier phase-out could also be associated with additional costs and could be received negatively (Flammer, 2013).

Included in the regression are three industry variables: Service Sector, which considers all companies within the service sector; Carbon Intensive Sector includes traditionally carbon-intensive industries such as transport, electricity, gas, etc., and Public Sector includes public administration companies. The use of these industries serves two main purposes. First, since the sectors are very different in carbon exposure, it should provide additional insight into how industries react to the decarbonisation announcements. Companies from the service sector are often software-driven and, therefore less emissions-intensive. While companies that are

clustered in the Carbon Intense Sector have significantly higher emissions compared to the two other Service or Public Sector companies. Public administration companies were selected as they have more linkages to government institutions.
Second, I use the different sectors to control for industry heterogeneity, which can arise as the period under consideration overlaps with the Covid-19 pandemic. The three industries are very heterogeneous and have experienced different impacts of the pandemic, which has been reflected in the share prices. Therefore, the use of these variables is intended to determine whether the industries affected differently by Covid-19 impact CAR.

Dividends and intangible assets are used to get a first insight into the agency problem, which is addressed in Hypothesis 3. More detailed descriptions of why these variables were applied are given after Equation (11). The variable return on assets (ROA) accounts for the profitability of the companies and measures the impact on the CAR (Flammer, 2013). This variable was chosen since Gallego-Álvarez et al. (2015) find in their study that emission reduction leads to higher operational performance, which they measure with ROA. Lastly, I use the logarithm of market capitalisation to measure the influence of firm size on the shareholder reaction. I follow Flammer (2013) and Krüger (2015) and use market capitalization to control for size. The variable is included since Griffin and Sun (2013) find different influences on carbon disclosure and firm size in their event study.

The following regression builds on Equation (9) but goes further and includes interaction terms. The interaction term is used to assess how the variables behave in relation to each other and to see whether the variables climate neutral and climate pledge depend on the climate intense variable. It makes the outcome more informative, allowing the regression to better reflect the individual company characteristics. Since the variable climate pledge always includes the climate neutral attribute (not necessarily the other way around). All possible interaction terms are included to account for the interaction of the three variables used in the event studies to answer Hypotheses 2 a), b), c).

$$CAR_i = \alpha + \beta_i Carbon\ Intense_i + \beta_i Service\ Sector_i + \beta_i Carbon\ Neutral_i + \beta_i Climate\ Pledge_i + \beta_i Carbon\ Intense_i * \beta_i Carbon\ Neutral_i + \beta_i Carbon\ Intense_i * \beta_i Climate\ Pledge_i + \varepsilon_i \quad (10)$$

The third regression aims to provide information about the possible agency problems and thus answer Hypothesis 3. Like the first two regression, CAR is the dependent variable. I

adopt an approach to identify an agency effect by considering the management's scope of possibilities. For this, I use the variables:

$$CAR_i = \alpha + \beta_i Dividend_i + \beta_i Book\ Leverage_i + \beta_i Liquidity_i + \beta_i CapEx_i + \beta_i Intangible\ Assets_i + \varepsilon_i \quad (11)$$

Additionally, I have split this regression into three separate regressions, which respectively examine liquidity, book leverage, and dividends in conjunction with the control variable market capitalisation. The log variable market cap, which controls for size, was used to measure the impact of agency concern variables independent of firm size. The results of the following equations are presented in Chapter 6.4.

$$CAR_i = \alpha + \beta_i Liquidity_i + \beta_i \log (Mkt\ Cap)_i + \varepsilon_i \quad (12)$$

$$CAR_i = \alpha + \beta_i Book\ Leverage_i + \beta_i \log (Mkt\ Cap)_i + \varepsilon_i \quad (13)$$

$$CAR_i = \alpha + \beta_i Dividend_i + \beta_i \log (Mkt\ Cap)_i + \varepsilon_i \quad (14)$$

Dividend is used as an explanatory variable since a payout of profits to shareholders results in fewer funds being available to the management. The scope for implementing unprofitable projects is therefore limited for management, reducing agency concerns (Jensen, 1986; Jensen and Meckling, 1976). The explanatory variable book leverage further tests for agency problems. Based on Jensen's (1986) theory, a high leverage ratio indicates low flexibility for the management to engage in non-essential projects such as CSR activities. Due to the debt obligation, the management is forced to be careful with cash and cannot exploit investment opportunities as companies with low leverage ratios have the possibility. The opposite is true for liquidity, which leads to more opportunities for wasteful or non-profit maximizing projects. The variable Liquidity includes cash and short-term investments and is tested as a variable since Jensen's (1986) and, building on this, Krüger's (2015) theory state that with higher cash reserves, management has a particularly large scope for CSR projects. As described previously, these CSR projects often represent costs for shareholders and are pursued by management for their own benefit and to promote their own profile and reputation. Liquidity is therefore, a measure to test the relationship between agency problems and earlier

carbon disengagement. The variable capital expenditure (CapEx) was included to introduce a link into the regression to test if a higher investment rate affects investors' behaviour towards announcements of planned carbon neutrality. The choice for the variable CapEx follows Ferrell et al. (2016) agency problem analysis.

5.2 Data

The dataset used is handpicked and consists of different sources. Firstly, I used the News Monitor from Thomson Reuters Refinitiv Eikon and searched systematically for relevant events. With the help of keywords, I looked for news items in which companies announce that they will become completely carbon neutral at a certain point in time or a division or production plant will become carbon neutral. To search for these announcements, I used the keywords: (“carbon neutrality”); (“carbon neutral”); (“carbon zero”); (“climate neutral”); (“climate neutrality”), and subsequently checked the articles for their relevance. In addition, I have screened all companies in the Dow Jones Industrial Index for climate neutrality messages. As a further data source, I examined all companies that participate in the Climate Pledge Action led by Amazon.com, Inc. and included them if the necessary screening was successful. In addition, it was determined at what point the phase-out should take place e.g., 2040. I follow a similar approach as Jacobs et al. (2010), Flammer (2013), Griffin and Sun (2013), who also use a dataset that is handpicked by screening news pages for keywords.

The time frame used ranges from 2020 to March 2022 and is chosen as the topic of carbon disclosure picked up momentum within the last two to three years, and most of the corporate carbon neutrality announcements were made within that time.

Only companies listed on a U.S. stock exchange are considered. After cleaning the dataset, a total number of 117 events are identified, which is sufficient for an event study. Comparable work as the event study from Fisher-Vanden and Thorburn (2011) as well contains 117 events, the event study of Klassen and McLaughlin (1996) includes 162 events, while the work of Chapple et al. (2013) uses 58 events.

The considered companies can be identified by company ticker, and the associated financial data can be retrieved from the Wharton Research Data Center (WRDS). The daily stock price is retrieved from the Center for Research in Security Prices (CRSP). The required accounting data, including dividends, market capitalisation, total assets, net income, cash and short-term investments, intangible assets, invested capital, CapEx, and the components of

book leverage, is retrieved from Compustat. The categorisation into the different industries was based on Compustat's Standard Industrial Classification (SIC) codes. Further description is available in Appendix 1.

Table 1: Data Sample

Table 1 provides a breakdown of the distribution of events. Panel A states how many events occurred in each of the three years under consideration. Panel B indicates when the companies state that they intend to achieve climate neutrality. The year is derived from the communication of the announcement. Panels C, D and E each indicate the distribution of company characteristics that will be used for further event studies. Namely, in Panel C, whether companies become entirely carbon neutral, or whether only a division becomes carbon neutral. Panel D shows the distribution of companies with a carbon intensive business model. How the classification was conducted can be seen in Appendix 1. Panel E presents the share of companies that declare their carbon neutrality by membership in the Climate Pledge Initiative.

Panel A: Year of Announcement

Year	N	Proportion
2020	17	15%
2021	82	70%
2022	18	15%

Panel B: Target Year of Carbon Neutrality

Year	N	Proportion
2020 - 2024	5	5%
2025 - 2029	11	10%
2030 - 2034	28	26%
2035 - 2044	42	38%
2045 - 2050	23	21%

Panel C: Full Carbon Reduction Commitment

	N	Proportion
Yes	102	87%
No	15	13%

Panel D: Carbon Intense Industries

	N	Proportion
Yes	68	58%
No	49	42%

Panel E: Climate Pledge Initiative

	N	Proportion
Yes	33	28%
No	84	72%

Table 2: Descriptive Statistics

Table 2, Panel A displays the descriptive statistics for the accounting and stock market data considered. The data is retrieved from Compustat and CRSP and are provided in millions of U.S. dollars. The sample period goes from 2020 to March 2022 and is matched to the day of the event. A more detailed description of the data used is provided in Appendix 1. The column Mean reports the average value for the considered variable of all companies included in the event study. SD represents the standard deviation, while 25th, Median and 75th indicate the first, second, and third quartiles. N provides the number of company observations included. For Panel B, is similar to Panel A. However, the variables included in Panel B have been set in relation to other variables. Dividends, CapEx, Intangible Assets, and Invested Capital, were divided by the Total Assets. For Market Capitalization, the logarithm was applied.

Panel A: Accounting Values

	Mean	SD	25th	Median	75th	N
Market Capitalization	148,753.82	227,128.27	28,941.02	89,520.5	208,077.09	117
Total Assets	206,170.89	517,604.92	17,116.00	63,034.0	148,629.00	117
Net Income	1,785.40	2,830.06	263.30	1,014.5	2,358.00	117
CapEx	1,478.65	2,427.52	112.60	542.0	1,670.00	117
Dividends	1,683.42	2,622.84	58.69	489.0	2,230.00	117
Intangible Assets	24,765.21	41,203.96	2,203.00	7,096.0	35,298.00	117
Invested Capital	71,731.77	105,977.08	11,131.06	34,866.5	70,367.00	117
Book Leverage	0.602	0.385	0.382	0.576	0.690	115
ROA	0.017	0.023	0.006	0.015	0.030	117
Liquidity	0.139	0.103	0.057	0.108	0.197	117

Panel B: Scaled Accounting Values

	Mean	SD	25th	Median	75th	N
log Market Cap	11.079	1.498	10.273	11.373	12.246	117
Dividends (scaled)	0.017	0.024	0.001	0.010	0.022	117
CapEx (scaled)	0.016	0.016	0.005	0.012	0.023	117
Intangible Assets (scaled)	0.239	0.205	0.036	0.20	0.410	117
Invested Capital (scaled)	0.581	0.191	0.525	0.604	0.706	117

Correlation Analysis

In a Pearson correlation matrix, I analyse the relationship between the accounting and stock market data used in the regressions. Table 3 compares the CAR of the (-1/1) day window with the independent variables used in the regression. The results of the correlation matrix show that the variable CAR does not correlate with the other variables. Some correlations among the accounting variables exist, however this does not impact the

regression analysis. The calculations were based on Pearson correlation coefficients, which include the following equation:

$$\rho(a,b) = \frac{cov(a,b)}{\sigma_a \sigma_b} \tag{15}$$

Where $cov(a,b)$ is the covariance between the two zero-mean random variables (Benesty et al., 2009). $\sigma_a \sigma_b$ are the standard deviations of variable a and variable b respectively.

Table 3: Correlation Matrix

Table 3 presents the results of the Pearson correlation matrix. The variables applied are the coefficients used in the regression analysis, and thus are the accounting values scaled by total assets as described in section 3.5.2. The dependent variable CAR for the (-1/1) day window was also included. The determination of whether there is a significant correlation was tested with p-values. Appendix 2 displays a table with the corresponding p-values (*p<0.05; **p<0.01; ***p<0.001). In the table, coefficients are significant for p < 0.05 starting at 0.24.

Pearson Correlation Matrix for (-1/1) Event Window										
Variable	Correlation Coefficients									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) CAR (-1/1)	1.00									
(2) Dividends	0.08	1.00								
(3) Book Leverage	-0.04	0.27	1.00							
(4) Liquidity	-0.14	-0.09	0.06	1.00						
(5) CapEx	-0.16	0.09	-0.02	-0.17	1.00					
(6) Intangible Assets	0.01	0.10	-0.15	-0.31	-0.12	1.00				
(7) log(Mkt Cap)	0.19	0.30	-0.03	0.19	-0.16	0.24	1.00			
(8) ROA	0.02	0.39	0.10	0.10	0.09	0.01	0.33	1.00		
(9) Invested Capital	0.04	0.13	-0.33	-0.25	0.36	0.43	-0.11	-0.01	1.00	
(10) Target Year	-0.05	0.03	0.09	-0.09	0.07	-0.05	-0.02	0.02	-0.06	1.00

6 Results & Analysis

The results section is structured as follows: First, I give an overview of the findings of the event studies. Furthermore, I subdivide the data set according to different company characteristics and conduct further event studies. I thereby provide answers to Hypotheses 1 and 2. I also present graphs showing how CARs evolve around the event dates. Next, I report the results of the various regression analyses. They provide general information on how the

CARs are being influenced. Finally, I test the impact of potential agency problems and address Hypothesis 3.

6.1 Event Study Results

In the event study, I examine the impact of the company's announcement to become carbon neutral on its share price. Figure 1 shows how the CAAR are formed around the event date. A period of (-20/20) is used to better understand the returns as they already move before and after the event date. Over this period, the CAAR amounts to 2.35% and the median CAR to 2.34%. It can be concluded that information leakage occurs, and investors anticipate the event (McWilliams et al., 1999). The market reacts affirmatively even before the event, which can be seen in Figure 1, as well as the actual daily mean abnormal returns in Table 4. In addition, one can see in Figure 1 that the companies' share prices also increased after the announcement. It can therefore be assumed that the stock market will not be able to assess the exact implications of the news immediately and needs some days to fully incorporate the information. Figure 1 shows that relatively few abnormal returns occur in the first 15-days of the 41-day period. A positive trend begins about five days before the announcement and continues for about seven days after the announcement before prices return to relatively normal.

Figure 1: CAAR for (-20/20) Day Event Window

Figure 1 illustrates the daily CAAR for the period of 20 trading days before and 20 trading days after the event. The figure presents the entire data set, including 117 company announcements. The daily returns (CAR) are summed up in the chart.

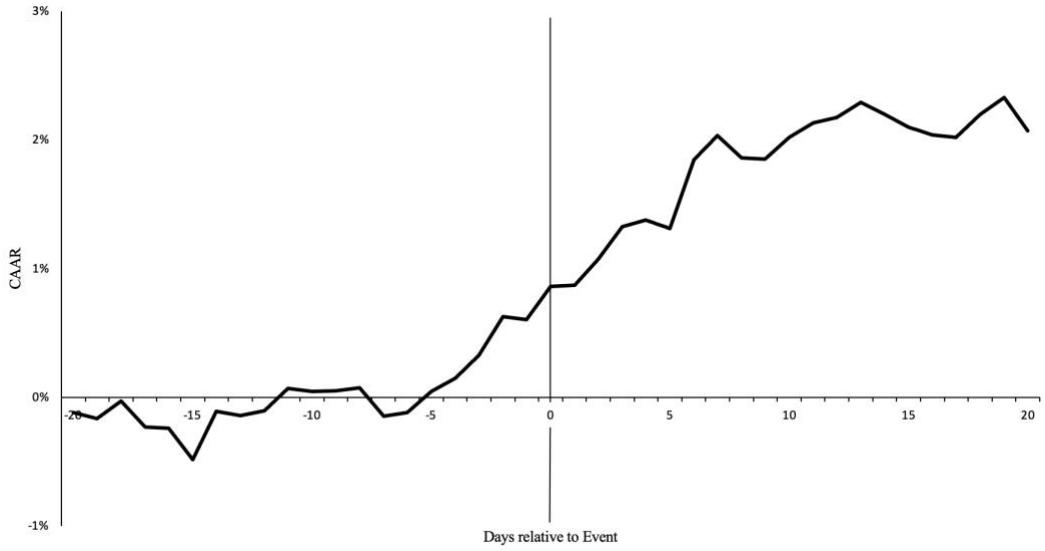


Table 4 shows the event study results for the different time windows. The comparison of positive to negative CARs for individual companies over the time windows is displayed and tends to more positive CARs. I cumulate the returns of the respective companies for the considered time windows and noted whether positive or negative totals result.

Except for the 3-day window (-1/1), all CARs are significant for the cross-sectional t-test, which implies that the H_0 can be rejected and thus can say that the mean CAR is not equal to zero. The Patell-Z test also shows significant results except for the (-1/1) time window. Nevertheless, it is important to note that a nonparametric test was also carried out. The Corrado Rank Test, which is conducted for every day on the (-5/5) timeframe, can be seen in Table 5. The test is never significant except for one day, which implies that induced volatility and cross-sectional correlation cannot be ruled out.

Table 4: Event Study Results

Table 4 presents the results of the event study analysis, which shows five different alternatives. The column Event Window indicates how long the considered period is. Column N states how many events fall into this subcategory. Pos/Neg indicates how many companies can record a cumulative positive or negative return at the end of the event window. The two columns, Mean and Median CAR indicate the values described in formula (4). The remaining two columns indicate the t-stat and Patell-Z test for significances and are based on the formulas (5) and (7). (*p<0.1; **p<0.05; ***p<0.01)

Event Study Results

Event Window	N	Pos/Neg	Mean Cumulated Abnormal Return (CAAR)	Median CAR	t-stat	Patell-Z Test
(-1/1)	117	68/49	0.25%	0.35%	0.94	1.06
(-3/3)	117	67/50	1.20%	0.59%	2.7***	1.93**
(-5/5)	117	61/56	1.43%	0.34%	2.48**	1.94**
(-10/10)	117	68/49	2.04%	1.27%	2.64***	2.64***
(-20/20)	117	81/36	2.35%	2.34%	2.33**	2.12**

When looking at the CAAR more closely, one can observe that the abnormal returns increase with the period under consideration. The immediate impact in the three-day window (-1/1) is a positive CAAR of 0.25%, while the influence in the 21-day window (-10/10) is much more pronounced at 2.04%.

The values can be compared with the three-day (-1/1) event study of Alsaifi et al. (2020), who examine carbon disclosure in the financial crisis from 2007 to 2009. They determine a CAAR of 1.19% in the (-1/1) time window for companies that participate in Carbon Disclosure Program (CDP) and 0.35% for companies that don’t participate in the initiative.

Table 5: CAR for 11 Day Window

Table 5 presents the results of the event study for the (-5/5) day window. The first column indicates the individual days of the event study and starts five trading days prior to the event and continues until five trading days after the event. Column N states how many company announcements were included that day. The column CAR is calculated by equation (4), whereas CAAR is the summation of the daily CAR's. The remaining two columns indicate the t-stat and Corrado Signed Rank Test for significances and are based on Equation (5) and (8). (*p<0.1; **p<0.05; ***p<0.01)

Event Study on a Single Day Basis

Event Window	N	CAR	CAAR	t-stat	Corrado Test
-5	117	0,17%	0,17%	0.91	-0,3
-4	117	0,10%	0,27%	1,19	0,48
-3	117	0,18%	0,45%	1,58	1,14
-2	117	0,30%	0,75%	2,24**	1,73**
-1	117	-0,03%	0,72%	2,09**	0,37
0	117	0,26%	0,98%	2,56**	1,09
1	117	0,01%	0,99%	2,40**	-0,45
2	117	0,20%	1,20%	2,57**	0,73
3	117	0,25%	1,45%	2,77***	0,08
4	117	0,05%	1,50%	2,65***	-0,24
5	117	-0,07%	1,43%	2,48**	-0,23

Table 5 displays the mean abnormal returns around the event date. On the event date itself, there is an abnormal return of 0.26%, which is supported by a significant t-test. Except for the first three days of the (-5/5) day window, all CARs show a significant cross-sectional t-test (at least 95% confidence interval). In addition, a nonparametric Corrado Signed Rank Test was carried out that almost exclusively produced insignificant values. Only on the second day before the event the Corrado Signed Rank Test reports a significant result.

Concluding from this, I can confirm Hypothesis 1, namely that the stock market will positively receive the announcement of planned climate neutrality. The significance is also confirmed by cross-sectional t-tests as well as Patell-Z tests. However, the hypothesis is not validated by the nonparametric Corrado test. My results follow the findings of Griffin and Sun (2013), who find a CAR of 0.103% on the day of the event. Their studies are based on carbon disclosure announcements. For the (-1/1) period, they find a CAAR of 0.468%.
The positive market reaction also reflects the theory of rising carbon prices, as discussed in Chapter 3.4. Higher carbon emissions are therefore seen as an additional cost, but the cost is reduced if companies can exit at an earlier point in time (Alsaifi et al., 2020; Jacobs et al., 2010). In addition, my results are consistent with the theory of Griffin et al. (2017) and

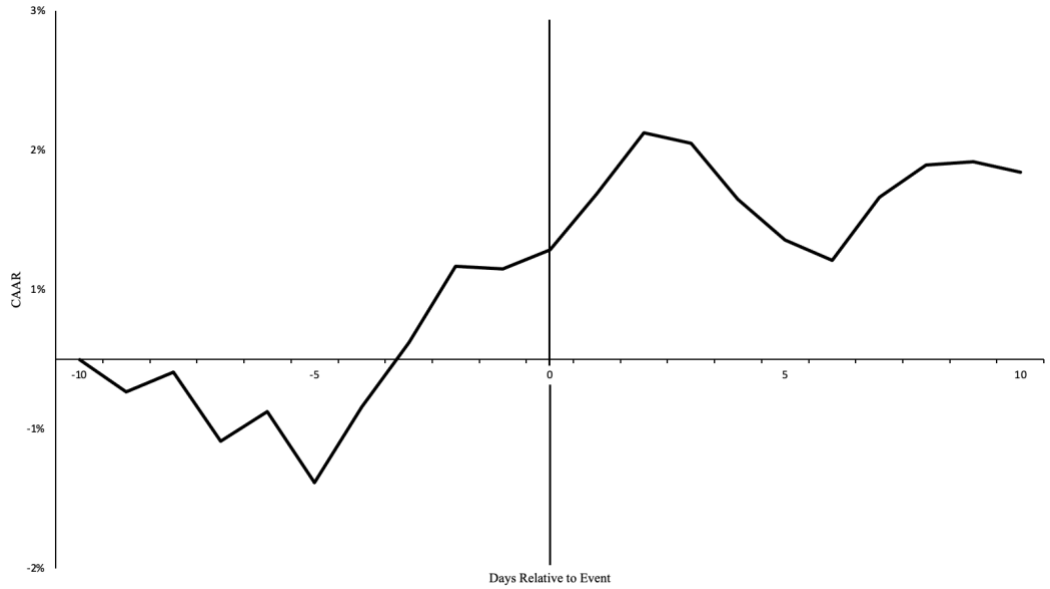
Matsumura et al. (2014) that each ton of greenhouse gas represents an equity discount that should be deducted from the value of the company.

6.2 Stock Market Response for Different Firm Characteristics

In addition, the data set is altered, and further event studies are carried out. The methodology is the same, but the considered companies are based on the Hypotheses 2, which is discussed in Appendix 1, companies were divided into carbon intensive and carbon efficient companies. The event studies are conducted with a (-10/10) day window to capture information leakage and lagged reactions. As shown in Table 6, the CAAR is very similar. However, the median for carbon intensive companies is considerably higher at 0,58% compared to 0,14%. In general, the CAAR is higher than the median CAR, which indicates that the maximum positive values are greater than the minimum negative values. Based on these values, Hypothesis 2 a) cannot be answered unambiguously. The CAAR is slightly lower for carbon intensive companies and thus contrary to the hypothesis that carbon intensive companies benefit more from the announcement. Beyond that, no further significant results are found, which does not allow an evident interpretation. Alsaifi et al. (2020) find contrasting results, namely that non-intensive industries experience better market reactions compared to carbon intensive industries. Their analysis is based on the (-1/1) period for carbon disclosure announcements. For non-intensive companies, they find a positive CAAR of 0.089% while carbon intensive companies experience a negative abnormal return of -0.198%. Figure 2 displays the CAAR of the carbon intensive Industries for the (-10/10) window. The plot that includes companies within a non-carbon intensive sector is displayed in Appendix 3.

Figure 2: CAAR for Carbon Intense Companies

Figure 3 illustrates the daily CAAR for ten trading days before and ten trading days after the event. The figure presents the companies that work in a carbon intense sector and includes 34 announcements. The daily returns (CAR) are summed up in the chart.

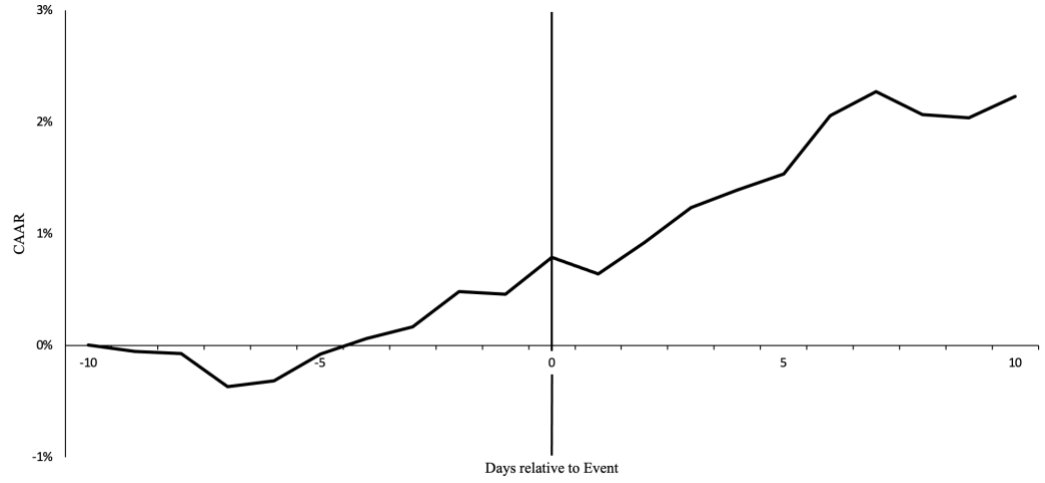


In the following event study, I address Hypothesis 2b) by distinguishing whether the companies have declared complete carbon neutrality or only achieved carbon neutrality for individual company divisions or production plants. It should be noted that the companies aiming for full carbon neutrality are considerably more in the data set, with 99 observations compared to 14 companies that only announce a partial carbon exit. For the group of companies that are committed to full decarbonisation, the number of companies that report a positive CAR is 60, whereas for 39 companies, I find a negative CAR. The relationship between positive to negative CAR is therefore a lot higher compared to the dataset that includes the companies that only announce a partial exit, where it is balanced at 7/7. The CAAR and the mean CAR are both higher, which is supported by significant tests. There is no significance in the event study of companies that are not committed to full carbon neutrality. Based on the distinctly higher mean and median CAR, as well as the distribution of positive to negative events, Hypothesis 2b) can be confirmed. It can be concluded that the magnitude of the announcement is substantial and that it is not only the symbolic effect that counts, which could already be achieved if parts of the company are climate neutral. Furthermore, it can be assumed that the news of a company becoming completely carbon neutral will lead to far greater media coverage compared to the news that only one production plant or one branch

of the company will become carbon neutral. This will allow the information to reach more investors who can price the knowledge into the share price. Figure 3 displays the CAAR of the companies that are committed to full decarbonisation for the (-10/10) window. Appendix 4 shows the plot that includes the companies that don't commit to full decarbonisation.

Figure 3: CAAR for Full Decarbonisation

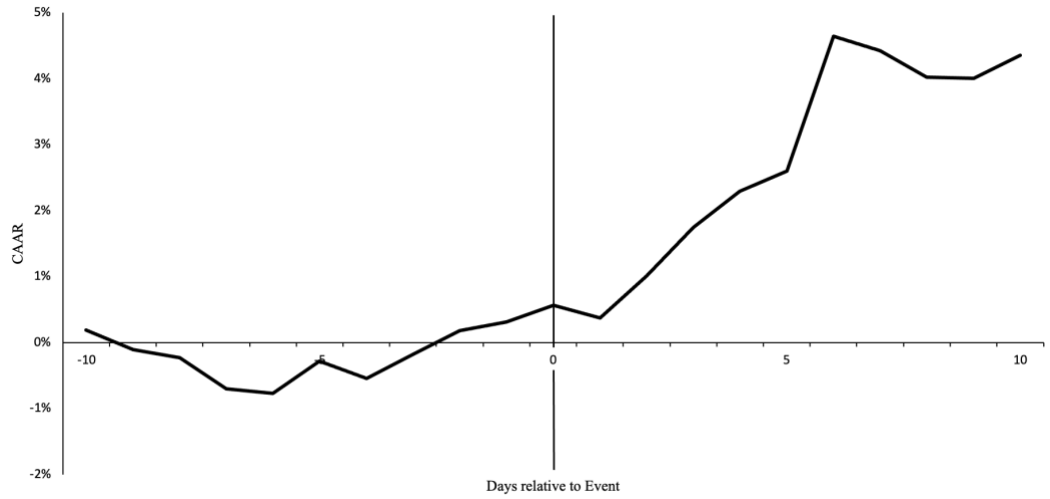
Figure 3 illustrates the daily CAAR for ten trading days before and ten trading days after the event. The figure presents the companies that are committed to full decarbonisation and includes 99 announcements. The daily returns (CAR) are summed up in the chart.



The third distinction I made is based on the voluntary Climate Pledge Initiative. In my dataset, 29 companies have committed through the initiative to reach the Paris climate targets at the latest by 2040, which is ten years ahead of the regular target date that is marked in 2050. Companies that join the Climate Pledge Initiative experience, on average the highest positive effect on the stock markets. The ratio of positive to negative reactions is 23/6, compared to 44/40 for companies that declare climate neutrality without joining the initiative. The CAAR and median CAR of 4.35% and 3.29%, respectively, are also well above the reference category, with 1.36% and 0.40% including significant levels.

Figure 4: CAAR for Climate Pledge Members

Figure 4 illustrates the daily CAAR for ten trading days before and ten trading days after the event. The figure presents the companies that announce carbon neutrality in conjunction with a membership in the Climate Pledge Initiative. The plot includes announcements from 29 companies. The daily returns (CAR) are summed up in the chart.



Hypothesis 2c) is therefore met as well, namely that companies that connect climate neutrality with a membership in the Climate Pledge Initiative experience positive market reactions to a larger extent. This can be explained by the fact that membership the Climate Pledge Initiative causes additional attention, and more market participants are exposed to the news. In addition, it can be assumed that membership in the initiative would create greater credibility that the climate targets will be met. Companies commit to targets, which the organisation sets, and it is therefore more difficult for them not to adhere to them, as they are also monitored by the organisation. In addition, more publicity is created for the announcement. On the one hand, this ensures a higher reputation, on the other hand, it can reduce the information asymmetries with investors, which according to Porter & van der Linde (1995) research, can explain the positive CAARs. This contrasts with the results of Fisher-Vanden and Thorburn (2011), who find negative returns for companies that join the voluntary environmental organisation Climate Leaders. For the (-2/2) window, they find a negative return of -1.28% for the period 2006-2008.

Table 6: Company Clustered Event Studies

Table 6 presents the results of the event study analysis, which shows six different alternatives. The column subcategories indicate by which criteria a distinction was made. A detailed description of the subsampling can be found in Appendix 1. Column N states how many events fall into this subcategory. Pos/Neg indicates how many companies can record a cumulative positive or negative return at the end of the (-10/10) day window. The two columns, Mean and Median CAAR indicate the values described in formula (4). The remaining two columns indicate the t-stat and Patell-Z test for significances and are based on the formulas (5) and (7). (*p<0.1; **p<0.05; ***p<0.01)

Event Studies for Subcategories on a (-10/10) Event Window

Subcathegories	N	Pos/Neg	(CAAR)	Median CAR	t-stat	Patell-Z Test
Carbon Intense Companies	34	18/16	1.34%	0.58%	1.19	0.8
Carbon Efficient Companies	50	26/24	1.37%	0.14%	1.02	1.76**
Commited to Full Carbon Neutrality	99	61/39	2.23%	1.71%	2.53**	2.53**
Not Commited to Full Carbon Neutrality	14	7/7	1.39%	-0.34%	0.84	0.77
Part of Climate Pledge	29	23/6	4.35%	3.29%	2.8***	2.03**
Not Part of Climate Pledge	84	44/40	1.36%	0.40%	1.48	1.87**
Entire Data Set	117	68/49	2.04%	1.27%	2.64***	2.64***

6.3 Multivariate Regression Analysis

The multivariate analysis provides additional information on determining whether specific company characteristics are responsible for the positive CARs. The first regression is based on equation (9), and the outputs are provided in
Table 7.

Table 7: Regression Results

Table 7 presents the summary statistics for the multivariate regression analysis showing firm characteristics together with accounting and stock market data from Compustat and CRSP. The table displays the results of five regressions, where CAR is the dependent variable for the respective event windows. Service Sector includes all companies in the service sector, Carbon Intense Sector includes companies within the transport, electricity, and gas sector, whereas Public Sector includes public administration companies. Further variable descriptions can be found in Appendix 1. The table shows the independent variables and the corresponding estimates, as well as the brackets, enclosed p-values (*p<0.1; **p<0.05; ***p<0.01)

Table 7: Regression Analysis

Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Carbon Intense	-0.002	-0.023*	-0.020	-0.005	-0.001
	(0.761)	(0.067)	(0.241)	(0.802)	(0.960)
Carbon Neutral	-0.019*	-0.009	0.020	0.021	-0.015
	(0.100)	(0.678)	(0.475)	(0.574)	(0.740)
Climate Pledge	0.008	0.026**	0.032**	0.051**	0.052**
	(0.202)	(0.024)	(0.045)	(0.015)	(0.034)
Target Year	0.0001	0.0002	0.0003	-0.0001	0.001
	(0.690)	(0.713)	(0.694)	(0.917)	(0.597)
Service Sector	-0.013	-0.038**	-0.042*	-0.056*	-0.039
	(0.178)	(0.026)	(0.070)	(0.062)	(0.264)
Carbon Intense Sector	-0.018**	-0.021	-0.029	-0.056**	-0.043
	(0.024)	(0.147)	(0.134)	(0.026)	(0.141)
Public Sector	-0.007	-0.019	-0.039	-0.014	0.084
	(0.716)	(0.583)	(0.410)	(0.817)	(0.243)
Dividend	-0.028	-0.179	-0.309	-0.474	-0.836*
	(0.818)	(0.412)	(0.293)	(0.219)	(0.067)
Intangible Asset	-0.017	-0.044	-0.069*	-0.099**	-0.095*
	(0.276)	(0.109)	(0.064)	(0.042)	(0.095)
ROA	-0.092	-0.290	-0.346	-0.750*	-0.131
	(0.462)	(0.199)	(0.254)	(0.061)	(0.779)
log(Mkt Cap)	0.006***	0.006	0.006	0.018***	0.015*
	(0.004)	(0.136)	(0.205)	(0.009)	(0.057)
Invested Capital	0.018	0.047*	0.071*	0.099**	0.061
	(0.238)	(0.093)	(0.057)	(0.045)	(0.285)
Constant	-0.051**	-0.041	-0.081	-0.207**	-0.142
	(0.045)	(0.371)	(0.191)	(0.012)	(0.137)
Observations	109	109	109	109	109
R^2	0.157	0.163	0.140	0.177	0.113
Residual Std. Error	0.026	0.047	0.063	0.083	0.097

By analysing the cross-sections of the different time windows, I can confirm the findings from Table 6 that companies in a carbon intensive industry have a more negative CAAR than the average of all companies considered. However, a significant value is only

present for the (-3/3) daytime window. The dummy variable, which considers whether a company undertakes complete climate neutrality, is the only coefficient within this regression that shows a major difference between the different timeframes. The only significant value is for the (-1/1) time window, which is negative at -0.019.

In the case of the Climate Pledge Initiative, there is a very clear picture, which is related to positive estimates for all time windows and is also entirely significant except for the (-1/1) CAR. It can be concluded that the initiative has a certain signalling effect and enhances the magnitude of the announcement of climate neutrality. My results are thus contrary to the event study from Fisher-Vanden and Thorburn (2011), where voluntary participation in greenhouse gas reduction programs resulted in negative abnormal returns. However, it is consistent with the results of Jacob et al. (2020) who find a positive abnormal return following the announcement of corporate philanthropic actions. If one looks at the variable Years to Zero, which indicates the years the company requires to become carbon neutral, one can see a positive effect, but no estimate is supported by any significance. One explanation for the predominantly positive estimates could be that investors generally favour the goal of carbon neutrality but prefer that this does not happen immediately. This theory would be analogous to the one proposed by Alsaifi et al. (2020), who find that reducing carbon comes at a cost, which is more substantial, the faster you implement the objectives. Industries are included for two reasons. Firstly, they differ in terms of carbon intensity. Secondly, they are integrated because they were affected differently by the consequences of the Covid-19 pandemic, and it is important to see whether this was visible in the impact on CAR. No clear differences can be identified for either question. First, in line with the previous results, no major difference between carbon intensive as well as non-intensive companies are identified for industry comparison. Secondly, based on this regression, no direct influence can be found for the different industries that have been differently exposed to Covid-19.

Looking at firm characteristics, I controlled for size using log values of market capitalization and invested capital. Both variables show for three of the five-event windows significant and always positive values, which implies that the CAR increases with the size of the company. This finding is not in line with prior cited scholars that have conducted similar research (Fisher-Vanden and Thorburn, 2011; Krüger, 2015). Nevertheless, other researchers have also reported positive correlations between size and CAR in CSR-related event studies (Flammer, 2013). I have also included three additional control variables, namely dividends, intangible assets (both scaled by total assets), and return on assets (ROA). All estimates show

negative signs, whereby intangible assets have the highest significance. More detailed analyses of these variables are provided in Chapter 6.4 which examines the effects of agency concerns.

The following regression is a further development and includes interaction terms to better identify the connection between the individual variables. The regression is based on Equation (10) and is conducted for the same five-event windows as the previous regression. The variables are similar and include the dummy variables that identify climate intense companies, companies that are committed to becoming fully carbon neutral, companies that belong to the Climate Pledge Initiative, and the Service Sector. In addition, I have implemented two interaction effects, where I multiply the variable climate intense with the variables climate neutral and climate pledge.

Table 8: Regression Results with Interaction Terms

Table 8 presents the summary statistics for the multivariate regression analysis showing firm characteristics from Compustat. The table displays the results of five regressions, where CAR is the dependent variable for the respective event windows. The variable descriptions can be found in Appendix 1. The table shows the independent variables and the corresponding estimates, as well as the in brackets, enclosed p-values (*p<0.1; **p<0.05; ***p<0.01)

Regression Analysis: Interaction Terms					
Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Carbon Intense	-0.018	-0.027	0.014	0.029	0.002
	(0.241)	(0.267)	(0.675)	(0.516)	(0.969)
Service Sector	-0.011	-0.044**	-0.056**	-0.068**	-0.033
	(0.303)	(0.011)	(0.013)	(0.025)	(0.341)
Climate Neutral	-0.017	-0.006	0.044	0.026	0.024
	(0.201)	(0.789)	(0.114)	(0.488)	(0.582)
Climate Pledge	0.006	0.034**	0.052**	0.067**	0.004
	(0.528)	(0.041)	(0.018)	(0.026)	(0.902)
Climate Intense x Climate Neutral	0.015	0.003	-0.034	-0.046	-0.042
	(0.372)	(0.899)	(0.344)	(0.352)	(0.458)
Climate Intense x Climate Pledge	-0.009	-0.024	-0.049*	-0.060	0.036
	(0.475)	(0.254)	(0.083)	(0.113)	(0.409)
Constant	0.020*	0.030	-0.016	0.002	0.019
	(0.081)	(0.116)	(0.523)	(0.959)	(0.635)
Observations	109	109	109	109	109
R^2	0.157	0.163	0.140	0.177	0.113
Residual Std. Error	0.026	0.047	0.063	0.083	0.097

The estimates are, for the most part, very similar to the previous Table 7 and follow the same interpretation. Service Sector, which includes firms that operate a service business model, shows mostly significant negative estimates, similar to the climate pledge variable, which has mostly significant positive estimates. No significances are given for the variables climate intense and climate neutral. For the interaction term between climate intense with climate neutral, there is a positive estimate in the short-term time frame of (-1/1) as well as (-3/3) days, which may indicate that the short-term response is favourable for companies that have a carbon-based business model and want to transform it. However, the estimates for the (-5/5), (-10/10), and (-20/20) day window are negative but don't indicate any significance.

The value of the (-5/5) window is significant and negative for the interaction term climate intensive with climate pledge initiative. One explanation could be that carbon-intensive companies must contractually commit to reducing their emissions by joining the Climate Pledge Initiative. Investors could expect additional costs for these companies from

reducing carbon emissions compared to companies with average carbon emission levels that join the Climate Pledge Initiative. This explanation follows the idea of Fisher-Vanden and Thorburn (2011) and Chapple et al. (2013).

6.4 Influence of Agency Problems

Next, I regress Equation (11), which includes several accounting figures, to find out if agency problems exist. The results are displayed in Table 9. As discussed in the literature review Chapter 4.2, multiple scholars see agency problems in CSR efforts, as the projects do not generate additional revenues nor save costs and are therefore not in the interest of the shareholders (Masulis and Reza, 2015). Based on the positive CARs identified in the event studies, one can conclude that shareholders do not envision any direct agency problems with regard to corporate carbon neutrality. It therefore differs from the event study analysis of Krüger (2015), which did not look at carbon disclosure but at more general CSR activities of companies and found predominantly negative CARs. Nevertheless, one can measure the impact of agency problems, which I do by following the approach of Jensen (1986), Krüger (2015), and Masulis and Reza (2015) to examine whether there are effects of the accounting ratios on the development of the CARs. I am following the previous analyses by regressing to the (-1/1), (-3/3), (-5/5), (-10/10), and (-20/20) day CAR. The choice of variables is explained in Chapter 4.2.

Table 9: Agency Problem Regression Results

Table 9 presents the summary statistics for the multivariate regression analysis showing firm characteristics together with accounting data from Compustat. The table displays the results of five regressions, where CAR is the dependent variable for the respective event windows. The variable descriptions can be found in Appendix 1. The table shows the independent variables and the corresponding estimates as well as the brackets enclosed p-values (*p<0.1; **p<0.05; ***p<0.01)

Regression Analysis: Liquidity					
Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Dividends	0.114	-0.087	-0.121	-0.060	-0.473
	(0.318)	(0.663)	(0.646)	(0.864)	(0.235)
Book Leverage	-0.013*	-0.017	-0.024	-0.038*	-0.015
	(0.061)	(0.164)	(0.141)	(0.079)	(0.545)
Liquidity	-0.055**	-0.047	-0.034	-0.073	-0.092
	(0.044)	(0.313)	(0.580)	(0.376)	(0.328)
CapEx	-0.282*	-0.140	-0.306	-0.388	0.134
	(0.087)	(0.624)	(0.419)	(0.439)	(0.813)
Intangible Assets	-0.020	-0.039	-0.045	-0.055	-0.058
	(0.151)	(0.103)	(0.152)	(0.186)	(0.218)
Constant	0.025***	0.042***	0.051**	0.074***	0.064**
	(0.004)	(0.007)	(0.012)	(0.006)	(0.034)
Observations	115	115	115	115	115
R^2	0.082	0.047	0.044	0.047	0.040
Residual Std. Error	0.028	0.048	0.064	0.085	0.096

When analysing this subsection, it is noticeable that none of the time frame estimates show statistical significance for the dependent variable dividend. Non-significance is also demonstrated by the regression in which dividend is isolated and regressed on CAR using only size as the control variable that can be seen in Table 10. For book leverage, all estimates show a negative sign, implying that with a higher debt ratio, one can expect a lower CAR. For the (-1/1) and
(-10/10) day windows, it is supported with a statistical significance on the 10% confidence level. Regressing formula (13) yields similar results, namely that book leverage is negatively correlated with CAR. Table 10 presents the results, which are significant except for the (-20/20) day window. These results are contrary to the theory of Krüger (2015), who argues that higher levels of debt and thus, lower agency problems should lead to higher CARs. It can be explained by the theory that companies with high CSR disclosure have lower debt levels (Pijourlet, 2013; Verwijmeren and Derwall, 2010). The rationale is that well-managed CSR companies are increasingly resorting to equity issuances as a form of financing (Pijourlet, 2013).

For the coefficient liquidity, all estimates are also negative, which follows Krüger's (2015) theory and may indicate an influence of agency concerns. An explanation could be that with higher liquid assets, the CARs are lower, which could be explained by the fact that investors believe that the cash reserves can be used more economically. It therefore follows the idea that CSR activity such as climate change mitigation is costly and not profit-maximising when carried out by companies that are exposed to the risk of agency problems. However, two factors must be considered. First, only the estimate for the (-1/1) time window is significant within the regression in Table 9 and 10. And second, the comparisons with Krüger's (2015) work is not directly applicable. For my study, as well as for Krüger (2015), are higher liquid assets associated with lower CARs. However, the CARs found in this study are always positive, while the CARs Krüger (2015) identifies are slightly negative for positive CSR events. Nevertheless, the intuition can be transferred, and it can be stated that carbon reduction programmes are less well received by companies with potential conflicts between investors and management. For CapEx, only the (-1/1) days CAR is significant and negative, which could have a similar interpretation to that of liquid assets, namely that at higher CapEx levels, more investments are made, such as earlier climate neutrality. For intangible assets, all estimates are negative, but no values can be confirmed by significances.

The regression analysis can therefore only partially answer Hypothesis 3, which suggests that companies prone to agency problems have lower CAR. Firstly, because significant values are only present in the (-1/1) time window. Secondly, while it is true that the liquidity coefficient supports the theory, leverage stands in contrast to this since a higher debt ratio and thus less scope for investments that are not in the interests of profit maximisation is associated with lower CAR.

Table 10: Split up Agency Problem Regression Results

Table 10 presents the summary statistics for the three multivariate regression analyses showing accounting data from Compustat. The table displays the results of three regressions, where CAR is the dependent variable for the respective event windows. The independent variables are used to test agency problems and the interpretation is described in Chapter 4.2. The p-values are based on robust standard errors, which are calculated with Equation (16). (*p<0.1; **p<0.05; ***p<0.01)

Panel A: Liquidity Analysis

Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Liquidity	-0.050**	-0.024	-0.001	-0.051	-0.073
	(0.027)	(0.600)	(0.990)	(0.571)	(0.400)
log(Mkt Cap)	0.004***	-0.0004	-0.001	0.005	0.004
	(0.004)	(0.914)	(0.903)	(0.507)	(0.485)
Constant	-0.037**	0.019	-0.021	-0.032	-0.018
	(0.044)	(0.617)	(0.699)	(0.705)	(0.803)
Observations	117	117	117	117	117
R^2	0.065	0.003	0.0002	0.010	0.009
Residual Std. Error	0.027	0.048	0.064	0.084	0.096

Panel B: Book Leverage Analysis

Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Book Levergae	-0.010*	-0.016*	-0.023**	-0.035*	-0.018
	(0.072)	(0.067)	(0.049)	(0.089)	(0.276)
log(Mkt Cap)	0.003**	-0.001	-0.001	0.004	0.004
	(0.028)	(0.816)	(0.843)	(0.558)	(0.577)
Constant	-0.027	0.030	0.038	-0.006	-0.007
	(0.110)	(0.468)	(0.506)	(0.945)	(0.921)
Observations	115	115	115	115	115
R^2	0.081	0.017	0.019	0.032	0.009
Residual Std. Error	0.027	0.048	0.064	0.084	0.096

Panel C: Dividend Analysis

Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Dividends	-0.017	-0.167	-0.262	0.352	-0.646
	(0.833)	(0.376)	(0.261)	(0.226)	(0.131)
log(Mkt Cap)	0.004***	0.0001	0.001	0.006	0.007
	(0.016)	(0.983)	(0.900)	(0.397)	(0.318)
Constant	-0.037**	0.014	0.012	-0.044	-0.040
	(0.025)	(0.718)	(0.829)	(0.598)	(0.582)
Observations	117	117	117	117	117
R^2	0.035	0.007	0.009	0.016	0.026
Residual Std. Error	0.028	0.048	0.064	0.084	0.095

6.5 Robustness Tests

To test the robustness of the event study, different time windows were used, namely (-1/1), (-3/3), (-5/5), (-10/10), and (-20/20). This enables a clear picture that confirms that a reaction can be seen around the event date. In addition, the dataset was subdivided based on different characteristics, confirming that the communication of climate neutrality results in positive short-term returns for all groups investigated.

For the testing metrics, in addition to the cross-sectional t-test, I used a Patell-Z test since it is robust to the cumulative distribution of the individual abnormal returns at event windows (Patell, 1976). However, the analysis with the nonparametric Corrado test does not confirm robustness against cross-sectional correlation, which is described in more detail in the Limitation's Chapter 7.

To obtain unbiased standard errors for the regression analysis and to control for heteroscedasticity, I also tested the regressions using the sandwich estimator of variance (Freedman, 2006). In line with other researchers, I test the regressions with robust standard errors (Flammer, 2013; Masulis and Reza, 2015; Buchanan et al., 2018). Due to heteroscedasticity, the linear model could have invalid parameters, which would distort the results (White, 1980). The following formula calculates standard errors that allow for these interfering factors.

$$HC1 = \frac{N}{N-K}(X'X)^{-1}X'diag[e_i^2]X(X'X)^{-1} \tag{16}$$

I follow the structure of Long & Ervin (2000), where N reflects the sample size and K accounts for the number of elements in β. The estimator $\hat{\beta}$ is described by $\hat{\beta} = (X'X)^{-1}X'y$ and the residual e_i is represented as $\widehat{e_i} = y_i - x_i\hat{\beta}$. The results for the third regression, which follows Equation (11), are displayed in Table 11. The estimates are the same, while the p-values differ slightly. The test confirms that the results are robust. For the remaining two regressions, which follow equations (9) and (10), the results are reported in Appendix 4 and 5 and are also in line with the previous analyses and therefore robust.

Table 11: Robustness Test

Table 11 presents the Robustness analysis that follows Equation (11) to determine the p-values. The sandwich estimator test displays different p-values compared to Table 9. The regression estimates are the same as in Table 9. The p-values are based on robust standard errors, which are calculated with Equation (16): (*p<0.1; **p<0.05; ***p<0.01)

Regression Analysis: Agency Problems					
Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Dividends	0.114	-0.087	-0.121	-0.060	-0.473
	(0.211)	(0.659)	(0.622)	(0.848)	(0.321)
Book Leverage	-0.013**	-0.017*	-0.024*	-0.038*	-0.015
	(0.024)	(0.056)	(0.050)	(0.075)	(0.374)
Liquidity	-0.055**	-0.047	-0.034	-0.073	-0.092
	(0.025)	(0.267)	(0.567)	(0.377)	(0.330)
CapEx	-0.282*	-0.140	-0.306	-0.388	0.134
	(0.210)	(0.507)	(0.403)	(0.394)	(0.843)
Intangible Assets	-0.020	-0.039*	-0.045	-0.055	-0.058
	(0.104)	(0.044)	(0.110)	(0.191)	(0.186)
Constant	0.025***	0.042***	0.051**	0.074**	0.064**
	(0.006)	(0.002)	(0.013)	(0.020)	(0.046)
Observations	115	115	115	115	115
R^2	0.082	0.047	0.044	0.047	0.040
Residual Std. Error	0.028	0.048	0.064	0.085	0.096

6.6 Limitations & Further Research

My work contains limitations that should be considered carefully when evaluating the results. Due to the contemporary nature of carbon neutrality and the regulatory amendments that have emerged in recent years, most events occur after 2020, which is why I have considered the period from 2020 to March 2022. It must be acknowledged that this timeframe overlaps with the Covid-19 pandemic, exposing it to high volatility in the financial markets. In addition, industry heterogeneity could be a disturbing factor, as I use companies from several industries that were affected very differently by Covid-19. Closer monitoring of individual industries could be an avenue for future research. Furthermore, is the dataset biased towards large companies, resulting in an average market capitalisation of approximately 148 billion U.S. dollars. In further research, the dataset should be expanded to include, for instance, all companies of the S&P500 Index or the American Small Cap Index Russel 2000.

Another limitation is the possible influence of cross-sectional correlation. If there is an aggregation of events because several companies announce climate neutrality at similar points

in time, it is possible that the Null Hypothesis is over-rejected and statistical significance is given (Kolari and Pynnönen, 2010). The Corrado test overcomes some of the limitations of the cross-sectional t-test and the Partell-Z test. However, no sufficient significances are found and therefore cross-correlation of abnormal returns cannot be ruled out.

There is also the general limitation that event studies only examine short-term stock market reactions and are unable to measure long-term influences. Future research should examine the relationship between an early phase-out of carbon emissions and the long-term financial performance of companies. The methodology of long-term regression analysis described in the literature review in Chapter 2.2 could be applied. Accounting values such as ROA, sales development, or profit margin could be analysed in this case. In addition, the variable Tobin's Q could be used to take a closer look at the development of corporate value in connection to carbon neutrality.

Lastly, a more detailed analysis of the carbon emissions on an individual company basis could be an avenue for further research. My classification into carbon intensive and non-carbon intensive companies was performed at the industry level. By including individual measurements such as tons of carbon per company, a more detailed analysis could be conducted to provide insights into how companies respond to carbon reductions.

7 Conclusion

The effect of corporate CSR activity on the share price has already been investigated in several event studies. My work builds on this widely discussed topic and examines how a company's carbon neutrality announcement affects its share price. I examine which firm characteristics cause the highest short-term abnormal returns and explain the causes of those effects. For my research, I create a unique dataset containing 117 corporate announcements on carbon neutrality in its basic form. The events relate to U.S. public companies from 2020 to March 2022. The period is chosen as the topic of corporate sustainability has gained relevance during this time and most of the company announcements occur within this period.

Several event studies are conducted where the time horizons are altered that a (-1/1), (-3/3), (-5/5), (-10/10), and (-20/20) day CAAR is determined. In addition, the dataset is characteristically separated by climate intense and non-intense companies, companies that declare a complete decarbonisation strategy, as well as by companies that announce their planned carbon neutrality in combination with a membership in the Climate Pledge Initiative.

On average, the events have a positive effect on the share prices of the companies. For the (-1/1) day window, I identify a CAAR of 0.23%. However, the return is substantially higher if the observation period is extended. For the (-5/5) time window, a CAAR of 1.4% is identified and for the (-20/20) time window, a return of 2.23% is found. Looking at Figure 1, one can see an information leakage, which leads to rising prices before the event. In addition, prices continue to rise post to the announcement of the event, which indicates that investors need several days to understand the full magnitude of the information.

Moreover, the companies are separated according to whether their business models are carbon intensive or not. No distinct difference is found in this respect. The second distinction is based on the defined objectives of the company's decarbonisation strategy. I have distinguished whether companies are aiming for complete carbon neutrality or rather for individual business areas to become carbon neutral. The companies that take more stringent measures performed notably better, with a short-term abnormal return of 2.23% compared with 1.39% within the (-10/10) window. Thirdly, I find that companies joining the Climate Pledge Initiative and thereby proclaiming carbon neutrality receive a positive CAAR of 4.35% in the (-10/10) time window.

In addition, I determine with a multivariate analysis that companies with high liquidity reserves benefit less from the events. However, significant values are only found for the (-1/1) CAR. This analysis is conducted to identify potential agency issues that could arise if management does not act in the interest of maximising profits for shareholders, but when they pursue their own interests, such as enhancing their reputation. Earlier carbon neutrality could be considered as such a project and can be tested by considering liquidity, book leverage, dividends, and CapEx (Jensen, 1986; Krüger, 2015; Masulis and Reza, 2015). From my analysis, no significant patterns can be identified that indicate agency problems for a carbon neutrality project.

The findings of my research demonstrate that shareholders see carbon neutrality as an important concern and reward companies that pursue early decarbonisation. From a company's point of view, it is important to implement a complete carbon neutrality strategy and communicate it properly. The projects are perceived as being particularly positive if a company joins the Climate Pledge Initiative. This ensures that the maximum phase-out date is latest by 2040 and signals that the company is seriously committed to contractually fixed targets. In addition, more attention will be generated, which will most likely be reflected in the company's reputation.

Finally, I can answer the previously raised question of whether investors follow the idea of Milton Friedman or Edward Freeman in the context of voluntary carbon reduction (Friedman M, 1970; Freeman R, 1984). Despite the associated costs of becoming carbon neutral at an early stage, investors reward it. They contrast with Friedman's theory that CSR projects are not in the name of profit maximisation and thus not in the interest of shareholders.

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Appendix

Appendix 1: Variable Description

The table provides information about all variables used in the regression analysis.

Variable	Description	Source
Carbon Intense	Dummy variable coded as 1 if the company is active in a carbon intense industry and 0 if not. The classification is based on SIC codes. Carbon Intense companies include corporations from the agriculture, mining, construction, manufacturing, transportation, electrics, gas, and sanity service sectors.	Compustat
Carbon Neutral	Dummy variable coded as 1 if the whole company becomes carbon neutral and 0 if individual divisions but not the entire company aim for decarbonisation.	Company Announcement
Climate Pledge	Dummy variable coded as 1 if the companies proclaim their carbon neutrality with a membership in the Climate Pledge Initiative and 0 otherwise.	The Climate Pledge
Target Year	Number of Years left between the announcement and the actual year the company achieves decarbonization.	Company Annoucement
Service Sector	Represents all companies within the service sector. It is based on SIC codes.	Compustat
Climate Intense Sector	Represents all companies within the transport, electricity, gas sector. It is based on SIC codes.	Compustat
Public Sector	Represents all public administration companies. It is based on SIC codes.	Compustat
Dividend	The variable dividend is scaled with total assets.	Compustat
Intangible Asset	The variable intangible asset is scaled with total assets.	Compustat
Return on Assets	Return on assets is the ratio of net income to total assets.	Compustat
Log(Mkt Cap)	Market capitalization is calculated with the number of outstanding shares multiplied by the share price on the day of the event. Logarithmic values are used.	Compustat / CRSP
Invested Capital	The variable invested capital was scaled with total assets.	Compustat
Book Leverage	Book Leverage is total long-term debt plus current liabilities divided by total long-term debt plus current liabilities plus total common equity.	Compustat
Liquidity	The variable Liquidity includes cash and short-term investments.	Compustat
CapEx	Capital expenditure is scaled by total assets.	Compustat

Appendix 2: P-Values for the Pearson Correlation Matrix

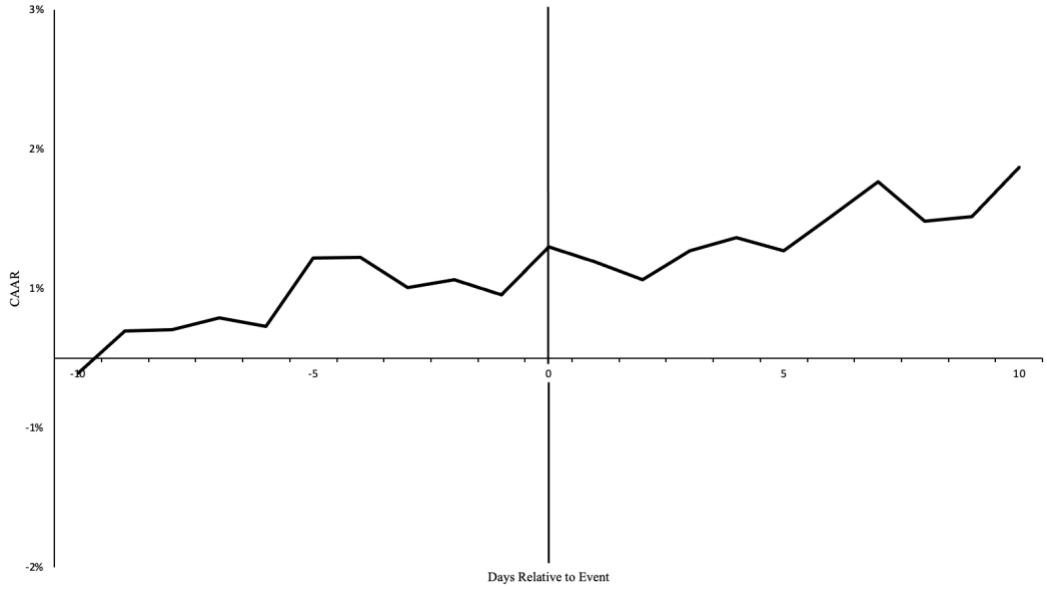
The table presents the p-values of the Pearson correlation matrix. The significances are based on: (*p<0.05; **p<0.01; ***p<0.001).

Appendix 1: p-values for Pearson Correlation Matrix for (-1/1) Event Window

Variable	p-values									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) CAR (-1/1)	0									
(2) Dividends	0.40	0								
(3) Book Leverage	0.66	0.005 **	0							
(4) Liquidity	0.15	0.34	0.55	0						
(5) CapEx	0.11	0.37	0.88	0.09	0					
(6) Intangible Assets	0.95	0.31	0.14	0.001 **	0.23	0				
(7) log(Mkt Cap)	0.052	0.002 **	0.76	0.051	0.09	0.01 *	0			
(8) ROA	0.84	0.00 ***	0.30	0.31	0.36	0.93	0.001 ***	0		
(9) Invested Capital	0.67	0.20	0.001 ***	0.01 *	0.00 ***	0.00 ***	0.28	0.92	0	
(10) Target Year	0.61	0.72	0.33	0.34	0.45	0.58	0.81	0.81	0.53	0

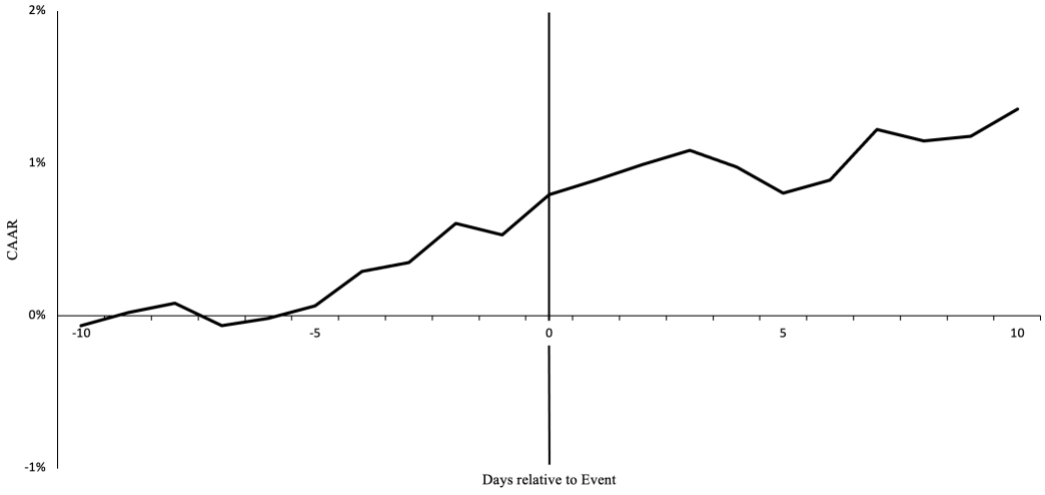
Appendix 3: No Carbon Intense Industry

Appendix 3 illustrates the daily CAAR for the period of 10 trading days before and 10 trading days after the event. The figure presents the companies that are not involved in carbon intense sectors. The plot includes announcements from 50 companies. The daily returns (CAR) are summed up in the chart.



Appendix 4: Not Part of Climate Pledge Initiative

Appendix 4 illustrates the daily CAAR for the period of 10 trading days before and 10 trading days after the event. The figure presents the companies that announce carbon neutrality without a membership in the Climate Pledge Initiative. The plot includes announcements from 84 companies. The daily returns (CAR) are summed up in the chart.



Appendix 5: Regression 1 with Robust Standard Errors

Appendix 5 presents the Robustness analysis that follows Equation (9) for the determination of the p-values. The sandwich estimator test displays different p-values compared to Table 7. The regression estimates are the same as in Table 7. The significance scale is as follows: (*p<0.1; **p<0.05; ***p<0.01)

Regression Analysis					
Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Carbon Intense	-0.002	-0.023*	-0.020	-0.005	-0.001
	(0.778)	(0.055)	(0.201)	(0.801)	(0.953)
Carbon Neutral	-0.019*	-0.009	0.020	0.021	-0.015
	(0.250)	(0.593)	(0.398)	(0.480)	(0.715)
Climate Pledge	0.008	0.026**	0.032**	0.051***	0.052**
	(0.164)	(0.011)	(0.029)	(0.005)	(0.032)
Target Year	0.0001	0.0002	0.0003	-0.0001	0.001
	(0.650)	(0.736)	(0.710)	(0.923)	(0.593)
Service Sector	-0.013*	-0.038***	-0.042**	-0.056**	-0.039
	(0.098)	(0.009)	(0.031)	(0.027)	(0.204)
Climate Intense Sector	-0.018**	-0.021	-0.029	-0.056*	-0.043
	(0.028)	(0.156)	(0.182)	(0.052)	(0.193)
Public Sector	-0.007	-0.019	-0.039**	-0.014	0.084
	(0.717)	(0.583)	(0.021)	(0.668)	(0.105)
Dividend	-0.028	-0.179	-0.309	-0.474	-0.836**
	(0.739)	(0.310)	(0.180)	(0.127)	(0.017)
Intangible Asset	-0.017	-0.044*	-0.069**	-0.099**	-0.095*
	(0.257)	(0.079)	(0.049)	(0.078)	(0.092)
ROA	-0.092	-0.290	-0.346	-0.750*	-0.131
	(0.272)	(0.347)	(0.373)	(0.209)	(0.783)
log(Mkt Cap)	0.006***	0.006*	0.006	0.018**	0.015*
	(0.001)	(0.064)	(0.185)	(0.018)	(0.087)
Invested Capital	0.018	0.047*	0.071**	0.099**	0.061
	(0.171)	(0.059)	(0.035)	(0.049)	(0.210)
Constant	-0.051**	-0.041	-0.081	-0.207**	-0.142
	(0.021)	(0.225)	(0.133)	(0.017)	(0.162)
Observations	109	109	109	109	109
R^2	0.157	0.163	0.140	0.177	0.113
Residual Std. Error	0.026	0.047	0.063	0.083	0.097

Appendix 6: Regression 2 with Robust Standard Errors

Appendix 6 presents the Robustness analysis that follows Equation (10) for the determination of the p-values. The sandwich estimator test displays different p-values compared to Table 8. The regression estimates are the same as in Table 8. The significance scale is as follows: (*p<0.1; **p<0.05; ***p<0.01)

Regression Analysis: Interaction Terms

Event Window	(-1/1)	(-3/3)	(-5/5)	(-10/10)	(-20/20)
Dependent Variable	CAR	CAR	CAR	CAR	CAR
Carbon Intense	-0.018	-0.027	0.014	0.029	0.002
	(0.480)	(0.197)	(0.478)	(0.390)	(0.963)
Service Sector	-0.011	-0.044**	-0.056**	-0.068**	-0.033
	(0.146)	(0.021)	(0.019)	(0.019)	(0.217)
Climate Neutral	-0.017	-0.006	0.044***	0.026	0.024
	(0.478)	(0.786)	(0.005)	(0.396)	(0.584)
Climate Pledge	0.006	0.034*	0.052**	0.067**	0.004
	(0.338)	(0.091)	(0.032)	(0.037)	(0.867)
Climate Intense x Climate Neutral	0.015	0.003	-0.034	-0.046	-0.042
	(0.565)	(0.899)	(0.173)	(0.252)	(0.410)
Climate Intense x Climate Pledge	-0.009	-0.024	-0.049*	-0.060	0.036
	(0.375)	(0.292)	(0.099)	(0.122)	(0.342)
Constant	0.020	0.030	-0.016	0.002	0.019
	(0.373)	(0.126)	(0.167)	(0.948)	(0.645)
Observations	109	109	109	109	109
R^2	0.157	0.163	0.140	0.177	0.113
Residual Std. Error	0.026	0.047	0.063	0.083	0.097