Corporate Carbon Offsets and Stock Performance: A Sectoral Analysis

Thiago Dalmédico Gil*
FGV EAESP, São Paulo, Brazil

Wesley Mendes Da Silva†
FGV EAESP, São Paulo, Brazil

Abstract

This study examines the relationship between corporate voluntary carbon offsets and stock performance, a topic that remains underexplored in financial and sustainability research. Using a staggered Difference-in-Differences (DID) approach, we find that participation in carbon offset programs does not significantly impact stock returns across key sectors, including energy, airlines, and technology. While carbon offset engagement does not hinder financial performance, it also fails to generate substantial positive effects.

Sectoral differences emerge in our analysis: energy firms show a slight negative trend in stock performance after adopting carbon offset strategies, possibly due to increased operational costs, while technology companies exhibit a marginally positive trend, reflecting growing investor interest in sustainability. However, the overall financial impact remains statistically insignificant. Furthermore, net-zero commitments appear to enhance corporate reputation without directly influencing short- to medium-term stock returns, as macroeconomic conditions and market volatility play a more dominant role. Event studies highlight the impact of negative media coverage on stock performance, with Shell experiencing a decline following critical reports on its carbon strategy. This underscores the role of investor sentiment in shaping financial outcomes for firms engaged in sustainability initiatives. Additionally, regulatory developments, such as the UK's updated advertising guidelines and the Voluntary Carbon Markets Integrity Initiative (VCMI), are driving greater transparency and accountability in corporate carbon disclosures. Despite the study's limitations—such as a small sample size of treated firms and potential

*thiago_d_gil@hotmail.com
†wesley.mendes@fgv.br

confounding factors—our findings provide valuable insights into the evolving carbon offset landscape. Future research should explore the long-term financial implications of carbon offsets as more firms engage in voluntary carbon markets, contributing to a more credible and robust sustainability framework.

Keywords: Voluntary carbon markets, stock returns, ESG investing, event study, difference-in-differences

1 Introduction

In recent years, corporate engagement in environmental initiatives has gained momentum, driven by a diverse array of motivations. These motivations encompass many factors, ranging from the pursuit of regulatory mandates to the desire to appeal to environmentally conscious consumers willing to pay premiums for sustainable products and services (Beyer et al., 2023; Heeb, Kölbel, Paetzold, & Zeisberger, 2023; Lyon & Maxwell, 1999). Additionally, forward-thinking companies seek to anticipate and adapt to forthcoming government regulations, while other strategic considerations come into play.

The concept of achieving a "net zero" economy has emerged as a central theme (Caldecott, Thomae, Mitchell, & Scott, 2022), echoing the commitments made by major financial institutions controlling trillions of dollars in assets. This paradigm shift towards "net zero" finance builds upon existing efforts, including the integration of climate risks by banks and insurers into their strategies and initiatives.

In this analysis, our primary objective is to investigate whether companies engaged in carbon offset initiatives outperform their peers in terms of stock returns. We leverage a comprehensive database of corporate carbon offsets provided by Verra, the world's largest global voluntary carbon standard, enriched with financial data from Refinitiv, to conduct the research.

The Verified Carbon Standard (VCS) program by Verra, established in 2006, plays a central role in the study. It allows certified projects to convert their greenhouse gas (GHG) emission reductions and removals into tradable carbon credits. These VCS projects encompass a wide array of technologies and measures aimed at reducing GHG emissions and removals across various sectors, from renewable energy to conservation and transport efficiency.

Our analysis combines data from 58 companies that engaged in carbon offseting utilizing VCS credits since 2020 and a plethora of comparable players that do not voluntarily offset carbon credits. To assess the impact of entering the carbon offset market on stock returns, we employ a staggered Differences-in-Differences (DID) analysis, comparing treated companies to control units from the same sectors.

Moreover, we present the concept of "phantom credits" as highlighted in an investigation published by The Guardian in January 18th, 2023, which scrutinizes the credibility and

additionality of certain carbon credits. These credits are purchased by prominent large companies, and we specifically focus on the stock performance of these companies that are explicitly named in the article. To conduct this analysis, we utilize an event study approach, which serves as a tool for estimating potential treatment effects in situations where conventional experimental designs are not viable. The goal is to assess whether the "phantom credits" buyers underperformed comparable companies in the aftermath of The Guardian's release.

Overall, the findings indicate that carbon offsets did not consistently exhibit statistically significant effects on annualized returns of companies across the years, emphasizing the importance of considering various factors and conducting year-specific analyses in investment decisions.

None of the DID treatment effects were statistically significant. Market trends, represented by the S&P500, had a significant influence on all sectors, while market volatility showed mixed effects. A stronger dollar was generally associated with lower stock returns, with some exceptions.

The exogenous intervention initiated by The Guardian seemed to have minimal impact on the companies explicitly mentioned in the article, except for the representative of the oil sector, which underperformed the peers in the absence of fundamental news after the exogenous intervention. While investors did not appear to react significantly to the investigation, the mentioned companies did make certain structural adjustments to their carbon policies and "net-zero" disclosures.

1.1 Literature Review

1.1.1 Why Do Companies Care About Carbon Emissions?

Corporate engagement in environmental initiatives can be driven by a variety of reasons, including cost reduction, appealing to eco-conscious consumers who are willing to pay more for sustainable products and services, anticipating future government regulations, and other factors. According to Lyon and Maxwell (1999), these motivations lead to three hypotheses: i) corporations might enhance the efficiency of their manufacturing processes, resulting in environmental benefits; ii) changes in the demand and supply for eco-friendly products could influence corporate behavior; and iii) companies may proactively adopt strategies to influence regulatory decisions in their favor.

Although empirical research demonstrates a connection between strong environmental performance and strong financial performance, the exact reasons for this correlation remain somewhat unclear. Among the plethora of confounding factors, it is possible that voluntary environmental initiatives complement regulatory efforts and yield significant advantages for both businesses and the general public.

Heeb et al. (2023) engaged a diverse group of investors, including experienced private

investors, high-net-worth impact investors, and other participants, to provide a broad perspective on investor behavior in the context of sustainable investments. The primary focus was to assess whether investors' willingness-to-pay (WTP) significantly correlated with the level of impact offered by these investments.

The researchers designed a framed field experiment in which investors were presented with a choice between a sustainable investment with a quantified impact and a financially equivalent investment with no impact. Participants' choices had real financial consequences, as they could earn real money, and their decisions carried genuine environmental implications. One key takeaway from the research is that, while there is a substantial WTP for sustainable investments with some impact, this willingness does not exhibit a significant variance between investments with varying levels of impact. In essence, investors' decision-making appears to be more driven by the inherent satisfaction derived from choosing sustainable options rather than a strict consequentialist evaluation of the environmental impact.

This outcome raises critical questions about the financial industry's role in sustainable investing. If investors primarily value the emotional satisfaction of making sustainable choices over the actual environmental impact, there is a potential risk of greenwashing. Financial institutions may be incentivized to create products that emphasize warm glow over tangible impact, particularly when providing impact comes at a cost.

Beyer et al. (2023) investigate how consumers react to information regarding GHG emissions associated with their food choices in real-world canteen settings. Collaborating with a German student union, the authors introduced various GHG emissions labels, including absolute emissions in grams, color-coded emissions in monetary terms, and contextualizations. The findings indicate that consumers reduced their food-related CO2 emissions by approximately 9% when presented with carbon footprint information in monetary units representing environmental costs, as compared to a baseline condition without such information. These insights underscore the influence of information presentation on consumer decisions related to carbon footprint data and carry implications for consumer behavior in practical contexts.

Similar studies find slightly different preferences when it comes to creditors of green financing facilities. Larcker and Watts (2020) question whether investors are inclined to sacrifice wealth in exchange for societal benefits. The authors compare 640 green securities with nearly identical securities issued by the same issuers (United States municipalities) on the same day for non-green purposes, and they find that the pricing of green and non-green issues is almost identical from an economic perspective. In other words, the so-called "greenium" (or green premium) is close to zero - or, precisely 0.45 basis points.

Regardless of investors preferences, climate risk has a known deteriorating effect on firms' financial performance. Hong, Li, and Xu (2019) explore the relationship between climate change-induced drought risks and the efficiency of food stock markets by examining data

from 31 countries with publicly-traded food companies. It relies on the Palmer Drought Severity Index (PDSI) to gauge long-term drought trends. The study finds that as global temperatures rise, exacerbating drought risks, countries experiencing negative drought trends witness poor profit growth in their food sectors, highlighting the adverse financial impacts of climate-related drought risks. Additionally, these countries tend to have lower returns on food stocks, indicating that stock prices might not fully reflect these risks. This underlines a potential underreaction in the market to climate change-induced drought risks, emphasizing the importance of considering climate-related factors when evaluating market efficiency, particularly within industries susceptible to climate change impacts like food production.

With specific regard to carbon emissions and their effects on financial performance, Matsumura, Prakash, and Vera-Muñoz (2014) examine the relationship between carbon emissions, voluntary disclosure of carbon emissions data by large exchange-listed firms, and firm value. The authors find that, on average, for every additional thousand metric tons of CO2 emissions, firm value decreases by USD 212,000. However, corporations that disclose their carbon emissions have a higher median value compared to non-disclosing firms, in excess of USD 2.3 billion[1]. The underlying suggestion is that capital markets penalize all firms for their carbon emissions, and further penalties are imposed on companies that do not disclose emissions properly.

Bolton and Kacperczyk (2021) investigate whether companies' carbon emissions influence their stock performance after considering various factors that typically predict returns. The authors use data from Trucost covering around 3,500 listed companies from 2005 to 2017, matched with FactSet returns and balance sheet data for all US-listed companies. After performing cross-sectional, time-series and business-cycle, profitability, and divestment regressions, the authors establish a positive relationship between carbon emissions and stock returns, suggesting that firms' emissions profiles significantly influence their stock performance. Moreover, the impact of carbon emissions on stock returns varies by emission

[1]They authors use a Heckman model to account for self-selection bias, estimating the relationship between carbon emissions and firm value.The Heckman model, also known as the Heckman two-step selection model or the Heckit model, is an econometric model used to address issues related to sample selection bias or self-selection bias in statistical analysis. In the context of the paper, the framework is used to correct for self-selection bias that may arise when examining the relationship between carbon emissions and firm value, especially when firms choose whether or not to disclose their emissions. In a first step, a probit or logit regression model is estimated to predict the likelihood of firms choosing to disclose their carbon emissions. This equation estimates the probability of selection into the sample, which means it models the factors influencing whether firms decide to disclose their emissions. The outcome variable in this step is typically binary, indicating whether a firm discloses its emissions (1) or not (0). In a second step, the actual relationship of interest is estimated. However, it includes a correction for sample selection bias by incorporating the inverse Mills ratio, which quantifies the effect of the selection process on the second-step, as an additional explanatory variable in the second equation.This allows the researchers to estimate the relationship between the variables of interest (in this case, carbon emissions) and the outcome variable (firm value) while accounting for the fact that some firms chose to disclose their emissions, while others did not.

type: scope[2] 1 and 2 emissions' premium is explained by industry factors, suggesting that investors do not differentiate firms within the same industry based on these emissions; scope 3 emissions exhibit a significant premium that remains even when controlling for industry effects.

Pastor, Stambaugh, and Taylor (2022) explore the performance of green assets (such as green stocks and bonds) compared to their brown counterparts, especially in the context of rising environmental concerns. Despite the lower expected returns associated with green assets (because investors tend to prefer green stocks in their model), there has been notable outperformance. For instance, green stocks in the U.S. significantly outperformed brown stocks during the study period by a cumulative return differene of 174%, largely driven by unexpected increases in environmental concerns. The authors show that positive returns for green assets were correlated with negative climate news.

Aswani, Aneesh, and Rajgopal (2024) evaluate the literature that claims a correlation between carbon emissions and stock returns, focusing on U.S. firms from 2005 to 2019. They specifically investigate two primary issues: the differences between vendor-estimated emissions and firm-disclosed emissions, and the implications of using unscaled emissions versus emissions intensity as metrics.

The study finds that stock returns are significantly correlated with vendor[3]-estimated emissions but not with actual emissions disclosed by firms. This discrepancy indicates that previous research may have misattributed the correlation between emissions and stock returns to actual emissions performance when it might actually be linked to fundamental financial indicators.

The authors argue that while unscaled emissions (total emissions) show a correlation with stock returns, emissions intensity (emissions scaled by firm size) does not. This finding suggests that emissions intensity is a more appropriate measure for assessing a firm's carbon performance because it accounts for size, avoiding mechanical correlations with production levels.

Barnett, Brock, and Hansen (2020) delve into the challenge of assessing the macroeconomic consequences of climate change while considering the inherent uncertainty in both climate science and economic modeling. It employs a structural modeling framework that integrates decision theory under uncertainty, nonlinear impulse response functions, and dynamic valuation through asset pricing. The paper explores the concept of "social cost of carbon" (SCC) as a measure to gauge the economic impact of carbon emissions, with a

[2]Scopes 1, 2, and 3 are a classification system used to categorize carbon emissions in an organizational context. Scope 1 covers direct emissions resulting from an organization's own activities, such as on-site fuel combustion. Scope 2 includes indirect emissions linked to purchased electricity, heat, or steam. Scope 3 encompasses all other indirect emissions arising from activities like supply chains, business travel, and employee commuting. These scopes enable organizations to comprehensively assess their carbon footprint and identify opportunities for emission reduction, aiding in sustainable and environmentally responsible practices.

[3]ESG data providers.

recognition that SCC, while simplified, serves as a valuable metric for policy evaluation.

An important insight of this research is the multiplicative impact of uncertainty: when both sources of uncertainty (climate and economic modeling) are significant, their combined effect can be substantial. This underscores the importance of considering both forms of uncertainty simultaneously. The analysis recognizes that decision-makers may have concerns about ambiguity over models and potential model misspecification. Just as individuals exhibit risk aversion, they may also be averse to ambiguity and misspecification, which can significantly affect players' decisions. As a result, climate efforts may arise as a risk management strategy amid extreme volatility from multiple sources.

Climate change is also a topic concerning dynamic hedging and portfolio optimization. Engle III, Giglio, Kelly, Lee, and Stroebel (2020) aim to offer a systematic way to hedge against climate change risk by using stocks in a mimicking portfolio. This portfolio is created with the objective of performing well when there is negative news about climate change. The authors extract a climate news series from textual analysis of articles in The Wall Street Journal, and the frequency and sentiment of climate-related news are used as indicators of climate risk.

The dynamic hedging strategy, exemplified by the above mentioned mimicking portfolio, consistently demonstrates superior performance when compared to alternative approaches, both in-sample and out-of-sample. To bolster the credibility of this portfolio's climate risk assessment, external ESG (Environmental, Social, and Governance) scores are used to validate the climate risk associated with the selected stocks. The presence of an optimal portfolio designed to mitigate the effects of climate-related news further underscores the significance of investors' concerns about the environmental impact on a company's performance, signaling that companies should also prioritize addressing these environmental factors.

Another important aspect that can drive companies' decisions to reduce or offset GHG emissions is corporate governance. Shive and Forster (2020) explore the relationship between firms' ownership structure (publicly traded versus privately held with or without sponsorship) and their propensity to emit greenhouse gases. The study examines conflicting perspectives on whether firms should engage in costly pro-environmental actions or focus solely on maximizing shareholder returns. By using comprehensive data from the US Environmental Protection Agency (EPA) regarding emissions and compliance records, the authors find that privately held independent companies emit fewer (one third) GHG compared to publicly traded firms. Moreover, privately owned firms are less likely to incur in environmental penalties imposed by the EPA, which suggests that such firms are better at avoiding regulatory violations.

The study also explores the impact of short-term investor pressure on emissions. It finds that a higher earnings response coefficient (as measured by the SUE[4] decile) is positively

[4]The SUE decile refers to the decile ranking of firms based on their Standardized Unexpected Earnings

related to emissions, indicating that firms facing greater short-term performance pressure emit more. However, the presence of a golden parachute at the firm is also positively associated with emissions, adding complexity to this relationship.

An important market aspect of carbon offsets that has not been actively discussed by the financial literature is the concept of "net zero", or, in other words, the idea of balancing the amount of GHG emissions produced with the amount removed from the atmosphere, aiming for a net zero output. This goal was emphasized at COP26 in Glasgow, where major financial institutions, controlling over USD 130 trillion in assets, committed to achieving net zero emissions (Caldecott et al., 2022). The move towards net zero finance isn't isolated; it builds on existing measures, such as banks and insurers integrating climate risks into their strategies and initiatives like the Task Force on Climate-related Financial Disclosures (TCFD) pushing for mandatory climate reporting.

However, reaching the ambitions set by the Paris Agreement, particularly limiting global temperature rise to below 2 degrees Celsius, requires rapid and significant emissions reduction. And while the financial sector's role is crucial, it's also complex. Merely moving investments from high-carbon to low-carbon sectors may not directly lower emissions in the real world, and practitioners and industry leaders have been actively developing market solutions to create a path towards a net zero economy.

A "Race to Zero" campaign was launched by a coalition of leading climate organizations and initiatives, including the UNFCCC. It was officially announced at the United Nations Climate Action Summit held in New York in September 2019. The initiative is part of a broader effort to mobilize action on climate change in the lead-up to the United Nations Climate Change Conference (COP26) and beyond.

The campaign involves various partners and stakeholders, including governments, cities, businesses, investors, and civil society organizations. These entities commit to taking robust actions and set clear goals and emission targets[5].

Between September 2021 and September 2022, the Race to Zero initiative witnessed substantial growth in participation. The number of participating companies increased from 4,481 to 8,307. The engagement of financial institutions surged from 289 to 595. The number of cities involved in the initiative rose from 765 to 1,136. Educational institutions participating in the initiative increased from 724 to 1,125 (UNFCCC, 2022).

To ensure the effectiveness and credibility of Race to Zero, the initiative has established a set of criteria that all participating members must adhere to. These criteria are divided into two main categories: the "Starting Line Criteria" and the "Leadership Practices"[6].

The Starting Line Criteria, often referred to as the "5 P's," outline fundamental procedural requirements for all individual members. These include making a formal pledge

(SUE) scores. SUE is a financial metric used in accounting and finance to assess how a company's actual earnings compare to the earnings that financial analysts and experts had predicted or expected.

[5]https://racetozero.unfccc.int/system/race-to-zero/

[6]https://racetozero.unfccc.int/system/criteria/

to achieve ”net zero” emissions, developing a clear plan to outline the pathway, taking immediate actions to reduce emissions, publicly reporting their progress transparently, and using their influence to advocate for climate action.

Additionally, the initiative provides guidance on Leadership Practices. These practices offer pathways for leading entities to show the way toward a ”net zero” economy and are highlighted in an interpretation guide.

Another key document comprised by the Race to Zero is the Lexicon, a document created to provide clear and standardized definitions for key terms related to the transition to a ”net zero” economy. The purpose of this document is to harmonize language and encourage consistent terminology usage among stakeholders.

The Lexicon includes definitions for various terms such as ”net zero,” ”carbon neutral,” ”offsetting,” ”residual emissions,” ”equity,” and many others. These definitions are drawn from reputable sources like the IPCC and the University of Oxford, as well as other authoritative guidance documents.

Regardless of Race to Zero, every member of the Organisation for Economic Co-operation and Development (OECD) aims to achieve net zero by 2050 at the latest, with many even aiming for 2045 or sooner. Between 2020 and 2021, net zero pledges from companies, cities, and other organizations tripled (Ernst & Young, 2022). Remarkably, one-third of these commitments are targeting 2045 or earlier. However, businesses, especially those in sectors with high emissions, find the transition toward net zero to be intricate, expensive, and challenging. Carbon credits are in the realm of this discussion, emerging as a market-oriented complimentary strategy for companies to (voluntarily) commit to broad environmentally responsible goals.

Voluntary business initiatives to curb climate change have grown with the creation of the Science Based Targets initiative (SBTi). The SBTi is a partnership between CDP (formerly Carbon Disclosure Project), the United Nations, World Resources Institute and the World Wide Fund for Nature (WWF). The institution provides companies with analytic materials stating how much and how quickly they need to reduce GHG to prevent negative effects of climate change, with a clear and straight alignment with the Paris Agreement temperature goals.

SBTi currently tracks 6,033 companies taking some kind of climate action, with 2,415 net zero commitments and 3,487 science-based targets[7]. Firms from different sectors (52 industries, including semiconductors, transportation, tobacco, mining, banks, and others) and from 86 countries are publicly listed as engaged towards net zero.

The data from the SBTi database indicates a significant uptrend in the business community’s interest in net zero and broader climate goals over the past few years. In 2018, only 49 companies had climate goals with a mere 18 committing to net zero objectives. Fast forward to 2023, the exponential growth underscores the increasing

[7]As of September, 2023 (available at https://sciencebasedtargets.org/companies-taking-action)

Table 1: Companies With Climate Commitments Over the Years

TThe table includes information regarding companies commited with climate goals, including "net zero", according to the SBTi database. Data from 2023 including information from January to September.

Year	Companies With Climate Goals	Companies With "Net Zero" Goals
2018	49	18
2019	154	48
2020	280	89
2021	1,021	392
2022	2,125	950
2023	2,484	904

relevance of carbon policies in the corporate sphere. The rise also points to the expanding opportunities and challenges in the voluntary carbon market, especially concerning carbon offsets.

Regarding the use of carbon credits to achieve net zero targets, the SBTi acknowledges that there is an ongoing and healthy debate about the role of carbon credits in climate strategy, especially regarding Scope 3 emissions (indirect emissions in the value chain). They recognize that when supported by robust policies, standards, and scientific evidence, the use of credits for abatement of Scope 3 emissions can serve as an additional tool in addressing climate change[8] carefully aligned with scientific standards.

The SBTi has clarified that it does not validate the quality of carbon credits; this responsibility lies with other entities better positioned to undertake that role. However, SBTi aims to provide clear guidelines for validating entities regarding the demand-side rules for using credits. This initiative is seen as a way to accelerate the decarbonization of value chains, allowing companies to offset emissions while working on reducing them at their source through innovation and technological advancements.

1.1.2 Investors' Behavior and Carbon Markets

While the existing literature has analyzed how companies perform concerning their emissions and carbon disclosure practices (Bolton & Kacperczyk, 2021; Matsumura et al., 2014), there remains a gap in our understanding of the relationship between carbon offsets and stock performance, even though it is know that companies rely on carbon offsets anticipating future regulations needs, or simply following ethic motivations (Hyams & Fawcett, 2013; Lovell, 2010). This gap in knowledge is the focal point of our current investigation.

Conscious investors, driven by a growing awareness of environmental concerns and a

[8]https://sciencebasedtargets.org/news/statement-from-the-sbti-board-of-trustees-on-use-of-environmental-attribute-certificates-including-but-not-limited-to-voluntary-carbon-markets-for-abatement-purposes-limited-to-scope-3

commitment to sustainable investing, could hypothetically prefer companies that actively engage in carbon offsets, in line with findings of Liang, Sun, and Teo (2022), who point out that funds that endorse responsible investments attracts more capital. This preference would derive from the belief that companies effectively managing their emissions through offsetting are more likely to exhibit better emissions performance overall. For these investors, supporting companies that take proactive steps toward environmental responsibility would aligns with their values and long-term sustainability goals. Such companies may also be viewed as more resilient in the face of future environmental regulations and climate-related risks, making them attractive investment choices.

Hart and Ahuja (2022) discuss a similar rationale, but related to carbon emissions. One of their hypotheses suggests that reducing emissions in a given time period will enhance a company's operating performance in the subsequent period by reducing costs related to raw materials, compliance, disposal, and liability. The study's findings confirm this direction, revealing that emissions reduction can indeed be associated with improved business performance. However, the authors also present a question: do lower emissions lead to enhanced profitability or do more profitable companies tend to invest in pollution prevention and emissions reduction activities?

Alternatively, there could be a contrasting perspective among investors, one that scrutinizes companies' decisions to purchase carbon credits. From this standpoint, investors could perceive the acquisition of carbon credits as an expense that erodes a company's free cash flow. This view posits that diverting financial resources toward offsetting emissions through credit purchases could limit a company's capacity to invest in research, development, or other value-enhancing initiatives. Investors who prioritize immediate financial returns could be less inclined to favor companies that allocate resources to carbon offsets, especially if they believe such expenditures do not yield tangible benefits or align with shareholder interests.

Walley and Whitehead (1994) emphasize that while "win-win" environmental solutions exist, they are rare and often overshadowed by the overall costs of environmental programs. The example of a chemical company is cited, where employee-generated environmental initiatives yielded impressive returns, but the overall corporate environmental projects resulted in a negative financial return.

Carbon offsets can also be a non-event for some investors. These individuals or institutions may not attach significant weight to a company's carbon offsetting practices when making investment decisions. Instead, they might focus primarily on traditional financial metrics or more tangible emissions reduction efforts. In this scenario, carbon offsetting, while important from an environmental standpoint, may not significantly sway investor sentiment or influence stock prices. For these investors, the financial impact of carbon offsetting, whether positive or negative, might be considered negligible in the grander scheme of investment considerations.

This research focuses on filling a gap in our understanding by examining the relationship between carbon offsets and a company's stock performance. We aim to find evidence of whether and when the cost of carbon offsets can either help or hurt companies.

1.1.3 Assessing Markets' Scrutiny on Carbon Markets

Beyond simply analysing whether carbon offsets lead to better stock performance, I aim to analyse whether investors care about carbon credits quality or additionallity.

One factor contributing to the discussion on the reputational aspects of carbon offsets is the potential existence of "phantom credits." This concept was introduced in an article published by The Guardian[9] on January 18th, 2023.

Guardian (2023) casts serious doubts on the efficacy of forest carbon offsets approved by Verra, which is the the leading global certifier in the voluntary carbon market. The investigation, conducted by The Guardian, Die Zeit, and SourceMaterial, suggests that circa 90% of rainforest offset credits commonly used by major corporations like Disney, Shell, Gucci, and others reporting actions towards carbon neutrality, are likely "phantom credits" that do not genuinely reduce carbon emissions. The analysis indicates that the threat to forests in these projects has been significantly overstated, with some projects demonstrating only minimal impact in preventing deforestation. The discussion raised concerns about the validity of claims made by companies regarding carbon neutrality and their climate action efforts, as they heavily rely on these (hypothetically) questionable carbon credits to offset their emissions.

The investigation mentions a study prepared by scholars at the University of Cambridge (Guizar-Coutiño, Jones, Balmford, Carmenta, & Coomes, 2022). The study revealed that while some projects had stopped deforestation, the areas protected were relatively small, with just four projects responsible for safeguarding three-quarters of the total forest. The authors utilized satellite images and pixel matching to find that reductions in reforestation were small in absolute terms but greater in sites located in high-deforestation settings, and did not appear to be substantially undermined by leakage activities in forested areas within 10 km of project boundaries.

Another study mentioned by The Guardian is West, Börner, Sills, and Kontoleon (2020).The authors use a quasi-experimental design, the synthetic control method, to assess the effects of 12 REDD+ projects in the Brazilian Amazon and compare the outcomes with the projects' initial predictions and baselines. The findings indicate that the accepted methods for calculating carbon credits might exaggerate the actual impact these projects have on preventing deforestation and mitigating climate change. Given the international focus on REDD+ in policies and carbon-offset initiatives, the authors

[9]Revealed: More Than 90% of Rainforest Carbon Offsets by Biggest Certifier Are Worthless, Analysis Shows. Available at https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe

present a call for a more balanced approach in forest carbon financing, controlling for conservation investment risks while maintaining the genuine environmental benefits of carbon offsets.

The discussion ignited by The Guardian shed a light over the real additionality of REDD+ projects. The methodology behind REDD+ often involves comparing current forest cover with a baseline scenario, typically based on past deforestation trends. This comparison can become problematic, especially when regional economic and political contexts change, as seen in the Brazilian Amazon between 2004-2012 and 2019.

The controversy regarding REDD+ projects and the impact caused by The Guardian resulted in a prompt response from Verra[10]. The central focus of Verra's reply is to address the allegations that Verra-certified REDD+ projects consistently over-issue carbon credits. The Guardian's article was based on studies using "synthetic controls" or similar methods, which Verra argues fail to consider project-specific factors contributing to deforestation, leading to significant miscalculations regarding the impact of REDD projects.

The studies cited in The Guardian's article, such as those by West et al. (2020) and Guizar-Coutiño et al. (2022) were acknowledged by Verra, but the registry said the mentioned research has limited utility for assessing the impact of REDD projects because the methodology does not account for site-specific drivers of deforestation. Verra argues that synthetic controls, as used in these studies, are not suitable for REDD projects due to the unique challenges of finding matching points inside and outside project areas.

Verra emphasized its commitment to developing and continually improving methodologies based on the best-available science and technology, with input from numerous academics and experts. Verra acknowledged that scrutiny of methodologies and contributions from experts are welcomed and actively encouraged through its standard, methodology, and project development processes, all of which include expert review and public consultations.

The repercussions of The Guardian's article on businesses can be viewed from several perspectives. First, it can influence investors' scrutiny over the authenticity of various carbon credits, such as REDD+ compared to reforestation, possibly leading to pricing disparities among different credits. Second, the article might have direct financial consequences on the returns of companies that The Guardian specifically identified (like Shell, Disney, Gucci, Salesforce, BHP, easyJet, and Leon) as purchasers of dubious "phantom credits". Lastly, it can reshape how companies articulate their offset strategies and the authenticity of the carbon credits they buy to achieve their environmental objectives.

Given The Guardian's explicit mention of companies that have purchased questionable carbon credits, it raises questions about how the investor community has responded to this news in terms of buying, holding, or selling shares of these companies. One hypothesis is that investors may have redirected their interest away from such firms, opting to invest

[10]https://verra.org/verra-response-guardian-rainforest-carbon-offsets/

in stocks of comparable peers that either abstain from buying "phantom credits" or are perceived to purchase higher-quality credits.

Another potential outcome of this debate might be a shift in how companies communicate their carbon offset strategies. Rather than indiscriminately chasing "net zero" objectives regardless of carbon credit quality, companies might now be more inclined to refine their reporting on offset policies. This could involve providing more detailed information about the credits they purchase, addressing potential concerns directly, or even moving away from the "net zero" terminology in favor of language that emphasizes environmentally responsible offset practices.

Given these theoretical outcomes, studying The Guardian's article as an exogenous intervention may shed light on causal impacts of scrutiny in the carbon market on companies' performance.

1.1.4 The "Net Zero" Concept at Risk

Concerns regarding the concept of net zero emissions arise from the proliferation of voluntary commitments made by countries, sub-national entities, and organizations. While these commitments have gained considerable attention and support, there is a legitimate worry that they may lack a consistent approach in designing pathways toward "net zero" (Fankhauser et al., 2022).

A key concern revolves around the role of carbon offsets in achieving net zero. Some entities may rely heavily on carbon offsetting without substantially reducing their own emissions, leading to questions about the environmental and social integrity of these offset projects.

Allen et al. (2020) present a taxonomy of carbon offsets, distinguishing between emission reductions and carbon removals. The authors highlight that avoided emissions, which involve emission reduction without carbon storage, should not be considered superior to other offset types based on permanence.

Entities seeking to achieve environmental goals through carbon credits must transparently report their activities, detailing how much carbon they have avoided/removed from the atmosphere and through what means. These reports need to be accurate and verifiable to maintain the integrity of the net zero framework.

Fankhauser et al. (2022) point that carbon offsetting is an important component of achieving climate goals, however it is crucial to recognize that the concept of net zero goes beyond simply balancing emissions with removals. Net zero commitments should not be viewed as a replacement for the urgent reductions in emissions that are essential to address the climate crisis effectively. In fact, achieving net zero requires even more significant efforts to eliminate challenging sources of emissions than what has been undertaken thus far.

While this debate is thriving among academic environmentalists, the field of finance academia is still in its early stages of discussing corporate strategies concerning carbon offsets from a net zero perspective. The criticism regarding corporations' offset strategies toward net zero is primarily vocalized by media vehicles, business journals and NGOs.

According to the Net Zero Tracker[11], as of June 2023[12], 929 companies from the Forbes Global 2000 list have committed to net zero targets, representing a substantial rise from 417 in December 2020. Furthermore, the collective annual revenue covered by these net zero commitments has rapidly expanded to two-thirds of the total annual revenue generated by the Forbes Global 2000.

Despite the trend, Net Zero Tracker reports only 4% of corporate net zero commitments meet the stringent "Starting Line Criteria" that were introduced by the UN Race to Zero campaign in June 2022. These criteria entail setting a precise net zero target, encompassing all GHG (including emissions from all scopes for companies), establishing clear conditions for the use of carbon offsets, publishing a comprehensive plan, implementing immediate emission-cutting measures, and providing annual progress reports on both short-term and long-term targets.

Additionally, only 37% of corporate net zero targets are found to fully encompass scope 3 emissions, based on self-reported data. Furthermore, just 13% of these corporate net zero targets specify quality conditions for the use of carbon offsets, indicating a lack of transparency and rigor in some of these commitments.

While the corporate sector has shown remarkable enthusiasm in embracing net zero emissions targets, there is a critical need for these commitments to exhibit greater credibility and rigor. Some companies, however, are making good progress in such credibility journey. The UNFCCC has reported Microsoft as a potential example[13].

Microsoft has committed to becoming carbon negative by 2030 and to removing all the carbon it has emitted, either directly or through electrical consumption since its founding in 1975, by 2050. This goal represents a significant step beyond carbon neutrality, driven by the recognition of the scientific, social, and economic impacts of climate change. Microsoft

[11]The Net Zero Tracker is a collaborative initiative involving four organizations with diverse expertise in climate and environmental issues. The Energy & Climate Intelligence Unit (ECIU) contributes to informed debates on energy and climate matters in the UK, emphasizing evidence-based decision-making. The Data-Driven EnviroLab (DDL) utilizes innovative data analytics and AI to address contemporary environmental challenges and inform policymaking. NewClimate Institute supports global climate research and action, connecting research findings with real-world decision-making processes. Oxford Net Zero, affiliated with the University of Oxford, provides expertise and guidance on achieving net-zero emissions to governments, industry leaders, and international organizations, drawing from extensive research in the field of climate neutrality. Together, these partners collaborate to create the Net Zero Tracker, offering valuable insights into global efforts to combat climate change and attain net-zero emissions goals.

[12]https://zerotracker.net/insights/net-zero-targets-among-worlds-largest-companies-double-but-credibility-gaps-undermine-progress

[13]https://unfccc.int/climate-action/un-global-climate-action-awards/climate-neutral-now/microsoft-carbon-negative-goal

aims to address emissions across all three scopes, including Scope 3 emissions in its value chain. Microsoft's Climate Innovation Fund, launched in 2020, will invest a billionaire amount over four years in new technologies to combat climate change. Additionally, the company appears to be working on environmental equity by partnering with Sol Systems to procure renewable energy in under-resourced communities. The commitment to carbon negativity goes beyond aligning with emission reduction pathways; it introduces the concept of climate equity by including historic emissions in its responsibility.

According to Microsoft (2023), the company seeks high-quality Carbon Dioxide Removal (CDR) projects that adhere to a set of principles. These principles distinguish between minimum viable project characteristics and ideal project characteristics. They aim to minimize harms associated with CDR projects and maximize benefits to local communities and ecosystems. Project developers must mitigate health risks, negative impacts on ecosystems, and adverse effects on local communities. They should avoid community displacement, toxic pollutants, and banned pesticides, promoting environmental justice. Microsoft emphasizes transparent, inclusive, and authentic community engagement, fair worker compensation, and Indigenous community involvement. Projects should also prioritize community needs, articulate benefits, and make revenue-sharing commitments. Additionality and conservative baselines are essential, ensuring carbon finance is required, and projects are not common practice. Robust carbon accounting and Monitoring, Reporting, and Verification (MRV) are crucial, involving credible MRV plans, scientific methods, and third-party verification when possible. The goal is to ensure that CDR projects effectively remove carbon and provide social and environmental benefits while adhering to rigorous standards.

The wording represents a shift from the opaque net zero claims of companies that merely report carbon offsets as a pathway toward compensating GHG emissions, regardless of the quality of credits purchased. It can, somehow, represent an example of a modern and UNFCCC-aligned way of communicating a carbon offset policy.

2 Data and Methodology

2.1 Do Investors Care About Carbon Offsets? Stock Returns of Companies Relying on The Voluntary Carbon Market

In this analysis, the main goal is to examine whether companies engaged in carbon offsets outperform, in terms of stock returns, their peers that do not participate in such initiatives. To achieve this, we rely on a comprehensive database provided by Verra, the largest global voluntary carbon standard. This database, enriched with financial data obtained from Refinitiv, forms the cornerstone the investigation.

The Verified Carbon Standard (VCS) is a program that enables certified projects

to convert their GHG emission reductions and removals into tradable carbon credits. Established in 2006, the VCS Program has evolved into the world's largest voluntary GHG initiative. VCS projects encompass a wide range of technologies and measures aimed at achieving GHG emission reductions and removals, spanning renewable energy, forest and wetland conservation and restoration, transport efficiency enhancements, and others. As of the latest data[14], there have been 1,179,217,445 VCUs (Verified Carbon Units) issued, with 638,017,855 VCUs retired. A total of 2,083 VCS projects are registered, of which 1,662 have VCUs issued, while 403 projects are registered but have not yet issued VCUs.

The VCU database encompasses[15] over 23 thousand entries, each associated with an individual carbon offset or retirement. It includes data dating back to 2009 and encompasses offsets generated by a diverse array of carbon projects. While Verra verifies each retirement, the data concerning the entity responsible for retiring the carbon credits is supplied by the companies engaging in credit offsetting. Consequently, the database lacks a consistent structure, as the same company may report different offsets using distinct entities, names, or even input names with typos.

Cleaning the VCU database proved to be a necessary task. Given the often inconsistent data provided by the companies offsetting VCUs, manual cleaning was imperative to establish coherence and reliability. One of the primary challenges was ensuring that the names of offsetting companies were consistent across the database. Companies sometimes appeared under different entities, used variations in names, or even introduced typographical errors, which could have led to misrepresentation or duplication in the dataset.

After refining the database, the next step was to identify a subset of companies that had a significant impact on carbon offsetting. To accomplish this, I applied a cutoff criterion of 100,000 credits (in the subtotal for years 2020, 2021, and 2022), which served as a threshold to exclude entries of companies engaged in relatively imaterial offsets in terms of size.

The outcome of this filtering and selection process was a refined database comprising 58 companies. These companies were collectively responsible for offsetting approximately 100 million metric tons of CO2 in terms of credits throughout their historical engagement in carbon offsetting activities. To put this into perspective, when considering the years 2020, 2021, and 2022 combined, this subsample represented a significant 37% of the total database, which originally contained around 8 thousand individual entries before the cleaning and filtering procedures were applied.

The resulting 58 companies include Delta Air Lines Inc., Salesforce.com Inc., Royal Dutch Shell plc, The Walt Disney Company, Volkswagen Group, Telstra Corporation Limited, The Boeing Company, Takeda Pharmaceutical Company Limited, Gucci (a

[14]October/2023.
[15]https://registry.verra.org/app/search/VCS/VCUs

subsidiary of Kering SA), Chevron Corporation, Interface Inc., DHL International GmbH, Natura & Co Holding S.A., Allianz SE, Eni S.p.A., Banco Santander S.A., WEX Inc., Nedbank Group Limited, Maple Leaf Foods Inc., JetBlue Airways Corporation, Etsy Inc., United Airlines Holdings Inc., Kuehne + Nagel International AG, AXA SA, Qantas Airways Limited, ENEOS Holdings Inc., Samsung Electronics Co., Ltd., Air France-KLM SA, PetroChina Company Limited, Norwegian Cruise Line Holdings Ltd., Netflix Inc., Toho Gas Co., Ltd., Apple Inc., The Goldman Sachs Group, Inc., Nestlé S.A., TotalEnergies SE, Church & Dwight Co., Inc., Zalando SE, Continental AG, Fortescue Metals Group Limited, Japan Petroleum Exploration Co., Ltd., Microsoft Corporation, BHP Group Limited, Shizuoka Gas Co., Ltd., Farfetch Limited, Delivery Hero SE, easyJet plc, Yamato Holdings Co., Ltd., Civitas Resources, Inc., Osaka Gas Co., Ltd., Jet2 plc, JPMorgan Chase & Co., Spotify Technology S.A., Bayer AG, Blue Apron Holdings, Inc., Booking Holdings Inc., Rémy Cointreau S.A., and Tipco Asphalt Public Company Limited.

To investigate whether investors care about carbon offsets in the voluntary market and whether companies that retire carbon credits in the capital markets achieve higher stock returns compared to their peers, I implement a staggered Differences-in-Differences (Callaway & Sant'Anna, 2021) analysis. The goal is to examine whether a company's decision to become a carbon offsetter in the voluntary carbon market has an impact on its stock returns compared to other companies in the same sector that do not engage in carbon offsets. This approach enables us to control for potential confounding factors and isolate the specific effect of becoming a carbon offsetter on stock returns.

The DID design evaluates the possible causal impact of a treatment or intervention by comparing changes in outcomes over time between a treated group and a control group. In our context, we are interested in assessing the impact of companies entering the voluntary carbon offset market on their stock returns.

Specifically, the staggered DID approach presented by Callaway and Sant'Anna (2021) provides a framework for estimating causal effects in settings where treatment is introduced at different times across units. The method builds on traditional DID by allowing treatment effects to vary across time and by unit, accommodating scenarios where groups do not receive the intervention simultaneously. The model calculates the Average Treatment Effect on the Treated (ATT) for each group and each time point, creating a "group-time" specific effect. It relies on two key assumptions: parallel trends, meaning that, in the absence of treatment, trends between treated and untreated groups would have remained the same, and no anticipation effect, meaning that no pre-treatment changes are influenced by the upcoming treatment. After estimating the group-time ATTs, these are aggregated to provide an overall ATT, weighted by group and period. This aggregation creates a comprehensive view of treatment effects across the study period, which is especially useful in policy analysis and program evaluation where treatments vary over time and across

different units.

In our case, the treated group consists of companies that entered the voluntary carbon offset market, and the control group comprises companies from the same sector that did not engage in such activities. We have collected data on the intervention dates for treated companies and paired them with control companies. We then estimate the effect of entering the carbon offset market on stock returns by examining how stock returns change before and after the intervention, while accounting for general time trends.

The selected covariates for this analysis are indicators that could potentially influence a company's stock return. First, we consider the return of the overall market, which is captured by the daily returns of the S&P500. This serves as an indicator of the general market trend and its impact on individual stocks. Next, we include a measure of risk aversion, represented by the daily percentage changes in the VIX index[16]. The VIX, often referred to as the "fear gauge", helps in understanding market sentiment and the propensity of investors towards risk. I also incorporate a parameter indicative of flight-to-quality movements. This is characterized by the daily returns of the dollar index[17], serving as a potential proxy for shifts in investor preference from equity investments to safer sovereign bonds. Lastly, I include a control for climate responsibility, a dummy variable for net zero commitments, based on data from the Net Zero Tracker[18].

The DID model can be expressed as follows:

$$\Delta Y_{it} = \beta_0 + \beta_1 \text{Treated}_i + \beta_2 \text{Post}_t + \beta_3 (\text{Treated}_i \times \text{Post}_t) + \boldsymbol{\beta}_4^\top \mathbf{X}_{it} + \epsilon_{it} \tag{1}$$

In this equation:

- ΔY_{it} represents the change in the outcome variable (in our case, stock returns) for company i at time t.

[16]The VIX, also known as the Chicago Board Options Exchange (CBOE) Volatility Index, measures the stock market's expectation of volatility based on S&P 500 index options. Often referred to as the "fear gauge" or "fear index," the VIX represents an estimate of future volatility over the next 30 days. It is calculated using the bid and ask prices of S&P 500 index options, reflecting investor sentiments about future market uncertainty. A high VIX value indicates increased fear or uncertainty among investors, suggesting a potential increase in market volatility, while a low VIX value suggests confidence and stability in the market. As such, the VIX is widely used as a tool for market sentiment and risk assessment, helping investors gauge the level of risk, fear, or stress in the stock market at any given time.

[17]The Dollar Index, often denoted as DXY, is a financial benchmark that measures the value of the U.S. dollar against a basket of foreign currencies. This basket typically includes six major world currencies: the Euro, Japanese Yen, British Pound, Canadian Dollar, Swedish Krona, and Swiss Franc. The index provides a comprehensive view of the dollar's performance in the global currency market. A higher value of the DXY indicates a stronger U.S. dollar relative to these currencies, signifying increased international purchasing power of the dollar. Conversely, a lower DXY value suggests a weaker dollar, implying decreased purchasing power abroad. Investors and economists closely watch the Dollar Index as it reflects international economic sentiment and the relative strength of the U.S. economy. It also influences global financial markets, affecting commodity prices, currency valuations, and international trade dynamics.

[18]https://zerotracker.net/

- Treated_i is an indicator variable equal to 1 for companies that entered the voluntary carbon offset market and 0 for those that did not.
- Post_t is an indicator variable equal to 1 for time periods after the entry into the voluntary carbon offset market and 0 for time periods before.
- β_0 is the intercept, representing the baseline outcome (stock returns) for companies that did not enter the carbon offset market before the intervention.
- β_1 captures the average treatment effect on the treated (ATT), representing the difference in stock returns between companies that entered the carbon offset market and those that did not before the intervention.
- β_2 represents the average time effect, capturing the general trend in stock returns over time for all companies.
- β_3 is the DID estimator, quantifying the treatment effect by comparing the change in stock returns between companies that entered the carbon offset market and those that did not before and after the intervention.
- $\boldsymbol{\beta}_4$ represents the coefficients associated with the vector of additional covariates, $\mathbf{X}_{it}$, in the regression model. Each element in $\mathbf{X}_{it}$ corresponds to a different covariate that may influence the outcome variable, specifically overall market returns, represented by daily changes of the S&P500 index, as well as changes in the VIX and in the Dollar Index, and a dummy for net zero commitments.
- ϵ_{it} is the error term.

The DID estimator, β_3, provides insights into the impact of entering the voluntary carbon offset market on stock returns. A statistically significant and positive β_3 suggests that entering the market is associated with an increase in stock returns compared to companies that did not enter. Conversely, a negative β_3 implies a negative impact on stock returns.

In order to compare treated units and comparable peers, I divide the companies into sectors and run the DID with control units from the same sectors. All these companies are large or mega caps, with stocks negotiated in the US market. The sectors are Oil & Gas, with 27 control units and 11 treated companies; Airlines, with 82 control units and 7 treated companies; Industrials, with 183 control units and 10 treated companies; Technology, with 61 control units and 11 treated companies; Financial, with 191 control units and 6 treated companies; and Consumers, with 97 control units and 9 treated companies.

The sector segregation is key to evaluate industry-specific factors. Bolton and Kacperczyk (2021) reveal that individual firm efforts to reduce emissions may not have a noticeable

impact on investors if most of the pricing effects are driven by industry-level filters. In other words, striving to be the best in class within a sector for emissions may not yield significant benefits based on the study's findings.

2.2 Do Investors Care About Additionality? An Event Study of "Phantom Credits" Buyers

In the ongoing discussion regarding the credibility of carbon offset practices, a significant development occurred with the publication the investigative report by Guardian (2023) on January 18th, 2023. As discussed, this report introduced the concept of "phantom credits" and raised concerns about the effectiveness of forest carbon offsets certified by Verra. The revelations not only challenged the veracity of corporate assertions regarding carbon neutrality but also ignited discussions about the legitimacy of their climate action plans. In this section, we employ an event study method to assess the impact of The Guardian's article on the stock returns of companies explicitly mentioned by the investigation, comparing them to a counterfactual scenario.

The event study methodology assesses the impact of a specific event on a stock's returns by comparing its observed performance to an expected performance model over an estimation period. In this method, we identify an "event date" (in our case, January, 18th of 2023, the date when The Guardian's report was released) and define an event window (2 days before and 10 days after the event) around this date to capture potential abnormal returns, which are deviations from the expected return model. I estimate expected returns based on the stock's historical relationship with a market index or benchmark, or a basked of assets, over a preceding estimation window, in line with the market model designed by Brown and Warner (1985). This model assumes a linear relationship between the security's returns and the benchmark returns.

By analyzing the difference between actual and expected returns during the event window, we calculate abnormal returns (ARs), which reflect the event's immediate impact on the stock. Cumulative abnormal returns (CARs) over the event window help to summarize the total impact across multiple days. If the ARs are statistically significant, they may indicate that the event had a material effect on the stock price.

To determine the expected returns for each company allegedly purchasing "phantom credits," the model assumes a linear relationship between the returns of these companies and the returns of the sector benchmark. For each company i, the return $R_{i,t}$ on day t is modeled as:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \epsilon_{i,t} \tag{2}$$

where:

- $R_{i,t}$ is the return on the stock of company i at time t,

- $R_{m,t}$ is the return on the sector benchmark (i.e., a basket of comparable assets from the same sector) at time t,
- α_i and β_i are the intercept and sensitivity to the benchmark returns, estimated using historical data over an estimation window before the event,
- $\epsilon_{i,t}$ is the error term, representing any abnormal influence on the stock returns beyond sectoral factors.

The abnormal return (AR) on a specific day t around the event is calculated as the difference between the actual return and the expected return derived from the market model:

$$AR_{i,t} = R_{i,t} - (\alpha_i + \beta_i R_{m,t}) \tag{3}$$

To evaluate the overall effect of the "phantom credits" news on a company over multiple days, we compute the cumulative abnormal returns (CAR) across an event window $[t_1, t_2]$:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{i,t} \tag{4}$$

where:

- t_1 and t_2 represent the start and end of the event window, respectively,
- $CAR_i(t_1, t_2)$ represents the accumulated abnormal returns from day t_1 to day t_2.

Assuming the abnormal returns $AR_{i,t}$ are normally distributed with a mean of zero and variance $\sigma^2(AR_{i,t})$, we test whether each $AR_{i,t}$ is significantly different from zero using:

$$t_{AR} = \frac{AR_{i,t}}{\sigma(AR_{i,t})} \tag{5}$$

For cumulative abnormal returns $CAR_i(t_1, t_2)$, the variance is the sum of the variances of $AR_{i,t}$ across the event window, assuming independence:

$$\sigma^2(CAR_i(t_1, t_2)) = \sum_{t=t_1}^{t_2} \sigma^2(AR_{i,t}) \tag{6}$$

The t-statistic for CAR is then:

$$t_{CAR} = \frac{CAR_i(t_1, t_2)}{\sqrt{\sigma^2(CAR_i(t_1, t_2))}} \tag{7}$$

Results are visualized in a plot. The plot shows cumulative abnormal returns (CAR) over time, with confidence intervals indicating different significance levels.

I have selected four companies, each from a different sector explicitly identified by The Guardian: easyJet (airline), Shell (energy), Disney (entertainment), and Salesforce (technology). Each of these companies will serve as a treated unit. To create the benchmarks for the market model, I will select comparable companies from the same sectors.

The benchmark for the airlines comprises Delta Air Lines, Southwest Airline, United Airlines, American Airlines, Alaska Air Group, Copa Holdings, SkyWest, JetBlue Airways, Air Transport Services Group, and Allegiant Travel.

The energy sector benchmark includes Exxon Mobil, Chevron, TotalEnergies, ConocoPhillips, BP, Petrobras, Enbridge, Equinor, Canadian Natural Resources, alongside TexGen.

The entertainment sector benchmark consists of Netflix, Live Nation Entertainment, Warner Bros. Discovery, Liberty Media, Fox Corporation, News Corp, Warner Music Group, TKO Group, and Endeavor Group Holdings.

The technology sector benchmark features Microsoft, Oracle, Adobe, Palo Alto Networks, Synopsys, Palantir Technologies, CrowdStrike Holdings, Fortinet, and Square.

3 Results

3.1 Carbon Offsets and Stock Performance

The treatment effect — engaging in Verra's carbon offset program — does not have a statistically significant impact on stock returns for the treated companies. Across all examined sectors, including energy, airlines, industrials, consumer, financial, and technology, there is no evidence that participation in carbon offset programs meaningfully enhances or detracts from the stock performance. The coefficients for the treatment variables are generally small and lack statistical significance, suggesting that the voluntary adoption of carbon offsets neither boosts nor hinders stock returns in a way that stands out.

Within specific sectors, trends do emerge, particularly in the energy sector. Here, while carbon offset initiatives do not have a statistically significant effect on returns, they appear to slightly weigh on returns following the intervention. This negative trend, though not conclusive, may reflect increased operational or compliance costs associated with adopting retirement strategies. In contrast, sectors like technology show some post-intervention variability but lack a clear directional trend that would imply consistent benefits or drawbacks from engaging in voluntary carbon offsets.

In terms of macroeconomic factors, the S&P 500 index, VIX, and the Dollar Index (DXY) stand out as significant drivers of stock returns. The S&P 500's strong and highly significant positive relationship across all sectors highlights the overarching influence of

broader market conditions on stock performance. The VIX, representing market volatility, also contributes to returns, especially in the technology sector, where it is significant, indicating the sector's sensitivity to market uncertainties. Meanwhile, the Dollar Index negatively impacts stock returns for several sectors, most notably for industrials and financials, suggesting that currency strength can weigh on operations within these sectors.

Lastly, net zero commitments are found to be statistically insignificant in affecting stock returns. This implies that companies' commitments to net-zero emissions, while notable for ESG reporting, do not translate into measurable financial gains or losses in the short to medium term in the stock market. Investors may value these commitments for reputational or risk management reasons, but they do not currently seem to impact stock performance directly.

Table 2: Impacts of Company Offsets on Stock Performance (DID Coefficients)
This table illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.

	DID Staggered Coefficients Per Sector					
	Energy	Airlines	Industrials	Consumer	Financial	Technology
Intercept	-0.161	0.131	-0.041	-0.059	-0.003	0.124
	(0.327)	(0.663)	(0.842)	(0.779)	(0.983)	(0.530)
INX_m8	0.427	-0.375	0.080	0.216	0.043	-0.413
	(0.227)	(0.561)	(0.855)	(0.635)	(0.933)	(0.310)
INX_m7	0.325	-0.380	0.809	0.427	0.048	-0.148
	(0.356)	(0.552)	(0.066)	(0.345)	(0.924)	(0.714)

(Continued)

	DID Staggered Coefficients Per Sector					
	Oil&Gas (Energy)	Airlines	Industrial	Consumer	Financial	Technology
INX_m6	0.161	-0.740	0.549	0.159	0.122	-0.247
	(0.649)	(0.250)	(0.213)	(0.727)	(0.808)	(0.542)
INX_m5	0.497	-0.031	0.109	0.319	-0.317	-0.305
	(0.158)	(0.962)	(0.804)	(0.482)	(0.527)	(0.452)
INX_m4	0.220	-0.059	0.091	0.123	0.005	-0.301
	(0.531)	(0.927)	(0.836)	(0.785)	(0.992)	(0.458)
INX_m3	0.547	-0.087	0.306	0.200	0.113	-0.356
	(0.122)	(0.893)	(0.486)	(0.659)	(0.821)	(0.378)
INX_m2	0.158	-0.255	0.005	0.045	0.069	-0.098
	(0.654)	(0.691)	(0.991)	(0.921)	(0.890)	(0.810)
INX_m1	0.410	-0.377	0.411	0.188	0.049	-0.495
	(0.243)	(0.558)	(0.350)	(0.679)	(0.922)	(0.221)
INX_0	-0.350	0.030	-0.405	0.076	-0.146	-0.044
	(0.309)	(0.962)	(0.346)	(0.864)	(0.768)	(0.912)
INX_1	-0.440	0.236	-0.380	-0.230	0.068	0.308
	(0.243)	(0.731)	(0.416)	(0.634)	(0.896)	(0.475)
INX_2	-0.425	0.678	-0.255	-0.245	0.166	0.271
	(0.257)	(0.321)	(0.587)	(0.612)	(0.751)	(0.530)
INX_3	-0.236	0.387	-0.405	-0.224	-0.120	0.216
	(0.529)	(0.571)	(0.386)	(0.643)	(0.819)	(0.616)
INX_4	-0.692	0.187	-0.306	-0.216	-0.097	0.453
	(0.066)	(0.785)	(0.513)	(0.654)	(0.854)	(0.293)
INX_5	-0.090	0.381	-0.094	-0.461	-0.046	0.550
	(0.812)	(0.577)	(0.842)	(0.340)	(0.930)	(0.203)
INX_6	-0.216	0.564	-0.236	-0.071	0.106	0.517
	(0.564)	(0.408)	(0.615)	(0.883)	(0.839)	(0.230)
INX_7	-0.458	-0.029	-0.321	-0.366	-0.067	0.216
	(0.221)	(0.966)	(0.491)	(0.447)	(0.898)	(0.616)
Treatment	-0.161	0.131	-0.041	-0.059	-0.003	0.124
	(0.327)	(0.663)	(0.842)	(0.779)	(0.983)	(0.530)
Post	0.372	-0.294	0.297	0.219	0.039	-0.322
	(0.267)	(0.630)	(0.478)	(0.612)	(0.935)	(0.408)
Treatment*Post	0.372	-0.294	0.297	0.219	0.039	-0.322

(Continued)

	DID Staggered Coefficients Per Sector					
	Oil&Gas (Energy)	Airlines	Industrial	Consumer	Financial	Technology
	(0.267)	(0.630)	(0.478)	(0.612)	(0.935)	(0.408)
S&P500	0.432	0.909***	0.857***	0.627***	0.947***	1.552***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
VIX	-0.009	-0.018	0.009	-0.008	0.004	0.034**
	(0.144)	(0.136)	(0.264)	(0.314)	(0.575)	(0.000)
DXY	-0.343	-0.158	-0.392***	-0.116	-0.278*	-0.163
	(0.000)	(0.270)	(0.000)	(0.295)	(0.019)	(0.122)
Net Zero	0.014	0.016	-0.225*	-0.150	-0.003	0.022
	(0.851)	(0.916)	(0.049)	(0.112)	(0.983)	(0.867)

Regarding the energy sector, some players are deeply engaged in carbon credits purchase. Shell, for instance, has been involved in credit purchases as part of its strategy to achieve net zero emissions by 2050. They are investing significantly in low-carbon energy solutions and have emphasized the importance of carbon credits, including nature-based solutions, to offset emissions from their operations[19]. Chevron also engages in carbon credit purchases as part of its broader sustainability efforts[20].

However, even if these companies may outperform peers in terms of climate transparency[21], this does not translate to stock performs as per figure 1.

The airlines sector is another ecosystem directly engaged in carbon offsets. While airlines can theoretically offset a significant portion of their emissions through carbon credits, there are growing concerns about the effectiveness of these offsets. Some airlines are reevaluating their reliance on carbon credits as a primary strategy for achieving carbon neutrality, especially in light of questions regarding offset accounting methods[22]. In terms of stock returns, figure 2 shows that buying Verra's credits does not statistically improve airlines' returns.

Industrial companies, specially the ones with net zero commitments, are actively investing in technologies that reduce GHG emissions. In terms of carbon credits, some of them - like Boeing - are also partnering with climate companies involved in higher quality

[19]https://www.shell.com/sustainability/our-climate-target/shell-energy-transition-strategy.html

[20]https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/052621-larger-buyers-of-carbon-credits-buying-entire-projects

[21]https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/101023-carbon-credits-buyers-outperforming-peers-in-climate-action-study

[22]https://www.bain.com/about/media-center/press-releases/2023/airlines-can-eliminate-up-to-70-of-emissions-by-2050-but-many-will-miss-their-net-zero-goals-if-air-traffic-continues-to-grow-faster-than-gdp/

Figure 1: Impact of Voluntary Carbon Offset Engagement on Energy Companies' Stock Returns: Staggered DID Analysis

This chart illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. The Net Zero Tracker is an independent tool focused on transparency and accountability, providing a comprehensive view of net zero targets and their robustness across nations, regions, cities, and major global companies. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.

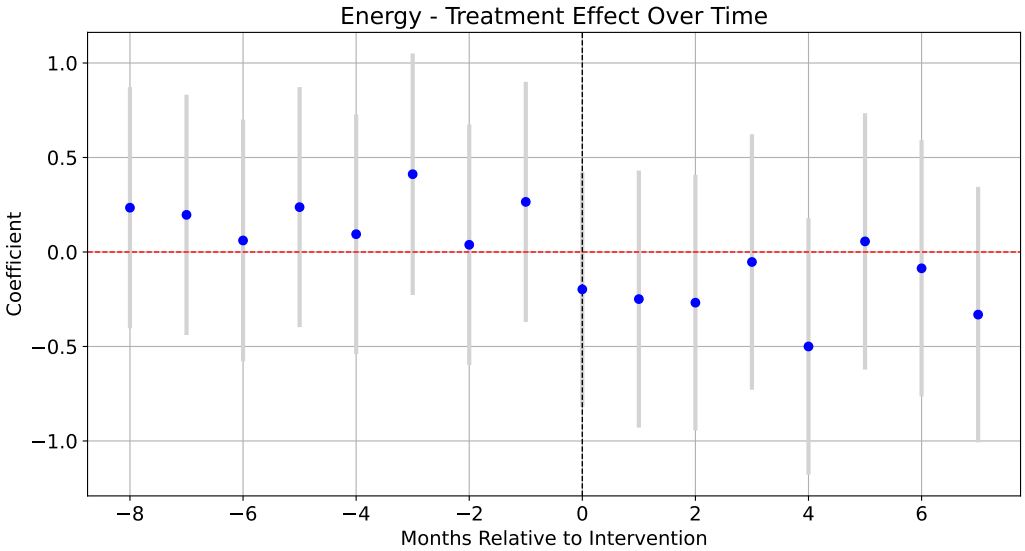
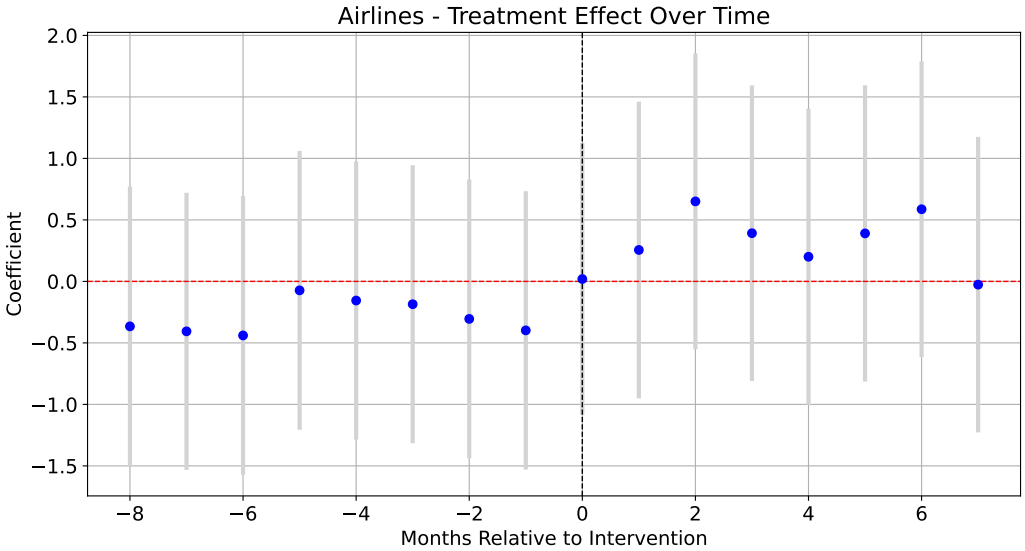


Figure 2: Impact of Voluntary Carbon Offset Engagement on Airlines' Stock Returns: Staggered DID Analysis

This chart illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. The Net Zero Tracker is an independent tool focused on transparency and accountability, providing a comprehensive view of net zero targets and their robustness across nations, regions, cities, and major global companies. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.



credits, such as carbon removal[23]. These other initiatives may explain why buying Verra's credits, majorly dominated by REDD+, does not affect stock returns.

In the consumer and e-commerce sector, Etsy has been one of the pioneers in sustainability. They became the first global e-commerce company to offset 100% of carbon emissions generated from shipping. This initiative involves purchasing verified emissions reductions, supporting projects like forest conservation and renewable energy[24]. Maple Leaf Foods also claims to be one of the world's first major carbon neutral food company[25].

Even though end consumers may be more climate-conscious, this does not translate into better stock returns from companies in the consumer sector after the intervention (figure 4).

Global banks are becoming more active in the carbon space. Not only from an offseting perspective, but also when it comes to providing clients with offset and/or carbon trading solutions[26]. However, voluntary offsets have close to zero impact on stock returns as per figure 5.

In the tech market, Microsoft has committed to becoming carbon negative by 2030[27]. Microsoft is actively sourcing a variety of carbon removal solutions, including forestry, soil carbon, and direct air capture projects. They prioritize high-quality projects that demonstrate durability and scientific verification[28]. Google has also made substantial commitments to sustainability, aiming to operate on 24/7 carbon-free energy by 2030. They invest in renewable energy projects and purchase carbon offsets to mitigate their emissions[29].

The causal impact of voluntary carbon programs on the stock returns of tech companies is not statistically significant (figure 6; however, there is a slightly positive trend that merits further exploration. While the data does not provide strong evidence to suggest that these carbon offset initiatives directly influence stock performance, the observed upward movement could indicate a growing investor interest in sustainability practices within the tech sector. This trend may reflect broader market sentiments favoring environmentally responsible companies, yet it is crucial to approach these findings with caution.

The analytical framework currently employed is insufficient to definitively link this trend to specific carbon policies or other confounding factors. For instance, the remarkable surge in valuations of tech companies during the early 2020s, driven by factors such as digital transformation and increased demand for technology solutions, complicates the narrative. As these companies have experienced unprecedented growth, attributing stock

[23]https://www.marketscreener.com/quote/stock/BOEING-4816/news/Boeing-to-Buy-62-000-MT-of-Carbon-Removal-Credits-From-Startup-Equatic-OPIS-44004996/
[24]https://www.etsy.com/news/on-etsy-every-purchase-makes-a-positive-impact/
[25]https://www.mapleleaffoods.com/news/maple-leaf-foods-releases-2021-sustainability-report/
[26]https://www.euronews.com/next/2021/07/07/uk-climate-change-banks-offsets
[27]https://www.microsoft.com/en-us/corporate-responsibility/sustainability/carbon-removal-program
[28]https://www.microsoft.com/en-us/corporate-responsibility/sustainability/carbon-removal-program
[29]https://carboncredits.com/microsoft-strikes-2-record-breaking-carbon-credit-deals/

Figure 3: Impact of Voluntary Carbon Offset Engagement on Industrial Companies' Stock Returns: Staggered DID Analysis

This chart illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. The Net Zero Tracker is an independent tool focused on transparency and accountability, providing a comprehensive view of net zero targets and their robustness across nations, regions, cities, and major global companies. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.

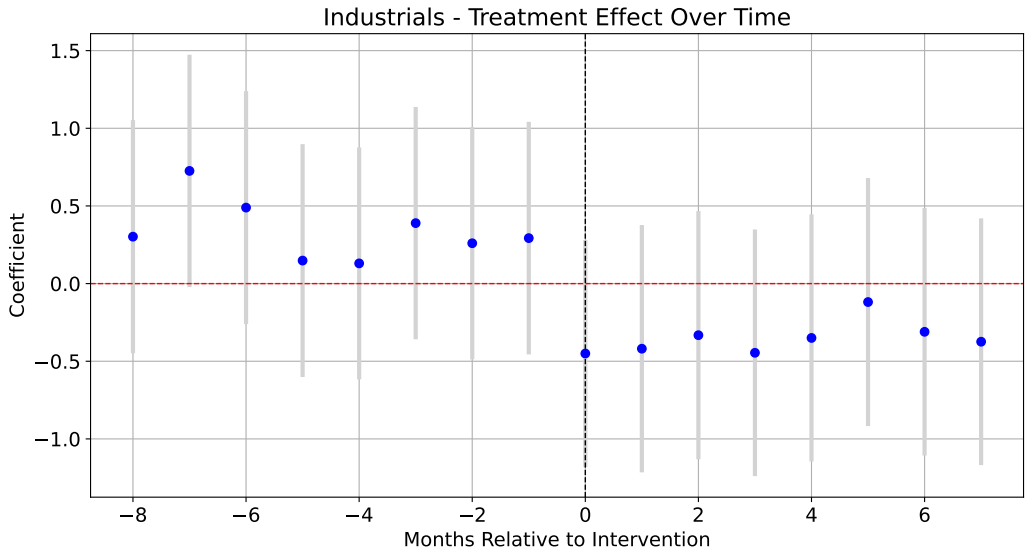


Figure 4: Impact of Voluntary Carbon Offset Engagement on Consumer Companies' Stock Returns: Staggered DID Analysis

This chart illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. The Net Zero Tracker is an independent tool focused on transparency and accountability, providing a comprehensive view of net zero targets and their robustness across nations, regions, cities, and major global companies. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.

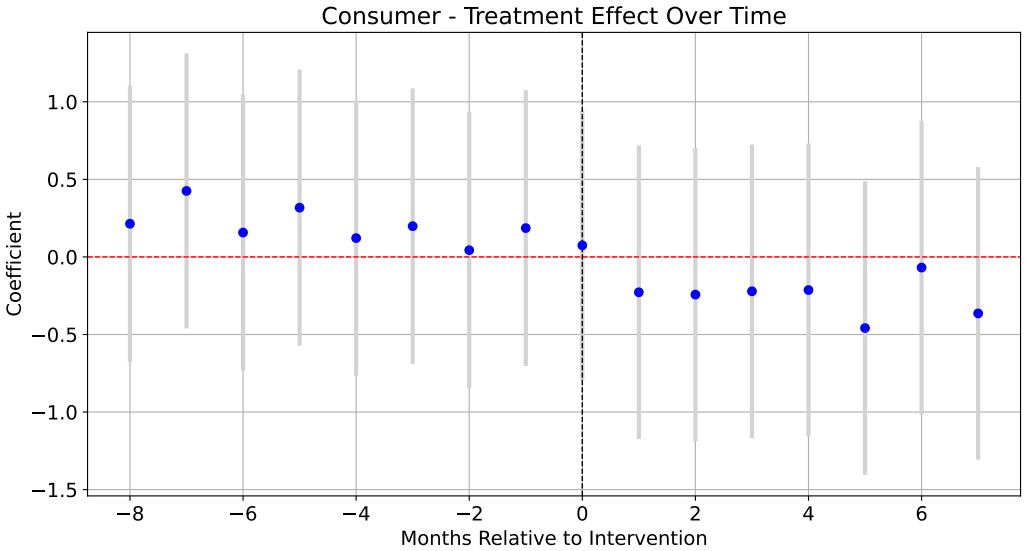
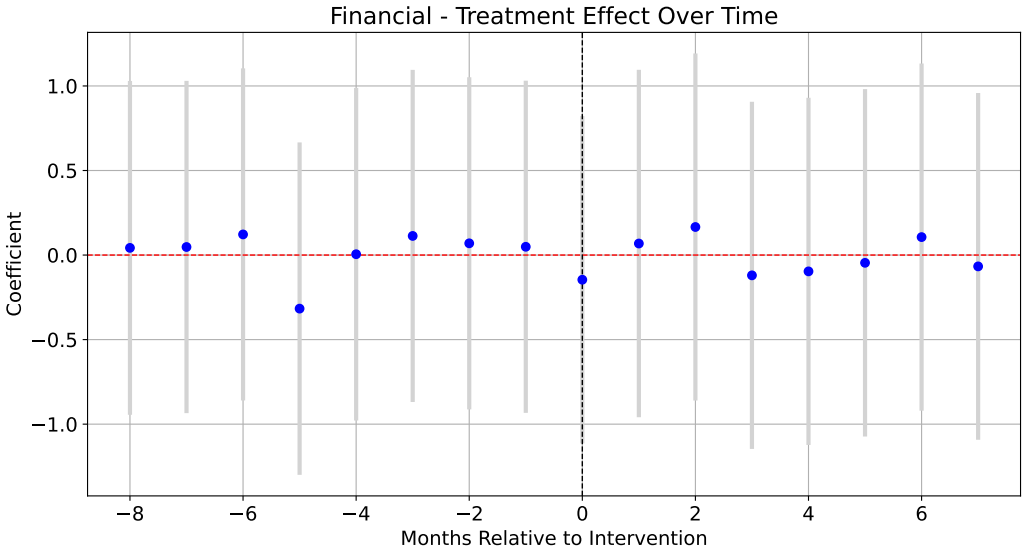


Figure 5: Impact of Voluntary Carbon Offset Engagement on Financial Companies' Stock Returns: Staggered DID Analysis

This chart illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. The Net Zero Tracker is an independent tool focused on transparency and accountability, providing a comprehensive view of net zero targets and their robustness across nations, regions, cities, and major global companies. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.



performance solely to voluntary carbon offsets overlooks the multifaceted influences at play, including market dynamics, investor behavior, and macroeconomic conditions.

In conclusion, the staggered DID approach reveals that voluntary carbon offsets do not have a statistically significant impact on stock performance. Instead, stock returns appear to be primarily influenced by broader market trends, risk aversion, and various macroeconomic factors.

These results dialogue with Aswani et al. (2024), as the authors conclude that while emissions are an important factor for societal concerns, they may not be as critical for individual firm assessments when considering stock returns. This distinction is vital for investors who may be influenced by the growing emphasis on ESG.

However, despite the lack of statistical significance, the trends suggest that carbon purchases may negatively affect the performance of brown sectors, such as energy, while potentially benefiting sectors like technology. This indicates a nuanced relationship where carbon offsets could enhance ESG reporting, contributing positively to investor perceptions in certain industries. However, it is essential to recognize that other confounding factors complicate the interpretation, making it challenging to draw definitive conclusions about the direct effects of carbon offsets on stock returns. Further research is needed to untangle these dynamics and provide a clearer understanding of how sustainability initiatives interact with market performance.

3.2 Event Study of "Phantom Credit" Buyers

The results from the event studies reveal mixed trends. Disney, Salesforce, and easyJet experienced positive returns following The Guardian's release on January 18, 2023, which is counterintuitive. This suggests that the investigation may not have significantly affected the stock performance of these companies.

In early 2023, Disney underwent a significant leadership change with the return of Bob Iger as CEO. Iger, who previously led the company from 2005 to 2020, resumed his role in November 2022 after the departure of his successor, Bob Chapek[30]. His return was met with optimism from investors and stakeholders, as Iger is widely recognized for his strategic vision and successful track record in transforming Disney into a global entertainment powerhouse. Actually, optimism gained traction even in the aftermath of Bob Chapek's departure[31]. As a result, the change in command seemed to play a more significant role in influencing stock prices than the carbon scandals.

On January 4, Salesforce announced a significant restructuring plan, which included laying off about 10% of its workforce, or roughly 7,500 employees. This decision was part

[30]https://www.latimes.com/entertainment-arts/business/story/2022-11-21/bob-chapek-disney-ouster-bog-iger

[31]https://finance.yahoo.com/news/disney-stock-soars-after-bob-iger-ceo-144709154.html

Figure 6: Impact of Voluntary Carbon Offset Engagement on Tech Companies' Stock Returns: Staggered DID Analysis

This chart illustrates the results of a staggered Difference-in-Differences (DID) analysis, assessing the effect of companies' engagement in a voluntary carbon offsets program on their stock returns. Each treated unit represents a company that initiated carbon credit retirements through Verra, with the first retirement marking the intervention date. The analysis uses control units from the same sector that have not yet engaged in carbon offsets to benchmark the performance of treated companies. The staggered design accommodates varied intervention dates, enabling a dynamic comparison of returns before and after each company's offset engagement relative to the controls. Monthly returns data captures shifts in returns, allowing the effect to be tracked over time. Additional controls for broader economic influences—such as S&P500 for market returns, the VIX for volatility, and the DXY index for the U.S. dollar—are included to isolate the treatment effect. This table also incorporates a dummy variable for net zero commitments, based on data from the Net Zero Tracker. The Net Zero Tracker is an independent tool focused on transparency and accountability, providing a comprehensive view of net zero targets and their robustness across nations, regions, cities, and major global companies. If a company has a registered net zero commitment on the Net Zero Tracker, the dummy variable is set to 1; otherwise, it is set to 0. In the table, coefficients for lead and lag terms relative to each intervention provide insights into stock return changes over time. Negative values to the left indicate pre-intervention periods, while positive values to the right represent post-intervention effects. The zero line serves as a baseline, showing deviations in returns attributed to carbon offset engagement, with confidence intervals around each point to reflect the accuracy of the estimates.

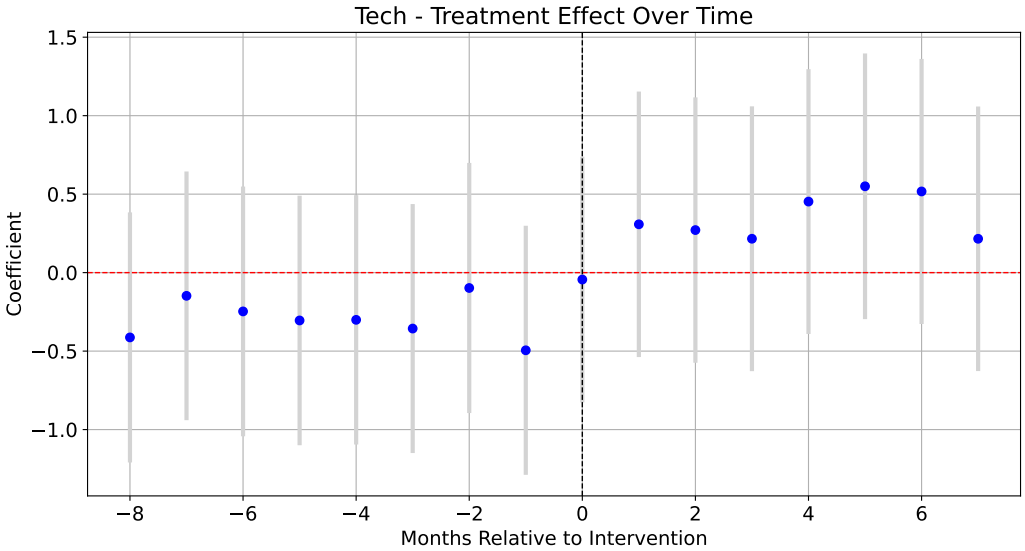
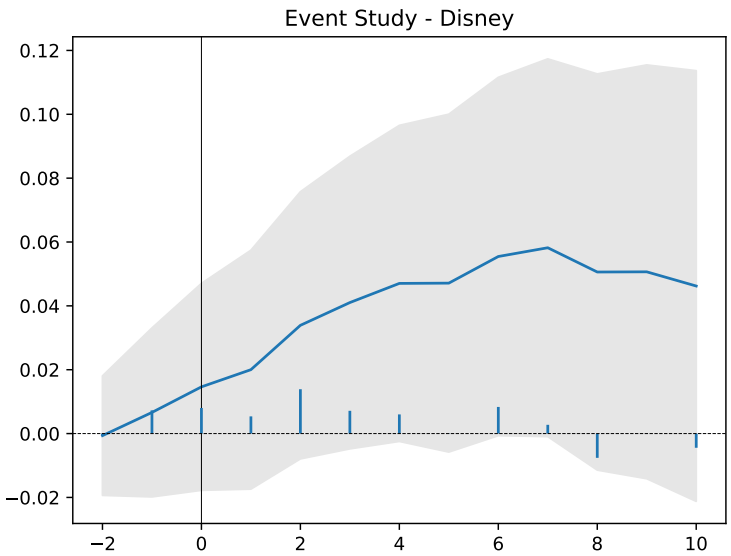


Figure 7: Market Reaction to Disney's "Phantom Credits" News: Cumulative Abnormal Returns Over Time

The resulting charts from the event study methodology visually represent the cumulative abnormal returns (CARs) of the stocks under analysis over the defined event window, which spans two days before and ten days after the specified event date of January 18, 2023. Each chart illustrates the trajectory of CARs, indicating how the stock's returns deviate from expected performance based on the market model, which incorporates historical relationships between the stocks and their sector benchmark. The x-axis denotes the days relative to the event date, while the y-axis quantifies the cumulative abnormal returns. Additionally, the charts include confidence intervals that delineate the significance levels of the observed abnormal returns, allowing for a clear understanding of the event's impact. Spikes or declines in the CAR line indicate periods of significant reaction to the event, highlighting whether the news about "phantom credits" had a material effect on the stock prices of the companies involved. The statistical significance of these abnormal returns is assessed using t-statistics, reinforcing the interpretation of whether the market's response to the event was statistically significant or merely a product of normal market fluctuations.



of a broader strategy to enhance profitability amid economic challenges[32]. Following this announcement, Salesforce's stock price initially faced some volatility as investors reacted to the news.

As the month progressed, Salesforce reported strong fourth-quarter earnings on January 31, 2023, revealling a 14% year-on-year increase in revenues[33]. This positive performance apparently led to a surge in investor confidence, and the stock jumped significantly. Some equity research analysts also began to adjust their price targets upward, with some projecting potential gains based on the company's strong market position and growth strategies[34].

Again, fundamentals appeared to play a significant role in determining stock price action, with accusations in the carbon market assuming an insignificant influence.

During 2023, easyJet reported a significant recovery post-pandemic, with expectations of beating profit forecasts due to strong demand for bookings. By late January, easyJet projected a pre-tax profit of £126 million for the year, a substantial turnaround from a previous loss of £178 million[35]. This positive trend was driven by a surge in consumer interest, particularly for summer travel, with EasyJet holidays reportedly 80% sold for the upcoming season3.

In subsequent months, EasyJet continued to build on this momentum, raising its full-year profit forecast to £260 million as summer demand soared[36]. The airline's shares rose significantly, reflecting investor confidence, although they remained below pre-pandemic levels.

Despite the positive momentum, the accusations in the carbon market were not sufficient to cause easyJet to underperform its peers. On the contrary, the company's fundamentals emerged as the main driver of its share price.

Lastly, Shell reported strong earnings for the fourth quarter of 2022, driven by high oil and gas prices, which reflected ongoing geopolitical tensions and supply constraints[37].

However, in the absence of other relevant news, Shell's stock price underperformed its peers immediately following The Guardian's report. The cumulative abnormal (negative) returns drove the upper bound of the confidence interval seemingly touch the zero-line between days 4 and 6 after the intervention (figure 10. This suggests that the hypothesis of Shell's share price being negatively affected by The Guardian's report is plausible.

The hypothesis is feasible in line with the literature that discusses investors attention

[32]https://finance.yahoo.com/news/analysts-revamp-salesforce-stock-price-000300697.html
[33]https://investor.salesforce.com/press-releases/press-release-details/2023/Salesforce-Announces-Strong-Fourth-Quarter-and-Full-Fiscal-2023-Results/default.aspx
[34]https://finance.yahoo.com/news/analysts-revamp-salesforce-stock-price-000300697.html
[35]https://www.lse.co.uk/news/easyjet-projects-beating-current-market-expectations-for-2023-9lxaz793nmaqfdz.html
[36]https://www.sharesmagazine.co.uk/news/shares/easyjet-raises-full-year-profit-forecast-as-summer-demand-soars
[37]https://reports.shell.com/annual-report/2023/strategic-report/market-overview.html

Figure 8: Market Reaction to Salesforce's "Phantom Credits" News: Cumulative Abnormal Returns Over Time

The resulting charts from the event study methodology visually represent the cumulative abnormal returns (CARs) of the stocks under analysis over the defined event window, which spans two days before and ten days after the specified event date of January 18, 2023. Each chart illustrates the trajectory of CARs, indicating how the stock's returns deviate from expected performance based on the market model, which incorporates historical relationships between the stocks and their sector benchmark. The x-axis denotes the days relative to the event date, while the y-axis quantifies the cumulative abnormal returns. Additionally, the charts include confidence intervals that delineate the significance levels of the observed abnormal returns, allowing for a clear understanding of the event's impact. Spikes or declines in the CAR line indicate periods of significant reaction to the event, highlighting whether the news about "phantom credits" had a material effect on the stock prices of the companies involved. The statistical significance of these abnormal returns is assessed using t-statistics, reinforcing the interpretation of whether the market's response to the event was statistically significant or merely a product of normal market fluctuations.

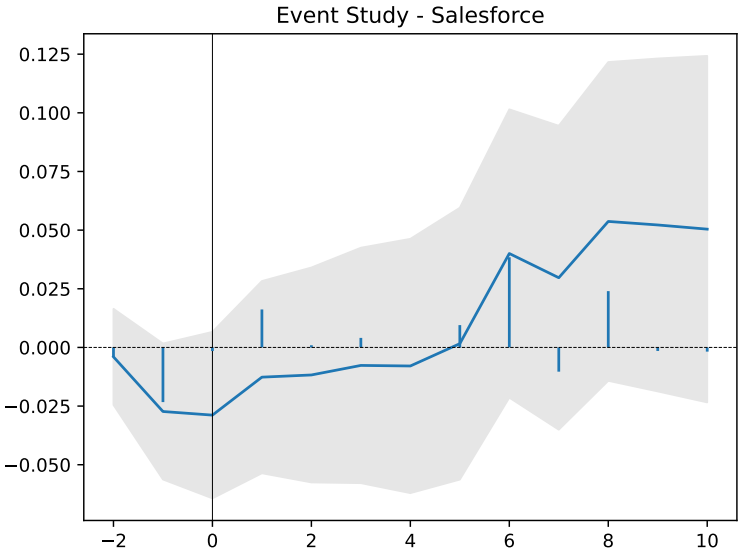


Figure 9: Market Reaction to easyJet's "Phantom Credits" News: Cumulative Abnormal Returns Over Time

The resulting charts from the event study methodology visually represent the cumulative abnormal returns (CARs) of the stocks under analysis over the defined event window, which spans two days before and ten days after the specified event date of January 18, 2023. Each chart illustrates the trajectory of CARs, indicating how the stock's returns deviate from expected performance based on the market model, which incorporates historical relationships between the stocks and their sector benchmark. The x-axis denotes the days relative to the event date, while the y-axis quantifies the cumulative abnormal returns. Additionally, the charts include confidence intervals that delineate the significance levels of the observed abnormal returns, allowing for a clear understanding of the event's impact. Spikes or declines in the CAR line indicate periods of significant reaction to the event, highlighting whether the news about "phantom credits" had a material effect on the stock prices of the companies involved. The statistical significance of these abnormal returns is assessed using t-statistics, reinforcing the interpretation of whether the market's response to the event was statistically significant or merely a product of normal market fluctuations.

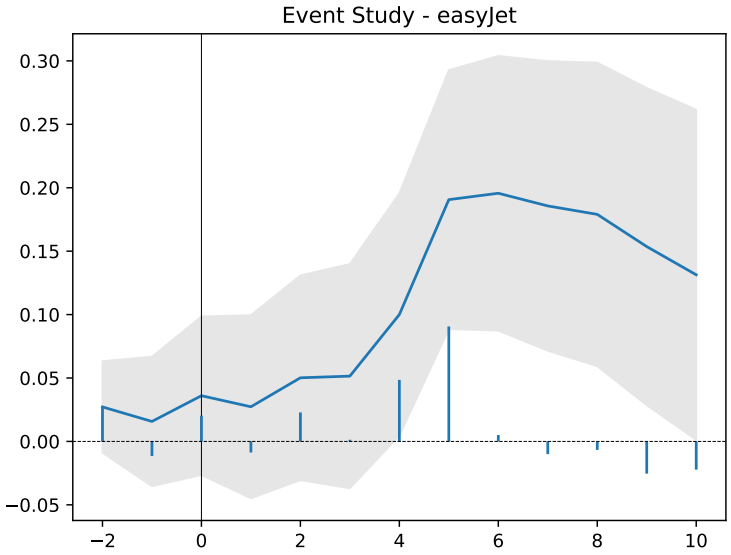
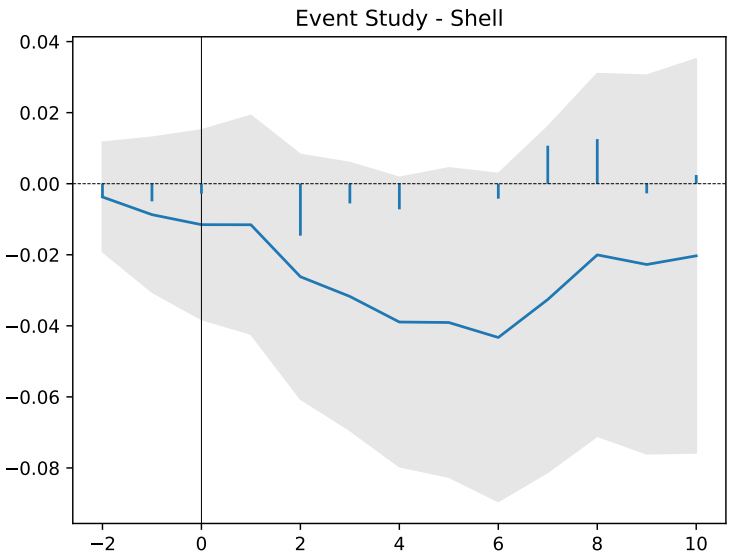


Figure 10: Market Reaction to Shell's "Phantom Credits" News: Cumulative Abnormal Returns Over Time

The resulting charts from the event study methodology visually represent the cumulative abnormal returns (CARs) of the stocks under analysis over the defined event window, which spans two days before and ten days after the specified event date of January 18, 2023. Each chart illustrates the trajectory of CARs, indicating how the stock's returns deviate from expected performance based on the market model, which incorporates historical relationships between the stocks and their sector benchmark. The x-axis denotes the days relative to the event date, while the y-axis quantifies the cumulative abnormal returns. Additionally, the charts include confidence intervals that delineate the significance levels of the observed abnormal returns, allowing for a clear understanding of the event's impact. Spikes or declines in the CAR line indicate periods of significant reaction to the event, highlighting whether the news about "phantom credits" had a material effect on the stock prices of the companies involved. The statistical significance of these abnormal returns is assessed using t-statistics, reinforcing the interpretation of whether the market's response to the event was statistically significant or merely a product of normal market fluctuations.



to climate-related news affecting companies in brown sectors. Liu, Kang, Guo, and Sun (2021) employ a mediating effect model that demonstrates how investor attention bridges the gap between air pollution and stock prices: increased pollution levels draw more investor attention, particularly on trading days marked by poor air quality. This attention can translate into higher stock prices for new energy firms as investors seek out alternative investments.

Similarly, negative news associated to carbon strategies employed by oil companies can have a similar effect. Investors increasingly prioritize sustainability and corporate responsibility, prompting them to reassess their portfolios in light of negative media coverage. This shift in focus can diminish the attractiveness of traditional brown sector investments.

In sum, the event studies reveal that while companies like Disney, Salesforce, and easyJet experienced notable stock price movements, these fluctuations were largely influenced by fundamental changes and broader market sentiments rather than the carbon-related news itself. The leadership change at Disney and the restructuring efforts at Salesforce, along with easyJet's recovery trajectory, highlight the significance of corporate governance and operational performance in shaping investor perceptions. This suggests that positive developments within a company can overshadow negative external (carbon-related) news, particularly in a market environment that values growth and recovery.

On the other hand, Shell's experience illustrates the potential repercussions of negative media coverage related to carbon strategies, with its stock underperforming amidst the release of critical information. This underlines the growing impact of sustainability concerns on investment decisions within the energy sector. As investor preferences increasingly shift towards companies that prioritize environmental responsibility, firms in the brown sectors must navigate this evolving landscape with a keen awareness of how their actions and external perceptions can influence stock performance. Overall, the findings emphasize the need for companies to maintain robust operational strategies while being proactive in addressing sustainability issues to foster investor confidence and enhance market resilience.

3.3 Discussion: Changes in Corporate Carbon Disclosures

Following The Guardian's article, some organizations have become more careful when examining voluntary carbon offsets, although this increased caution might not be directly linked to the article.

In February, 2023, The Committee of Advertising Practice (CAP) and the Broadcast Committee of Advertising Practice (BCAP) in the United Kingdom have updated their advertising guidance to address the use of "carbon neutral" and "net zero claims" in

advertising[38]. These updates reflect the principles outlined in the Competition and Markets Authority's (CMA) guidance on environmental claims for goods and services. This move comes in response to consumer confusion and concerns regarding the meaning of such claims in advertising.

Back in 2021, the Advertising Standards Authority (ASA) conducted research on consumer understanding of "carbon neutral" and "net zero" claims in advertising. The key findings of this research indicated that was a lack of consensus on the meaning of these claims among consumers.

Consumers often believed that "carbon neutral" implied an absolute reduction in carbon emissions, leading to potential disappointment when offsetting was revealed. Claims related to air travel, energy, and automotive sectors attracted more attention, and transparency about offsetting and target dates was deemed essential. In response to these findings, CAP and BCAP advised advertisers to consider the following guidance: avoid unqualified carbon neutral, net zero, or similar claims, and provide information explaining the basis for such claims; clearly communicate whether emissions are actively being reduced or if claims are based on offsetting; and qualifying information should be prominently placed and easily accessible to consumers[39].

The Voluntary Carbon Markets Integrity Initiative (VCMI), a supervision entity created during the COP26 in 2021, released its final Claims Code of Practice in June, 2023. The document provides guidance for companies on the credible use of carbon credits in their climate commitments and associated claims.

The code focuses on ensuring that carbon credits contribute to additional greenhouse gas reductions or removals beyond existing actions. It introduces three tiers of claims: VCMI Silver, Gold, and Platinum, each requiring a proportionate purchase and retirement of high-quality carbon credits relative to a company's remaining emissions (VCMI, 2023). Companies must also comply with Foundational Criteria and obtain third-party assurance.

The document outlines comprehensive criteria for carbon-crediting programs, encompassing effective governance, emissions impact, and sustainable development. It emphasizes the need for transparent and accountable program governance, robust tracking of mitigation activities, and the provision of transparent information to the public. Additionally, the criteria stress the importance of ensuring the additionality and permanence of emission reductions, using conservative and scientific methods for quantification, and avoiding double counting. Furthermore, the document underscores the significance of adhering to social and environmental safeguards while contributing to the net-zero transition. It also encourages the prioritization of carbon removal projects to achieve net-zero emissions and advises companies to incorporate carbon dioxide removals into their carbon credit

[38]https://www.asa.org.uk/news/updated-environment-guidance-carbon-neutral-and-net-zero-claims-in-advertising.html

[39]https://www.theguardian.com/business/2023/mar/01/airline-green-adverts-banned-uk-lufthansa- asa

portfolios.

Following this trend, Gucci, the luxury goods company, has taken steps to align its environmental efforts with more rigorous standards[40]. Initially, the company set a goal to become carbon neutral back in 2018. Over time, Gucci's environmental strategy has evolved to encompass a "nature-positive" approach. This approach involves not only achieving carbon neutrality but also actively contributing to environmental conservation and regeneration efforts. Gucci is now focusing on initiatives such as protecting and restoring biodiversity, investing in regenerative agriculture practices, and providing support to local communities. In essence, the company has expanded its commitment beyond carbon neutrality to embrace a broader and more holistic approach to environmental sustainability and positive impact.

Even before The Guardian's article, easyJet has unveiled a "roadmap to net zero" emissions by 2050[41], which includes plans to stop offsetting carbon emissions by its planes. The airline previously signed a three-year contract in late 2019 to offset all its CO2 emissions, but changed the approach in order to achieve its net-zero goal through various other measures, including introducing hydrogen-powered jet engines, using sustainable aviation fuel, operating more fuel-efficient planes, and implementing carbon capture technology.

In light of recent developments, companies and institutions are showing increased vigilance in their actions and disclosures concerning carbon offsets. The tightening of scrutiny parameters on voluntary carbon offsets by various institutions reflects a growing awareness of the importance of transparent and credible climate claims.

4 Conclusion

This study underscores the importance of assessing the relationship between corporate voluntary carbon offsets and stock performance, an aspect that has remained relatively unexplored in existing literature. The nexus between sustainability initiatives and financial outcomes for companies has gained increasing attention in recent years, and understanding the implications of carbon offsetting on stock returns is crucial for investors, policymakers, and corporate decision-makers alike.

The staggered Difference-in-Differences (DID) approach demonstrates that engaging in carbon offset programs does not significantly affect stock returns across various sectors, including energy, airlines, and technology. While participation in such initiatives does not appear to hinder stock performance, it also fails to yield substantial positive effects.

Notably, in the energy sector, some firms show a slight negative trend following carbon

[40] https://www.reuters.com/sustainability/carbon-credit-market-confidence-ebbs-big-names-retreat-2023-09-01/

[41] https://corporate.easyjet.com/sustainability/net-zero-pathway/default.aspx

offset engagement, suggesting that increased operational costs may offset potential benefits from a valuation perspective. In contrast, technology companies exhibit a marginally positive trend in stock performance, indicating growing investor interest in sustainability practices, even though the overall impact remains statistically insignificant.

The lack of a significant relationship between net zero commitments and stock returns suggests that while these commitments may enhance corporate reputation and appeal to certain investors, they do not directly translate into measurable financial gains in the short to medium term. This is primarily compounded by macroeconomic factors, such as market volatility and broader economic conditions, which play a more dominant role in shaping stock returns. The findings highlight the need for companies to recognize the broader market dynamics at play and to manage their sustainability initiatives with a strategic focus that aligns with investor expectations and market trends.

In addition to the broader findings on carbon offset programs, the event studies provide insights into how specific incidents of negative media coverage can significantly influence stock performance, particularly in the context of Shell. Following the publication of critical reports regarding carbon strategies (Guardian, 2023), Shell experienced notable underperformance in its stock price a few days after the intervention, as reflected in the cumulative abnormal returns. This suggests that negative publicity can exacerbate existing investor concerns about a company's sustainability practices, potentially overshadowing any positive financial indicators, such as strong earnings reports.

Discussing the evolution of carbon practices disclosures, the evolving regulatory landscape surrounding carbon claims signifies a shift towards greater accountability and transparency in corporate sustainability efforts. The recent updates from the UK's Committee of Advertising Practice and the establishment of the Voluntary Carbon Markets Integrity Initiative (VCMI) underscore the importance of credible carbon accounting and the implications of carbon offset practices on corporate reputations. Companies like Gucci and easyJet are adapting their environmental strategies in response to these shifts, demonstrating a commitment to not just carbon neutrality but also broader environmental stewardship. As firms navigate this landscape, it will be essential for them to adopt transparent sustainability strategies that resonate with investors while fulfilling regulatory requirements.

However, it is essential to acknowledge the limitations of this research. The relatively small sample size of treated companies in the DID approach may have constrained the ability to detect statistically significant effects, and the study's findings should be interpreted with caution. Additionally, while the event studies provide valuable insights, it may not fully account for all confounding factors that could influence stock performance.

Looking ahead, further research in this domain holds promise. As the dataset expands with more companies participating in voluntary carbon offset markets, future studies may yield clearer and more statistically robust insights into the impact of carbon offsets on

stock performance. Additionally, exploring the evolving landscape of carbon claims and regulatory frameworks, as evidenced by updates in advertising guidelines and initiatives like VCMI, will be crucial. This field not only helps us understand how investors approach carbon offsets as a means of environmental responsibility, but also contributes to the development of a more robust and credible voluntary carbon market.

Bibliography

Allen, M., Axelsson, K., Caldecott, B., Hale, T., Hepburn, C., Hickey, C., ... Smith, S. (2020). The oxford principles for net zero aligned carbon offsetting. *The Oxford Principles for Net Zero Aligned Carbon Offsetting*.

Aswani, J., Aneesh, R., & Rajgopal, S. (2024). Are carbon emissions associated with stock returns? *Review of Finance*, *28*(1), 75–106.

Barnett, M., Brock, W., & Hansen, L. P. (2020). Pricing uncertainty induced by climate change. *The Review of Financial Studies*, *33*(3), 1024–1066. doi: 10.1093/rfs/hhz124

Beyer, B., Chaskel, R., Euler, S., Gassen, J., GROßKOPF, A.-K., & Sellhorn, T. (2023). How does carbon footprint information affect consumer choice? a field experiment. *Journal of Accounting Research*, *Fourthcoming*.

Bolton, P., & Kacperczyk, M. (2021). Do investors care about carbon risk? *Journal of Financial Economics*, *142*(2), 517-549.

Brown, S. J., & Warner, J. B. (1985). Using daily stock returns: The case of event studies. *Journal of Financial Economics*, *14*(1), 3-31.

Caldecott, B., Thomae, J., Mitchell, J., & Scott, M. (2022). How can net zero finance best drive positive impact in the real economy. *Discussion Paper, Finance Sector Expert Group for Race to Zero and Race to Resilience, United Nations*.

Callaway, B., & Sant'Anna, P. H. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, *225*(2), 200-230.

Engle III, R. F., Giglio, S., Kelly, B. T., Lee, H., & Stroebel, J. (2020). Hedging climate change news. *Review of Financial Studies*, *33*(3), 1184-1216.

Ernst, & Young. (2022). Essential, expensive and evolving: the outlook for carbon credits and offsets. *EY Net Zero Centre report*.

Fankhauser, S., Smith, S. M., Allen, M., Alexsson, K., Hale, T., Hepburn, C., ... Wetzer, T. (2022). The meaning of net zero and how to get it right. *Nature Climate Change*, *12*, 15-21.

Guardian. (2023). Revealed: more than 90 percent of rainforest carbon offsets by biggest certifier are worthless, analysis shows. *The Guardian*.

Guizar-Coutiño, A., Jones, J. P. G., Balmford, A., Carmenta, R., & Coomes, D. A. (2022). A global evaluation of the effectiveness of voluntary redd+ projects at reducing deforestation and degradation in the moist tropics. *Conservation Biology*, *36*(6).

Hart, S. L., & Ahuja, G. (2022). Does it pay to be green? an empirical examination of the relationship between emission reduction and firm performance. *Business Strategy and the Environment*, *5*(1), 30–37.

Heeb, F., Kölbel, J. F., Paetzold, F., & Zeisberger, S. (2023). Do investors care about impact? *The Review of Financial Studies*, *36*(5), 1737-1787.

Hong, H., Li, F. W., & Xu, J. (2019). Climate risks and market efficiency. *Journal of Econometrics*, *208*(1), 265-281.

Hyams, K., & Fawcett, T. (2013). The ethics of carbon offsetting. *Climate Change*, *4*.

Larcker, D. F., & Watts, E. M. (2020). Where´s the greenium? *Journal of Accounting and Economics*, *69*(2-3).

Liang, H., Sun, L., & Teo, M. (2022). Responsible hedge funds. *Review of Finance*, *26*(6), 1585–1633.

Liu, F., Kang, Y., Guo, K., & Sun, X. (2021). The relationship between air pollution, investor attention and stock prices: Evidence from new energy and polluting sectors. *Energy Policy*, *156*.

Lovell, H. C. (2010). Governing the carbon offset market. *Wiley Interdisciplinary Reviews: Climate Change*, *1*.

Lyon, T., & Maxwell, J. W. (1999). Voluntary approaches to environmental regulation: A survey. *in: Environmental Economics: Past, present and future*.

Matsumura, E. M., Prakash, R., & Vera-Muñoz, S. C. (2014). Firm-value effects of carbon emissions and carbon disclosures. *The Accounting Review*, *89*(2), 695-724.

Microsoft. (2023). Criteria for high-quality carbon dioxide removal.

Pastor, L., Stambaugh, R. F., & Taylor, L. A. (2022). Dissecting green returns. *Journal of Financial Economics*, *146*, 403–424.

Shive, S., & Forster, M. (2020). Corporate governance and pollution externalities of public and private firms. *The Review of Financial Studies*, *33*(3), 1296-1330.

UNFCCC. (2022). Taking stock of progress - september 2022: First joint progress report across un-backed global climate campaigns: Race to resilience and race to zero.

VCMI. (2023). Claims code of practice. *Voluntary Carbon Markets Integrity Initiative*.

Walley, N., & Whitehead, B. (1994). It's not easy being green. *Harvard Business Review*, *72*, 46-52.

West, T. A. P., Börner, J., Sills, E. O., & Kontoleon, A. (2020). Overstated carbon emission reductions from voluntary redd+ projects in the brazilian amazon. *Proceedings of the National Academy of Science*, *117*(39), 24188-24194.