

An Empirical Investigation of the Effects of The European Green Deal on the Financial Position and Emissions of STOXX Europe 600 Companies

VIVIENNE J. A. DOSOO*

JUSTUS J. KLOSE**

Master Thesis
Department of Finance
Stockholm School of Economics
Supervisor: Per Strömberg

May 13, 2024

Abstract

This study investigates the impact of the European Green Deal on the financial position and greenhouse gas emissions of European companies in the STOXX Europe 600 index. The main methodology applied in the paper is a triple difference-in-difference approach to isolate the effect of the European Green Deal for companies regulated by the European Emissions Trading System (EU ETS) with a higher-than-average debt-to-asset ratio. The results of this investigation show that the European Green Deal has led to a decline in profitability, total assets and investment for companies within the high-debt group. Scope 1 carbon emissions for this group increased after the European Green Deal relative to their low-debt peers. Overall, the results indicate that companies with higher debt levels did not reduce their emissions to the same degree as their low-debt peers while also being more adversely affected in terms of their financial performance.

Keywords: Carbon Pricing, Sustainability, Europe, Corporate Finance, Debt

We would like to thank our supervisor Per Strömberg for his support and guidance throughout our thesis.

*42494@student.hhs.se

**42495@student.hhs.se

Contents

1	Introduction	1
2	Literature Review and Hypotheses Development	3
2.1	Literature Review	3
2.1.1	Theory of Cap-and-Trade	3
2.1.2	The European Union Emissions Trading System	4
2.1.3	Corporate Finance Aspects of Carbon Prices	8
2.2	Hypotheses Development	11
3	Theory and Methodology	13
3.1	Sampling Data Collection and Data Cleaning	13
3.2	Descriptive Statistics and Statistical Data Quality	16
3.2.1	Descriptive Statistics by Year	16
3.2.2	Descriptive Statistics by Debt Level	19
3.2.3	Time Fixed Effects	21
3.2.4	Company Fixed Effects	22
3.2.5	Correlation Matrix for Logged Variables	22
3.2.6	Standard Errors	23
3.3	Research Design	25
3.4	Pre-Trends	27
3.4.1	Visual Pre-Trend Analysis	28
3.4.2	Statistical Pre-Trend Analysis	29
3.5	Research Limitations	31
3.5.1	Stable Unit Treatment Value Assumption (SUTVA)	32
4	Results	33
4.1	Hypothesis 1	33
4.2	Hypothesis 2	38
4.3	Hypothesis 3	41
5	Discussion	43
6	Conclusion	45
7	Sources and References	46
8	Appendix I	49
9	Appendix II	50

1 Introduction

The European Union Emissions Trading System (EU ETS) is the largest global cap-and-trade system for carbon and carbon equivalent emissions certificates. At any time up to 80% of global emissions certificate trading volume can be accounted for by the EU ETS (European Commission, 2024). The scheme was introduced in 2004 and worked primarily through the allocation of free allowances to a limited number of sectors. Since then, the EU ETS has expanded to cover more sectors and greenhouse gases. The ambition of the European Commission is to cover more than 75% of European emissions by the mid-2020s (European Commission, 2021).

In 2021, the European Commission adopted a variety of proposals to reduce emissions by 55% relative to 1990 by 2030. The proposals included increasing the rate of reduction of certificates available each year from 1.7% to 2.2%, eliminating the ability to use new emissions certificates to cover pre-2021 emissions as well as expanding coverage to account for emissions from smaller installations and eliminating access to non-European carbon certificates for installation emissions (European Commission, 2021).

The legislation was based on the European Green Deal, a policy goal announced by Commission president Ursula von der Leyen in 2020. In financial and political media, the European Green Deal was hailed as the most ambitious climate legislation ever introduced at an international scale, while it was also criticised by many climate activists as not having enough teeth to drive forward real positive climate outcomes (Wolf et al., 2021). As a result of the European Green Deal, carbon prices in the EU ETS increased from below EUR 20 to more than EUR 80 between 2020 and 2023 with prices reaching as high as EUR 100 (World Bank, 2023).

The goal of this master thesis is to analyse the European Green Deal from both a corporate finance and emissions perspective. The significantly higher financial burden from higher carbon prices and the more stringent regulation regarding how certificates can be used have likely had a much more far-reaching effect on companies than the phases of the EU ETS prior to the Green Deal (Wolf et al., 2021). We aim to understand how this increased burden on company financials has affected company profitability, balance sheets and carbon emissions. We are particularly interested in identifying whether companies with higher debt levels were affected differently compared to their peers with lower debt levels. The rationale behind this

distinction is that companies with higher debt levels should find it harder to access external capital due to their increased credit risk, whereby banks do not want to provide further credit lines out of fear that companies could default on their interest payments. As such, companies with higher debt levels would have less means to invest in more energy-efficient production processes and technologies to mitigate the effect of higher carbon prices. Consequently, high-debt companies should struggle to mitigate the financial impacts of the European Green Deal, leading to both worse financial performances and lower reductions in carbon emissions.

In order to establish causality, we use a triple difference-in-difference approach assigning treatment to companies that are in the EU ETS and have higher-than-average debt levels before and after the European Green Deal. The logic behind is that company debt levels are a financial company characteristic that can impact company policy and financials in relation to a carbon price shock through a variety of channels. For instance, company debt reduces the ability of companies to acquire further external funding which may be necessary to finance capital expenditures used to replace older production technologies with more energy-efficient alternatives (i.a.: Bartram et al., 2018). The companies in our sample that are regulated by the European Emissions Trading Scheme account for between 33% and 40% of total annual European carbon emissions in any given year during the sample period (Wood, 2023).

Our results indicate that high-debt companies experience decreases in profits, revenues and the size of their balance sheets. For instance, high-debt companies saw 0.346 and 0.254 log point reductions in net income and capital expenditure after the European Green Deal. Moreover, high-debt companies increased their Scope 1 CO₂ emissions by 0.21% relative to low-debt companies, because of the European Green Deal.

From a public policy perspective, our results indicate the need to take company debt levels into account when allocating public funding tied to emissions reductions targets. Without additional external funding, high debt companies will likely experience reductions in profitability and operating capacity without effectively investing in technologies that allow for emissions reductions.

This thesis adds to the current literature by focusing on the corporate finance effect of European climate policy rather than on risk factors and company returns like most other papers in the field (Ramos-Garcia, 2023). Moreover, the European Green Deal and its related policy have not yet been explored in detail through an empirical evaluation of its financial effects.

2 Literature Review and Hypotheses Development

This section will first provide an overview of the theory which underlies the rationale for the setup of a European Emissions Trading Scheme. Finally, the section will describe the four primary hypotheses which are based on the preceding literature review. The hypotheses focus on a variety of key financial variables as well as Scope 1 emissions to evaluate both the impact of company debt and the European Green Deal on company financial and climate performance.

2.1 Literature Review

The literature review introduces the theory of cap-and-trade and the EU ETS. Next, the section will summarise the previous empirical finance literature on the effects and effectiveness of the EU ETS. Lastly, the review will highlight the current state of literature surrounding carbon pricing and its effect on corporations.

2.1.1 Theory of Cap-and-Trade

In the absence of government intervention, carbon emission's negative effect on the global climate is an important externality (Weitzman, 1974). Externalities exist when the costs and benefits related to an economic transaction do not fully accrue to the parties relevant in a transaction (Goulder and Schein, 2013). For carbon emissions specifically, producers of emissions-intensive products only cover the costs of their production inputs, such as the raw materials, machinery and services related to the production, development and delivery of the product. The additional cost to society that results from the emissions created during the production process do not financially accrue to the seller.

A cap-and-trade system aims to eliminate this negative externality by forcing producers to pay a price for their emissions. This is done through a "cap", i.e. setting a maximum number of emissions that can be emitted in a certain jurisdiction during a specified period, usually one year. The cap is typically enforced through the allocation or auction of certificates that allow the certificate's owner to emit a specified amount of carbon, or carbon equivalents during the relevant period. When a company needs to emit greenhouse gases during its production process, it must bid for certificates in the auction or acquire more certificates from other regulated companies in a secondary emissions certificates market (Goulder and Schein, 2013).

Diversity across firm characteristics, such as production technologies and processes, means that firms have different marginal costs of emissions abatement (MAC), which leads to varying costs of reducing emissions in production across firms. Companies with a low MAC will prefer

to reduce their emissions using investment in cleaner technologies or more efficient production processes while in the short term it may be more cost efficient for companies with high MACs to buy emissions certificates. These differences should produce an efficient carbon price where companies that can reduce their emissions cheaply will do so. Moreover, the proceeds raised in the auction from the high-MAC companies can be used to fund public projects which reduce emissions. Examples of these projects include investing in more sustainable public infrastructure or funding incentive programmes that help fund clean innovation or aid high-MAC companies subject to abatement requirements in their green transition (Goulder and Schein, 2013).

A cap-and-trade system is also in line with Weitzman's (1974) theory of regulation in which Martin Weitzman shows that regulation that imposes a price on an externality rather than imposing technologies or other practical restrictions is the most efficient regulatory pathway to achieving policy goals. According to Weitzman, pricing the externality is more efficient because price-based regulation can best account for company heterogeneity and because the regulator cannot foresee and take into account all possible future pathways. At the same time, pricing the externality allows companies to remain open to new technologies and innovations or to finding more efficient pathways to achieving a policy goal than might have otherwise been suggested by the regulator.

Overall, a cap-and-trade system has three main policy objectives: firstly, to incentivise corporate reductions in carbon emissions by putting a price on greenhouse gases (GHG); secondly, to spur innovation by making the search for cleaner production technologies more profitable; thirdly, to raise revenue for the state through the auctioning of carbon certificates.

2.1.2 The European Union Emissions Trading System

The EU ETS is the cornerstone of the EU's policy to combat climate change and a key tool for reducing greenhouse gas emissions cost-effectively. It is the first large greenhouse gas emissions trading scheme in the world and remains the biggest one to date (Council of the European Union, 2024). The EU ETS currently covers approximately 10,000 companies in energy-intensive sectors such as steel and cement production, in electricity and heat generation and in commercial aviation. Overall, the EU ETS currently covers around 40% of EU emissions.

The EU ETS has operated in phases, each with distinct characteristics, goals, and regulations. Initially, the rationale for structuring the EU ETS in phases was to avoid an

outsized economic shock moving from almost no financial penalty for emissions to a high financial burden for emitting companies.

Phase I (2005-2007):

The first phase of the EU ETS primarily acted as a trial run to evaluate the feasibility of a European-wide emissions trading scheme (European Commission, no date). The focus was primarily on the power and industrials sectors with certificates being allocated for free, based on historical emissions data. After the allocated certificates were used up, companies had to trade for more emissions rights with companies that had a certificate surplus. However, an overallocation of certificates led to a collapse in the European carbon price, rendering the system effectively inefficient, even though the scheme covered around 45% of Europe-wide production emissions (De Clara and Mayr, 2018).

Phase II (2008-2012):

The second phase expanded the coverage of the EU ETS to more industrial chemicals that influence global temperatures, such as nitrous oxide (European Commission, no date). Certificates were still allocated for free but the number of certificates per company was more restricted and allocation rules were harmonized across member states. In the previous phase, divergent allocation algorithms across member states led the effectiveness of the scheme to differ considerably across the Union. While the carbon price initially increased, the onset of the global financial crisis led to a reduction in industrial output and a concomitant reduction in the demand for allowances resulting in a drop of the carbon price back to Phase I levels (European Commission, no date). The linear reduction factor of GHG emissions was 1.74% during phase two of the EU ETS. Essentially, this means that emissions allowances per companies were reduced by 1.74% per year relative to the initial allowance (European Commission, no date).

Phase III (2013-2020):

In the third phase, free allowances were replaced by auctions as the primary mechanism of allocating emission allowances. Moreover, the EU ETS was extended to cover more industries, including the European aviation sector. The move from a primarily allowance-based to an auction-based approach led to several periods of increased carbon prices. However, the system still suffered from an excessive availability of certificates and thus failed to significantly impact the production choices of a meaningful number of companies (Lynch et al., 2023).

Phase IV (2020-2030):

Phase IV of the EU ETS was part of the “Fit for 55” package which acts as an implementation strategy of the EU Green Deal. The EU Green Deal is the European Union’s transition and sustainability strategy announced by the European Commission in December 2019. The key target of the strategy is to make Europe the first climate-neutral continent by 2050. The EU Green Deal encompasses economic, ecological and social aspects which together should lead Europe towards a sustainable future (European Commission, 2019).

The “Fit for 55” package includes proposals which target a 55% net GHG emissions reduction compared to 1990 levels until 2030. Among the proposals was the EU ETS reform, first proposed in 2021 and adopted in April 2023. The reform increased the linear reduction factor from at 2.2% to 4.4% per year, extended the ETS to the maritime shipping sector and laid the foundations for the creation of a separate ETS (ETS2) for fuel combustion emissions from sectors such as construction or road transport (Appunn & Wettengel, 2024). The reform also addressed the issue of carbon leakage by introducing a carbon border adjustment mechanism (CBAM), which penalizes the import of energy-intensive products into the EU (European Commission, n.d.). Phase III further increased coverage to include a variety of other greenhouse gases and a second reduction in the number of certificates allocated or auctioned off and introduced performance benchmark requirements for companies who still received free allocations to induce production technology changes. The carbon pricing mechanism was complemented by several EU institutions, such as the Innovation Fund and the Modernization Fund which were aimed at providing companies with financial support for investments in more carbon-efficient technologies (European Commission, 2021). While the jury on the effectiveness of these programmes is still out, the 4.4% linear reduction target set by the European Commission is very ambitious and will significantly continue to affect companies operating within the EU.

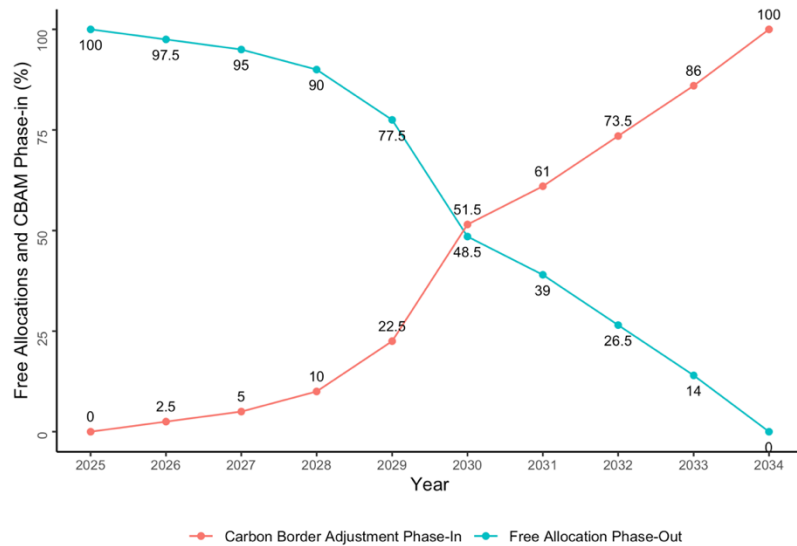


Figure 1 EU ETS Free Allowances Phase-Out and CBAM Phase-In.

Note. Adapted from *International Carbon Action Partnership*, 2023 (<https://icapcarbonaction.com/en/news/eu-adopts-landmark-ets-reforms-and-new-policies-meet-2030-target>).

In light of the introduction of the ambitious “Fit for 55” package, the exact effects on carbon prices are uncertain. However, literature agrees on a relatively steep increase of carbon prices within the next ten years. While the average auction carbon price in 2023 was EUR 83.24 for example, Pietzcker, Osorio and Rodrigues (2021) estimate that the 55% EU emission reduction target will require a 200% increase of carbon prices of carbon prices by 2040. Le Guendal (2022) analysed carbon projections according to different Intergovernmental Panel on Climate Change (IPPC) scenarios and found that a 1.5-degree pathway, in line with the EU’s climate target, requires an 800% increase of carbon prices by 2060.

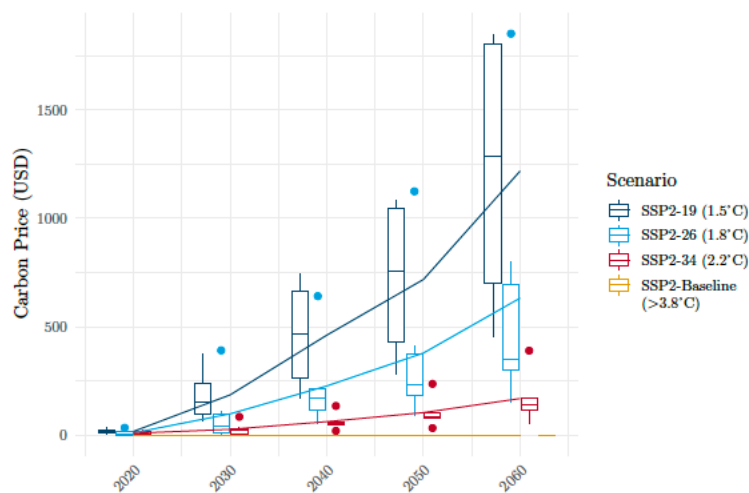


Figure 2 Long-term carbon price scenarios.

Note. From “Financial Modelling of Climate-related Risks,” by T. Le Guendal, 2022, *Thèse de doctorat de l’Institut Polytechnique de Paris préparée à École nationale de la statistique et de l’administration économique*, p. 68.

According to Ugolini, Reboredo and Ojea-Ferreiro (2024) changes in policy, technology and market dynamics such as those brought about by the EU ETS can cause a climate transition risk for businesses and investors. Transition risk refers to the financial challenges companies and investors may face as regulatory changes alter consumer preferences, increase cost of production through carbon prices or render old practices obsolete, causing stranded assets. Collectively, these factors may have an impact on investment choices, market dynamics, and the financial stability of businesses unprepared for the green transition. Ugolini et al. (2024) study Credit Default Swap (CDS) spreads using a measure of company value exposure to the cost of carbon externality and find that vulnerable EU companies, i.e. with high emission levels, are disproportionately affected by transition risk and consequently have higher cost of capital and higher credit risk.

2.1.3 Corporate Finance Aspects of Carbon Prices

Over the course of the last five years, the European carbon price has significantly decoupled from the carbon prices established by other emissions trading schemes around the globe (World Bank, 2023). While most emissions trading systems have hovered between zero and twenty US dollars per ton of carbon, the European carbon price has risen to around USD 100 since the European Green Deal and the concomitant introduction of Phase IV of the EU ETS. This development post-2020 provides an interesting ground for the analysis of the effects of higher carbon prices on the financial positions of companies that are regulated by an emissions trading scheme.

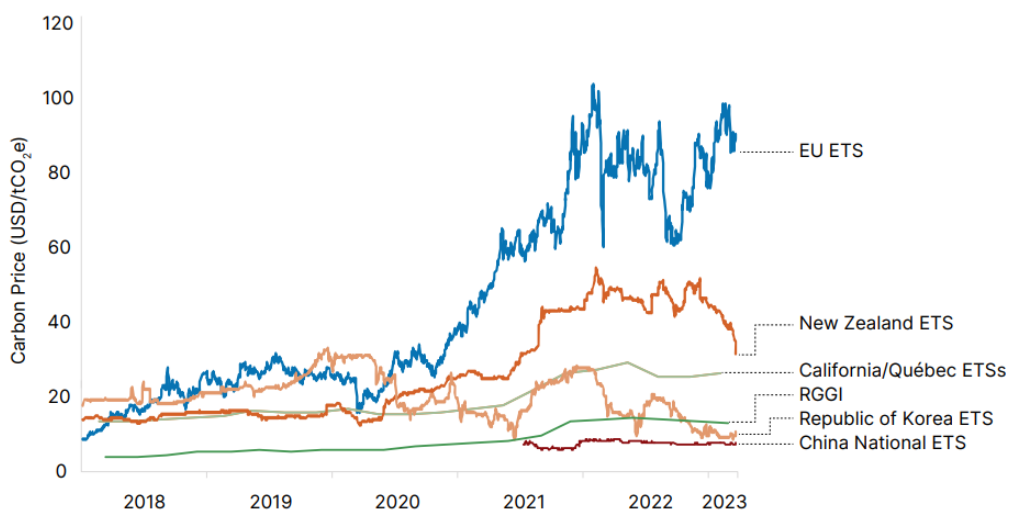


Figure 3 Carbon Prices in Global Emission Trading Systems.

Note. Based on data from ICAP Allowance Price Explorer. Prices for the RGGI initiative and for the California and Québec CaT from the primary market whereas for the other systems the prices reflect.

From a modelling perspective, there are three main types of econometrics methods commonly used in academia to infer the effects of carbon prices on the financial performance and positions of companies. The first method is high frequency identification (Känzig and Konradt, 2023). This method uses surprise company announcements to track the immediate effects on asset prices.

The second method commonly employed in literature is a control-based identification of the effects of carbon prices. Känzig and Konradt (2023) find for instance that carbon prices are driven by a factor of past economic and financial data that is orthogonal to the macroeconomic component which drives asset prices and financial data. This allowed the authors to quantitatively identify effects of carbon prices that are not correlated to other financial indicators.

Finally, the most frequently employed econometric method consists of a variety of panel data approaches. Examples of this include Känzig and Konradt (2023) who use a yearly panel of European countries to compare the effects of carbon taxes and carbon prices across the continent. They found carbon prices to be effective at reducing emissions since their EU-wide implementation reduces the risks of carbon leakage. In other words, when a block of countries adopts a policy that incentivises emissions reductions it is harder for companies to move emissions abroad by changing suppliers or shifting imports to nearby countries with a laxer climate regulation. The authors conclude that carbon pricing at a multi-country level is an effective way to incentivise corporate decarbonisation.

Many studies that investigate the impact of carbon prices on company choices, financial positions or production technologies rely on company-level panel data to evaluate the effects that policies had over a specified time horizon. Martinsson et al. (2023) for instance use a panel of Swedish companies to investigate how Swedish companies reacted to the introduction of a carbon tax in Sweden. They estimate carbon price elasticities defined as the change in CO₂ emissions in response to a change in the marginal cost of emitting CO₂. The authors identify an economically significant negative relationship between the cost of emitting CO₂ and the amount of CO₂ emitted by manufacturing companies. Furthermore, the authors find significant sectoral heterogeneity with the highest emitters and that companies with high abatement costs have much lower emissions elasticities than other companies. This means that the highest emitters, on average, reduce their emissions intensities less for every unit increase in the cost of carbon.

In a similar approach, Colmer et al. (2020) use a Difference-in-Difference approach to find that the EU ETS has reduced emissions around 8% to 12% for companies that are regulated versus unregulated companies. They examine the changes in a variety of outcome variables, such as emissions intensities, and compare how they change for regulated companies relative to unregulated companies during pre-policy announcement, during the announcement phase and finally once the policy has been implemented. The authors further found that companies that were regulated tended to reduce their emissions by updating their capital stock. This means that companies reduced emissions by switching to more carbon-efficient production technologies.

Apart from the effect that the EU ETS has had on emissions, research has also looked at how the financial positions of companies have been affected by the inclusion in the European carbon pricing mechanism. Lambertides and Tsouknidis (2023) focus on the effect of carbon prices on the probability of default of regulated companies across the phases of the EU ETS using the Merton (1973) credit risk approach. Analysing these metrics in a difference-in-difference regression they find that regulated companies had a 0.3% higher default probability after the start of Phase III of the EU ETS than non-regulated companies. This result shows that carbon prices were becoming more effective only once the EU started to reduce the number of certificate allocations and started to auction off certificates in the carbon market.

Martin et al. (2014) find that companies tend not to relocate in response to higher carbon prices. This result is promising for advocates of the effectiveness of carbon pricing policies, as the result indicates that the risk of carbon leakage is non-existent or at least relatively small compared to previous uncertainties about companies leaving the carbon-pricing jurisdiction to emit in other parts of the world.

Finally, some papers also evaluate the impact of cap-and-trade systems on companies with differing financial capacity. Bartram and Kim (2021) look at how the state-wide cap-and-trade system in California affected financially constrained and financially unconstrained companies. They found that companies that were more financially constrained, as measured by debt-to-asset ratios, are more likely to move their emissions to states that do not have a cap-and-trade system. Companies that were more financially constrained tend to have excess capacity in their production sites across the US, allowing them to adjust production volumes without having to employ additional capital expenditure. As a result, financially constrained companies can shift production from California to other states without emissions trading systems. Financially constrained companies strictly increased their emissions company-wide. The authors

emphasise the importance of internationally coordinated environmental policy to respond to multinational corporations' ability to shift production strategically to jurisdictions with more favourable climate regulations.

2.2 Hypotheses Development

The introduction of the European Green Deal is believed to represent a pivotal change in European climate policy. While the EU strives to be a forerunner in terms of climate change mitigation, the effects of the tightening of controls has not yet been investigated in detail. This thesis examines the financial and operational implications of policy tightening related to the "Fit for 55" package on European companies.

Our hypotheses address on five key areas: profitability, capital expenditure, asset and liability management, GHG emissions and financial stability, focusing on different strategic responses of companies with different debt burdens to the costs of carbon emissions.

H1. The profits and profitability of high-debt companies that are part of the EU ETS should decline after the European Green Deal.

The five-fold increase in carbon prices will affect all companies that are regulated by the European emissions trading scheme. As such, profitability and profits for all companies that must purchase emissions certificates should decline after the European Green Deal. Companies with higher debt levels should have a harder time adjusting their production technologies since access to capital should be more restrictive for high-debt companies (Caragano et al., 2020).

H2. Capital expenditure and total assets for high-debt companies that are part of the EU ETS should decline after the European Green Deal.

With company profitability decreasing because of the European Green Deal and the concomitant increase in carbon prices, companies with higher debt should find it more difficult to finance their capital expenditure in general and to invest in more sustainable alternative technologies. Moreover, since companies with high debt levels tend to have higher capital expenditure than low-debt companies. High-debt companies have a greater need for ongoing capital expenditures to continue to run their current operations.

Lower capital expenditures for high-debt companies should also lead to a decrease in the total assets of high-debt companies. Furthermore, the lower expected profitability should lead

to a lower debt capacity due to potential debt covenants and a lower willingness of banks and fixed income investors to refinance company debt (Ramos-Garcia, 2023).

H3. Scope 1 emissions and emissions intensities should decline for low-debt companies and increase for high-debt companies after the European Green Deal, that are part of the EU ETS.

Higher emission prices should incentivise all EU ETS companies to reduce their exposure to emissions-intensive technologies (Ramos-Garcia, 2023). Higher factor prices for high-emissions production technologies should come through two channels. Firstly, higher carbon prices should incentivise companies to substitute high-emissions production processes with low emissions technologies. Secondly, high-debt companies that do not have the spending capacity to pivot their production may be forced to outright reduce their production volume for high-emissions products in the long term (Wang et al., 2022). In the short term, emissions may go up relative to low-debt companies due to increased investment in carbon abatement from low-debt companies.

Emissions intensities for high-debt companies should increase relative to low-debt companies. Company revenues and net income are hypothesised to decrease (H1) while Scope 1 emissions should not fall as quickly per unit of revenues as for low-debt companies. This is again due to the lower capacity of high-debt companies to use capital expenditures (H2) or retained earnings (H1) to finance abatement technologies.

3 Theory and Methodology

In line with the most commonly applied methodology to study the effect of carbon prices in academia, this study uses a deductive approach to empirically investigate the impact of the EU ETS on company financial stability, profitability, investment spending and emission levels. Our analysis is grounded in a quantitative framework, employing Difference-in-Differences (DiD) analysis which allows to isolate the effect of the policy intervention on financial indicators.

3.1 Sampling Data Collection and Data Cleaning

All company financial data and emissions data were retrieved from Thomson Reuter’s Eikon Refinitiv. Our sample comprises all 600 *STOXX Europe 600* constituents and the sample period is the timeframe from December 2017 to December 2023. All data are denominated in Euros. To keep with a convention prominent in related papers, i.e., Lambertides and Tsouknides (2023), financial companies and Real Estate Investment Trusts (REITs) were excluded in the final sample. The remaining dataset comprises 467 companies.

For each of the 467 companies we obtained the following annual financial data: Short-Term Debt, Long-Term Debt, Total Assets, Market Capitalisation, Net Income, Return on Assets, EBITDA Margin, Enterprise Value and Capital Expenditure. Moreover, we obtained direct GHG emissions data, i.e. Scope 1 emissions from Eikon. We excluded Scope 2 and 3 emissions in order to avoid double counting of emissions. Our panel dataset was further reduced to 454 companies since 13 companies did not report Scope 1 emissions for any of the fiscal years from 2017 to 2023. Furthermore, we obtained information on participation in the EU ETS, the Full-time Equivalent (FTE), the Country of Headquarters and the Industry for each company. Refer to Table 1 for an overview of the panel dataset.

Observations (N)	Timeframe	Companies	Countries	Industries (GICS)	Average Company Size	Average ETS Participants
3269	2017-2023	454	19	59	44,788	91

Table 1 Panel Data Overview

Because of restricted data availability on Eikon we collected fiscal year data rather than calendar year data. As such, 2023 corresponds to $t = 3$ until 2017 which corresponds to $t = -3$. Our dataset comprises 3269 observations over the timeframe from 2017 to 2023. Companies are incorporated in 19 different countries, belong to 59 different Global Industry Classification Standard (GICS) specifications and have an average size of a 44,7788 full-time equivalent.

Over the timeframe from 2017 to 2023, the annual average of companies participating in the EU ETS was 91, corresponding to 20% of our sample. A detailed description of the sample is presented in Appendix I.

After merging our data several financial and environmental metrics were calculated:

- **Emission Intensity:** Calculated as Scope 1 emissions divided by revenue, providing a comparable measure of emissions relative to economic output.
- **EBITDA:** Calculated by multiplying EBITDA margin by revenue to derive the absolute EBITDA value.
- **Debt to Assets Ratio:** Calculated as the sum of long-term debt and short-term debt divided by total assets, providing a leverage metric.
- **After Green Deal Indicator:** A binary variable indicating fiscal years before and after the introduction of the EU Green Deal. The period from 2020 to 2023, or from $t = 0$ to $t = 3$, corresponds to the post Green Deal period. Since the EU Green Deal was announced in December 2019 and negotiated within the EU during the entirety of 2020, and the 55% reduction target was announced in 2020, phase IV of the EU ETS starts in 2020. Accordingly, we use 2020 as $t = 0$, even though the “Fit for 55” strategy are a work-in-progress and new measures are gradually proposed and agreed since 2021 until today (Council of The European Union, 2024) .

The gathered data were scrutinised for missing data and outliers. All data manipulation and statistical tests were conducted with the software R. To reduce the impact of outliers, the data were transformed to logarithmic data. Logarithmic transformation was chosen as treatment rather than the removal of outliers to avoid losing valuable information because of our relatively small dataset. Logarithmic transformation also appears appropriate firstly because of the highly skewed nature of financial ratios, i.e. Return on Assets, EBITDA Margin, secondly because of extreme values for emissions data due to few high emitters, and lastly because of potential for tail monetary values, i.e. Short-Term Debt, Long-Term Debt, Total Assets, Market Capitalisation, Enterprise Value, Capital Expenditure, due to company size. Because some of our observations include zero or are close to zero logarithmic transformation was done the formula $\ln(1 + x)$ for all datapoints but for the dummy variables. Refer to Table 2 for a summary of the dataset.

Variable	N	Mean	Median	Std. Dev.	Skew	Kurt	Min	Q1	Q3	Max
Short-term Debt	3084	19.29	19.64	3.46	-3.04	17.94	0.00	18.31	21.03	26.16
Long-term Debt	3155	21.13	21.45	2.75	-3.33	25.11	0.00	20.18	22.58	26.53
Total Liabilities	3199	22.65	22.48	1.93	0.27	3.32	16.54	21.38	23.89	28.58
Debt to Assets	3061	0.25	0.24	0.15	0.47	3.07	0.00	0.14	0.35	0.92
Total Assets	3199	23.22	23.04	1.72	0.30	3.33	17.38	22.10	24.33	28.64
Enterprise Value	3110	23.25	23.08	1.21	0.39	2.96	19.03	22.39	24.01	26.79
Market Capitalisation	3163	23.01	22.87	1.13	0.44	3.12	19.38	22.21	23.74	26.72
CapEx Spending	3165	19.33	19.35	1.78	-0.65	7.52	0.00	18.31	20.44	24.00
Net Income	3006	20.10	19.97	1.35	0.085	3.38	13.94	19.22	20.96	24.32
Revenue	3226	22.29	22.26	1.55	-0.22	3.07	15.44	21.35	23.44	26.60
EBITDA	3127	20.74	20.64	1.40	0.17	3.14	14.15	19.79	21.65	25.01
EBITDA Margin	3191	0.22	0.19	0.16	0.76	15.08	-1.11	0.12	0.30	2.22
Return on Assets	2881	0.058	0.05	0.084	2.55	76.50	-1.10	0.024	0.082	1.23
Full-time Equivalent	2394	9.48	9.63	1.84	-0.81	4.74	0.00	8.47	10.83	13.42
EU ETS	3045	0.21	0.00	0.41	1.40	2.97	0.00	0.00	0.00	1.00
Scope 1 Emissions	2748	10.72	10.66	3.32	-0.11	3.28	0.00	8.66	12.69	19.01
Emission Intensity	2743	0.00016	0.0000075	0.00063	7.74	77.92	-0.00000039	0.0000015	0.000035	0.0098

Table 2 Summary Statistics Panel Data After Logarithmic Transformation. Sample Period 2017 – 2023.

3.2 Descriptive Statistics and Statistical Data Quality

This section summarises the changes in our variables of interest throughout the sampling period and highlights how company characteristics differ between the treated and untreated groups of companies.

3.2.1 Descriptive Statistics by Year

The sub-section examines how our variables of interest have changed from year to year through our sample period. To do so, the data is presented as several times series showing the average values among all sample companies throughout the sampling period from 2017 to 2023.

EU ETS Data:

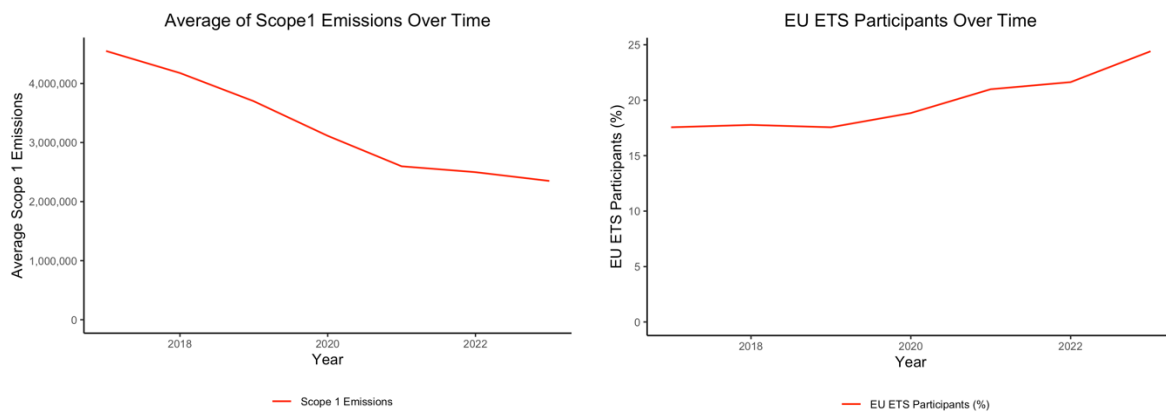


Figure 4 Descriptive Statistics by Year – Average EU ETS Data Over the Sample Period

Throughout the sampling period Scope 1 emissions declined by almost 50% from 4,500,000 tons for the average company to just under 2,500,000 tons. Various papers such as Rodriguez-Sanchez et al. (2022) have hypothesised that this steep decline is the result of the Coronavirus pandemic and the economic downturn that was experienced by most European economies due to the invasion of Ukraine by Russian forces as well as the high inflationary period following the end of coronavirus restrictions across the continent (Mardani et al., 2019). EU ETS membership increased from 17% to 25%.

Key Financial Data:

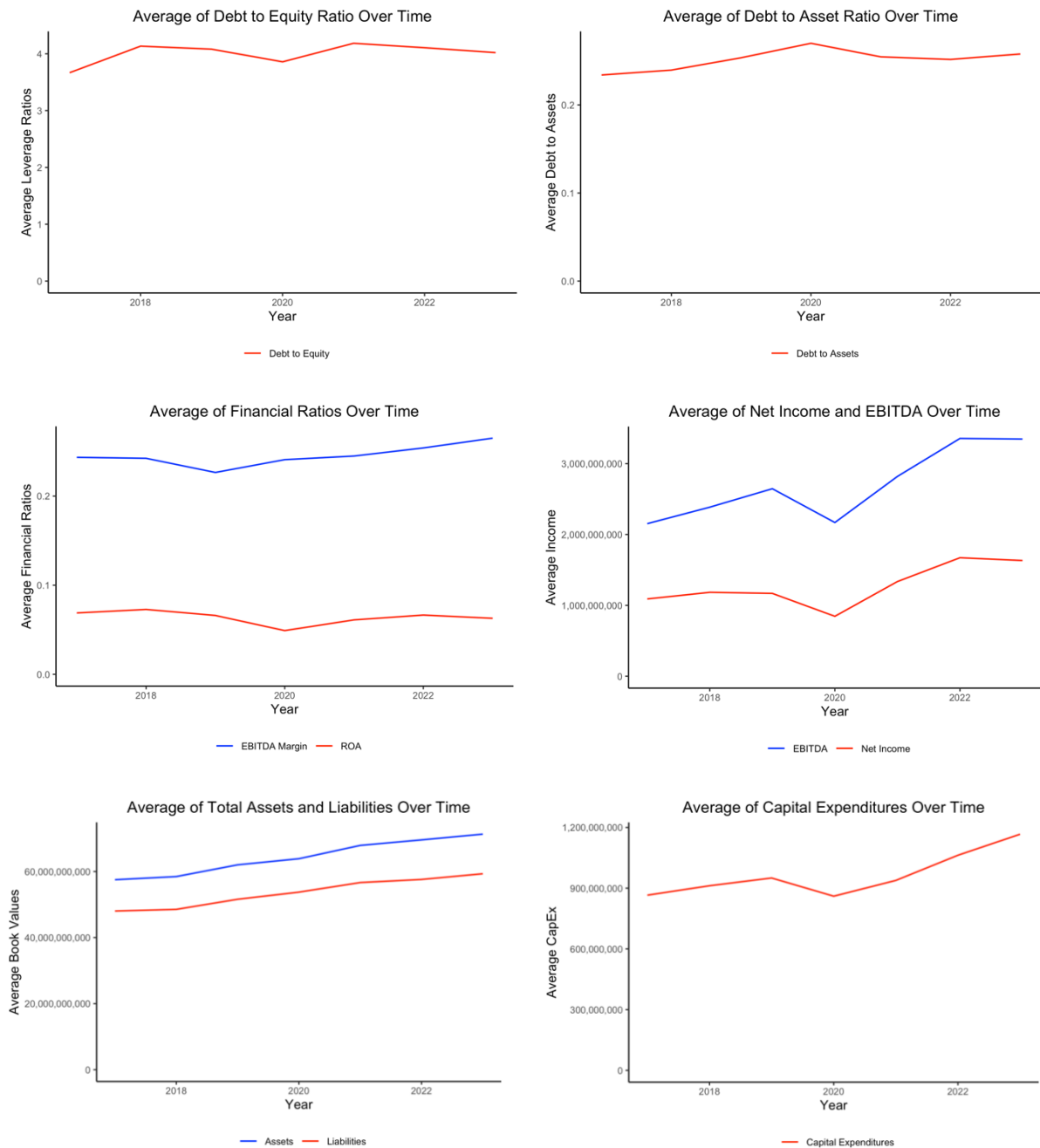


Figure 5 Descriptive Statistics by Year – Average Financial Data Over the Sample Period

Total assets and liabilities remained on a slow but relatively steady upward trend throughout the sampling period, even throughout the Covid-19 pandemic. Both, total assets and liabilities, grew at a CAGR of approximately 17%. EBITDA, net income and capital expenditure on the other hand experienced a drop during the Covid-19 pandemic but recovered to their pre-covid trends around 2021. EBITDA dropped around 19% while net income and capital expenditures dropped by 28% and 9% respectively. All three variables recovered to pre-covid levels by the

end of the sampling period with annual average growth rates of 22%, 24% and 18% for EBITDA, net income and capital expenditures respectively.

In terms of financial ratios, the relatively stable growth of most STOXX Europe 600 companies throughout the pandemic is reflected in our financial ratios of interest. Both the EBITDA margin and the return on assets stayed relatively constant throughout the period with only small dips during the Covid pandemic. With regard to leverage ratios, we can observe a relatively small initial increase in the average debt-to-equity ratio from 2017 to 2018. Debt-to-equity averages subsequently stayed relatively stable with a small decrease during the Covid Pandemic in 2020. The debt-to-asset ratios, on average, also stayed relatively constant with a small uptick during the pandemic and a subsequent decline.

Overall, the average data shows several stable trends with small dips during the pandemic but no particularly notable results. However, the dataset displays a considerable amount of variance with the standard deviation of the dataset's variables varying between 0.5 and 4.5 times the actual mean of the same data.

3.2.2 Descriptive Statistics by Debt Level

This sub-section describes the averages for our variables of interest split by companies with higher-than-average and lower-than-average ratios of debt to assets and split by pre- and post-Green Deal levels.

EU ETS Data:

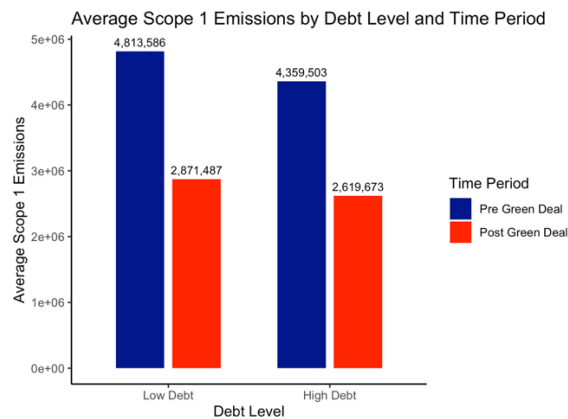


Figure 6 Descriptive Statistics by Debt Level – Average Scope 1 Emission by Time Period

In our sample, both low-debt and high-debt companies are in the EU ETS approximately equally with both type of company having a 22% likelihood of being represented in the EU ETS. However, low-debt companies have Scope 1 emissions that are around 15% higher than their counterparts which are more indebted. The trend for both high- and low-debt groups is decreasing with an average emissions reduction compared to Pre-Green Deal levels of 34.9% for low-debt companies and an average reduction of 38.3% for high-debt companies.

Key Financial Information:

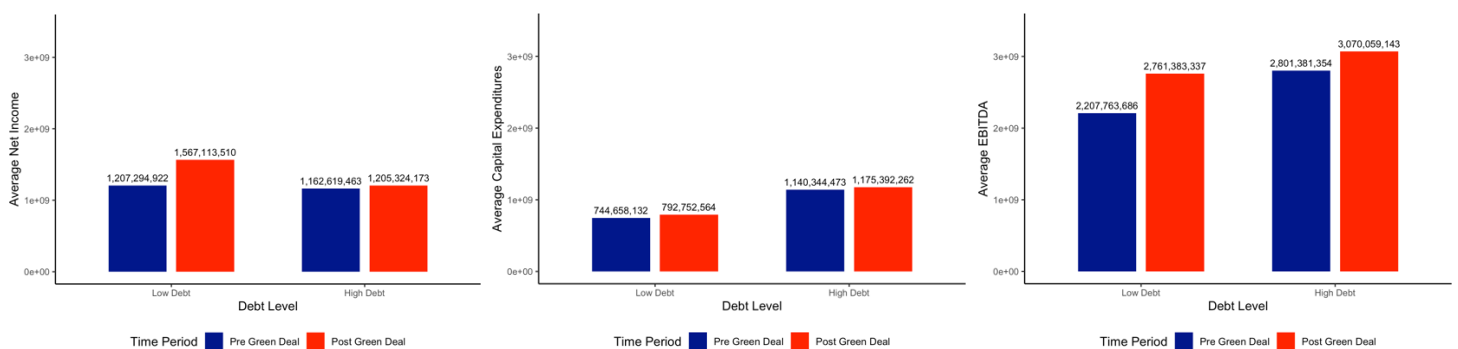


Figure 7 Descriptive Statistics by Debt Level – Average Key Financial Figures by Time Period

While low- and high-debt companies are almost evenly matched in terms of net income, high-debt companies have higher EBITDA values and spend approximately 67% more on new capital investments. Comparing pre- to post-Green Deal levels it is observable that on average low-debt companies see a larger increase in their profitability, that is in their net income and

EBITDA figures, than their high-debt counterparts. Average capital expenditures remain relatively stable for both groups after the EU Green Deal. This is unsurprising as such companies likely use debt to finance the acquisitions of new assets.

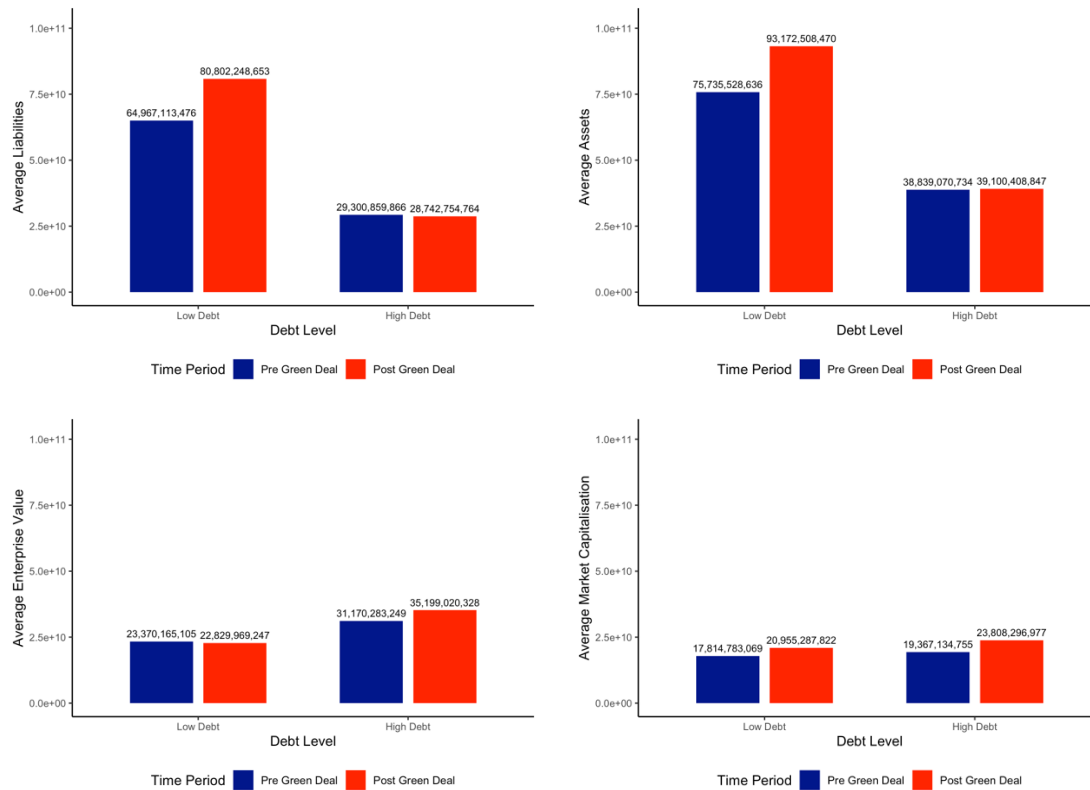


Figure 8 Descriptive Statistics by Debt Level – Average Market and Book Values by Time Period

Low-debt companies however have around 2.5 times the amount of assets and liabilities that high-debt companies hold. While debt and asset levels remained stable for high-debt companies post-Green Deal, low debt companies saw a 24.4% increase in their average debt levels and a 23% increase in their average asset levels indicating that low-debt companies grew considerably in size. Further, high-debt companies have more a significantly higher enterprise value as well as a slightly higher market capitalisation. While enterprise values remained relatively stable for low-debt companies, high-debt companies enterprise values increase on average. Market capitalisation increased for both high- and low-debt companies between pre- and post-Green Deal.

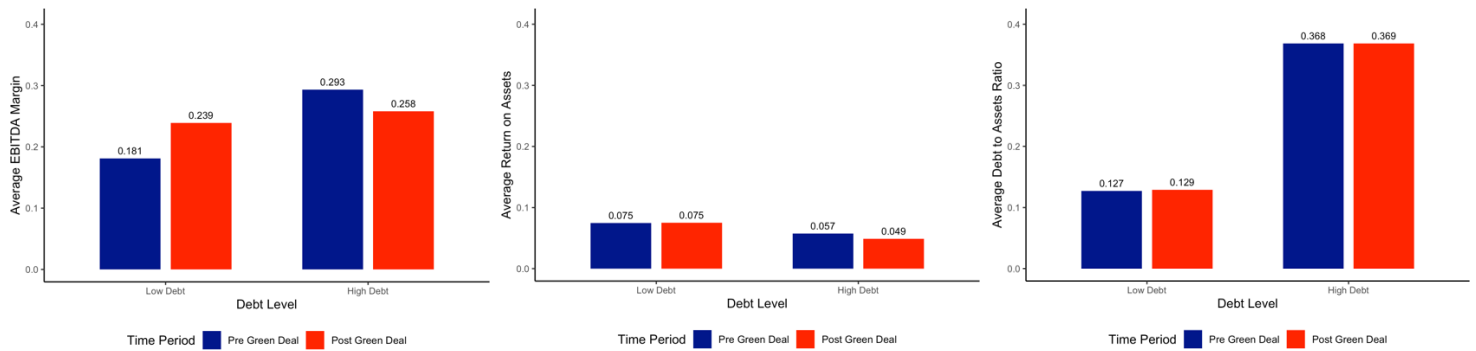


Figure 9 Descriptive Statistics by Debt Level – Key Financial Ratios by Time Period

High-debt companies are more profitable in terms of EBITDA margins while earning lower returns on assets. This is unsurprising as high-debt companies have approximately the same level of revenues in a given year as low-debt companies while having a higher EBITDA margin and less total assets. Return on assets remained stable for low debt companies but decreased by 14% for high debt companies. Intuitively, the average EBITDA margin increased by 32% for low-debt companies but decreased by 11.9% for high-debt companies. Debt to asset ratios remained stable for both groups.

If we look at the decomposition of debt between the two types of companies, we can clearly see that the higher company debt for high-debt companies primarily comes from their much heavier use of long-term rather than short-term financing. This is in line with the higher capital expenditure numbers as long-term financing is usually used to finance non-current asset purchases.

3.2.3 Time Fixed Effects

From our preceding data analysis, we were able to identify that almost all our variables follow different trends over time. In most cases, a slow increase in variable values from year to year, with the notable exception of Scope 1 emissions, interrupted a temporary decline during 2020 likely caused by the COVID-19 pandemic. In response, we have introduced time fixed effects to eliminate shocks to variable values that occurred during specific time periods but are unrelated to the European Green Deal. Time fixed effect take the form of yearly dummy variables.

3.2.4 Company Fixed Effects

The visualisation in Appendix II shows a heat map of industry averages for each sector in our analysis by variable. Darker shades of red in industry bands indicate higher averages while greener colours indicate smaller averages. As can be seen by the colour variations there are some systematic differences between industry averages. Consequently, we used individual fixed effects in our analysis to account for systematic variations at the company level. Company fixed effects eliminate the variation across individual companies by eliminating variation that is unique to individual companies from the analysis through the introduction of company dummies. This reduces the likelihood that our panel estimators identify idiosyncratic company-specific variations that are not caused by factors related to the European Green Deal.

3.2.5 Correlation Matrix for Logged Variables

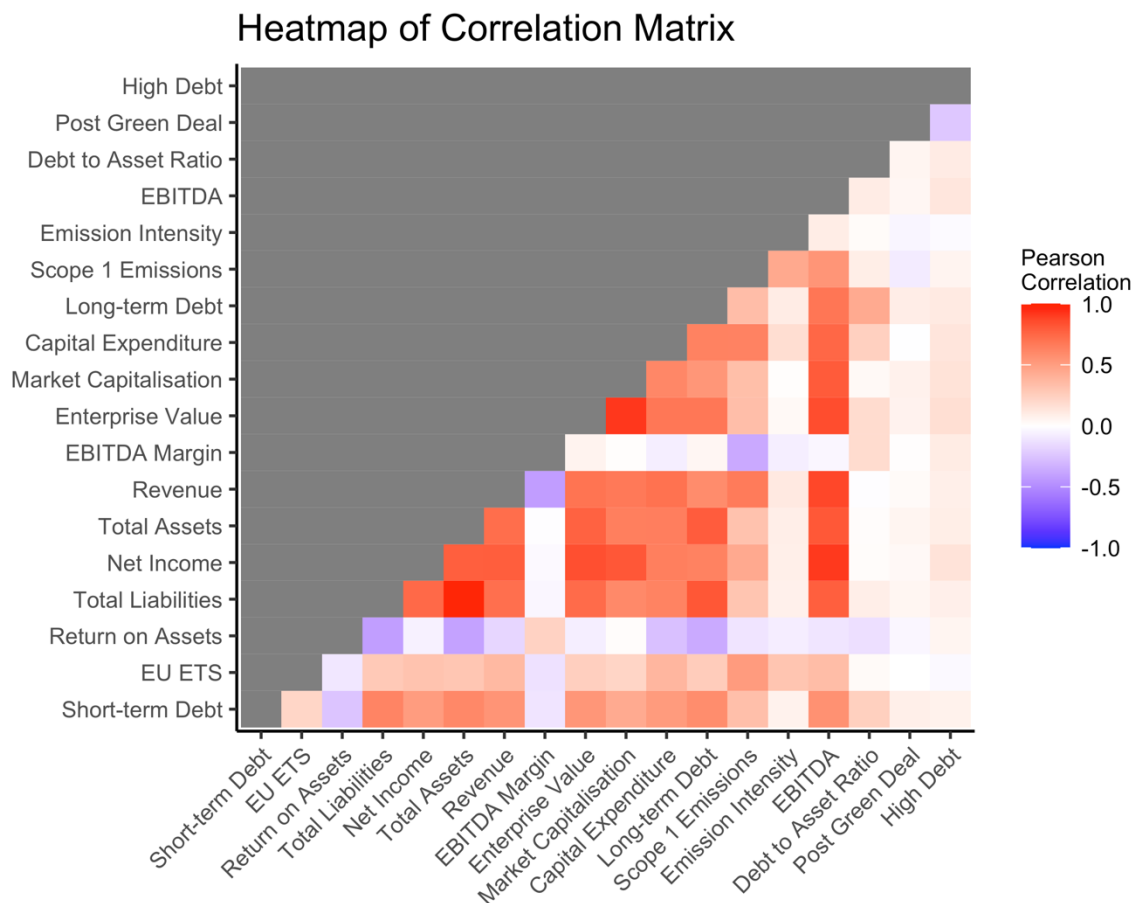


Figure 10 Correlation Matrix

To determine potential multicollinearity issues, we analyse the correlations between the metrics in our panel data set. Figure 4 shows a heatmap of the correlation matrix of all variables in our dataset. Very high correlations are observed between total assets and total liabilities

(0.98), between net income and total assets (0.73), revenue (0.79) and EBITDA (0.81), between total liabilities and net income (0.74) and between market capitalisation and enterprise value (0.91). These highly positive correlations demonstrate the relationship between company size and absolute profit values. Moreover, since the correlation matrix shows the correlations for our log data set, the highly positive correlations show that profits and balance sheet size are positively related.

The correlation coefficient between Scope 1 emissions and total assets is 0.67. This indicates that larger companies have higher environmental impacts.

Long-term debt and total liabilities are strongly correlated (0.80), which indicated that long-term debt takes up a significant component of total liabilities. Also, higher capital expenditures correlate strongly with both larger asset bases (0.71) and higher revenues (0.68) which might show the importance of investment and maintenance. Lastly, the moderately negative correlation between ROA and total liabilities (-0.41) might be suggestive of over-leverage or leverage-induces inefficiencies.

3.2.6 Standard Errors

We apply three types of standard errors to our models to ensure the robustness of our estimators. The first is the simple OLS standard error commonly used in an OLS regression framework. While this is the most applied standard error it is also downward biased in a panel environment like ours. Especially in the presence of fixed effects (Petersen, 2009).

OLS standard errors require residuals to be independently and identically distributed, however since our data shows a general slow and steady upward trend for most variables as well as systematic differences across industry groups our residuals are likely clustered. Moreover, our results may also show heteroskedasticity. The large variety in companies as well as scales on which our data is measured creates potentially very different standard errors and standard deviations across the data. We thus use two additional types of standard errors to check the robustness of our estimators.

For our first clustered standard errors, we follow Petersen's (2009) recommendation to use company-level clusters for our sample. Since our paper is primarily focused on corporate financial variables, such as net income or total assets, there are likely much larger differences between companies than between years. This was also observable in our data overview where most variables showed high differences between sectors and companies grouped by debt or emissions intensity levels. Moreover, clustered standard errors are particularly important in the

presence of fixed effects. In the context of company-level fixed effects for instance, an OLS standard error would expect the standard error to rise alongside the number of company observations, however since fixed effects account for company-level differences in our case, this increase is zero and thus not proportional with the number of observations (Petersen, 2009).

The final standard error specification that we apply are standard errors clustered by both company and time. While most of our variables show relatively little change period to period, our data panel still has seven individual periods leaving room for potential serial correlations for our dependent variables, although this effect should be mitigated by our time fixed effects and our use of log data. We apply company-time double clustering as recommended by Bertrand et al. (2004) to further take the risks of autocorrelation into account and add an additional level of prudence to our analysis.

3.3 Research Design

We chose a Difference-in-Differences methodology to study the impact of the EU ETS on company financials post the EU Green Deal because of its appropriateness and robustness for assessing policy effects over time. The approach allows us to evaluate the EU ETS's causal effect by comparing changes in financial outcomes for a treatment group against a control group.

For our study, we chose the triple difference estimator (hereafter DDD) which serves as an enhancement of the DiD approach.

$$\begin{aligned} \bar{Y}_{it} = & \beta_0 + \beta_1 T_i + \beta_2 B_i + \beta_3 Post_t + \beta_4 T_i \times B_i + \beta_5 T_i \times Post_t + \beta_6 B_i \times Post_t \\ & + \delta_1 T_i \times B_i \times Post_t + \alpha_i + \alpha_t + \epsilon_{it} \end{aligned} \quad (1)$$

For the DDD estimator, the population is split up into two groups A and B for which there is a treatment (T) and a control state (C). Additionally, there are two time-periods, post and pre-treatment. As a result, sample average \bar{Y} or $E[Y|T, B, Post]$ can take on eight values where T, B and Post are either 0 or 1. The DDD estimator $\hat{\delta}_1$ (equation 3) is equivalent to the difference between two DiD (equation 2) estimators $\hat{\delta}$: for Treatment groups A and B:

$$\hat{\delta} = [(\bar{Y}_{T,Post} - \bar{Y}_{T,Pre}) - (\bar{Y}_{C,Post} - \bar{Y}_{C,Pre})] \quad (2)$$

$$\begin{aligned} \hat{\delta}_1 = & [(\bar{Y}_{T=1,B=1,Post=1} - \bar{Y}_{T=1,B=1,Post=0}) - (\bar{Y}_{T=0,B=1,Post=1} - \bar{Y}_{T=0,B=1,Post=0})] \\ & - [(\bar{Y}_{T=1,B=0,Post=1} - \bar{Y}_{T=1,B=0,Post=0}) - (\bar{Y}_{T=0,B=0,Post=1} - \bar{Y}_{T=0,B=0,Post=0})] \end{aligned} \quad (3)$$

As the DDD estimator accounts for multiple dimensions of variation it can reduce bias in the estimation. Olden and Møen (2022) claim that the DDD approach can reduce omitted variable bias when compared to the DiD approach and describe the DDD estimator as heterogeneity test and robustness check.

For the DDD estimator to be unbiased the model must be correctly specified. Moreover, the average error term must be zero on average $E[\epsilon_i] = 0$. Additionally, the error term cannot be correlated with any other variable in the equation (Albouy, n.d.).

The underlying assumptions for DDD are parallel trend assumption, the common trend assumption and the stable treatment effect assumption. The parallel trend assumption for DDD is not required to be fulfilled twice for both Treatment groups. Rather the relative outcomes of

treatment group 1 and treatment group 2 have to move in the same direction as the relative outcomes of control group 1 and control group 2. In other words, it is assumed that the gap between the treated state and the control state would have evolved in similar way for both treatment groups A and B. The common trend assumption posits that any unobserved factors aside from the treatment, which affect both treatment and control groups, evolve analogously over time. The stable treatment effect requires that the treatment effect remains constant over the period of observation (Olden & Møen, 2022).

The DDD estimator allows to disentangle the effects of carbon prices on company financials across companies with varying levels of emission intensity and leverage. This methodology is particularly justified given the desired effect of the EU Green Deal across various sectors and businesses. With the emphasis on lowering carbon footprints, the Green Deal is anticipated to disproportionately affect companies with higher emissions and energy intensity. Likewise, it is expected that companies with higher leverage have less leeway to direct resources to other areas than abatement. Employing the DDD estimator, bias that could result from comparing groups that differ in their vulnerability to the policy change is also reduced. This additional layer of analysis, which accounts for unobserved heterogeneity that could potentially distort our results, guarantees a more precise identification of observable financial consequences directly attributable to the policy intervention.

To create the treatment groups, we divided our dataset into four segments based on debt to asset ratios. Moreover, we used the binary identifier EU ETS which indicates whether the company is part of the emissions trading system (1), or not (0). Additionally, the binary After Green Deal Indicator was used as post-treatment identifier. The post-treatment period therefore corresponds to 2020-2023, or $t = 0 - 3$. The pre-treatment period was defined as 2017-2019, or $t = (-1) - (-3)$.

We calculated the debt to asset ratio means based on pre-treatment values. Next, we assigned two dummy variables to each row. Companies that were below the mean leverage ratio were classified as Low Debt (0), while companies that were above the mean leverage ratio were classified as High Debt (1). We also divided the treatment groups by median rather than arithmetic mean as an alternative specification. Both specifications yielded next to identical results.

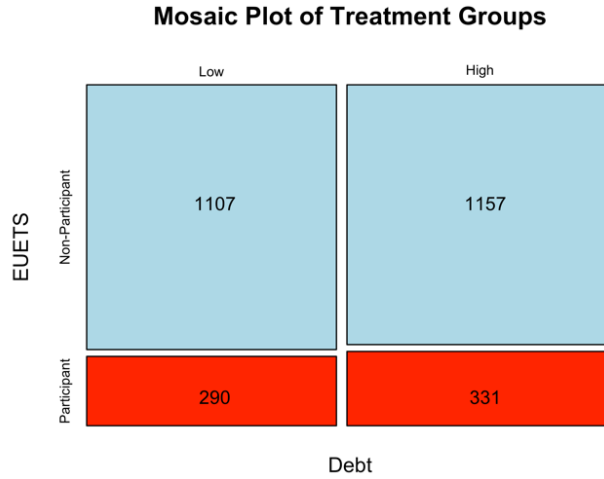


Figure 11 Observations Within Treatment Groups

We defined the treatment group A as *High Debt* = 1 and the treatment group B as *EUETS* = 1. As aforementioned the *Pre* and *Post* Treatment periods are before and after the EU Green Deal respectively. Hence, our empirical findings are obtained through the panel data regression model as follows:

$$\begin{aligned}
 \bar{Y} = & \beta_0 + \beta_1 HighDebt + \beta_2 EUETS + \beta_3 PostGD + \beta_4 HighDebt * PostGD \\
 & + \beta_5 HighDebt * EUETS + \beta_6 PostGD * EUETS + \beta_7 HighDebt * PostGD \\
 & * EUETS + FirmFE + TimeFE
 \end{aligned}
 \tag{4}$$

3.4 Pre-Trends

One key assumption of difference-in-difference and triple difference-in-difference specifications is that trends between treated and non-treated groups are parallel before treatment occurs (Angrist and Pischke, 2008). The pre-treatment parallel trends assumption allows for the interpretation of difference-in-difference results as a causal relationship between the treatment and the outcome, as they indicate that the change in trend measured by the difference-in-difference estimator is likely due to the treatment rather than capturing a divergence in the trends of the treatment and control groups that had already started prior to the treatment occurring.

Therefore, this section examines the possible existence of pre-trends within our data using both time series graphs of our different treatment and control groups as well as a quantitative model that estimates whether statistically significant pre-trends are present within our data.

3.4.1 Visual Pre-Trend Analysis



Figure 12 Pre-trend analysis for triple Difference-in-Differences research design

Based on the time series above, it is clearly observable that the parallel trends assumption holds for low- and high-debt non-participants. Apart from a sudden spike in emissions intensity for high-debt EU ETS non-participants after the Green Deal as well as the relatively unparallel log numbers for the return on assets of all companies, non-participants' values move in a highly parallel fashion throughout and before our sampling period.

In terms of EU ETS participants, the trends displayed by our outcome variables are much less parallel visually. In fact, the pre-treatment trends for high- and low-debt participants look to be almost cointegrated with high-debt companies displaying negative movements in outcome variables while low-debt companies move positively and vice versa. Notably, we can still see big movements in participant values at the time of or after our treatment in 2020. For instance. Capital expenditures for low-debt participants start rising significantly after 2020 while there is no discernible change in high-debt capital expenditures.

Consequently, it is not possible to determine whether the assumption of parallel pre-treatment trends holds or not from our visual analysis. Moreover, the graphs displayed do not account for company and time fixed effects, like the model specified in equation (4). In the next subsection we therefore statistically evaluate the potential presence of pre-trends with company and time fixed effects. The intuition is to evaluate whether pre-treatment trends are parallel when accounting for company- and time-specific shocks and unobserved variances that are specific to companies and over time that are not related to our study.

3.4.2 Statistical Pre-Trend Analysis

To statistically evaluate whether the data exhibits diverging trends pre-treatment, we follow Roth et al. (2023) and specify a model described by equation (4) which is tested using time dummies. Specifically, we add a time dummy for every period pre-treatment as well as letting each time dummies interact with our treatment variables (whether a company is in the EU ETS or not, and whether a company has above or below average debt).

We then test whether our time and debt interaction terms are statistically significant from zero using a standard t-test where the t-statistic is calculated by dividing each estimator by its respective OLS standard error. Importantly, this statistical analysis is carried out using both time and company fixed effects to examine whether the pre-trends are parallel with the closest possible specification to our actual model set out in the previous section. Since the pre-trend analysis only looks at years before the Green Deal, the Post Green Deal dummy is replaced with time dummies for every annual observation pre-Green Deal.

We further examine the estimators graphically with their 95% confidence intervals added to visualise whether our pre-trend estimators are statistically different from zero.

In sum, out of the 64 coefficients calculated for our pre-treatment period (2017-2019), only two estimators were statistically significant at the 10% level, with all other estimators displaying far higher p-values, mostly between the 50% to 70% levels.

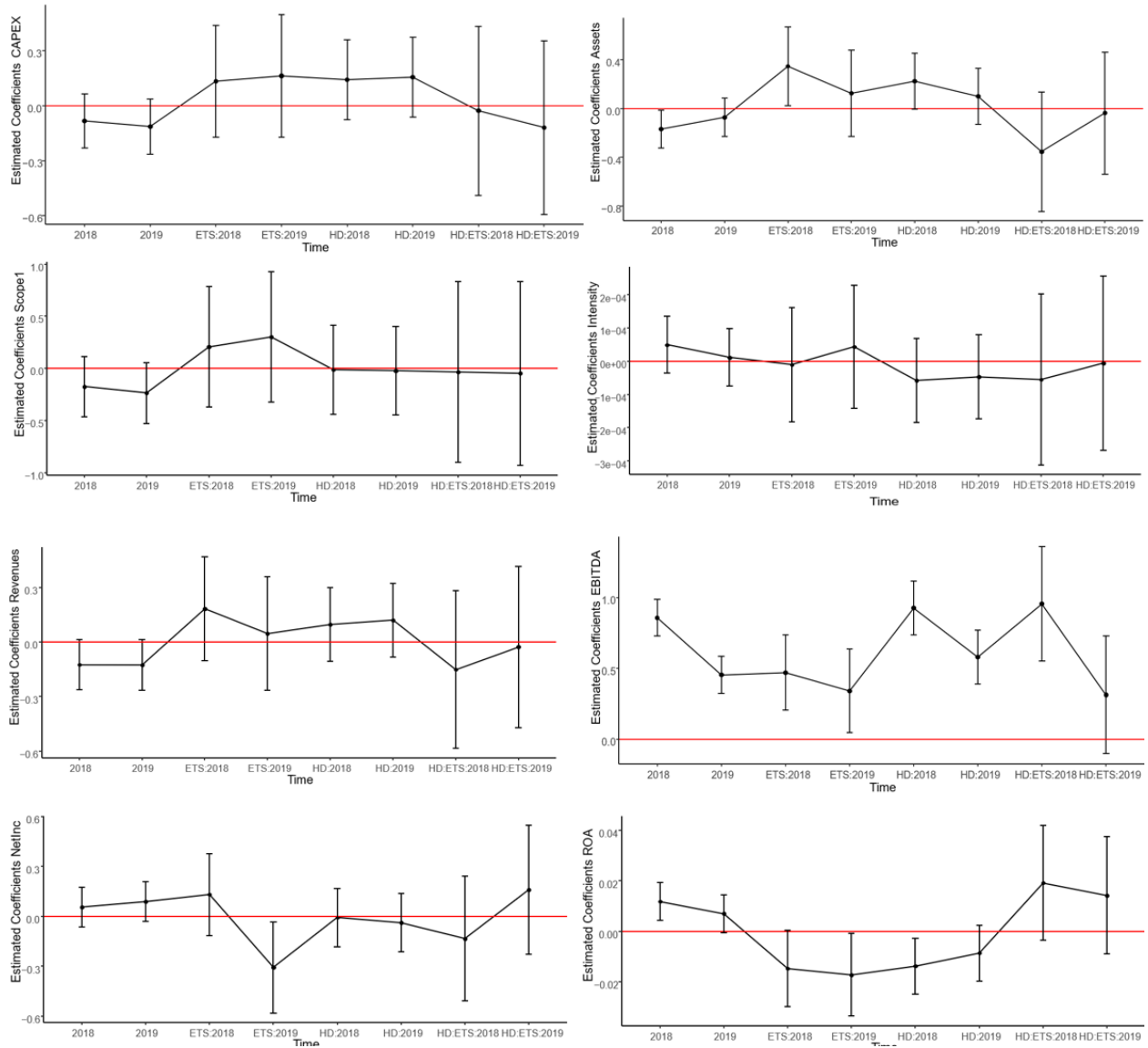


Figure 13 Pre-trend coefficient estimators with 95% Confidence Interval

Note. For the purposes of better illustration, the high debt dummy has been abbreviated to HD and the EU ETS dummy has been abbreviated to ETS.

3.5 Research Limitations

Our data are impacted by the limited coverage of carbon accounting. We excluded 13 companies which did not report GHG emissions. A further 173 companies did not report Scope 1 emissions for the full timeframe of 7 years. Moreover, our sample only covers listed entities, limiting the applicability of our results to private entities.

Additionally, our study does not evaluate the price pass-through of carbon prices to the consumer. Further studies could consider factors such as elasticity of demand and competitiveness within industries to disentangle the effects of carbon prices on the consumer price index. For instance, Clarkson et al. (2015) find that the impact of carbon prices on company performance and profitability depend largely on a company's market power as measured by the Herfindahl-Hirschman Index.

Moreover, our study does not control for whether companies anticipated the Green Deal and thus adapted their operating and financial structures before the Green Deal and its related policies were implemented. Since the 2019 European parliamentary elections were dominated by climate-related political issues and European policy initiatives are often preceded by lengthy public discussions, large European companies will have likely had some time, pre-Green Deal, to take mitigating corporate actions, such as changing the energy mix of production before the Green Deal's policies started to be enforced.

A company's control over its own debt-to-asset ratio and emissions intensity also implies that treatment could not be entirely independently assigned as companies can actively adjust their debt and emissions levels within a certain range in relation to their peers. The problems arising from self-selection could have been mitigated to some extent through an event study or high frequency identification that examine the immediate effects of the announcement and implementation of the Green Deal. However, as our outcome variables, such as Scope 1 emissions, total assets or net income are observed periodically rather than through immediate market reactions, such as study design was infeasible given the present context.

Finally, given the context of our investigation, our results are specific to STOXX Europe 600 companies and the European Green Deal post-2020. Thus, the generalisability of our results to other European companies as well as industries and countries not covered by the European Emissions Trading Scheme is limited.

3.5.1 Stable Unit Treatment Value Assumption (SUTVA)

We cannot rule out that our treatment and control variables (i.e. high-debt versus low-debt) were completely independent of one another in affecting our outcomes. For instance, companies with high debt levels may have accumulated debt before the Green Deal in anticipation of future climate regulation. In this case, high debt is itself an outcome of European climate policy rather than a predictor of its effects. Furthermore, the pass-through of carbon prices to the consumer may have generated additional income for non-EU ETS or low-debt companies which were able to keep prices stable as they were either able to reduce their emissions or not affected by the prices at all. As a result, we cannot with complete certainty confirm that the stable unit treatment variation assumption holds for the specification of our treatment (Angrist and Pischke, 2008).

Our use of time and company fixed effects should eliminate some of the concerns regarding the violation of SUTVA. For instance, our company fixed effects should absorb some of the unobserved variations that are created by common shocks across geographies or industries. Moreover, our time fixed effects should account for common shocks across geographies within specific time periods. For instance, the common shock of the Covid-19 pandemic.

Finally, our clustered standard error specification should also alleviate some of the problems related to potential violations of the SUTVA assumption by accounting for the possibility of shocks that are different across company and time clusters. Further, if clusters are affected by common unobserved shocks, clustered standard error specification should account for these biases to some extent by increasing the standard error estimate appropriately (Anrgist and Pischke, 2008).

4 Results

4.1 Hypothesis 1

H1. The profits and profitability of high-debt companies that are part of the EU ETS should decline after the European Green Deal.

Difference in Differences Results: Revenue				
	Revenue		Revenue	
	(1)	(2)	(3)	
High Debt	0.028 (0.021)	0.028 (0.027)	0.028 (0.027)	
EU ETS	0.081** (0.034)	0.081* (0.048)	0.081* (0.048)	
High Debt:Post GD	-0.024 (0.020)	-0.024 (0.025)	-0.024 (0.025)	
High Debt:EU ETS	-0.044 (0.041)	-0.044 (0.058)	-0.044 (0.058)	
Post GD:EU ETS	0.026 (0.031)	0.026 (0.044)	0.026 (0.044)	
High Debt:Post GD:EU ETS	-0.131*** (0.044)	-0.131** (0.055)	-0.131** (0.055)	
Fixed Effects	Company + Time	Company + Time	Company + Time	
Cluster	No	Company	Company + Time	
F Statistic	7.359*** (df = 6; 2382)			
Notes:		***Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.		

Table 3 Difference in Differences Panel Regression Results 1

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level once as well as at company and time level following Petersen (2009).

DDD Results: EBITDA

	EBITDA		
	(1)	(2)	(3)
High Debt	0.072** (0.035)	0.072* (0.039)	0.072 (0.043)
EU ETS	0.064 (0.058)	0.064 (0.063)	0.064 (0.082)
High Debt:Post GD	-0.068** (0.034)	-0.068 (0.042)	-0.068 (0.057)
High Debt:EU ETS	-0.119* (0.069)	-0.119 (0.075)	-0.119 (0.094)
Post GD:EU ETS	0.077 (0.053)	0.077 (0.062)	0.077 (0.088)
High Debt:Post GD:EU ETS	-0.101 (0.074)	-0.101 (0.091)	-0.101 (0.115)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	4.160*** (df = 6; 2333)		

Notes:

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 4 Difference in Differences Panel Regression Results 2

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level once as well as at company and time level following Petersen (2009).

DDD Results: Net Income

	Net Income		
	(1)	(2)	(3)
High Debt	-0.030 (0.048)	-0.030 (0.053)	-0.030 (0.064)
EU ETS	-0.041 (0.079)	-0.041 (0.105)	-0.041 (0.090)
High Debt:Post GD	-0.034 (0.047)	-0.034 (0.053)	-0.034 (0.084)
High Debt:EU ETS	-0.048 (0.095)	-0.048 (0.127)	-0.048 (0.117)
Post GD:EU ETS	0.296*** (0.072)	0.296*** (0.097)	0.296** (0.105)
High Debt:Post GD:EU ETS	-0.364*** (0.102)	-0.364*** (0.112)	-0.364*** (0.095)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	8.405*** (df = 6; 2252)		

Notes:

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 5 Difference in Differences Panel Regression Results 3

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level as well as at company and time level following Petersen (2009).

DDD Results: Return on Assets

	ROA		
	(1)	(2)	(3)
High Debt	-0.011*** (0.003)	-0.011*** (0.004)	-0.011*** (0.003)
EU ETS	0.001 (0.005)	0.001 (0.007)	0.001 (0.008)
High Debt:Post GD	-0.003 (0.003)	-0.003 (0.003)	-0.003 (0.003)
High Debt:EU ETS	-0.007 (0.006)	-0.007 (0.008)	-0.007 (0.008)
Post GD:EU ETS	0.018*** (0.005)	0.018*** (0.006)	0.018** (0.006)
High Debt:Post GD:EU ETS	-0.016** (0.007)	-0.016** (0.007)	-0.016** (0.005)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	14.520*** (df = 6; 2179)		
Notes:		***Significant at the 1 percent level.	
		**Significant at the 5 percent level.	
		*Significant at the 10 percent level.	

Table 6 Difference in Differences Panel Regression Results 4

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level as well as at company and time level following Petersen (2009).

The triple difference in difference estimator shows that high-debt companies that are in the EU ETS experienced a 0.131% reduction in revenues after the European Green Deal relative to low-debt EU ETS participants. Adding the statistically significant estimators together, the total effect of the Green Deal on high-debt EU ETS companies was a 0.126% reduction in revenues. Economically, this decrease in revenue could be interpreted as a loss of market share (Clarkson et al., 2015). Thus, high-debt companies may have struggled to compete in the European marketplace by adapting to higher carbon prices.

Our results show no statistically significant change in EBITDA after treatment for high-debt EU ETS companies. In contrast to EBITDA, net income fell significantly and robustly by approximately 0.364% after the European Green deal for high-debt companies relative to control and by 0.068% in total. The result is particularly interesting given that low-debt companies in the EU ETS saw a 0.294% increase in net income after the European Green Deal. This divergence in net profits could have several interpretations. Firstly, high-debt companies could have experienced this fall in net income due to their relatively higher total interest

payments, as the Green Deal was followed by an inflationary period with sustained periodic increases in interest rates around the globe. Since the difference between EBITDA and net income are depreciation, amortisation, taxes and interest, the major difference between our net income results are likely the higher debt burdens of high-debt companies that come with increased interest burdens through the post-Green Deal periods.

Finally, high-debt companies experienced a 0.016% drop in their return on assets relative to other groups after the European Green Deal and a total drop of 0.009%. Moreover, low-debt companies in the EU ETS actually saw an increase in their ROA post-2020. These results are in line with the reduction or increase in net income for high-debt and low-debt companies after the European Green Deal respectively.

Overall, high-debt companies saw a decline in revenues, net income and return on assets after the European Green Deal. Economically, these results could have a variety of interpretations. Firstly, a loss of market share after the European Green Deal which could have caused the decline in revenues resulting in lower net income and profitability. This loss in market share could have been caused by a lack of investment in energy-efficient technologies by high-debt companies. Further, general expansion and product development should have also been negatively impacted by the increased carbon prices and more stringent climate regulations after the Green Deal. Thus, high-debt companies were essentially paralysed and unable to keep up with their competition in terms of quality or price reductions.

Another interpretation is that companies with above-average debt levels were impacted by a dual shock of higher interest rates and higher carbon prices. In this scenario, high-debt companies' net income was impacted both by higher total interest payments and higher carbon prices. This interpretation also offers an explanation for why company EBITDA did not decline significantly after the Green Deal, but net income for high-debt companies did. However, this scenario is unable to explain the reduction in revenues for high-debt companies directly.

4.2 Hypothesis 2

H2. Capital expenditure and total assets for high-debt companies that are part of the EU ETS should decline after the European Green Deal.

DDD Results: Capital Expenditure			
	Capital Expenditure		
	(1)	(2)	(3)
High Debt	0.002 (0.047)	0.002 (0.055)	0.002 (0.048)
EU ETS	0.024 (0.077)	0.024 (0.072)	0.024 (0.086)
High Debt:Post GD	0.020 (0.045)	0.020 (0.062)	0.020 (0.058)
High Debt:EU ETS	0.101 (0.092)	0.101 (0.094)	0.101 (0.113)
Post GD:EU ETS	0.080 (0.070)	0.080 (0.089)	0.080 (0.080)
High Debt:Post GD:EU ETS	-0.258*** (0.099)	-0.258** (0.123)	-0.258* (0.109)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	1.731 (df = 6; 2357)		
Notes:		***Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.	

Table 7 Difference in Differences Panel Regression Results 5

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level as well as at company and time level following Petersen (2009).

After the European Green Deal, the capital expenditure of high-debt companies in the EU ETS dropped by approximately 0.254% relative to low-debt and non-EU ETS companies. Economically, the decrease in capital expenditure could be explained by the lower profits of high-debt companies after the European Green Deal. While low-debt companies may have been able to invest in more modern production processes to reduce their carbon emissions, high-debt companies will have been less able to do so as their lower profitability will have likely disincentivised banks and investors to inject capital in companies that already have relatively more debt and thus likely also higher default risks. However, this explanation is invalidated slightly by the statistically insignificant PostGD:EU ETS estimator which indicates that low-debt companies in the EU ETS did not increase their capital expenditures in response to the European Green Deal. If low-debt companies reacted to the European Green deal by investing in more energy-efficient machinery, this estimator should have been positive and

statistically significant. While the estimator is positive at 0.08, the high standard error means that the result does not bear significant statistical meaning.

Overall, however, the interpretation that high-debt companies had to reduce their capital expenditure due to a lack of access to external funding still holds. Moreover, high-debt companies which experienced a drop in income (H1) will likely also have had less cash available from internal sources such as retained profits to keep up their capital expenditures.

DDD Results: Total Assets			
	Total Assets		
	(1)	(2)	(3)
High Debt	0.103*** (0.019)	0.103*** (0.031)	0.103*** (0.028)
EU ETS	0.103*** (0.032)	0.103** (0.043)	0.103** (0.038)
High Debt:Post GD	0.009 (0.019)	0.009 (0.029)	0.009 (0.031)
High Debt:EU ETS	-0.024 (0.038)	-0.024 (0.048)	-0.024 (0.052)
Post GD:EU ETS	-0.003 (0.029)	-0.003 (0.043)	-0.003 (0.038)
High Debt:Post GD:EU ETS	-0.152*** (0.041)	-0.152*** (0.049)	-0.152** (0.047)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	14.647*** (df = 6; 2382)		
Notes:		***Significant at the 1 percent level.	
		**Significant at the 5 percent level.	
		*Significant at the 10 percent level.	

Table 8 Difference in Differences Panel Regression Results 6

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level as well as at company and time level following Petersen (2009).

The results indicate that companies with high debt that were in the EU ETS saw a reduction in total assets of around 0.152% after the European Green Deal relative to controls and a 0.054% total increase. In light of the reductions in profits, profitability and capital expenditures discussed in the previous hypothesis, the reduction in total assets is likely the result of lower capital expenditures as well as potential sales of assets forced upon high-debt companies due to the reduced economic viability of high-emissions assets. This could have a variety of reasons. For instance, equity investors may have demanded that high-debt companies reduce their reliance on high-emissions assets. Since high-debt companies do not have the financial wiggle

room to compensate with capital expenditures in new assets, resulting in a reduction in the assets of high-debt companies.

The second interpretation is that high-debt companies had to reduce their assets as debt investors were not willing to provide new capital to high-debt companies and in some cases, debt covenants may have been triggered forcing companies to reduce their balance sheet to stay in line with previously agreed ratios such as debt-to-profit ratios (Caragano et al., 2020).

4.3 Hypothesis 3

H3. Scope 1 emissions and emissions intensities should decline for low-debt companies and increase for high-debt companies after the European Green Deal, that are part of the EU ETS.

Difference in Differences Results: Scope 1 Emissions			
	Scope 1 Emissions	Scope 1 Emissions	Scope1
	(1)	(2)	(3)
High Debt	0.058 (0.054)	0.058 (0.080)	0.058 (0.071)
EU ETS	0.267*** (0.088)	0.267*** (0.091)	0.267** (0.091)
High Debt:Post GD	-0.049 (0.053)	-0.049 (0.085)	-0.049 (0.076)
High Debt:EU ETS	-0.298*** (0.103)	-0.298*** (0.106)	-0.298*** (0.078)
Post GD:EU ETS	-0.178** (0.078)	-0.178** (0.081)	-0.178** (0.064)
High Debt:Post GD:EU ETS	0.210* (0.109)	0.210 (0.133)	0.210 (0.118)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	2.030* (df = 6; 2148)		
Notes:	***Significant at the 1 percent level. **Significant at the 5 percent level. *Significant at the 10 percent level.		

Table 9 Difference in Differences Panel Regression Results 7

Note. This table shows the results of the panel regression following the DDD model in equation (4), including control variables. The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level as well as at company and time level following Petersen (2009).

High-debt companies that are in the EU ETS increased their carbon emissions relative to other companies after the European Green Deal by 0.210. This result is not robust to all specifications. In contrast, low-debt companies statistically significantly reduced their CO2 emissions after the European Green Deal. This finding can be interpreted as a result of high-debt companies' lower ability to invest in abatement. Low-debt companies on the other hand can use their higher debt capacity to finance additional capital expenditure and other abatement measures.

Another possibility is that high-debt companies were forced to rely more heavily on older technologies with higher per-unit emissions in the production process. This interpretation would also explain the reduction in total assets for high-debt EU ETS companies after the European Green Deal. According to this interpretation, lower earnings and profits would force

high debt companies to rely more heavily on older productive assets that have lower asset values from an accounting perspective.

DDD Results: Emission Intensity			
Intensity (Scope 1 Emissions per Revenue in Millions)			
	<i>Panel Regression</i>	<i>Coefficient Test</i>	<i>Coefficient Test</i>
	(1)	(2)	(3)
High Debt	0.009 (0.025)	0.009 (0.011)	0.009 (0.008)
EU ETS	0.168*** (0.041)	0.168** (0.072)	0.168* (0.081)
High Debt:Post GD	-0.010 (0.024)	-0.010 (0.010)	-0.010 (0.010)
High Debt:EU ETS	-0.102** (0.048)	-0.102 (0.076)	-0.102 (0.067)
Post GD:EU ETS	-0.196*** (0.036)	-0.196** (0.089)	-0.196** (0.079)
High Debt:Post GD:EU ETS	0.112** (0.051)	0.112 (0.099)	0.112 (0.082)
Fixed Effects	Company + Time	Company + Time	Company + Time
Cluster	No	Company	Company + Time
F Statistic	6.575*** (df = 6; 2148)		
Notes:		***Significant at the 1 percent level.	**Significant at the 5 percent level.
		*Significant at the 10 percent level.	

Table 10 Difference in Differences Panel Regression Results 8

Note. This table shows the results of the panel regression following the DDD model in equation (4). The timeframe (1) post Green Deal is defined as 2020 – 2023, the pre-treatment timeframe (0) is defined as 2017 - 2019. T-statistics are displayed in parentheses. All regressions include time and company fixed effects. Robust standard errors are clustered at company level as well as at company and time level following Petersen (2009).

Our results show that emissions intensities for high-debt companies increased by 0.112% relative to low-debt companies after the EU ETS. The total effect for high-debt companies has been a 0.018% reduction in emissions intensity when adding up all statistically significant estimators. The interpretation of our intensity results remains similar to our log Scope 1 emissions results. While high-debt companies reduced their Scope 1 emissions to reduce the burden of the carbon price on their financial performance, their reduced relative capital expenditures indicate that high-debt companies have been less able to replace their existing capital stock with new and potentially more efficient production technologies. While low-debt companies used their financial capacity to invest in carbon abatement.

5 Discussion

To summarise, our results indicate that companies with high debt levels have seen reductions in their profits, profitability, capital expenditures and total assets while not reducing their Scope 1 carbon emissions and emissions intensities by the same magnitude as their low-debt peers. Since low-debt EU ETS firms reduced their emissions and emissions intensities relative to pre-treatment levels, our results also show that the European Green Deal was effective at incentivising low-debt firms to reduce emissions.

Furthermore, low-debt EU ETS companies saw increases in net income and return on asset while their total assets and capital expenditure levels were not affected in a statistically significant manner. This indicates that the higher carbon prices and more stringent regulations after the European Green Deal did not negatively affect the financial performance of low-debt firms. While it is not easy to make a definitive statement, a likely interpretation is that low-debt firms shifted their capital expenditures to replace existing productive assets with more energy-efficient alternatives. The increases in profits and profitability for low-debt companies also indicate that this replacement process did not negatively impact financial performance.

High-debt companies had to reduce their asset bases and capital expenditures in response to the lower profits and profitability after the Green Deal. As a result, high-debt firms likely had to accept the higher carbon prices and more stringent regulation through a decrease in profits and a reduction in productive assets.

From a public policy perspective, this duality shows that regulators need consider companies' financial capacities when allocating funds tied to climate targets. While the EU ETS successfully regulates high emitters, to warrant its effectivity the Union must ensure that company financials are taken into account since companies with high debt levels are less likely to respond to current regulation with a decrease in their Scope 1 carbon emissions.

The most effective way to induce emissions reductions for high-debt companies is likely to be funding made available to high-debt firms conditional on achieving a set of predefined emissions reduction targets. EU or national level grants for instance would have the advantage of funding emissions reductions without increasing company debt levels. We also found that high-debt companies experienced decreases in net income but not EBITDA as a result of the Green Deal. Thus, it is likely that high interest payments negatively affected company profits. Since Caragano et al. (2020) found that emissions intensities and the cost of debt are positively

correlated, high-debt companies in the EU ETS would likely benefit more from funding alternatives that do not require taking on higher debt.

Apart from high-debt companies' likely reluctance to use more debt to finance a green transition, their inability to do so may also stem from banks and investors being more unwilling to lend to high emitters. Garcia et al. (2023) found that carbon prices can increase company default risks as measured by the distance to default while Lambertides and Tsouknides (2023) found that the EU ETS has already negatively impacted high emitters credit risk in phase III of the program. This increased credit risk along with the worse financial performance found in this study make it likely that high-debt EU ETS firms face more stringent external limits to their ability to finance their green transition through debt. Thus, these results also call into question the use of green or blue bonds and similar green debt financing instruments in the context of the European Green Deal, as low-debt companies are less likely to want to take on more debt and would have to do so under less favourable terms.

The decrease in emissions and emissions intensities for low-debt companies, on the other hand, suggests that companies with a higher potential financing capacity are unlikely to require further government aid when responding to regulatory or price-based emissions reduction incentives.

6 Conclusion

This master thesis evaluates the effect of the European Green Deal and its associated economic policies through a triple difference-in-difference analysis where treatment was assigned to companies, regulated by the EU ETS, with above-mean debt-to-asset ratios. The companies in our sample that were also regulated by the EU ETS accounted for between 30% and 40% of total European emissions in any given year (Wood, 2023). Our analysis found that while high-debt companies saw decreases in profits, sales, total assets and liabilities, they also increased carbon emissions relative to low-debt peers. Our interpretations of this result included the theory that companies with higher debt levels find it more difficult to access external capital. Thus high-debt companies which are forced to reduce capital expenditures are unable to invest sufficiently in more efficient technologies.

In the context of European policy, our results suggest that companies with higher debt levels may require additional fiscal or technological support to achieve the emissions targets set out by the European Commission to prevent negative economic implications of the EU's climate policy which could harm the Union's competitiveness in the long-run. Moreover, our results suggest that public funding for emissions reduction projects should focus on companies with relatively higher debt levels in particular. Low-debt companies were not negatively financially affected by the European Green Deal while reducing their emissions significantly more than high-debt firms.

In this light, future studies should focus on the relative increase in Scope 1 emissions for companies with high debt levels as well as more detailed breakdowns of company capital expenditures by both green investment and the upkeep or update of the current stock of assets of companies. Moreover, to assess the potential impact of the EU's increased climate ambition and the associated financial strain on high-debt EU companies on the competitiveness of the European economic area, the carbon border adjustment mechanism should be investigated in more detail.

7 Sources and References

Abadie, A. *et al.* (2017) *When should you adjust standard errors for clustering?* [Preprint]. doi:10.3386/w24003.

Albouy, D. (n.d.). Economics 131 Section Notes: Program Evaluation and the Difference in Difference Estimator. Econometric Laboratory, UC Berkeley. https://eml.berkeley.edu/~webfac/saez/e131_s04/diff.pdf

Angrist, J.D. and Pischke, J.-S. (2009) *Mostly harmless econometrics: An empiricist's companion*. Princeton, NJ: Princeton University Press.

Appunn, K., & Wettengel, J. (2024, April 10). Understanding the European Union's Emissions Trading Systems (EU ETS). Clean Energy Wire. <https://www.cleanenergywire.org/factsheets/understanding-european-unions-emissions-trading-system#:~:text=New%20linear%20reduction%20factor%3A%204.3,scope%20of%20the%20EU%20ETS>.

Bartram, S.M., Hou, K. and Kim, S. (2018) 'Real effects of climate policy: Financial constraints and Spillovers', *SSRN Electronic Journal* [Preprint]. doi:10.2139/ssrn.3262211.

Bertrand, M., Duflo, E. and Mullainathan, S. (2004) 'How much should we trust differences-in-differences estimates?', *The Quarterly Journal of Economics*, 119(1), pp. 249–275. doi:10.1162/003355304772839588.

Bolton, P. and Kacperczyk, M. (2020) *Do investors care about carbon risk?* [Preprint]. doi:10.3386/w26968.

Caragano, A. *et al.* (2020) 'Is it worth reducing GHG emissions? exploring the effect on the cost of debt financing', *Journal of Environmental Management*, 270, p. 110860. doi:10.1016/j.jenvman.2020.110860.

Clarkson, P.M. *et al.* (2015) 'The valuation relevance of greenhouse gas emissions under the European Union Carbon Emissions Trading Scheme', *European Accounting Review*, 24(3), pp. 551–580. doi:10.1080/09638180.2014.927782.

Colmer, J. *et al.* (2020) 'Does pricing carbon mitigate climate change? company-level evidence from the European Union Emissions Trading Scheme', *SSRN Electronic Journal* [Preprint]. doi:10.2139/ssrn.3725482.

Council of the European Union. (2024, January 27). Fit for 55: Reform of the EU emissions trading system. Council of the European Union. <https://www.consilium.europa.eu/en/infographics/fit-for-55-eu-emissions-trading-system/>

European Commission. (n.d.). ETS2: Buildings, road transport and additional sectors. European Commission. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/ets2-buildings-road-transport-and-additional-sectors_en

European Commission. (2019). COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF

THE REGIONS. https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF

Development of EU ETS (2005-2020) (no date) *Climate Action*. Available at: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/development-eu-ets-2005-2020_en (Accessed: 26 April 2024).

Goulder, L. and Schein, A. (2013) *Carbon taxes vs. cap and trade: A critical review* [Preprint]. doi:10.3386/w19338.

International Carbon Action Partnership (2023) *EU adopts landmark ETS reforms and new policies to meet 2030 target*, *International Carbon Action Partnership*. Available at: <https://icapcarbonaction.com/en/news/eu-adopts-landmark-ets-reforms-and-new-policies-meet-2030-target> (Accessed: 29 April 2024).

Känzig, D. and Konradt, M. (2023) *Climate policy and the Economy: Evidence from Europe's carbon pricing initiatives* [Preprint]. doi:10.3386/w31260.

Lambertides, N. and Tsouknidis, D. (2023) 'Climate regulation costs and firms' distress risk', *Financial Markets, Institutions & Instruments*, 33(1), pp. 3–30. doi:10.1111/fmii.12184.

Le Guendal, T. (2022). *Financial Modeling of Climate-related Risks* [PhD Thesis]. Institut Polytechnique de Paris.

Lynch, B. and O'Hagan-Luff, M. (2023) 'Finally, it seems to be working – the evolving valuation effect of the European Union's Emissions Trading System', *The European Journal of Finance*, 30(3), pp. 229–248. doi:10.1080/1351847x.2023.2204195.

Martin, R. *et al.* (2013) *Industry compensation under relocation risk: A company-level analysis of the EU Emissions Trading Scheme* [Preprint]. doi:10.3386/w19097.

Martinsson, G. *et al.* (2024) 'The effect of carbon pricing on company emissions: Evidence from the Swedish CO2 tax', *The Review of Financial Studies* [Preprint]. doi:10.1093/rfs/hhad097.

Mengden, A. (2023, September 5). *Carbon Taxes in Europe*. Tax Foundation. <https://taxfoundation.org/data/all/eu/carbon-taxes-in-europe-2023/>

Merton, R.C. (1974) 'On the pricing of corporate debt: The risk structure of interest rates', *The Journal of Finance*, 29(2), p. 449. doi:10.2307/2978814.

Oestreich, A.M. and Tsiakas, I. (2015) 'Carbon Emissions and Stock Returns: Evidence from the EU emissions trading scheme', *Journal of Banking & Finance*, 58, pp. 294–308. doi:10.1016/j.jbankfin.2015.05.005.

Olden, A., & Møen, J. (2022, April 22). The triple difference estimator. *The Econometrics Journal*, 25(3), 531–553.

Petersen, M. (2009) *Estimating standard errors in finance panel data sets: Comparing approaches* [Preprint]. doi:10.3386/w11280.

Pietzcker, R. C., Osorio, S., & Rodrigues, R. (2021, July 1). Tightening EU ETS targets in line with the European Green Deal: Impacts on the decarbonization of the EU power sector. *Applied Energy*, 293(116914), 13–14.

Ramos-García, D., López-Martín, C. and Arguedas-Sanz, R. (2023) ‘Climate transition risk in determining credit risk: Evidence from companies listed on the STOXX europe 600 index’, *Empirical Economics*, 65(5), pp. 2091–2114. doi:10.1007/s00181-023-02416-8.

Rodríguez-Sánchez, A. *et al.* (2022) ‘Estimating the effect of the COVID-19 pandemic on pollutant emissions in Europe’, *Atmospheric Pollution Research*, 13(5), p. 101388. doi:10.1016/j.apr.2022.101388.

Roth, J. *et al.* (2023) ‘What’s trending in difference-in-differences? A synthesis of the recent econometrics literature’, *Journal of Econometrics*, 235(2), pp. 2218–2244. doi:10.1016/j.jeconom.2023.03.008.

Scope of the EU emissions trading system (2021) *Climate Action*. Available at: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/scope-eu-emissions-trading-system_en (Accessed: 26 April 2024).

Ugolini, A., Reboredo, J. C., & Ojea-Ferreiro, J. (2024, June). Is climate transition risk priced into corporate credit risk? Evidence from credit default swaps. *Research in International Business and Finance*, 70(102372), 15–17.

Vassalou, M. and Xing, Y. (2002) ‘Default risk in equity returns’, *SSRN Electronic Journal* [Preprint]. doi:10.2139/ssrn.297319.

Wang, E., Nie, J. and Zhan, H. (2022) ‘The impact of carbon emissions trading on the profitability and debt burden of listed companies’, *Sustainability*, 14(20), p. 13429. doi:10.3390/su142013429.

Weitzman, M. L. (1974). Prices vs Quantities. *The Review of Economic Studies*, 41(4), 477-491

Wooldridge, J.M. (2013) *Introductory econometrics: A Modern Approach*. 5th edn. South-Western Pub.

Wolf, S. *et al.* (2021) ‘The European Green Deal — more than climate neutrality’, *Intereconomics*, 56(2), pp. 99–107. doi:10.1007/s10272-021-0963-z.

Wood, J. (2023) *Which EU countries are making the most progress with their emissions reductions?*, *World Economic Forum*. Available at: <https://www.weforum.org/agenda/2023/09/eu-greenhouse-gas-co2-emissions/> (Accessed: 12 May 2024).

Zieliński, T. (2013). Merton’s and KMV Models in Credit Risk Management. *Risk Perception in Financial and Non-Financial Entities*, 127, 123–135.

Data

European Central Bank (no date) *Yield curve spot rate, 1-year maturity - government bond, nominal, all issuers whose rating is triple A - euro area (changing composition), Euro Area (changing composition), Daily - Businessweek, ECB Data Portal*. Available at: https://data.ecb.europa.eu/data/datasets/YC/YC.B.U2.EUR.4F.G_N_A.SV_C_YM.SR_1Y (Accessed: 24 January 2024).

Eikon Refinitiv, company financials. (Retrieved 2024-01-18)

Eikon Refinitiv, stock returns. (Retrieved 2024-04-24)

8 Appendix I

Summary Statistics Sample Period 2017 – 2023, non-logarithmic data

Variable	N	Mean	Median	Std. Dev.	Skew	Kurt	Min	Q1	Q3	Max
Short-term Debt	3084	3,702,909,275.45	339,553,680.36	15,257,533,089.60	8.22	87.59	0.00	89,481,686.02	1,359,613,238.02	230,022,912,760.00
Long-term Debt	3155	9,454,062,808.90	2,076,123,960.00	24,975,945,320.79	5.78	47.64	0.00	581,466,667.49	6,378,773,544.12	331,739,629,780.00
Total Liabilities	3199	53,636,730,341.00	5,822,100,000.00	199,260,733,750.17	7.36	67.96	15,202,185.74	1,932,759,339.11	23,624,896,577.99	2,582,764,761,600.00
Debt to Assets	3061	0.25	0.24	0.15	0.47	3.07	0.00	0.14	0.35	0.92
Total Assets	3199	64,375,720,447.90	10,155,323,431.80	212,276,233,317.11	7.20	66.26	35,373,514.70	3,972,006,190.54	36,844,073,600.00	2,755,812,838,400.00
Enterprise Value	3137	27,919,290,969.62	10,386,501,169.73	47,625,740,124.50	3.68	20.19	-30,762,598,062.34	5,215,800,000.00	26,585,949,284.72	432,424,683,732.26
Market Capitalisation	3163	20,312,106,533.97	8,538,449,549.00	35,719,183,130.02	4.86	34.42	261,174,283.68	4,405,870,570.25	20,465,438,140.31	402,892,788,630.67
CapEx Spending	3165	963,332,508.42	252,406,121.09	2,174,950,183.09	5.05	36.30	0.00	89,800,000.00	757,000,000.00	26,365,000,000.00
Net Income	3135	1,279,416,575.47	440,314,660.19	2,605,360,575.76	4.85	39.10	-8,008,000,000.00	200,499,240.03	1,220,750,000.00	36,544,443,300.00
Revenue	3228	13,925,736,237.67	4,634,627,000.00	27,741,334,420.58	5.69	48.43	-76,958,434,161.98	1,865,881,070.69	15,087,841,484.02	356,299,801,600.00
EBITDA	3202	2,695,445,619.22	883,198,661.65	5,677,585,767.09	4.91	37.88	-19,195,551,431.06	362,836,320.94	2,457,468,628.41	72,868,261,994.44
EBITDA Margin	3203	0.25	0.21	0.45	-15.59	498.30	-13.54	0.13	0.34	8.19
Return on Assets	2881	0.064	0.051	0.12	11.39	211.10	-0.67	0.025	0.086	2.44
Full-time Equivalent	2394	44,787.86	15,187.00	80,034.36	3.79	21.49	0.00	4,787.25	50,395.75	675,805.00
EU ETS	3045	0.21	0.00	0.41	1.40	2.97	0.00	0.00	0.00	1.00
Scope 1 Emissions	2748	3,185,642.84	42,789.28	14,194,050.96	7.46	68.90	0.00	5,740.00	325,532.00	179,700,000.00
Emission Intensity	2743	0.00016	0.0000075	0.00063	7.75	78.28	-0.00000039			

9 Appendix II

Heterogeneity between Sectors in Panel Data

