Predicting Real Decarbonization Rates from Corporate Climate Change Disclosure

An analysis of the relationship between corporate climate change disclosure and real decarbonization rates

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Abstract

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This thesis is dedicated to my dad, who taught me the value of hard work.

Acknowledgments

Thank you so much to my Dad because he's the best.

This is a quote.

Author

1 Introduction

1.1 Motivation

Questions

Can quantiative forecasting play a central role in enhancing our understanding of global emissions? Will it allow us to make strategic decisions when decarbonizing? Can we build a more sustainable future with a targeted approach that uses data to identify potential for improvement? What other data do we need to increase our prediction accuracy and understend the impact of business strategies on decarbonization? Can we predict future decarbonization rates and, if so, what is the best way to do it?

Why is this important? and the interesection of academic and business interest

Those are only a few of the very important and interesting questions that drew me to research decarbonization and to focus on the role of corporate emission-level data in the process. I believe that research in this area is crucial to advance our ability to build a more sustainable future. Furthermore, the answers to these questions can help us make better decisions and build a more sustainable future while also creating value for businesses. Additionally, the call for more data in decarbonization comes not only from the academic world but also from the fact that many business opportunities arise from the climate transition that inevitably requrie good and valid information to determine which companies and sectors are winners and loosers, which are the champions in the decarbonization process, which are the laggards, and which are the companies that are greenwashing. I believe that studying specifically corporate emissions and forecasting decarbonization rates as I am doing in this thesis can be useful to three key stakeholders:

The key stakeholders

1. **Investors** who are increasingly interested in understanding the climate risk of their portfolios and in identifying the companies that are best positioned to succeed in the transition to a low-carbon economy. For examples, companies such as BlackRock [insert quotation here] are enhancing their sustainable investing strategies and offering more sustainable investment products to their clients.

2. **Companies** who are increasingly interested in understanding their climate risk and in identifying the best strategies to reduce their emissions and to succeed in the transition to a low-carbon economy. Additionally, companies might be interested in benchmarking against their peers in the sector to understand how they are performing relative to their competitors and to identify the best practices.

3. **Policy makers** who are increasingly interested in understanding the climate risk of their countries and in identifying the best strategies to reduce their emissions and to succeed in the transition to a low-carbon economy. A sector and company level analysis can be useful in determining optimal targets for new policies, identifying the best practices, and understanding the impact of new policies on the sector and on the economy.

Connection between computer science and decarbonization

Finally, I believe that the use of data and modeling techniques can help us build a more sustainable future in a practical, nonpolitical, and unbias way. Estimating emissions is an amazing example of how Computer Sicence and Statistical models can help us achieve real impact driving strategic decisions. I argue furthermore that it is only through a quantitative driven approach that we can dimistify the climate debate and make progress in the climate transition. I am confident that work in the modeling decarbonization has an incredible potential to create value for business and society and especially with increasing data availability and computational power, the time is ripe to make progress in this area. As I will explain in the next sections, this thesis is only possible thanks to incresased data availablity and to the willingness of corporates to disclose their emissions.

1.1.1 Emission Scopes

The thesis will assume familiarity with the concept of Scopes 1, 2, and 3 emissions which I am going to explain in this section. In carbon-accounting and emissions reporting, it is very important to distinguish between three types of emissions: Scope 1, Scope 2, and Scope 3 emissions. Each category represents a different level of emissions associated with an organization's activities.

- **Scope 1** emissions are direct emissions from owned or controlled sources. This includes emissions from company vehicles, and emissions from chemical processes or combustion in owned or controlled boilers, furnaces, etc.

- **Scope 2** emissions are indirect emissions from the generation of purchased electricity, steam, heating, and cooling consumed by the reporting company. These emissions occur at the facility where the energy is generated, not at the point of consumption.
- **Scope 3** emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company. This includes both upstream and downstream emissions, encompassing a wide range of activities such as the extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

Understanding these scopes is critical for organizations aiming to fully assess and manage their carbon footprint.

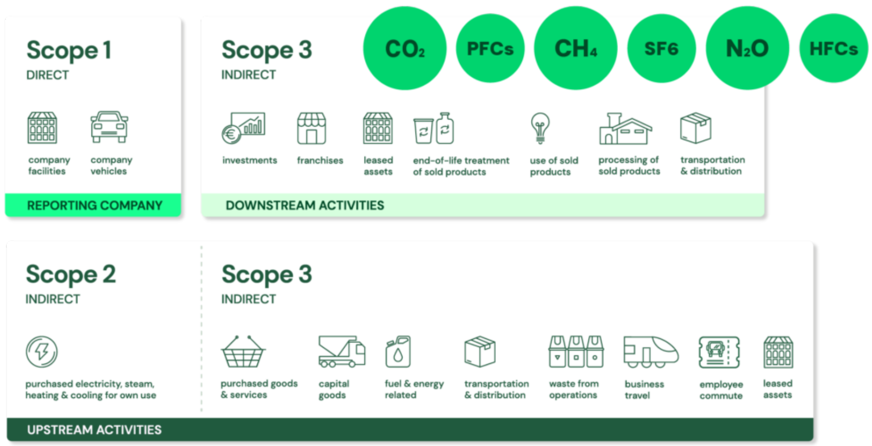


Figure 1.1.1: Caption of Scopes 1, 2, and 3 Emissions. Adapted from [5].

1.1.2 A business oriented framework to justify decarbonization

The Paris Agreement sets forth ambitious objectives to combat climate change, aiming to cap the increase in global temperatures to 2°C, with an aspirational target of 1.5°C, above pre-industrial levels. This is to be achieved through a series of significant measures, including reaching net-zero greenhouse gas emissions by 2085 and a reduction of these emissions by 10% by 2030 [20]. These goals require substantial transformations in global economic structures, especially in the realms of energy consumption and the development of renewable energy sources. For instance, in the United States, attaining deep decarbonization necessitates a national overhaul in the way energy is produced and used, with implications for urban planning and land management [15]. Similarly, in the European Union, deep decarbonization could be pursued via either a demand-driven system or a centralized approach to manage carbon emissions. However, achieving more ambitious targets will require a broader mix of technologies and greater intersectoral synergy [16].

Numerous policy instruments, particularly carbon taxation, are progressively being implemented in major developed economies. Some experts advocate for a global carbon tax as a potent mechanism to expedite decarbonization in the energy sector.

However, this approach encounters several hurdles, including substantial capital investment needs, competition between different sectors, varying environmental policies across regions, and the challenge of securing public acceptance for changes in energy consumption habits [19].

In my opinion, regardless of the specific outcomes of a global carbon tax, the transition to a low-carbon economy is inevitable and will have a profound impact on the business world. This is because, despite the decrease in 2020 due to the COVID-19 pandemic, global energy-related CO 2 emissions remained at 31.5 Gt, contributing to CO2 reaching its highest ever average annual concentration in the atmo-sphere of 412.5 parts per million in 2020 – roughly 50% higher than when the industrial revolution began. Global energy-related CO 2 emissions are expected to rebound and continue increasing, as demand for coal, oil, and gas recovers along with the economy [6]. It seems like carbon emissions are arguably the greatest negative externality that is currently affecting global markets, we don't yet have a single global policy to regulate emissions, that is not game theory optimal for a country to commit to lowering emissions before others, but chances are that if the decabonization strategy is not implemented, the world will face a climate crisis that will have a profound impact on the economy. Interestingly, the more we wait to implement a decarbonization strategy, the more likely it will be that the transition will need to be more abrupt, and in this case firms that are not prepared will face significant risks, while firms that are prepared will have a competitive advantage. As Professor Serafeim argues, such transition should not be seen as an inefficiency, but rather as a demand for innovation and a source of new business opportunities [17]. Indeed, by transitioning to a low-carbon economy, companies can create value for their shareholders, employees, and society at large. Therefore, if a company is to succeed in a modern business landscape, it must do so by alignign its profit strategy with a concrete purpose strategy, which includes a commitment to lowering carbon emissions. When it comes to sustainability, the transition will require significant changes in the way companies operate, and it will create both risks and opportunities [17]. For instance, companies that are able to reduce their emissions will be better positioned to succeed in the transition, while companies that are unable to do so will face significant risks. The transition will also create opportunities for new business models and technologies, and it will require companies to adapt to new regulations and policies. In this context, it is crucial for companies to understand their climate risk and to identify the best strategies to reduce their emissions and to succeed in the transition to a low-carbon economy. This is where the role of data and modeling techniques becomes crucial. Not only can these techniques help companies understand their climate risk, but they can also help companies identify the best strategies to reduce their emissions and to succeed in the transition to a low-carbon economy. Under this framework, it is therefore not surprising to see that companies are increasingly interested in understanding their climate risk and in identifying the best strategies to reduce their emissions and to succeed in the transition to a low-carbon economy and are increasingly more willing to disclose them.

1.2 Carbon Disclosure Project Data

Figure 1.2.1: Carbon Disclosure Project Logo. Adapted from [8].

The primary data source for this thesis is the Carbon Disclosure Project (CDP) Climate Change Questionnaire [9], which was kindly provided to me by the Climate and Sustainability Impact Lab from the Digital Design Institute at the Harvard

Business School [13]. The Carbon Disclosure Project is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states and regions to manage their environmental impacts [8]. The importance of the CDP is widely recognized by the business and the academic communities. As Ban Ki Moon, former Secretary General of the United Nations, states "The work of CDP is crucial to the success of global business in the 21st century... helping persuade companies throughout the world to measure, manage, disclose and ultimately reduce their greenhouse gas emissions. No other organization is gathering this type of corporate climate change data and providing it to the marketplace" [8]. The Carbon Disclosure Project Sustainability Questionnaire uses the Greenhouse Gas (GHG) Protocol as a reporting model for carbon-related data [4]. It is one of the largest datasets of self-reported GHG emissions and collects a wide range of information on climate change-related topics. The questionnaire provides a globally consistent disclosure standard for GHG emissions and information on a firm's activities to reduce GHG emissions. The CDP is backed by a large number of institutional investors, including banks, insurance companies, asset management companies, and pension funds holding US$100 trillion in assets (i.e., CDP signatories), which act as "norm entrepreneurs" [18]. Currently more than 23,000 companies disclose their emission data through the survey, representing two thirds of global market capitalization [8].

Motivations Behind Corporate Disclosure to the CDP

The Carbon Disclosure Project (CDP) questionnaire has not only gained increasing popularity among companies but has also become a pivotal tool for investors and other stakeholders in evaluating corporate climate risks. It plays a crucial role in identifying effective strategies for emission reduction and in navigating the transition towards a low-carbon economy. The growth in the completion and publication rates of the CDP questionnaire reflects its importance, with institutional investors exerting a notable influence on climate change disclosure through corporate communication channels [11]. Consequently, the annual increase in the number of companies engaging in disclosure highlights a substantial data pool, invaluable for analyzing the decarbonization process and projecting future emission trends. The rationale for companies to disclose varies, encompassing regulatory compliance, investor expectation alignment, reputation enhancement, peer benchmarking, emission reduction opportunity identification, and risk assessment. Furthermore, disclosing to CDP entails two independent steps: the first involves the completion of the questionnaire, while the second involves the publication of the response. The latter step is particularly significant, as it demonstrates a company's commitment to transparency and accountability, thereby enhancing its reputation and credibility [11].

1.2.1 Current Metrics and Limitations

The CDP survey assigns a score that ranks the performance of companies when decarbonizing. For reference, 48% of S&P companies scored high-performance band B ratings and above in their Carbon Disclosure Project (CDP) reports in 2014 [21]. When assiging a score, CDP assesses the level of detail and comprehensiveness in a response, as well as the company's awareness of environmental issues, its management methods and progress towards environmental stewardship [7]. Additionally, specifically for climate-change scores, to recieve an A-level grade a copmany must verify at least 70% of Scope 1, Scope 2 and Scope 3 emissions with a CDP-approved verification standard. Among other criteria, to score an A on Climate Change, companies must have robust governance and oversight of climate issues, rigorous risk management processes, verified scope 1 and 2 emissions and be reducing emissions across their value chain. Most Climate Change A List companies as of 2022 have well established emissions targets that have been approved by the SBTi, and evidence of targets which cover their scope 3 emissions [7].
While the CDP score is a valuable and widely recognized metric, it has several limitations. First, the CDP score is assigned based on adherance to best-practices and does not provide a future outlook on the company-specific ability to reduce emissions. It signals that the company is currently adhearing to best practices, but

Figure 1.2.2: Caption of CDP Scoring Grades. Adapted from [7].

there is no immediate way to know by how much will the company be able to reduce its emissions in the future. Second, the CDP score is based on self-reported data, which can be subject to biases and errors. Third, the score does not provide an estimate of the company's future emissions, which is crucial for investors and policy makers. Thus, the score can be useful as a first metric and this leaves the door open for more sophisticated models to be developed which is the main goal of this thesis, in particular when it comes to forecasting next-year emissions and whether a company will perform better or worse in the future compared to its peers.

2
Data

2.1 Data Formats

The reports can be requested from the CDP website [8], they available both in PDF and a structured CSV format. The CSV files encompass the responses submitted to the CDP questionnaire, which form the foundation of the predictor and response variables for this thesis. My work is a continuation of the initial data processing that was executed by Climate and Sustainability Impact Lab [13] and kindly shared with me in the form of various stata files and a repository containg both the raw and processed data, where the multiple sections had been extracted from the survey and aligned across different years. I then imported all the data and further processed it to create the training and tests sets for the following models.

2.2 CDP Report Structure

The CDP survey has X primary sections, with each section containign a list of subsecitons with relevant questions. This is a list of the primary sections as well as a brief introduction to the types of questions present in the section:

- **C0 - Introduction:** General description of the organization, along with information on where the company operates geographically, the currency used to report financial information, and the reporting boundary (whether it is financial or operational control), and the ISIN if the company is public

- **C1 - Governance:** Governance structures and processes related to climate change within the organization. It includes questions about board-level oversight of climate-related issues, the roles and responsibilities of management in addressing climate change, and how climate-related risks and opportunities are integrated into the company's overall governance framework. This section provides insight into the company's commitment to addressing climate change at the highest level of its organizational structure.

- **C2 - Risks and Opportunities:** Identification of processes that the organization uses to identify, assess, and respond to climate-related risks and opportunities. It includes questions regarding the definition of time horizons (short, medium, and long-term) for these risks and opportunities, and specific related details. This section aims to understand how the company perceives and manages potential impacts of climate change on its business, highlighting its approach to mitigating risks and capitalizing on new opportunities arising from the changing climate landscape.

- **C3 - Business Strategy:** This section examines the company's business strategy in relation to climate change. It explores whether the organization's strategy includes a transition plan that aligns with a 1.5°C world scenario, detailing the nature and publicly available aspects of this plan. The focus is on understanding how the company's strategy is designed to adapt to and mitigate climate-related issues, and how it plans to transition towards a lower-carbon, more sustainable business model. This section also looks at how feedback is collected from shareholders on the transition plan, emphasizing the integration of climate considerations into the core business strategy.

- **C4 - Targets and Performance:** This section presents an in-depth analysis of the company's specific emissions targets, including which emissions scopes are covered, targeted reduction percentages, and the current progress towards these goals. It also examines the emissions reduction initiatives that the company had active during the reporting year, detailing associated investments and the expected payback period. This part of the report effectively illustrates both the targets set by the company for reducing emissions and the concrete initiatives underway to achieve these objectives.

- **C5 - Emissions Methodology:** Insights into the company's emissions methodology, including any structural changes that may have occurred. It outlines the base year emissions against which progress is measured and explains the methodology employed to collect and report emission data. Additionally, it highlights the protocols and standards adhered to, ensuring the accuracy, consistency, and comparability of emissions data over time.

- **C6 - Emissions Data**: This section covers both Scope 1 and Scope 2 emissions. It includes relevant details, such as the categorization of Scope 2 emissions as either location-based or market-based. Additionally, the section provides insights into emission intensity per product, allowing for a detailed examination of emissions in relation to the company's products and operations.

- **C7 - Emissions Breakdowns:** This is the section where company emissions (scope 1 and 2) are broken down into various sub-categories based on country/region, business division, and sector production activity. Most importantly, this section also provides a breakdown of changes in gross global emissions (Scope 1 and 2 combined), and for each of them a specification of how your emissions compare to the previous year. **Emissions breakdowns will be further analyzed in the response variable discussion and linked to this section.**

- **C8 - Energy:** A comprehensive description of energy purchases and consumption, with a specification of renewable and non-renewable sources as well as consumption breakdowns by location. This section is useful in understanding whether the company is actively purchasing renewable energy and whether the firm's activity are energy intensive.

- **C9 - Additional metrics:** Description of other sustainability related metrics such as investments in low carbon research and developement, transport technologies, and product/services

- **C10 - Verification:** This section provides a comprehensive description of the verification methodologies that the firm implements to verify and audit its emissions scopes. The report includes the proportion of verified emissions by scopes, verification standards and status.

- **C11 - Carbon Pricing:** Assesment of whether the company is subjected to a carbon tax and, if so, in which geographies and under which regimes along with a description of the percentage of emission scopes covered by the policy and the strategies that the company is implementing to comply with the regulations. Additionally, the section asks whether the company has an internal price of carbon and its related objectives.

- **C12 - Engagement:** Analysis of the company's effort to engage with its value chain to reduce carbon emissions. In particular, the company discloses which agents does the company collaborate with, whether the company requires suppliers to meet certain sustainability criteria, and whether the company engages with customers to drive awareness on climate related issues. Additionally, the company discloses whether it engages with policy makers in a way that could influence climate related policy, law, or regulation

- **Other Sections:** Sections beyond C12 are not relevant for the purpose of the thesis. They include details on biodiversity and signoff details among other metrics.

2.3 A Case Study on Two CDP Reports

To begin the discussion on exploratory data analysis, I must first address the complexities of emission accounting and reporting within the framework of CDP data, highlighting its distinct nature compared to the more standardized field of financial reporting. That is, despite ongoing improvements, emission reporting still falls short of the robust standards established in financial accounting. I will highlight this by analyzing the 2022 CDP reports from two markedly different companies: General Motors (GM) in the automotive sector and Jet Blue in the airline industry. These reports underscore the highly company-specific nature of emission data, with significant variances stemming from diverse operational practices, especially across different industries. This results in a substantial reliance on text-based and free-form answers within the CDP reports, presenting unique challenges for data analysis. To navigate this complexity, a critical starting point is to analyze the inherent differences in these reports, which will inform and refine our modeling approach. By understanding and accommodating these industry-specific nuances, we aim to develop a more accurate and representative model of emission reporting and reduction strategies as well as identifying potential areas of improvement.

2.3.1 General Motors 2022 CDP Report

General Motors Company (GM), a global leader in the automotive industry, is headquartered in Detroit, Michigan, USA. Renowned for its ownership and production of the Chevrolet, GMC, Cadillac, and Buick brands, GM was the largest automaker in the United States by sales in 2022. GM's commitment to sustainability is evident in its strategic approach to reducing Scope 1, Scope 2, and

Scope 3 greenhouse gas (GHG) emissions, with comprehensive governance and ambitious environmental targets.

Scope 1 and Scope 2 Emissions

GM has set forth aggressive targets to reduce its Scope 1 and Scope 2 emissions by 71.4% by 2035, relative to its 2018 baseline. In 2018, GM reported Scope 1 emissions of 1,763,555 metric tons CO2e and Scope 2 emissions of 3,924,338 metric tons CO2e. By the reporting year 2022, GM achieved a reduction to 1,252,906 metric tons CO2e for Scope 1 and 2,150,694 metric tons CO2e for Scope 2, marking significant progress towards its goal. This reduction aligns with the 1.5 degrees Celsius strategy set by the Paris Agreement, underscoring GM's commitment to global climate initiatives [10, 23].

GM's strategy includes enhancing energy efficiency across its manufacturing operations and increasing the use of renewable energy. In 2021, GM implemented over 300 energy efficiency improvements, such as upgrading to more efficient equipment and increasing renewable electricity use from 23% to 25%, contributing to GHG reductions in Scope 2 emissions.

Scope 3 Emissions

Addressing Scope 3 emissions, GM has set a target to achieve a 50.4% reduction in its vehicle use emissions, from a baseline of 0.0002466 metric tons of CO2 per kilometer to 0.0001223136. GM's strategy to meet this target includes transitioning to an all-electric vehicle (EV) future, with plans to introduce 30 new EV models by 2025 and aspirations to be fully electric by 2035. Partnerships to increase renewable energy generation and deploy EV chargers, in collaboration with EvGo, further exemplify GM's holistic approach to reducing its carbon footprint across the value chain.

Key Takeaways

- **Strategic Emissions Reduction:** GM's targeted reductions in Scope 1 and Scope 2 emissions demonstrate a strong commitment to environmental stewardship, leveraging technological advancements and renewable energy.
- **Leadership in Electric Vehicles:** GM's aggressive transition to an all-EV lineup by 2035 highlights its leadership role in transforming the automotive industry towards sustainability.
- **Comprehensive Approach to Sustainability:** Through its Scope 3 emissions reduction target, GM addresses the broader environmental impact of its products, emphasizing the importance of a comprehensive strategy that extends beyond direct emissions.

GM's sustainability efforts showcase a deep commitment to reducing its environmental impact and leading the automotive industry towards a more sustainable future. By strategically targeting Scope 1, Scope 2, and Scope 3 emissions, GM is not only adhering to global climate agreements but also setting a precedent for corporate responsibility in addressing climate change.

2.3.2 JetBlue Airways Corporation 2022 CDP Report

JetBlue Airways Corporation has been steadfast in its commitment to environmental stewardship, focusing on reducing Scope 1, Scope 2, and Scope 3 greenhouse gas (GHG) emissions across its operations. The airline's governance structure emphasizes sustainability, with strategic initiatives overseen by its board and executive team, underscoring a comprehensive approach to addressing climate change.

Scope 1 and Scope 2 Emissions

In the reporting year 2022, JetBlue's Scope 1 emissions totaled 6,853,927 metric tons CO2e, predominantly from jet fuel combustion, a primary challenge within the airline industry. Scope 2 emissions amounted to 25,945 metric tons CO2e, reflecting the emissions from electricity consumption. These figures demonstrate JetBlue's significant environmental footprint, necessitating aggressive measures for reduction. JetBlue's strategies to mitigate these emissions include modernizing its fleet with more fuel-efficient aircraft, such as the Airbus A220 and A321neo, and investing in sustainable aviation fuel (SAF) to reduce lifecycle GHG emissions associated with jet fuel. Additionally, the airline is transitioning its ground service equipment to electric power, aligning with its commitment to lower Scope 1 and Scope 2 emissions.

Scope 3 Emissions

JetBlue's Scope 3 emissions are a crucial component of its sustainability strategy, addressing emissions from purchased goods and services, capital goods, and fuel-and-energy-related activities not included in Scope 1 or 2. In 2022, the emissions reported were as follows:

- Purchased Goods and Services: 44,922 metric tons CO2e, estimated for catered food and onboard product.
- Capital Goods: 485,629 metric tons CO2e, associated with aircraft ground equipment and spare parts.
- Fuel-and-Energy-Related Activities: 1,391,126 metric tons CO2e, highlighting the broader impact of JetBlue's operational energy use.

These figures were calculated using the Quantis Scope 3 tool, demonstrating JetBlue's reliance on standardized methodologies to quantify and manage its indirect emissions. The airline's commitment to understanding and reducing its Scope 3 emissions is evident through its detailed reporting and targeted reduction strategies, including investments in SAF and efficiency improvements across its value chain.

Key Takeaways

- **Comprehensive Climate Strategy:** JetBlue's efforts to reduce Scope 1, Scope 2, and Scope 3 emissions underscore a holistic approach to sustainability, addressing both direct and indirect sources of GHG emissions.
- **Innovation and Efficiency:** Through fleet modernization, SAF investments, and operational efficiencies, JetBlue is actively working towards reducing its environmental impact, despite the inherent challenges of the airline industry.
- **Scope 3 Emissions Challenge:** JetBlue's detailed reporting on Scope 3 emissions highlights the complexity of addressing indirect emissions. The airline's engagement with its supply chain and investment in sustainable practices exemplify a forward-thinking approach to environmental responsibility.

JetBlue's sustainability efforts reflect a deep commitment to reducing its carbon footprint and contributing to the global fight against climate change. By addressing Scope 1, Scope 2, and Scope 3 emissions with targeted strategies and investments, JetBlue is paving the way for a more sustainable future in aviation.

2.4 Data Sources

2.4.1 Data: Climate Change Response Questionnaire

The main data source comes from the CDP Climate Survey, it contains the response surveys from all companies from 2011 to 2022. The data was partially cleaned and processed by the Climate and Sustainability Impact Lab [13] before being shared with me. This comprehensive dataset was provided a repository that includes both raw and processed data in the form of Stata files. Organized by firm-years, each observation in the dataset corresponds to a specific firm in a given year, and is structured in a panel format, having a unique id year pair to uniquely identify each entry. The original dataset contained $34,588$ firm-years across 11 years. Since the analysis controls for financial and industry-specific predictors, I decided to focus on public companies, which represent 71% of the firm-years in the dataset. Therefore, $9,785$ firm-years were dropped from the analysis because they did not have an ISIN code, which is a unique identifier for public companies.

Important Considerations on the CDP Data

- **Reporting year lag:** The data from a given year corresponds to the financial and operational data from the previous year.This was an important consideration when merging the CDP data with other data sources, such as the Worldscope financial data.

- **Data processing:** The original data processing entailed the extraction of multiple sections from the survey, which were then systematically aligned across different years, ensuring consistency across times and adjusting the format when the questions on the CDP surveyed changed or were slightly modified. It is important to note that the fact that some questions were not asked in some years, and that the questions were not always the same across years, is a significant challenge for the analysis which is specifically focused on forecasting emissions.

2.4.2 Data: Worldscope Fundamental Core Items

In addition to the CDP Climate Survey data, financial predictors were obtained using the Worldscope database [3] accessed through Wharton Research Data Services (WRDS) [22]. Worldscope offers detailed standardized financials, allowing for comparisons of financial information across companies from various industries worldwide. This database boasts a long history, with over 35 years of data for key developed markets dating back to 1980 and more than 25 years for emerging markets. With its extensive coverage of over 100,000 companies in more than 120 countries, including full standardized coverage of over 30 developed and emerging markets and accounting for 99% of global market capitalization, Worldscope is a comprehensive source for firm-level data. Specifically, I queried the fundamental annuals through Worldscope via WRDS, which provided key global information such as *revenue*, *total assets*, *number of employees*, and *net income*, which I then used as predictors for my analysis [3]. Data was retrieved based on the ISIN code, and resulted in 96% of the firm-years having matching financial data. Of those, 17% had missing values for *at least one* of the selected financial variables, thus the corresponding firm-years were dropped from the data-set. This choice has been made as firms with missing financial data are likely to have total assets less than 1 million, thus I removed them following a similar criteria enstablished by Serafeim et Al. [**?**].

2.4.3 GICS Data

Accessed through WRDS using Capital IQ, the Global Industry Classification Standard (GICS) provides the framework for this study's industry analysis. GICS, a collaborative creation by MSCI and S&P Dow Jones Indices, offers a hierarchical, four-tiered classification system, encompassing Sectors, Industry Groups, Industries, and Sub-Industries. This standard ensures a consistent approach to defining company activities worldwide, crucial for comparative financial analysis. The classification of a company within GICS hinges on its principal business activity, with revenue being a primary determinant. The system also considers earnings and market perception, elements that contribute to the annual refinement of the classifications to mirror evolving market conditions. This research utilizes the 25 industry groups defined within GICS, facilitating a detailed examination of firm-level data against a backdrop of global industry standards [1, 2]. I queried the GICS data only for the firm-years that had matching financial data, resulting in 19,200 firm-years with complete financial and GICS data. GICS data was avaialble for 99% of the firm-years that had matching financial data.

Figure 2.4.1: Global Industry Classification Standard (GICS) Structure [2].

2.4.4 Data Cleaning Process Flowchart:

This is a visual representation of the data cleaning process described in the data sources with a specification of the number of firm-years dropped at each step:

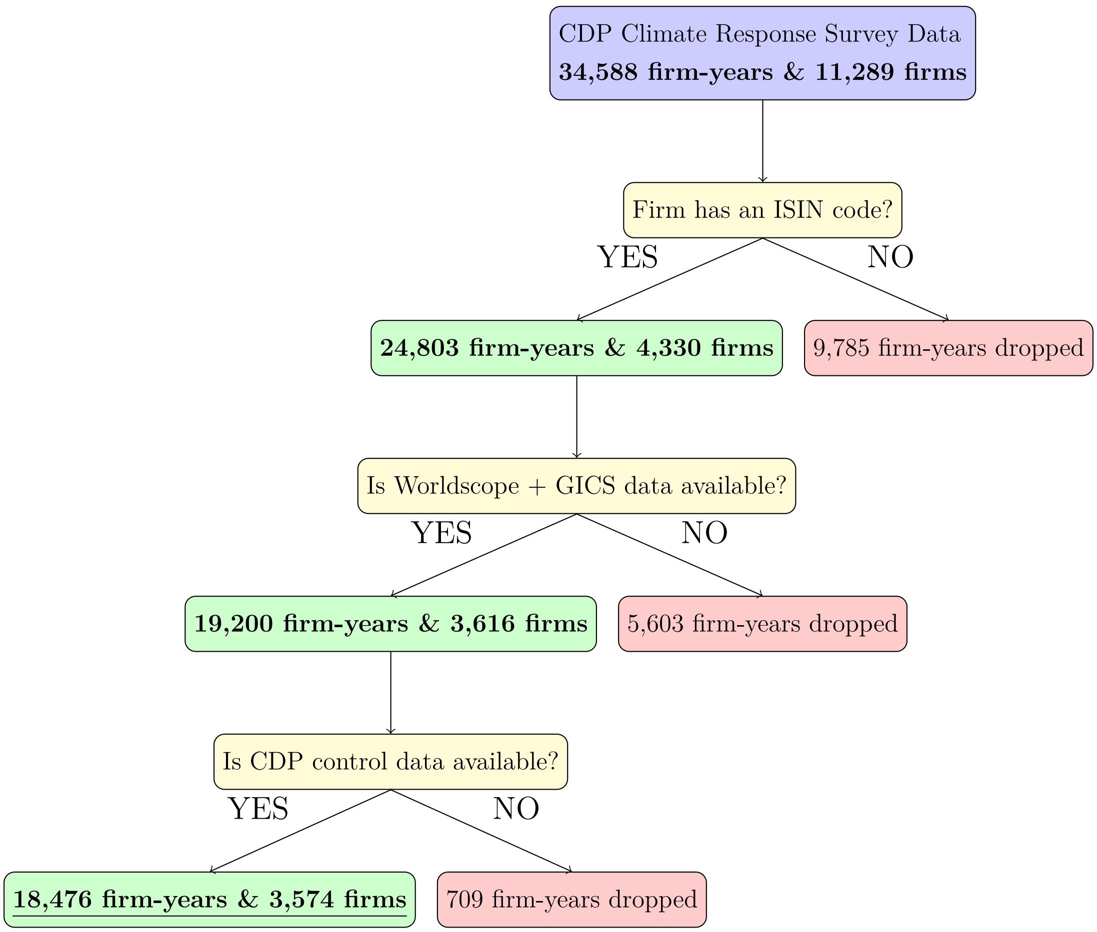


Table 2.4.1: Data Cleaning Process Flowchart

The final dataset contains **18,476 firm-years across 3,574 firms, with complete CDP, Worldscope, and GICS data**.

2.4.5 Variable Dictionary

Table 2.4.2 provides an overivew of the predictors used in the analysis, including their type, description, and source. Predictors are divided into three primary categories:

- **Firm Information:** Variables that describe the firm's characteristics, such as its unique identifier, reporting year, headquarters country, headquarters continent, and industry sector.
- **Financial Predictors:** Variables that capture the firm's financial performance, including total revenue, total assets, total employees, net income, and market capitalization.
- **CDP Predictors:** Variables derived from the CDP Climate Survey, such as the firm's emissions, energy consumption, and climate-related targets and initiatives.

Variable	**Type**	**Description**	**Source**
Firm Information			
ID	categorical	unique firm identifier	CDP
Year	numerical	reporting year	CDP
Country	categorical	headquarters country	CDP
Continent	categorical	headquarters continent derived from country	CDP
Industry	categorical	Global Industry Classification Standard 25 industry sectors	GICS
Financial Predictors			
log(Revenue)	numerical	natural logarithm of total revenue	Worldscope

Continued on next page

Table 2.4.2 – *Continued from previous page*

Variable	**Type**	**Description**	**Source**
log(Assets)	numerical	natural logarithm of total assets	Worldscope
log(Assets 1yr gr.)	numerical	natural logarithm of total assets growth	Worldscope
log(Employees)	numerical	natural logarithm of total employees	Worldscope
log(Empl. 1y gr.)	numerical	natural logarithm of total employees growth	Worldscope
log(Net Income)	numerical	natural logarithm of net income	Worldscope
log(Market Cap)	numerical	market capitalization	Worldscope
log(Roe)	numerical	natural logarithm of return on equity	Worldscope
log(Revenue)	numerical	natural logarithm of total revenue	Worldscope
CDP Predictors			
Variable5	Type5	Description5	Source5
Variable6	Type6	Description6	Source6

Table 2.4.2: Variable Dictionary

2.4.6 The Response Variable: Real Decarbonization Rate

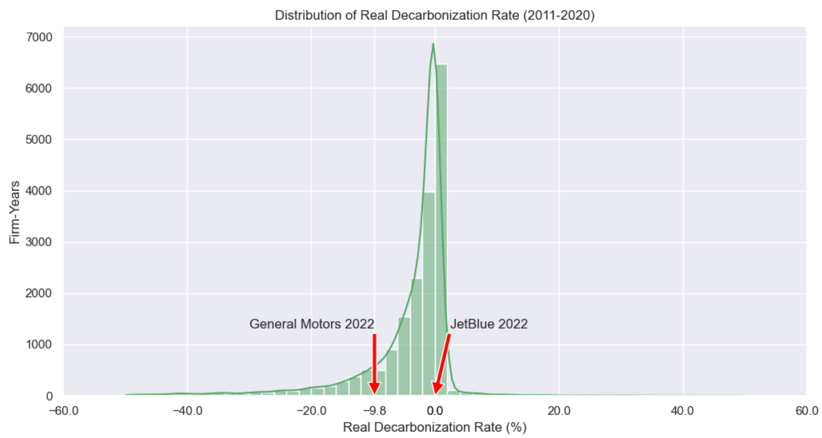


Figure 2.4.2: Real Decarbonization Rate

2.4.7 Real Decarbonization Rate Breakdown by Continent

Figure 2.4.3 and the relative table show the mean real decarbonization rate by continent across all CDP reporting years from 2011 to 2022. As expected, there is significant class imbalance between continents, with Europe having the most number of firms, followed by North America and Asia. There is a significant difference in the mean decarbonization rate across continents, with Europe having the best mean decarbonoization rate with an average yearly decrease of -4.94% and Africa having the worst mean decarbonization rate with an average yearly decrease of -2.81%. Overall, the data suggests that operating in an environment with more incentives to report and reduce emissions, such as Europe, is associated with a higher mean decarbonization rate. This is consistent with the findings of Downar et al. [14] which shows in a UK-based study that firms with a carbon disclosure mandate reduced emissions by 8% without negatively impacting their financial operating performance. The hypothesis will be further tested in the following sections.

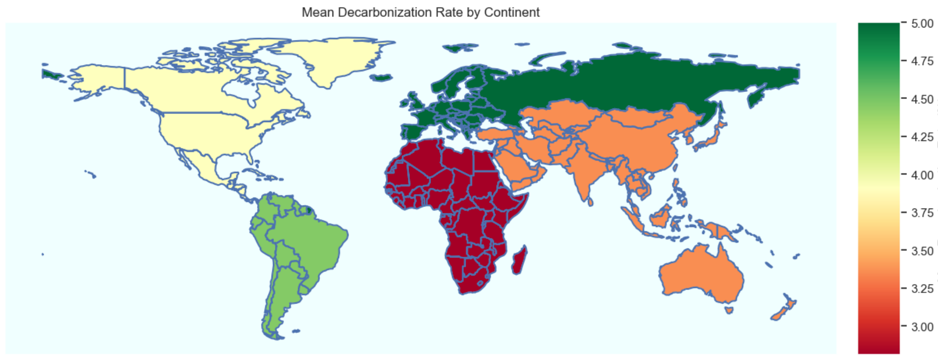


Figure 2.4.3: Mean *real decarbonization rate* by continent from 2011 to 2022

Continent	# firms	Mean	Median	Std
Africa	79	-2.8%	-0.9%	5.9%
Asia	1175	-3.1%	-1.0%	6.4%
Europe	1217	-4.9%	-1.9%	8.6%
North America	933	-3.5%	-1.0%	7.3%
Oceania	101	-3.1%	-0.6%	6.9%
South America	90	-4.0%	0.0%	10.1%

2.4.8 Real Decarbonization Rate Breakdown by Sector

Figure 2.4.4 and the relative table show the mean real decarbonization rate by sector across all CDP reporting years from 2011 to 2022. The data shows that the mean decarbonization rate varies significantly across sectors, with the best mean decarbonization rate in the Software and Services sector, with an average yearly decrease of -6.67%, and the worst mean decarbonization rate in the Materials sector, with an average yearly decrease of -2.46%. Additionally, there are significant differences in the number of firms across sectors, with the Capital Goods sector having the most number of firms, 475 and the Household and Personal

Products sector having the least number of firms, 43. Differences in sectors are important to consider, as they can be indicative of the difficulty of decarbonizing a given industry. For example, our data suggests that Transportation and Materials are the sectors with the worst mean decarbonization rates, which is consistent with the findings of Davis et al. [12] which suggest that difficult-to-decarbonize energy services include aviation, long-distance transport, steel and cement production.

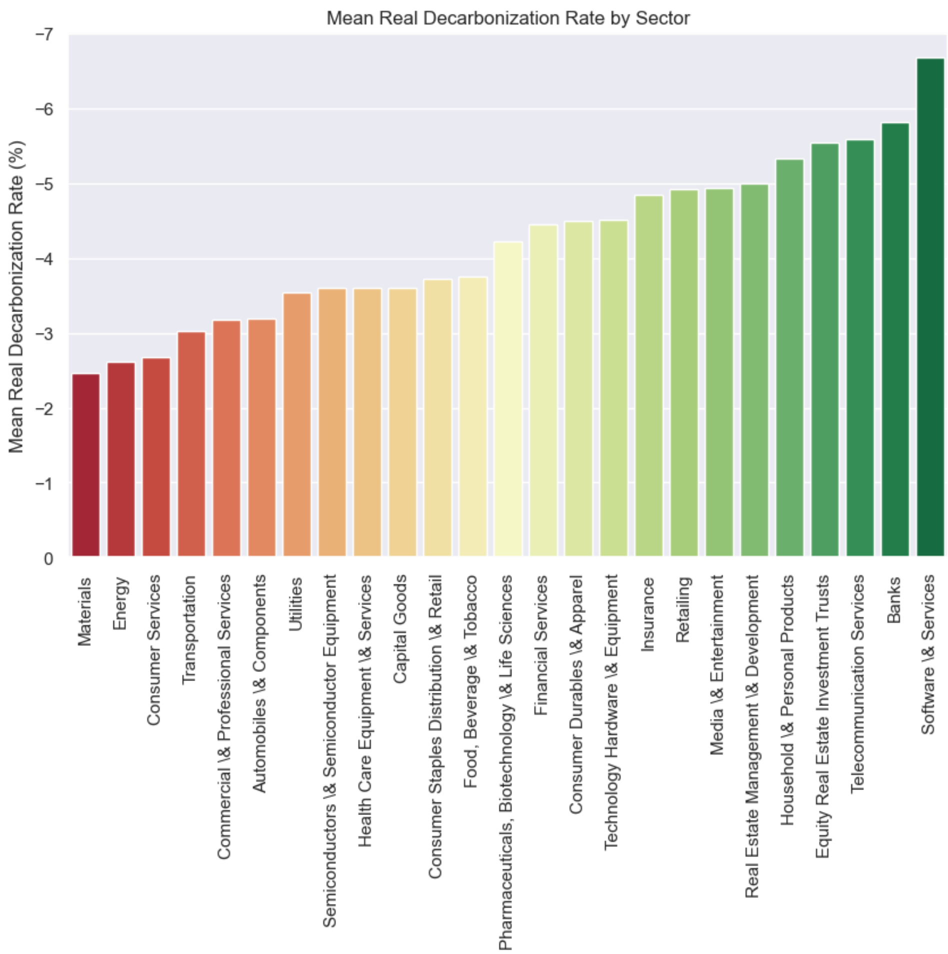


Figure 2.4.4: Mean Real Decarbonization Rate by Sector

Sector	# firms	Mean	Median	Std
Automobiles & Components	124	-3.2%	-1.91%	5.54%
Banks	166	-5.82%	-2.9%	9.46%
Capital Goods	475	-3.6%	-1.1%	6.87%
Commercial & Professional Services	134	-3.18%	-0.04%	7.7%
Consumer Durables & Apparel	127	-4.5%	-1.4%	8.28%
Consumer Services	89	-2.67%	-0.96%	6.65%
Consumer Staples Distribution & Retail	65	-3.72%	-1.9%	6.72%
Energy	151	-2.62%	-0.15%	5.66%
Equity Real Estate Investment Trusts	96	-5.53%	-2.33%	8.9%
Financial Services	158	-4.45%	-0.6%	8.98%
Food, Beverage & Tobacco	187	-3.75%	-1.5%	6.63%
Health Care Equipment & Services	100	-3.6%	-0.9%	7.45%
Household & Personal Products	43	-5.33%	-2.4%	8.09%
Insurance	96	-4.85%	-2.0%	8.39%
Materials	420	-2.46%	-0.6%	5.78%
Media & Entertainment	70	-4.93%	-0.54%	8.25%
Pharmaceuticals, Biotechnology & Life Sciences	97	-4.23%	-1.8%	7.63%
Real Estate Management & Development	53	-4.99%	-1.1%	8.86%
Retailing	115	-4.93%	-1.3%	9.43%
Semiconductors & Semiconductor Equipment	79	-3.6%	-0.5%	8.15%
Software & Services	140	-6.67%	-2.85%	10.21%
Technology Hardware & Equipment	185	-4.5%	-1.8%	8.76%
Telecommunication Services	77	-5.58%	-2.34%	9.26%
Transportation	155	-3.02%	-1.0%	6.3%
Utilities	173	-3.54%	-0.1%	8.08%

2.4.9 Real Decarbonization Rate Breakdown by Country

Figure 2.4.5 shows the mean real decarbonization rate by country across all CDP reporting years from 2011 to 2022. There are significant differences both in the number of firms and in the mean decarbonization rate across countries. Table 2.4.5 shows summary statistics for the worst 10 performing countries with nonzero mean real decarbonization rates. For a complete list of countries, see appendix table.

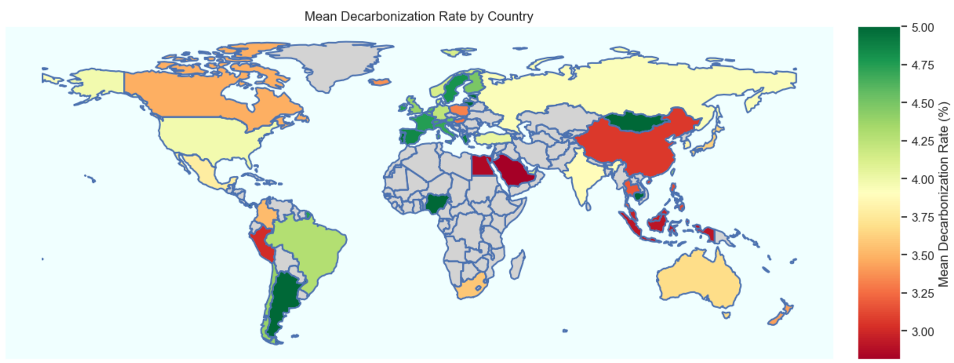


Figure 2.4.5: Mean Decarbonization Rate by Country

Country	# firms	Mean	Median	Std
Saudi Arabia	1	-0.6%	-0.6%	nan%
Egypt	2	-1.46%	0.0%	2.85%
Indonesia	10	-1.53%	0.0%	2.76%
Malaysia	13	-1.57%	0.0%	6.19%
Cayman Islands	2	-1.62%	0.0%	7.54%
Peru	1	-1.67%	0.0%	4.53%
China	78	-1.76%	0.0%	5.85%
Hong Kong	35	-1.7%	-0.27%	7.43%

Continued on next page

Country	# firms	Mean	Median	Std
Philippines	12	-1.83%	0.0%	4.57%
Thailand	19	-1.85%	0.0%	5.8%

Table 2.4.5: Emission Breakdown by Country

2.4.10 Real Decarbonization Rate Breakdown by Year

Figure 2.4.6 shows the mean and median real decarbonization rate by year across all CDP reporting years from 2011 to 2022. The data shows that the mean and median decarbonization rates have been (assuringly) decreasing over time.

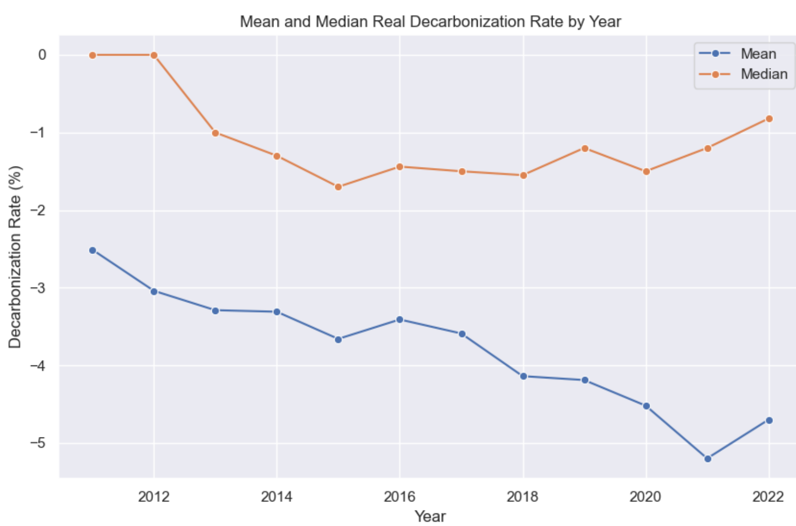


Figure 2.4.6: Mean and Median Real Decarbonization Rate by Year

	Count	Mean	Median	Std
Year				
2011	1109	-2.51%	0.0%	6.09%
2012	1252	-3.04%	0.0%	6.03%
2013	1317	-3.29%	-1.0%	5.85%
2014	1322	-3.31%	-1.3%	6.01%
2015	1388	-3.66%	-1.7%	6.1%
2016	1451	-3.41%	-1.44%	5.97%
2017	1483	-3.59%	-1.5%	6.68%
2018	1374	-4.14%	-1.55%	7.69%
2019	1530	-4.19%	-1.2%	8.08%
2020	1701	-4.52%	-1.5%	8.59%
2021	2088	-5.2%	-1.2%	9.75%
2022	2461	-4.7%	-0.82%	9.79%

2.4.11 Feature Engineering: Financial Predictors

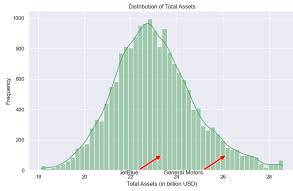
Figure 2.4.7 shows the distribution of the financial predictors used in the analysis. This is a list of each predictor along with a brief description of how it was derived:

- **Total Assets 2.4.7a**: The total assets of the firm, which is a measure of the firm's size and the scale of its operations. Directly obtained from the Worldscope database and transformed using the natural logarithm $log(1 + \text{Total Assets})$.

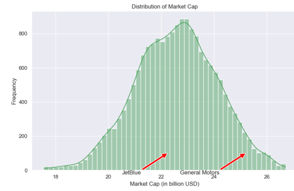
- **Market Capitalization 2.4.7b**: The market capitalization of the firm, which is a measure of the firm's size and the scale of its operations. Directly obtained from the Worldscope database and transformed using the natural logarithm $log(1 + \text{Market Cap})$.

- **Return on Equity 2.4.7c**: The return on equity of the firm, which is a measure of the firm's profitability. Since the return on equity is a percentage which can be negative, the following transformation was used: $log(1 + \frac{\text{ROE}}{100})$.

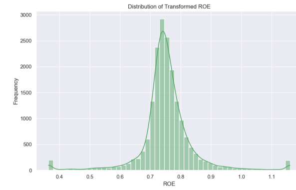
- **Revenue 2.4.7d**: The total revenue of the firm, which is a measure of the firm's size and the scale of its operations. Directly obtained from the Worldscope database and transformed using the natural logarithm $log(1 + \text{Revenue})$.
- **Net Income 2.4.7e**: The net income of the firm, which is a measure of the firm's profitability. Directly obtained from the Worldscope database and transformed using the natural logarithm $log(1 + \text{Net Income})$.
- **Employees 2.4.7f**: The total number of employees of the firm, which is a measure of the firm's size and the scale of its operations. Directly obtained from the Worldscope database and transformed using the natural logarithm $log(1 + \text{Employees})$.
- **Total Assets 1yr Growth 2.4.7g**: The one year growth of the total assets of the firm, which is a measure of the firm's growth. Directly obtained from the Worldscope database and since the growth can be negative, the following transformation was used: $log(1 + \frac{\text{Total Assets 1yr Growth}}{100})$.
- **Employees 1yr Growth 2.4.7h**: The one year growth of the total number of employees of the firm, which is a measure of the firm's growth. Directly obtained from the Worldscope database and since the growth can be negative, the following transformation was used: $log(1 + \frac{\text{Employees 1yr Growth}}{100})$.
- **Net Income over Assets 2.4.7e**: The net income of the firm over its total assets, which is a measure of the firm's profitability. The feature was calculated with the following formula $log(1 + \frac{\text{Net Income}}{\text{Total Assets}})$.



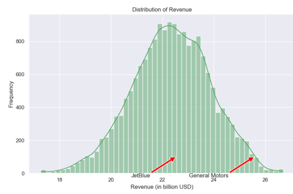
(a) Total Assets



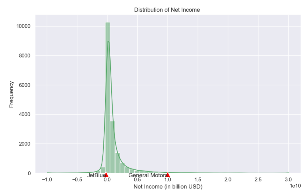
(b) Market Capitalization



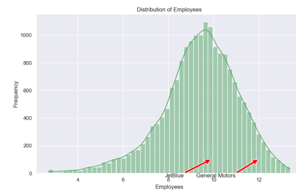
(c) Return on Equity



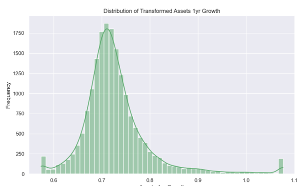
(d) Revenue



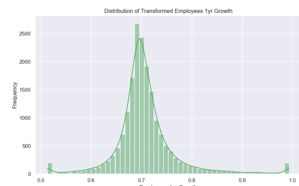
(e) Net Income



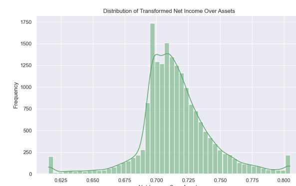
(f) Employees



(g) Tot. Assets 1yr Growth



(h) Employees 1yr Growth



(i) Net Income Over Assets

Figure 2.4.7: Financial Predictors

Note: for full-size images, see appendix.

- Number of firms and unique isins
- Number of variables
- Number of firms per sector

2.5 Response Variable Analysis

2.6 Predictor Variable Analysis

- Here I can put cool visualizations
- Here I can start explainig the data
- Here I can take inspiration from Kaggle
- Here is can do some clustering?

2.7 Building the training set

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3

Chapter 3

3.1 Introduction to Modeling

Key Results

3.2 Impact of Year and Current Decarbonization Rate on Next-Year Decarbonization Rate

- In model (1) from Table 3.2.1, we start by predicting *Next-Year Decarbonization Rate* using year and ghg change real. We observe how on average we predict a 22% decrease in real decarbonization rate, as well as a positive and significant correlation between previous year and next year decarbonization rate. In particular, controlling for year, an increase in decarbonization rate from the previous year corresponds to 0.3 predicted next year increase in decarbonization rate.

- In model (2) from Table 3.2.1, we add our first random effect: a random intercept for the firm unique identifier code. Mixed effect models are particularly suited when we have repeated measures on the same individuals, in our case, the same firms. In particular, including an effect for each individual firm allows to take into account the correlation between each firm's timeseries without introducing an excessively high number of parameters. When adding Id as a random effect, the model's AIC decreases from 94134.242 to 94018.79, signaling a significant improvement in the model's fit. Furthermore, the signs of the coefficient yeear and ghg change real remain the same, and the coefficient for year remains significant.
- **Key Finding:** Adding a random effect significantly improves the model's fit, and we will therefore iterate to find the optimal combination of random effects to then identify a comprehensive set of fixed effects that best predict decarbonization rates.

Table 3.2.1: Model Comparison: Fixed Effects Only vs. Random Intercept for Firm Id

	Dependent variable:	
	Next Year Decarbonization Rate	
	OLS	*linear mixed-effects*
	(1)	(2)
Year	-0.228^{***}	-0.257^{***}
	(0.021)	(0.021)
Ghg.Change.Real	0.295^{***}	0.210^{***}
	(0.009)	(0.009)
Constant	-1.985^{***}	-2.141^{***}
	(0.129)	(0.138)
Random Effects:		
Number of Firms		1870
sd(Firms)		2.142
Akaike Inf. Crit.	94134.242	94018.786
Bayesian Inf. Crit.	94164.354	94056.427
Note:		*p<0.1; **p<0.05; ***p<0.01
		Second model has firm Id as a random intercept

3.2.1 Impact of Industry Sector on Next-Year Decarbonization Rate

- In model (1) from table 3.2.2, we add an important categorical predictor: industry. As explained in the EDA, Industry is derived using the Global Industry Classification stantard and it comprehends 20 industry categories. The hypothesis we want to test is whether the industry a firm operates in significantly affects decarbonization rate, and I expect the result to show that it does. We chose as reference category the Software, Services industry, which is the category that corresponds to the lowest (best) mean decarbonization rate. In this way, coefficients of other industries are expected to be positive and will represent the difference in decarbonization rate compared to the reference category.

- As we can observe from the Table, when controlling for year and previous year decarbonization rate, and having firm Id as a random effect, almost all industry sectors are significant, and the results are in line with what we found in the Exploratory Data Analysis section. In particular, sectors that displayed a higher (worse) mean decarbonization rates, such as the Energy, Materials, and Transportation sectors, have higher coefficients. Therefore, the model predicts that firms in these sectors will have a lower next-year decarbonization rate compared to the reference category. This makes sense as these sectors are known to be more carbon-intensive, and the model suggests that the carbon-intensive nature holds true even when controlling for time and previous year decarbonization rate. We can infer that there likely are factor that make a sector inherently difficult to decarbonize. An example to support this finding is the case of decarbonizing cement production, which is a key category in the Material sector and contributes to a significant portion of global emissions. Cement production is inherently carbon-intensive, and the industry has been struggling to find a viable alternative to the traditional production process. This is a clear example of how the industry a firm operates in can significantly affect its decarbonization rate.

- The fact that firms Ids are nested into sector, as each firm is assigned to a primary GICS sector, allows to add Industry as a random effect on the model, nested into firm Id. The implementation is shown in model (2) from table 3.2.2, and although there is an increase in the AIC, the coefficients for *Year* and *Ghg Change Real* remain significant and with the same sign and similar magnitude.

Key takeaways:

- The industry a firm operates in significantly affects its decarbonization rate, and the effect holds true even when controlling for time and previous year decarbonization rate.

- The fact that firms Ids are nested into sector, as each firm is assigned to a primary GICS sector, allows to add Industry as a random effect on the model, nested into firm Id. From now on, we will include industry as a random effect in all the following models.

Table 3.2.2: Model Comparison: Fixed Effects Only vs. Random Intercept for Firm Id and Industry

	Dependent variable:	
	Next Year Decarbonization Rate	
	linear mixed-effects	
	(1)	(2)
Year	-0.260^{***} (0.021)	-0.259^{***} (0.021)
Ghg.Change.Real	0.206^{***} (0.009)	0.209^{***} (0.009)
IndustryAutomobiles, Components	3.851^{***} (0.631)	
IndustryBanks	1.870^{***} (0.568)	
IndustryCapital Goods	3.347^{***} (0.519)	
IndustryCommercial, Professional Services	4.121^{***} (0.645)	
IndustryConsumer Durables, Apparel	2.356^{***} (0.631)	
IndustryConsumer Services	3.528^{***} (0.715)	
IndustryConsumer Staples Distribution, Retail	3.216^{***} (0.698)	
IndustryEnergy	4.069^{***} (0.592)	
IndustryEquity Real Estate Investment Trusts	1.207^{*} (0.656)	
IndustryFinancial Services	2.591^{***} (0.607)	
IndustryFood, Beverage, Tobacco	3.452^{***} (0.574)	
IndustryHealth Care Equipment, Services	3.062^{***} (0.653)	
IndustryHousehold, Personal Products	1.674^{**} (0.797)	
IndustryInsurance	2.519^{***} (0.617)	
IndustryMaterials	4.475^{***} (0.522)	
IndustryMedia, Entertainment	2.226^{***} (0.779)	
IndustryPharmaceuticals, Biotechnology, Life Sciences	2.721^{***} (0.626)	
IndustryReal Estate Management, Development	2.227^{**} (0.874)	
IndustryRetailing	1.527^{**} (0.683)	
IndustrySemiconductors, Semiconductor Equipment	3.585^{***} (0.702)	
IndustryTechnology Hardware, Equipment	2.381^{***} (0.614)	
IndustryTelecommunication Services	1.770^{***} (0.657)	
IndustryTransportation	3.754^{***} (0.605)	
IndustryUtilities	3.487^{***} (0.562)	
Constant	-5.196^{***} (0.484)	-2.395^{***} (0.241)
Random Effects:		
Number of Firms	1870	1870
Number of Industries		25
sd(Firms)	1.953	1.93
sd(Industry)		0.972
Akaike Inf. Crit.	93891.439	93919.569
Bayesian Inf. Crit.	94109.755	93964.738
Note:		*p<0.1; **p<0.05; ***p<0.01
		Second model has firm Id and Industry as random intercepts.

3.2.2 Impact of Country and Continent on Decarbonization

- A predictor we will next consider is georgraphical location. Location is important in understanding decarbonization rates, as different countries have different policies and regulations that can affect a firm's ability to decarbonize.

- In model (1) from Table 3.2.3, we start by predicting *Next-Year Decarbonization Rate* using year, ghg change real, and continent. Our reference category is Europe, and we expect the coefficients for the other continents to be positive, as we expect firms in other continents to have a lower decarbonization rate compared to firms in Europe. The results are in line with our expectations, and all coefficients are significant.

- In model (2) from Table 3.2.3, we add country as a random effect, nested into continent. The AIC increases, but the coefficients for year and ghg change real remain significant and with the same sign and identical magnitude. This is a good sign, and it suggest that our panel data can be effectively modeled using a mixed effect model with firm Id, industry, and country nested into continent as random effects.

- **Key Finding:** The continent a firm is located in is significantly associated with its decarbonization rate, and the effect holds true even when controlling for time and previous year decarbonization rate and having firm Id and industry as random effects. Furthermore, adding country nested into continent as a random effect does not significantly change the model's fit, and we will therefore include it in all the following models.

Table 3.2.3: Impact of Country and Continent on Decarbonization

	Dependent variable:	
	Next Year Decarbonization Rate	
	(1)	(2)
Year	-0.267^{***}	-0.267^{***}
	(0.021)	(0.021)
Ghg.Change.Real	0.207^{***}	0.207^{***}
	(0.009)	(0.009)
ContinentAfrica	1.895^{***}	
	(0.409)	
ContinentAsia	1.714^{***}	
	(0.202)	
ContinentNorth America	1.377^{***}	
	(0.185)	
ContinentOceania	1.585^{***}	
	(0.519)	
ContinentSouth America	1.058^{**}	
	(0.524)	
Constant	-3.282^{***}	-2.027^{***}
	(0.258)	(0.413)
Random Effects:		
Number of Firms	1871	1871
Number of Industries	25	25
Number of Continents	6	6
Number of Countries		48
sd(Firms:Industry)	1.789	1.766
sd(Industry)	0.975	0.97
sd(Continent)		0.74
sd(Country:Continent)		0.349
Akaike Inf. Crit.	93831.892	93834.542
Bayesian Inf. Crit.	93914.702	93894.767
Note:		*p<0.1; **p<0.05; ***p<0.01
		Second model adds Country nested in Continent as random intercepts.

3.2.3 Impact of Financial Predictors on Decarbonization

- In model (1) from Table 3.2.4, we start by predicting *Next-Year Decarbonization Rate* using year, ghg change real, market cap, employees, and revenue, employees 1 year growth, assets 1 year growth, total assets, net income over assets, and return on equity. We find that only market cap is significant, with revenue being significant at the 10% level. The coefficient for market cap is negative, and the coefficient for revenue is positive. This is in line with our expectations, as we expect larger firms to have a more negative (higher) decarbonization rate, and we expect firms with higher revenue to have a less negative (lower) decarbonization rate. Since the revenue coefficient is not significant at the 5% level, and there are many omitted variables that could be affecting the results, we will not draw any conclusions from this model. We will focus on retaining both market cap and revenue in the next model, and we will focus on understanding how assets and empllyees growth affect next year decarbonization rate in the following model.

- In model (2) from Table 3.2.4, we add assets growth. We find that assets growth is not significant, and the coefficients for market cap and revenue remain significant and with the same sign and similar magnitude. Although not significant, the coefficient for assets growth is positive, which seems to suggest that firms with higher assets growth have a lower decarbonization rate.

- In model (3) from Table 3.2.4, we add employees growth. We find that employees growth is not significant, and the coefficients for market cap and revenue remain significant and with the same sign and similar magnitude. Employees growth is positive, which seems to suggest that firms with higher employees growth have a lower decarbonization rate.

Table 3.2.4: Impact of Financial Predictors on Decarbonization

	Dependent variable:		
	Next Year Decarbonization Rate		
	(1)	(2)	(3)
Year	−0.258*** (0.021)	−0.256*** (0.021)	−0.256*** (0.021)
Ghg.Change.Real	0.204*** (0.009)	0.205*** (0.009)	0.205*** (0.009)
Market.Cap	−0.405*** (0.115)	−0.520*** (0.088)	−0.529*** (0.089)
Employees	0.047 (0.093)		
Revenue	0.234 (0.156)	0.154* (0.091)	0.162* (0.092)
Employees.1Y.Gr	−0.024 (1.222)	0.489 (1.070)	
Assets.1Y.Gr	1.020 (1.099)		0.791 (0.954)
Tot.Assets	−0.225 (0.138)		
Net.Income.Over.Assets	−2.597 (4.659)		
Roe	−0.662 (1.239)		
Constant	8.158** (3.222)	5.854*** (1.605)	5.618*** (1.573)
Random Effects:			
Number of Firms	1871	1871	1871
Number of Industries	25	25	25
Number of Continents	6	6	6
Number of Countries	48	48	48
sd(Firms:Industry)	1.733	1.729	1.729
sd(Industry)	0.898	0.899	0.898
sd(Continent)	0.74	0.746	0.745
sd(Country:Continent)	0.275	0.274	0.277
Akaike Inf. Crit.	93831.892	93834.542	93793.357
Bayesian Inf. Crit.	93914.702	93894.767	93913.807

Note: *p<0.1; **p<0.05; ***p<0.01

Third Model focuses on employees and assets growth

A
Some extra stuff

Here is a useful table of distributions.

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