

Corporate Greenhouse Gas Emissions, Reduction Programs, and  
Targets:  
An Analysis of Relationships and Patterns  
Internship Report  
ESG Analysis Project  
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Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
1.1	Motivation . . . . .	3
1.2	Problem Statement . . . . .	3
1.3	Research Questions . . . . .	3
<b>2</b>	<b>Fundamentals and Related Research</b>	<b>3</b>
2.1	Corporate Emissions Measurement Frameworks . . . . .	3
2.2	Types of Reduction Programs . . . . .	3
2.3	Target-Setting Approaches . . . . .	4
2.4	Previous Research . . . . .	4
<b>3</b>	<b>Methodology</b>	<b>4</b>
3.1	Data Sources . . . . .	4
3.2	Analytical Approach . . . . .	4
3.3	Methods Used . . . . .	5
3.4	Evaluation Metrics . . . . .	5
<b>4</b>	<b>Dataset Creation and Data Preparation</b>	<b>5</b>
4.1	Dataset Descriptions . . . . .	5
4.2	Data Cleaning Procedures . . . . .	5
4.3	Missing Data Treatment . . . . .	5
4.4	Variable Transformations . . . . .	6
<b>5</b>	<b>Exploratory Data Analysis</b>	<b>6</b>
5.1	Emissions Patterns . . . . .	6
5.1.1	Geographic Distribution . . . . .	6
5.1.2	Industry Distribution . . . . .	6
5.2	Target-Setting Behavior . . . . .	6
5.3	Program Implementation Trends . . . . .	8
<b>6</b>	<b>Key Relationship Models and Evaluation</b>	<b>8</b>
6.1	Impact of Target Characteristics . . . . .	8
6.2	Impact of Program Implementation Elements . . . . .	9
6.3	Contextual Factors: Industry and Region . . . . .	9
6.4	Overall Predictive Power (Brief Note) . . . . .	10
6.5	Limitations . . . . .	10

<b>7</b>	<b>Discussion</b>	<b>10</b>
7.1	Interpretation of Key Findings . . . . .	10
7.2	Business Implications . . . . .	10
7.3	Policy Considerations . . . . .	11
<b>8</b>	<b>Conclusion</b>	<b>11</b>
8.1	Summary of Findings . . . . .	11
8.2	Answers to Research Questions . . . . .	11
8.3	Future Research Directions . . . . .	11

# 1 Introduction

## 1.1 Motivation

Climate change presents one of the most significant challenges of our time, with corporate greenhouse gas emissions playing a substantial role in global carbon footprints. As stakeholders increasingly demand corporate climate action, companies worldwide have implemented various emission reduction programs and set targets to demonstrate their commitment to sustainability. Understanding the effectiveness of these initiatives is crucial for both corporate strategy and public policy development.

## 1.2 Problem Statement

Despite widespread adoption of corporate sustainability initiatives, there remains significant uncertainty regarding which approaches yield meaningful emissions reductions. Companies implement diverse programs and targets, but the relationship between these initiatives and actual emissions outcomes is often unclear. This knowledge gap hinders effective decision-making for both corporate sustainability professionals and policymakers.

## 1.3 Research Questions

This analysis addresses two primary research questions:

1. What patterns exist in the data regarding corporate greenhouse gas emissions, reduction programs, and targets?
2. What relationships can be derived between corporate greenhouse gas emissions, reduction programs, and targets based on the available data?

# 2 Fundamentals and Related Research

## 2.1 Corporate Emissions Measurement Frameworks

Corporate greenhouse gas (GHG) emissions are typically categorized into three scopes according to the Greenhouse Gas Protocol, the most widely used international accounting tool:

- **Scope 1:** Direct emissions from owned or controlled sources (e.g., fuel combustion).
- **Scope 2:** Indirect emissions from purchased energy (electricity, steam, etc.).
- **Scope 3:** All other indirect emissions in the value chain (upstream and downstream).

This framework provides a comprehensive approach, though reporting completeness varies, especially for Scope 3.

## 2.2 Types of Reduction Programs

Companies implement various emission reduction programs, broadly including:

- **Energy efficiency:** Reducing consumption.
- **Renewable energy:** Transitioning to low-carbon sources.
- **Operational changes:** E.g., transportation optimization, supply chain engagement.
- **Carbon capture:** Technologies to sequester emissions (less common in data).

The specific programs analyzed in this report fall into categories such as Energy Saving, Energy Alternatives, Audits, and Governance structures, based on the available MSCI data.

## 2.3 Target-Setting Approaches

Common emission reduction target approaches include:

- **Absolute targets:** Reducing total emissions.
- **Intensity targets:** Reducing emissions per unit of output/revenue.
- **Science-based targets (SBTs):** Aligning goals with climate science (often a combination of absolute/intensity).

Key parameters analyzed include scope coverage, target type, time frame, and ambition level (percentage reduction).

## 2.4 Previous Research

Previous research on corporate sustainability effectiveness often shows mixed results, sometimes finding links to financial performance but struggling to establish clear causal links between specific initiatives and emissions outcomes due to data limitations and methodological challenges. This report focuses on exploring patterns and correlations within the specific MSCI dataset.

# 3 Methodology

## 3.1 Data Sources

This analysis utilizes four primary MSCI datasets provided for the project:

- **Company Emissions Data:** Emissions (Scopes 1, 2, limited 3), financial metrics, identifiers.
- **Reduction Targets Data:** Target details (type, scope, ambition, progress).
- **Reduction Programs 1 Data:** High-level strategies (manufacturing, transport, etc.).
- **Reduction Programs 2 Data:** Specific program details (type, year, oversight).

Datasets were linked using the unique company identifier `ISSUERID`.

## 3.2 Analytical Approach

A multi-stage approach was followed:

1. **Data Preparation:** Integrating datasets, cleaning identifiers and codes, handling missing values (primarily through case-wise deletion for correlations or simple imputation where necessary), and deriving key metrics (e.g., emission trends, target ambition categories).
2. **Exploratory Data Analysis (EDA):** Examining distributions, trends, and patterns using descriptive statistics and visualizations.
3. **Relationship Analysis:** Investigating correlations and associations between emissions, targets, and program variables using statistical tests.
4. **Pattern Exploration:** Briefly exploring common implementation patterns (e.g., program co-occurrence, high-level sequencing).
5. **Modeling Exploration (Brief):** Initial exploration using modeling techniques to assess predictive relationships (details reserved for further work).

### 3.3 Methods Used

The primary methods employed for this internship report include:

- **Descriptive Statistics:** Summarizing central tendencies, distributions, and frequencies.
- **Correlation Analysis:** Using Pearson's  $r$  and Spearman's  $\rho$  to assess linear and monotonic relationships.
- **Group Comparisons:** Using statistical tests (like t-tests or ANOVA conceptually, though specific tests not detailed here) to compare means (e.g., emission trends across different groups).
- **Visualization:** Using charts (bar charts, scatter plots, maps) to illustrate patterns and relationships.
- *Note:* While pattern mining (association rules) and predictive modeling (ML/DL) were explored, their detailed results are complex and considered beyond the primary scope of this concise internship report, reserved for potential future work (e.g., thesis).

### 3.4 Evaluation Metrics

Relationships were primarily evaluated using:

- **Correlation coefficients** ( $r$ ,  $\rho$ ).
- **Statistical significance** (p-values, conceptually considered).
- **Magnitude of differences** in means or trends between groups.

## 4 Dataset Creation and Data Preparation

### 4.1 Dataset Descriptions

The analysis utilized the four MSCI datasets, linked via `ISSUERID`. Key datasets included:

- **Company Emissions:** 19k companies with emissions and financial data. High missingness for Scope 3 ( $\sim 75\%$ ).
- **Reduction Targets:** 58k target entries for 7k unique companies. High missingness for progress ( $\sim 65\%$ ) and offsets ( $\sim 98\%$ ).
- **Reduction Programs 1:** 2.8k companies with high-level strategy data. High missingness ( $\sim 65\%$ ) for most strategy fields.
- **Reduction Programs 2:** 52k program entries for 7k unique companies. High missingness for oversight ( $\sim 80\%$ ).

(Refer to Data Dictionaries for full details).

### 4.2 Data Cleaning Procedures

Standard cleaning involved harmonizing identifiers, country/industry codes, date formats, and categorical values.

### 4.3 Missing Data Treatment

Given the high levels of missing data, analyses primarily used pairwise complete observations for correlations and descriptive statistics. Where group comparisons were made (e.g., average trends), they were based on available data for those groups. The prevalence of missing data is a key limitation noted in the Evaluation section.

## 4.4 Variable Transformations

Key derived variables included:

- **Emissions Trend:** 3-year CAGR of Scope 1+2 intensity (`CARBON_SCOPE_12_INTEN_3Y_GIC_CAGR`). Negative values indicate improvement.
- **Target Ambition Categories:** Based on `CBN_TARGET_REDUCE_PCT` (e.g., Low  $\leq 10/15\%$ , Medium 10-30%, High  $\geq 30\%$ ).
- **Program Implementation Score (Conceptual):** Considered factors like program count, type variety, and oversight where available.
- **Benchmarks:** Comparing company metrics to relevant industry/regional averages.

## 5 Exploratory Data Analysis

### 5.1 Emissions Patterns

#### 5.1.1 Geographic Distribution

The dataset covers companies globally, with concentrations in the US, China, Japan, India, and Europe. Significant regional variations in emissions trends were observed:

- Europe showed the strongest average improvement trend (-5.14%).
- North America also showed improvement (-3.20%).
- Asia-Pacific, on average, showed a slight worsening trend (+0.56%).
- Top improving countries included Finland (-9.37%), Denmark (-6.87%), and the UK (-6.45%).

#### 5.1.2 Industry Distribution

Emission profiles varied greatly by industry:

- High absolute emissions were concentrated in sectors like Electricity Production, Cement, Refined Petroleum, and Basic Metals.
- Intensity varied, with sectors like Cement showing very high intensity, while Financial Services and Technology were low.
- Some high-emitting sectors like Electricity Distribution (-6.03%) and Basic Metals (-4.49%) showed strong average improvement trends, while others like Lignite Mining (+3.71%) showed a slight worsening trend.

### 5.2 Target-Setting Behavior

- Target setting is common among reporting companies (7k companies have targets).
- Absolute targets (53%) are more frequent than intensity targets (21%).
- A significant portion of targets are ambitious ( $\geq 30\%$  reduction goal).
- Relationships observed:
  - Higher absolute emitters set more targets but tend to set less ambitious percentage goals.
  - Companies with more Scope 3 emissions set more targets.
  - At the country level, more target-setting correlates strongly with better emission trends.

### 3. Geographic and Industry Context Matters

#### 3.1 Country-Level Target Count vs. Emission Trends Based on 45 Countries with $\geq 10$ Companies

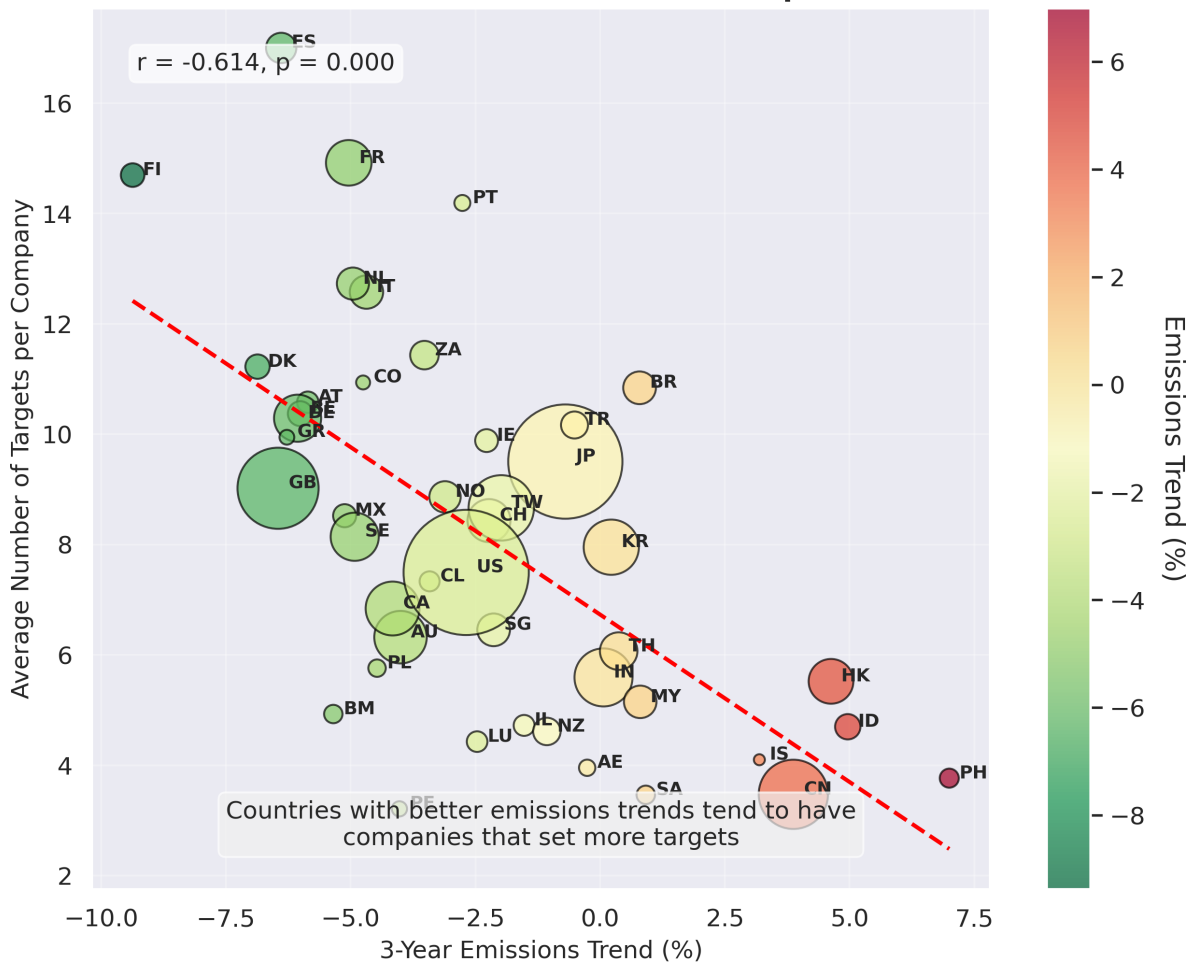


Figure 1: Figure 3: Geographic and Industry Context Matters (Geographic Distribution of Emissions Trends).

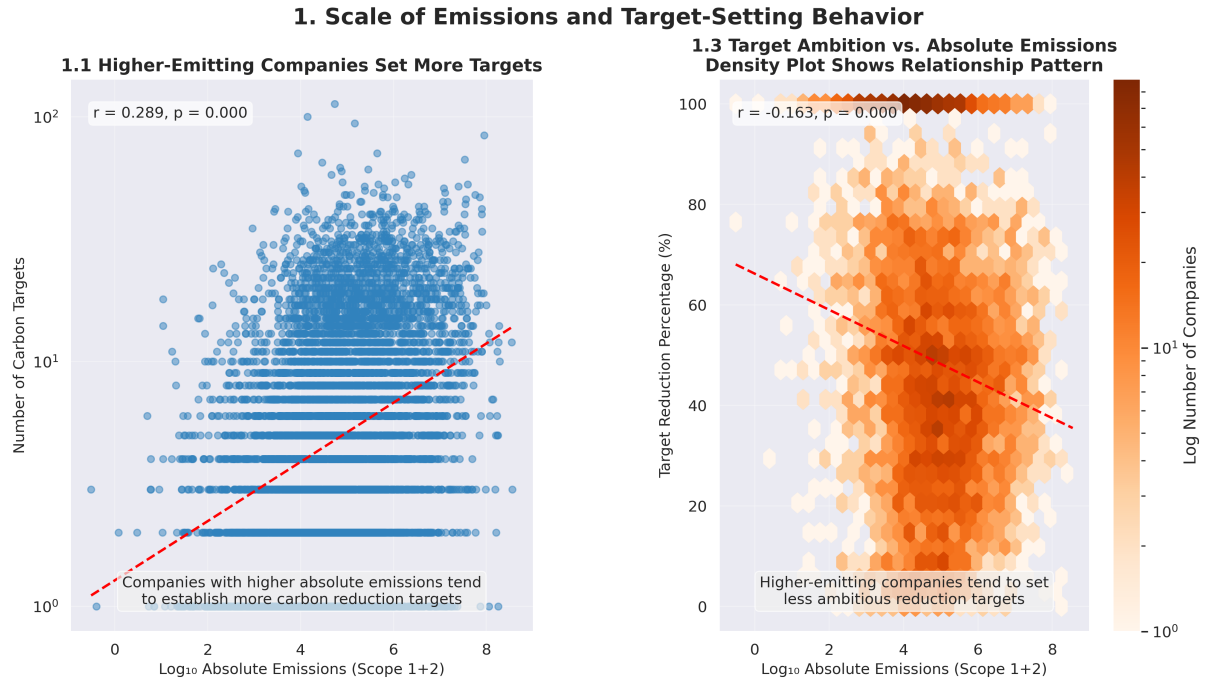


Figure 2: Figure 1: Scale of Emissions and Target-Setting Behavior (Target Count vs. Log Absolute Emissions and Target Ambition vs. Absolute Emissions).

### 5.3 Program Implementation Trends

- Most companies report multiple programs (avg. 7 per company in Programs 2 dataset).
- Common program categories include Energy Saving, Energy Alternatives, and Responsible Level/Governance.
- Reporting of program implementation peaked around 2020-2022.
- Governance is evolving: Board-level oversight reporting increased significantly over time. Companies reporting executive oversight show better average trends (-1.67%) than those without (+0.67).

## 6 Key Relationship Models and Evaluation

This section focuses on evaluating the key relationships identified through statistical analysis and initial modeling explorations, relevant to the research questions. (Detailed predictive modeling results are reserved for future work).

### 6.1 Impact of Target Characteristics

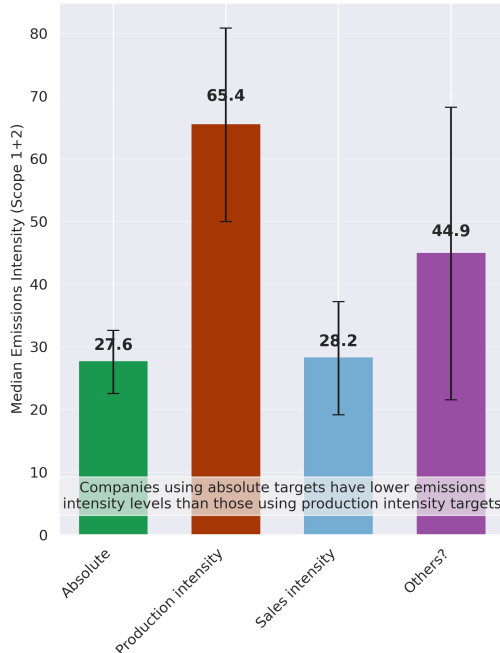
- **Ambition Level:** Companies with medium-ambition targets (10-30% reduction) showed the best average emission intensity trends (-3.82%), closely followed by high-ambition targets (-3.70%). Both performed significantly better than companies with no reported targets (+1.19%).
- **Target Progress:** Companies reporting substantial progress towards (or exceeding) their targets demonstrated the strongest emission reductions. For instance, those reporting 175-200% progress had an average trend of -8.7%. (Note: High missing data for progress).



- **Target Type:** Companies using absolute targets tended to have lower average intensity than those using intensity targets, though this relationship was weak ( $\rho = -0.1$ ). The effectiveness seemed more linked to ambition and progress than type alone.

## 2. Types of Targets and Their Effectiveness

2.1 Emissions Intensity by Target Type (No Winsorization)



2.3 Target Progress and Emissions Trends (No Winsorization)

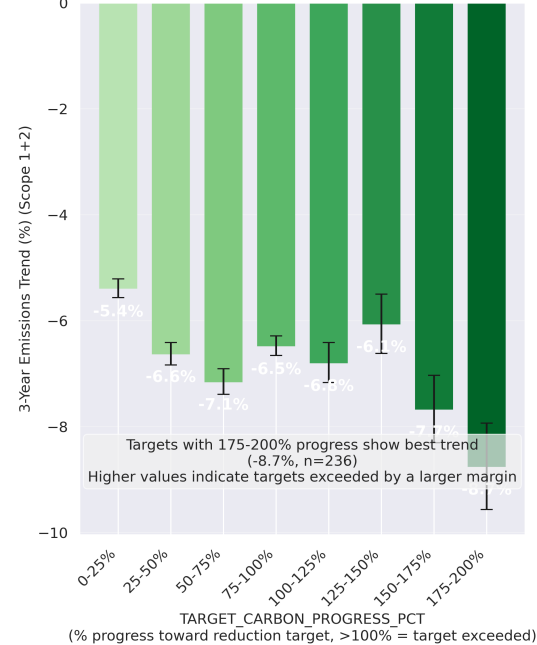


Figure 3: Figure 2: Types of Targets and Their Effectiveness (Emissions by Target Type and Target Progress vs. Emission Trends).

## 6.2 Impact of Program Implementation Elements

- **Audits and Verification:** The presence of formal energy audits correlated strongly with improved trends. External independent audits showed the best average trend (-7.21%), followed by internal audits (-5.33%) and ISO 50001 certification (-3.65%), all outperforming general statements or no evidence.
- **Governance:** As noted in EDA, executive/board oversight was associated with better trends (-1.67%) compared to no evidence (+0.67%).
- **Program Scope/Quality (from Programs 1):** While data is sparse, companies with more comprehensive strategies (e.g., "All or core facilities/products") tended to show better trends than those with "Some" or "General statements", though correlations were generally weak overall.

## 6.3 Contextual Factors: Industry and Region

- The strength and even direction of relationships between targets/programs and emission trends often varied significantly depending on the industry and region, confirming these as crucial mediating factors.
- For example, the correlation between higher emissions and target ambition was positive in some industries but negative in others. Similarly, program effectiveness differed markedly across sectors (e.g., Retail vs. Manufacturing).

## 6.4 Overall Predictive Power (Brief Note)

Initial modeling explorations (details omitted) suggested that while targets and program elements show correlations with emission trends, their overall power in predicting future trends is modest compared to factors like a company’s existing emissions profile, size, industry, and recent historical performance. This implies programs and targets are part of the picture, but not the sole determinants.

## 6.5 Limitations

These findings are subject to significant limitations:

- **Correlation vs. Causation:** Analyses are correlational; causality cannot be definitively established. Good performance might lead to target setting, or vice-versa, or both could be driven by other factors (e.g., regulation, management quality).
- **Data Gaps:** High levels of missing data for key variables (Scope 3, target progress, program oversight, strategy details) limit the robustness and scope of conclusions.
- **Reporting Quality:** Reliance on self-reported data may introduce bias.
- **Time Lag:** Effects of programs and targets may take time to manifest, potentially longer than the available data window.

# 7 Discussion

## 7.1 Interpretation of Key Findings

The analysis suggests that corporate actions related to climate targets and programs are associated with emissions performance, but the picture is complex and highly context-dependent. The prevalence of target-setting indicates widespread corporate acknowledgement of the issue. The finding that medium-ambition targets correlate with the best average trends is intriguing – perhaps reflecting a balance between ambition, feasibility, and focused execution.

Strong governance and verification mechanisms (audits) appear consistently linked to better outcomes, suggesting that the \*quality\* and \*oversight\* of implementation matter significantly, potentially more than the sheer number of programs.

The dominant role of industry and region highlights that emissions reduction is not a one-size-fits-all challenge. Sectoral characteristics (technology pathways, regulatory pressures, value chain structure) and regional factors (energy mix, policy environment) heavily influence both the problems and the effectiveness of solutions.

## 7.2 Business Implications

For companies, the findings tentatively suggest that:

- Setting targets, particularly realistically ambitious ones (e.g., 10-30% initially), is associated with better performance trajectories on average.
- Investing in robust governance (executive oversight) and verification (especially external audits or certifications like ISO 50001) may be crucial for program effectiveness.
- Strategies should be tailored to the specific industry context and regional operating environment.
- Tracking progress diligently is important, as significant progress correlates with strong reductions.

## 7.3 Policy Considerations

For policymakers, the analysis suggests:

- Policies encouraging credible target-setting and transparent reporting remain important.
- Mechanisms promoting or supporting independent verification and robust governance could enhance the effectiveness of corporate initiatives.
- Sector-specific and regionally-sensitive policies may be more effective than purely universal approaches.
- Addressing data gaps, especially for Scope 3 and program specifics, is crucial for better monitoring and evaluation.

## 8 Conclusion

### 8.1 Summary of Findings

This internship report analyzed patterns and relationships within corporate GHG emissions, reduction targets, and sustainability programs using MSCI data. Target-setting is widespread and generally correlates with improved average emission trends, especially when progress is made. Medium-ambition targets (10-30% reduction) and programs with strong oversight and external verification showed the strongest associations with favorable trends. However, these relationships are heavily mediated by industry sector and geographic region, indicating context is critical. Structural factors like existing emissions profiles and company size remain strong determinants of emission trajectories.

### 8.2 Answers to Research Questions

**1. What patterns exist?** Key patterns include widespread adoption of absolute targets, significant regional variation in emission trends (Europe improving most, Asia-Pacific least), strong industry differentiation in emission profiles, and increasing board-level oversight of environmental issues.

**2. What relationships can be derived?** Statistically significant correlations suggest relationships between target setting (especially medium ambition and high progress) and improved trends, and between strong governance/audits and improved trends. However, these are associations, not proof of causation, and are strongly influenced by industry and region. Predictive modeling explorations indicated programs/targets have modest predictive power compared to company characteristics and baseline emissions.

### 8.3 Future Research Directions

This work serves as a foundation for a potential bachelor thesis. Future research directions include:

- Employing causal inference methods to better isolate the impact of specific programs and targets.
- Developing more sophisticated metrics for program quality and implementation effectiveness.
- Incorporating more granular policy and macroeconomic data to better model regional effects.
- Deepening the analysis of Scope 3 emissions as data improves.
- Utilizing advanced NLP techniques on program descriptions and qualitative reports.

- Expanding the time-series analysis component.