

Corporate Greenhouse Gas Emissions, Reduction Programs, and Targets

An Analysis of Relationships and Patterns
Anwendungsorientiertes Projektpraktikum – Data Science

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1 Introduction

1.1 Motivation

Climate change represents one of the most pressing challenges of our era, and the role of corporate greenhouse gas emissions in driving global carbon footprints cannot be overstated. In response to growing stakeholder pressure, companies have launched a variety of emissions reduction initiatives and set ambitious targets to demonstrate their environmental commitment. Evaluating the effectiveness of these corporate actions is essential not only for refining corporate sustainability strategies but also for informing public policy frameworks.

1.2 Problem Statement

Although numerous firms have adopted sustainability programs and published emissions targets, there remains significant ambiguity about which specific measures translate into tangible emissions reductions. Diverse program types and target-setting approaches complicate the picture, and the empirical relationship between these initiatives and actual emissions outcomes is not always clear. This gap in understanding limits the ability of sustainability professionals and regulators to make evidence-based decisions.

1.3 Research Questions

This report seeks to address two central questions:

1. What patterns emerge in the MSCI data with respect to corporate greenhouse gas emissions, reduction programs, and targets?
2. What relationships can be discerned between emissions outcomes and the implementation of reduction programs and targets?

2 Fundamentals and Related Research

2.1 Corporate Emissions Measurement Frameworks

Corporate greenhouse gas accounting generally follows the three-scope model defined by the Greenhouse Gas Protocol, which has become the de facto international standard. Scope 1 covers direct emissions from sources that the company owns or controls, such as on-site fuel combustion. Scope 2 encompasses indirect emissions from the generation of purchased energy (electricity, steam, etc.), while Scope 3 captures all other indirect emissions occurring along the value chain. Reporting completeness varies considerably across companies, with Scope 3 often the least consistently disclosed.

Transitioning from measurement to action, firms have developed a range of emissions reduction programs, which we discuss next.

2.2 Types of Reduction Programs

Corporate programs to lower emissions span several broad categories. Energy efficiency initiatives aim to reduce consumption through equipment upgrades and process optimization. Renewable energy programs focus on sourcing low-carbon electricity or on-site generation technologies such as solar or wind. Operational changes, including transportation optimization and supply chain engagement, target indirect emissions. Finally, emerging carbon capture technologies seek to sequester CO₂, though uptake remains limited. The MSCI datasets classify these efforts into Energy Saving, Energy Alternatives, Audits, and Governance structures, providing both high-level and detailed program attributes.

2.3 Target-Setting Approaches

Companies typically adopt one or more of three target types. Absolute targets mandate a fixed reduction in total emissions, while intensity targets aim to lower emissions relative to an output metric (e.g., per unit of revenue). Science-based targets (SBTs) combine either absolute or intensity goals with a requirement to align reductions with climate science benchmarks. In this analysis, we pay particular attention to the scope coverage, target type, time horizon, and ambition level (percentage reduction) specified by each firm.

3 Methodology

3.1 Data Sources

This analysis draws on four MSCI datasets, each linked by the unique company identifier ISSUERID. The first dataset contains annual emissions for Scopes 1 and 2 (with limited Scope 3 coverage), alongside key financial metrics and identifiers. The second dataset details reduction targets, including target type, scope, ambition percentage, and reported progress. The third provides an overview of high-level program strategies (e.g., manufacturing, transport), and the fourth lists specific program instances with attributes such as implementation year and oversight mechanism.

3.2 Analytical Approach

Our investigation followed a multi-stage process. We began with data preparation, harmonizing codes, cleansing identifiers, formatting dates, and handling missing values via case-wise deletion or simple imputation where necessary. We also derived metrics such as three-year Compound Annual Growth Rates (CAGR) of emissions intensity and categorized target ambition levels. Next, exploratory data analysis (EDA) examined distributions and temporal trends through descriptive statistics and visualizations. We then conducted relationship analyses using correlation measures and group comparisons to assess associations between emissions outcomes and program or target variables. Finally, we performed preliminary modeling explorations to gauge predictive relationships; detailed model results are reserved for future thesis work.

3.3 Methods Employed

In this internship report, the key methods comprised descriptive statistics for summarizing central tendencies and distributional properties; correlation analysis using Pearson’s r and Spearman’s ρ to evaluate linear and monotonic associations; and comparative tests (t-tests, ANOVA frameworks) to examine differences across categories. Visual tools—including bar charts, scatter plots, and maps—illustrated these findings. Pattern mining and machine learning techniques were explored conceptually but are not detailed in this document.

3.4 Evaluation Metrics

To assess relationships, we relied on correlation coefficients (both r and ρ), conceptual statistical significance (p-values), and the magnitude of differences in means or growth rates between groups.

4 Dataset Creation and Data Preparation

4.1 Dataset Descriptions

The emissions dataset encompasses approximately 19 000 companies, with comprehensive Scopes 1 and 2 data but over 75 % missing in Scope 3 reporting. The reduction targets dataset contains around 58 000 entries for 7 000 firms, although progress and offset metrics are missing in over 65 % and 98 % of cases, respectively. Programs 1 covers about 2 800 companies at a high strategic level, with most fields missing in over 65 % of records. Programs 2 includes 52 000 program instances across 7 000 companies, but oversight details are absent in roughly 80 % of entries. For full variable definitions, refer to the Data Dictionaries.

4.2 Data Cleaning Procedures

We standardized all identifiers, harmonized country and industry codes, converted dates to ISO format, and recoded categorical fields to a consistent taxonomy. Outlier detection flagged implausible emissions values, which were reviewed case by case.

4.3 Missing Data Treatment

High missingness necessitated a pairwise approach: correlations and descriptive statistics use complete-case observations, while group comparisons draw on available data per group. We document missing-data patterns as a limitation in Section 6.5.

4.4 Variable Transformations

Key derived variables include the three-year CAGR of combined Scope 1 and 2 intensity (negative values indicate improvement), target ambition categories (Low: <10 %, Medium: 10 % to 30 %, High: >30 %), a conceptual Program Implementation Score combining program count, type diversity, and oversight presence, and benchmarks comparing each company's metrics to its industry and regional averages.

5 Exploratory Data Analysis

5.1 Emissions Patterns

5.1.1 Geographic Distribution

When examining regional trends, Europe stands out with the strongest average improvement at -5.14% , closely followed by North America (-3.20%). In contrast, the Asia-Pacific region has experienced a modest worsening trend ($+0.56\%$). Among individual countries, Finland (-9.37%), Denmark (-6.87%), and the United Kingdom (-6.45%) lead in emissions reductions (see Figure 1).

5.1.1.1. Geographic and Industry Context Matters

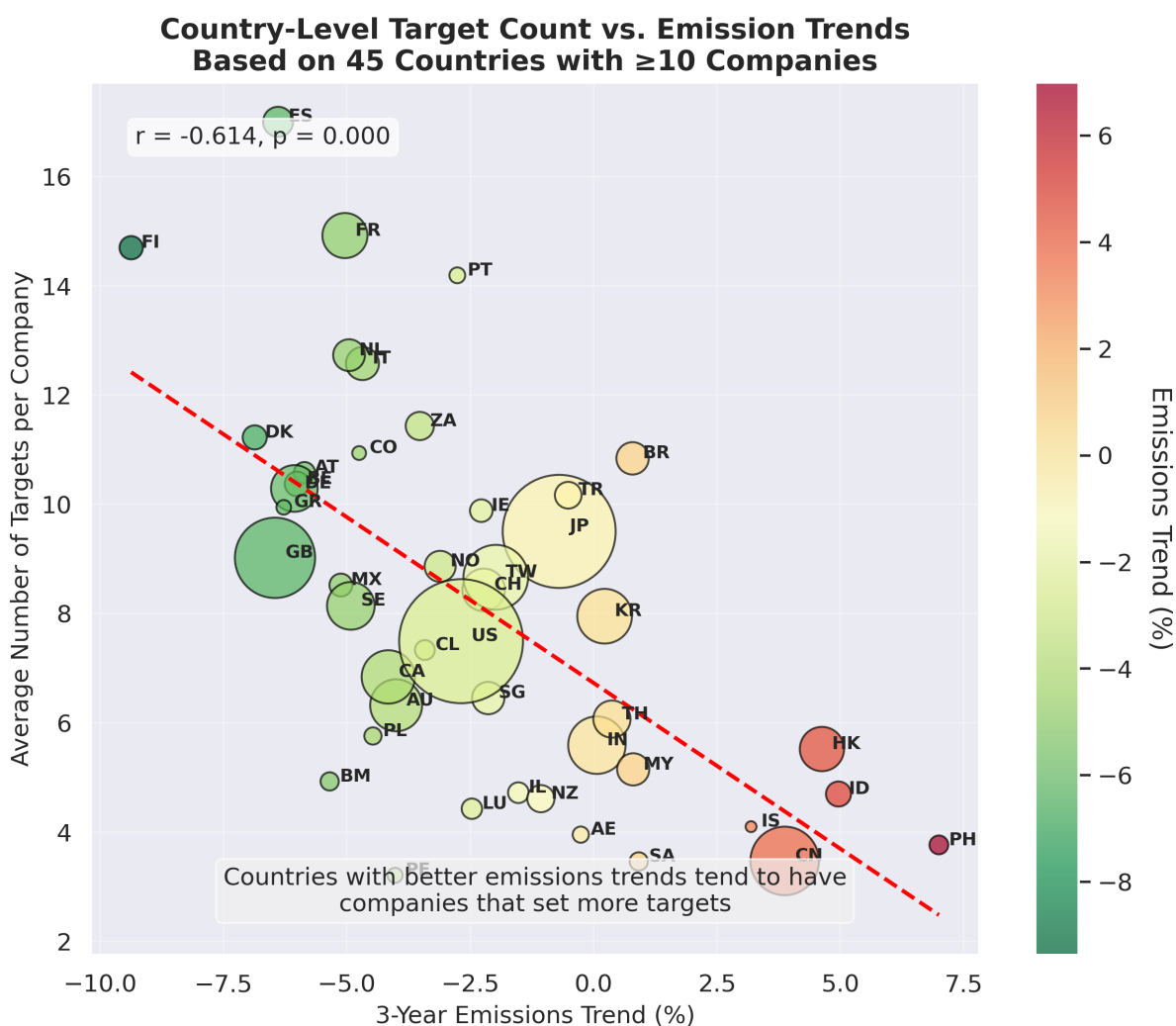


Figure 1: Geographic distribution of three-year emissions intensity trends.

5.1.2 Industry Distribution

Industry profiles vary substantially. Sectors such as Electricity Production, Cement, Refined Petroleum, and Basic Metals exhibit the highest absolute emissions. Intensity metrics reveal that Cement firms have the greatest emissions per unit output, while Financial Services and Technology report the lowest. Interestingly, some high-emitting industries—Electricity Distribution (−6.03 %) and Basic Metals (−4.49 %)—demonstrate strong improvement, whereas Lignite Mining shows a worsening trend (+3.71 %).

5.2 Target-Setting Behavior

Target adoption is widespread: roughly 7 000 companies report at least one reduction target. Absolute targets (53 %) are more prevalent than intensity targets (21 %), and a substantial share of firms aim for reductions exceeding 30 %. Analysis indicates that companies with higher baseline emissions tend to set more targets but often opt for lower percentage ambitions, while those with larger Scope 3 footprints are more proactive in target setting. At the national level, greater target prevalence correlates with stronger emissions improvements.

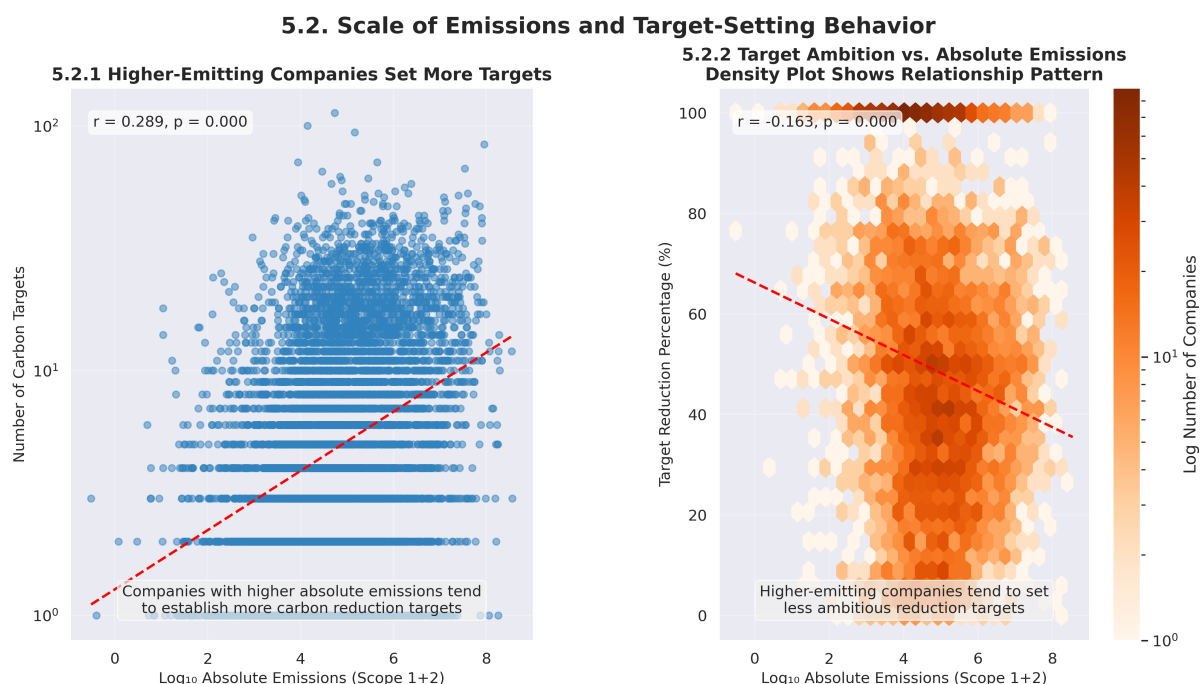


Figure 2: Relationship between emissions scale, target count, and target ambition.

5.3 Program Implementation Trends

On average, firms report seven program instances; common categories include Energy Saving, Energy Alternatives, and Governance structures. Program reporting peaked between 2020 and 2022, coinciding with heightened regulatory scrutiny. Governance oversight—particularly board-level reporting—has risen markedly; firms with executive oversight show an average improvement of −1.67 %, compared to +0.67 % for those without.

6 Key Relationship Models and Evaluation

6.1 Impact of Target Characteristics

Analysis of target ambition reveals that medium-ambition targets (10–30%) achieve the strongest average improvements (−3.82%), with high-ambition targets closely behind (−3.70%), both outperforming firms with no targets (+1.19%). Progress reporting further amplifies these effects: companies exceeding 175% of their target show an average reduction of −8.7%. While absolute targets correlate weakly with lower intensity (Spearman’s $\rho \approx -0.1$), ambition and progress emerge as the predominant drivers of effectiveness (Figure 3).

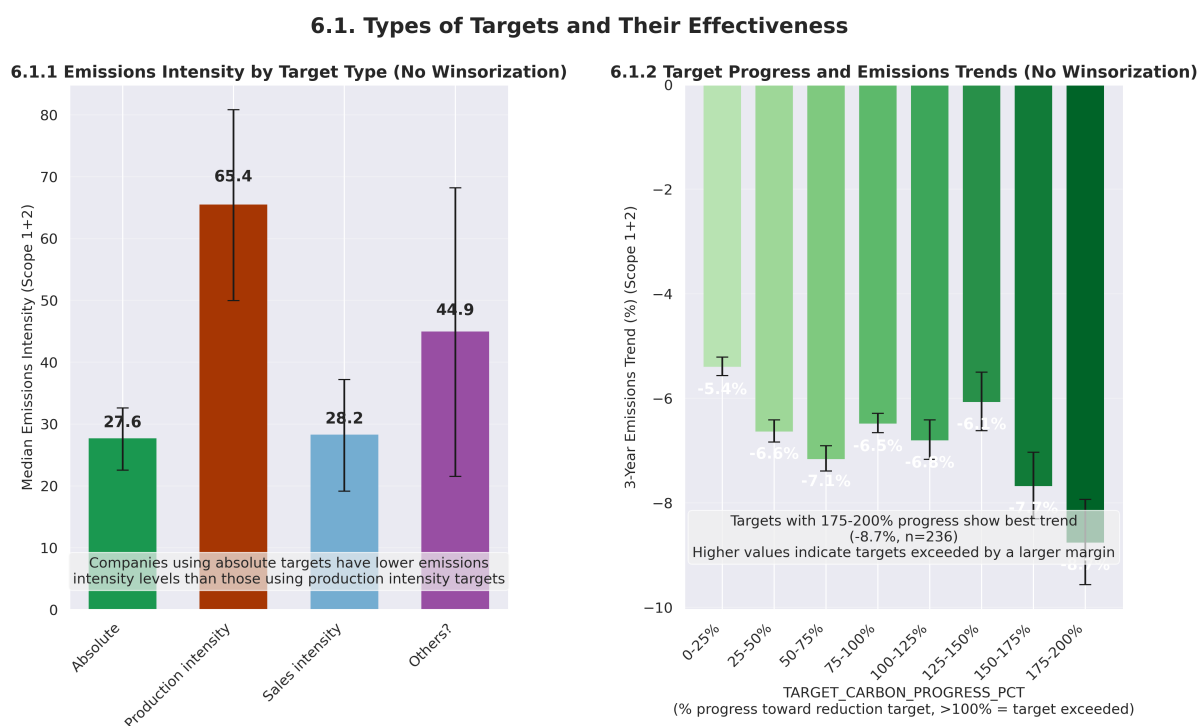


Figure 3: Effectiveness of target types and progress levels on emissions trends.

6.2 Impact of Program Implementation Elements

Formal energy audits exhibit the strongest association with emissions improvements: external independent audits average −7.21%, internal audits −5.33%, and ISO 50001 certification −3.65%. Firms with executive or board oversight also perform better (−1.67%) compared to those lacking such governance (+0.67%). A more comprehensive program scope—covering all core facilities or products—tends to yield better outcomes than partial or generic strategies, though data sparsity limits statistical strength.

6.3 Contextual Factors: Industry and Region

Both the direction and magnitude of relationships between programs or targets and emissions trends vary significantly by industry and region. In some sectors, higher initial emissions align with loftier ambition, whereas in others the opposite holds. Similarly, program effectiveness diverges across industries such as Retail versus Manufacturing, underscoring the importance of contextual tailoring.

6.4 Overall Predictive Power (Brief Note)

Preliminary modeling suggests that while targets and program variables contribute to predicting emissions outcomes, their incremental predictive power is modest compared to firm fundamentals—such as baseline emissions, size, and industry. This indicates that programs and targets form part of a broader explanatory framework.

6.5 Limitations

Several caveats apply. Our analysis is correlational, so causality cannot be definitively established—strong performance may enable target setting as much as vice versa. High missingness in key variables (Scope 3, progress, oversight) constrains robustness, and reliance on self-reported data may introduce bias. Finally, the impact of interventions may manifest over longer horizons than the available data window.

7 Discussion

7.1 Interpretation of Key Findings

Our findings indicate that corporate target setting and program implementation are associated with better emissions outcomes, although these relationships are highly context-dependent. Medium-ambition targets appear to strike an optimal balance between feasibility and impact, and robust governance—especially external audits—enhances program effectiveness. Sectoral and regional factors further modulate these effects, confirming that a one-size-fits-all approach is unlikely to succeed.

7.2 Business Implications

For practitioners, these results suggest prioritizing realistically ambitious targets (10–30%), investing in oversight mechanisms, and tailoring strategies to industry and regional conditions. Diligent progress tracking is also critical, as demonstrated by the outsized improvements among firms reporting high achievement.

7.3 Policy Considerations

Policymakers should continue encouraging transparent target setting and reporting, while supporting independent verification frameworks. Sector- and region-specific incentives may yield greater impact than universal mandates. Addressing data gaps—particularly in Scope 3 emissions and program details—will be essential for robust monitoring.

8 Conclusion

8.1 Summary of Findings

This report examined global corporate GHG emissions alongside reduction targets and programs using MSCI data. We find that widespread target adoption correlates with improved emissions trends, most notably when firms set medium-ambition goals and achieve significant progress. Strong governance and verification mechanisms further bolster effectiveness, though these relationships vary by industry and region. Core firm characteristics—such as existing emissions profiles and size—remain critical determinants of outcomes.

8.2 Answers to Research Questions

1. **Patterns:** Absolute targets dominate, Europe leads in emissions improvements, and high-emitting sectors show diverse intensity trends. Board-level oversight has increased over time.
2. **Relationships:** Medium-ambition and high-progress targets, along with strong audit and governance practices, align with better outcomes. However, associations vary by context and are not strictly causal.

8.3 Future Research Directions

The internship findings lay the groundwork for a bachelor thesis. Key future avenues include refining program quality metrics, employing causal inference techniques, integrating additional public datasets (e.g., CDP disclosures), extending time-series analyses, and applying natural language processing to qualitative program descriptions.