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Smoke Signals: Finding Leading Indicators of Corporate Decarbonization

Moving toward accurate projected emissions

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Executive summary

Modeling companies' future emissions trajectories is a key element of transition finance, both for assessing alignment with climate objectives and for understanding potential investment risks from emissions.[1]

While many policy recommendations call for the use of "forward-looking" methodologies to gauge future emissions, we argue that financial decision makers need empirically verified predictive indicators to make better-informed investment decisions. In this paper:

- We identified potential transition indicators along four phases of a company's transition journey: target and governance indicators, low-carbon indicators such as capex, green-bond investments or green patents, revenue-based indicators such as green revenues or fossil-fuel-based revenues, as well as its recent emissions trajectory.

- We identified indicators with historically predictive power over three-, four- and five-year periods for changes in absolute Scope 1 and 2 emissions, using appropriate statistical-analysis techniques.

- We found regional differences in our predictive analysis, with the strongest statistical confidence in climate indicators found in the European and Asia-Pacific developed equity markets, and the weakest in the U.S.

- These results may help investors as they seek to build faster-transitioning portfolios and identify companies likely to reduce emissions more slowly, warranting closer engagement.

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[1] Paolo D'Orazio and Marco Miglietta, "How Green Is Green Finance? A Critical Literature Review," Risks 13, no. 4 (2023): 66.
"OECD Guidance on Transition Finance: Ensuring Credibility of Corporate Climate Transition Plans," OECD, 2022.

Introduction

Anticipating companies' future decarbonization paths is critical for assessing their alignment with the low-carbon transition and managing related investment risks. Historical decarbonization rates may not, however, reliably predict future emissions given shifting government policies and evolving technologies.

Why emissions projections matter for assessing climate alignment

In the context of measuring alignment with climate goals, such as those defined by the Paris Agreement, projecting portfolio emissions has become increasingly important. It helps avoid unintended consequences from focusing solely on present-day financed emissions — such as a bias against high-emitting sectors — and instead prioritizes real-economy decarbonization. In response, the Task Force on Climate-related Disclosures (TCFD), whose recommendations have been adopted by the International Financial Reporting Standards (IFRS), has promoted the use of "forward-looking metrics" for portfolio emissions to assess future risks and opportunities.[2] This approach is further supported by the best-practice guidance from the COP26 Portfolio Alignment Team.[3] Projected emissions also form a key input to more advanced metrics, such as the MSCI Implied Temperature Rise (ITR).

Building on this, the Glasgow Financial Alliance for Net Zero (GFANZ) issued guidance to strengthen company emissions projections by adjusting targets through the incorporation of a quantified credibility assessment — drawing on indicators such as validation by the Science-Based Targets initiative (SBTi). The guidance stopped short, however, of distinguishing genuine decarbonization signals from decarbonization ambitions.
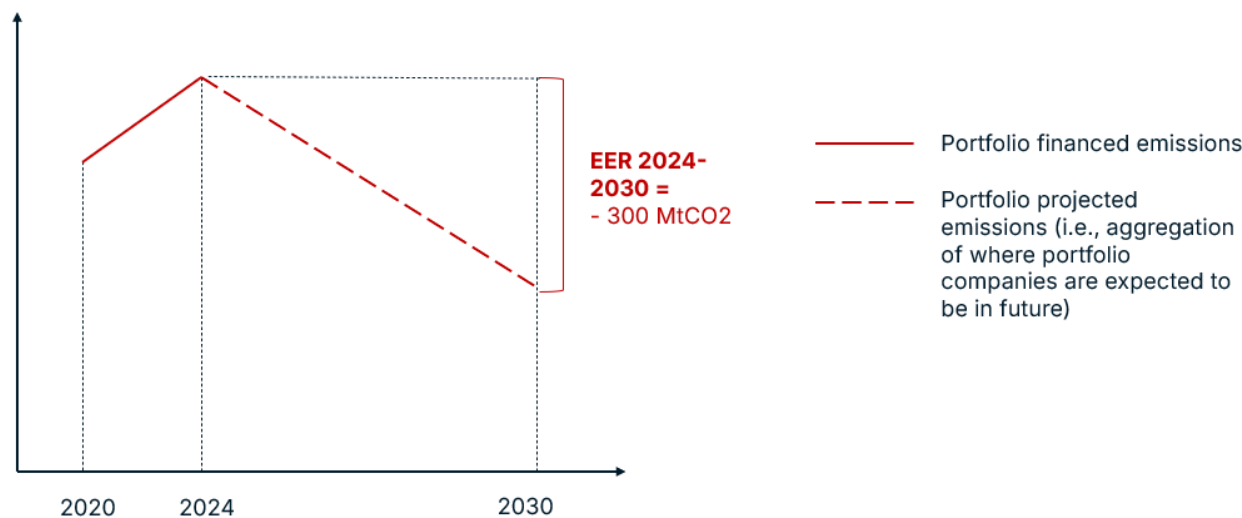
To further support forward-looking analysis, the Partnership for Carbon Accounting Financials (PCAF) introduced the concept of expected emissions reduction (EER),[4] a metric that quantifies the volume of emissions a portfolio is expected to reduce exposure to by a specified future date (as illustrated below). While EER marks important progress, it still leaves open the critical question of how best to forecast company emissions.

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[2] "Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures," TCFD, October 2021.

[3] "Measuring Portfolio Alignment. Technical Considerations," Portfolio Alignment Team, 2021.

[4] "New guidance and methods for public consultation. Part A." PCAF, November 2024.

Stylized EER computation as proposed by PCAF

Source: MSCI ESG Research and PCAF as of November 2024

Existing forward-looking methodologies such as EER or ITR typically rely on assumption-driven forward projections that may lack precision in predicting emissions — and, more critically, they are rarely subjected to statistical testing. For a methodology to be credibly predictive, ex-ante estimates of future company emissions must demonstrate a statistically significant positive correlation with the ex-post realized emissions trend. This approach requires a sufficiently large sample of companies to enable robust statistical testing. In our analysis, we leveraged a large global dataset to evaluate the predictive power of ex-ante predictions in multiple ways.

Emissions forecasts are also key to evaluating energy transition risks

Beyond measuring climate alignment, emissions projections are also critical for assessing companies' exposure to financially material transition risks. MSCI's Energy Transition Framework is one such tool and is designed to evaluate business transition risks expected to materialize in the next five to seven years. The framework consists of two key components: transition pressure, defined as the financial risk exposure stemming from emissions, and transition readiness, which reflects a company's ability to manage and mitigate this pressure over time.

The transition-readiness assessment relies on indicators that may help forecast companies' progress toward a lower-carbon-intensive business model. As with climate-alignment metrics, this requires moving beyond simple emissions projections to identifying leading indicators that demonstrate the empirical evidence of predictive value.

Using statistical analysis to move from data to predictive models

The objective of this research is to help institutional investors move from assumption-driven emissions projections to statistical forecasts with demonstrable predictive power. We do this by first identifying which indicators are proven to be predictive of corporate decarbonization and then, through regression analysis, examining how these indicators can be combined to forecast emissions reductions. A key challenge in this process is the limited historical depth of climate-related data, which extends back a maximum of only 10 years. To address this, our research follows three key steps:

1) **Conceptual mapping.** We identified the economic transmission channels through which companies transition to a low-carbon economy and explored which datasets may act as indicators of the transition steps.

2) **Empirical testing.** We assessed whether indicator values from the past were significantly correlated with subsequent changes in companies' carbon emissions. This cross-sectional analysis required choosing time periods that were long enough for causal effects to unfold and reveal potential predictive patterns.

3) **Combining predictive signals.** We evaluated whether combining multiple leading indicators in a multi-factor model can improve forecasting accuracy relative to single-indicator approaches. We demonstrated one way in which the signals may be combined as an illustrative example, rather than a prescription of how it should be done.
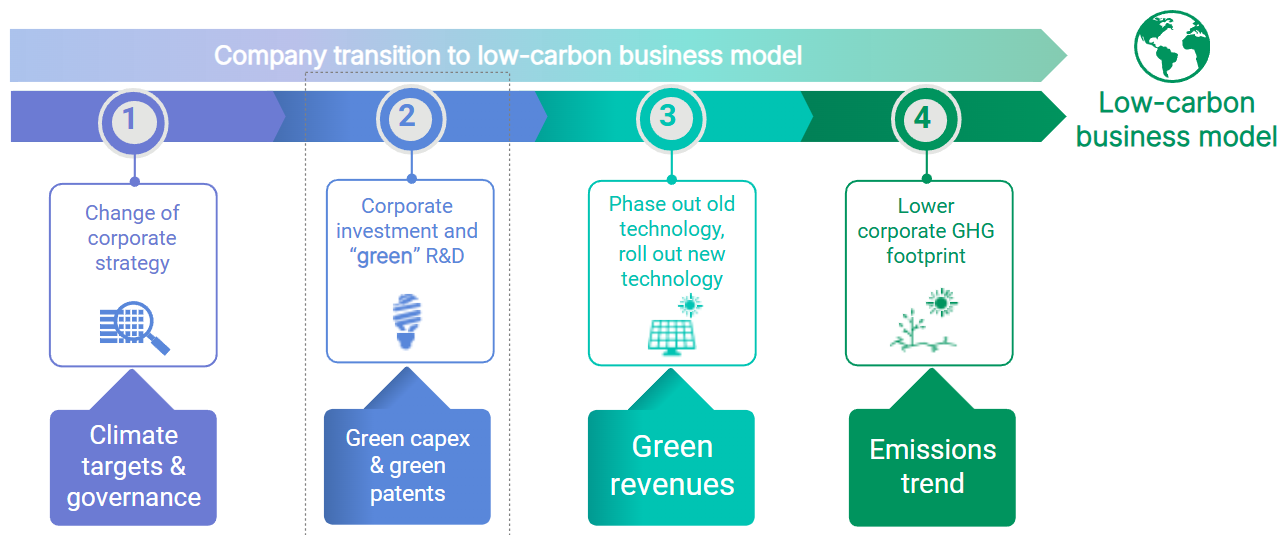
Our work aligns with previous findings in academic literature. For example, Bolton and Kacperczyk (2023) and Ramadorai and Zeni (2024) found that companies setting emissions-reduction targets were more likely to reduce actual emissions over time, suggesting that such targets may serve as a valid leading indicator of climate-transition progress.

Improved forecasting of emissions has both practical and academic applications. For portfolio managers, it can inform engagement and support stock selection aligned with climate targets or transition risk mitigation. For academic research, it enables more accurate estimations of future carbon costs. For instance, Pastor et al. (2024) relied on long-term, assumption-based projections from MSCI ITR metrics to estimate companies' future social costs of carbon emissions — projections that could be enhanced using more predictive, data-driven models.

Economic transmission channels and their indicators

As the first step in our modeling, we identified the economic transmission channels through which companies transition to a low-carbon business model. Broadly, this transition can be understood in four sequential phases, each associated with a set of observable indicators, as summarized below.

Stylized phases of companies' low-carbon transition and related indicators

Source: MSCI ESG Research

Our focus was on identifying causal indicators that reflect economic changes likely to persist and may therefore serve as leading signals for investment applications. These indicators were tested empirically for their predictive relationship with subsequent emissions reductions.

1) **The first phase** involves companies setting emissions-reduction targets or integrating climate objectives into governance structures, such as linking executive compensation to sustainability outcomes. These governance and strategy-level actions are widely cited as causal signals of future behavior. For example, Ioannou et al. (2016) found that firms setting CDP targets and aligning them with executive compensation were more likely to reduce emissions reductions. Dahlmann et al. (2019) reported similar results, while Freiberg et al. (2021) argued that firms with internal climate targets were more likely to adopt external standards, such as those of the SBTi. A comparable effect has also been observed at the national level by Tenreyro and De Silva (2021).

2) **In the second phase**, companies redirect capital and innovation toward developing new low-carbon products or technologies. Indicators at this stage include green capital expenditures[5] and green patent activity, which may provide early evidence of a tangible shift in business operations.

3) **The third phase** is characterized by measurable changes in business outputs, such as a declining share of fossil-fuel-based revenues and a growing share of green revenues.[6] These

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[5] Capital expenditure in renewable-power-generation assets (wind, solar, biomass, hydro and other renewables) as a proportion of total company capital expenditure (including networks infrastructure, all power-generation assets and other capital expenditure).

[6] Corporate revenues as reported or estimated by the MSCI Sustainable Impact Metrics methodology.

metrics capture operational reorientation, signaling a move beyond strategic intent to demonstrated outcomes.

4) **The final phase** involves actually reducing emissions. While this is the outcome that alignment metrics ultimately seek to capture, relying on historical emissions trends as predictors of future reductions is less certain. We empirically test whether emissions trajectories exhibit meaningful autocorrelation, i.e., whether past trends persist.

Notably, while phase one indicators (such as climate targets and governance reforms) have been relatively well-studied, far less research has examined the full set of indicators across all four phases. Moreover, when indicators such as green capex or green revenues are discussed in the literature, the focus is often on financial performance (such as EPS growth or stock return) rather than emissions performance. Part of the challenge lies in the limited history of reported carbon emissions data until recently. Decarbonization can only be assessed over a period of several years, as emissions evolve far more slowly than financial returns. For example, Giese et al. (2021) analyzed the financial attributes of companies with higher green revenue but did not link these indicators to decarbonization outcomes.[7]

This study seeks to broaden the empirical assessment to include all four transition phases and to test whether the corresponding indicators, individually and in combination, offer predictive insights into emissions outcomes.

The specific indicators used in our analysis are shown in the next table and include 8,183 issuer companies within the MSCI ACWI Investable Market Index (IMI). Limiting the sample to firms with a continuous history of reported Scope 1 and 2 emissions reduced the universe to 5,424 companies. Further detail on data sources and structure, preprocessing steps and assumptions can be found in the Appendix.

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[7] The authors found that in the utilities, materials and energy sectors, companies in the top quintile of green revenue share showed stronger EPS growth and higher returns than those in the bottom quintile.

Indicators used for the four transition phases for MSCI ACWI IMI constituents

Category	Data	Short description	Coverage in 2023
Emission variable	**Carbon emissions (Scope 1+2)**	**The sum of Scope 1 and Scope 2 emissions. The metric to forecast is relative change (%) in emissions**	**5424**
Targets & governance	Low Carbon Transition score	Measures a company's level of alignment to the Low Carbon Transition	4685
	Low Carbon Transition mgmt score	Measures how well a company manages risk and opportunities related to the Low Carbon Transition, uses key issue mgmt scores: carbon emission and footprint, financing environmental impact, opportunities in clean tech and renewables	4685
	Environmental opportunities theme score	Weighted average of the key issue scores that fall under the Environmental Opportunities Theme: Opportunities in Clean Tech, Opportunities in Green Building, and Opportunities in Renewable Energy	1834
	Greenhouse gas mitigation score	Based on the combination of the three mitigation data points: use of cleaner sources of energy; energy consumption management and operational efficiency enhancements; and CDP disclosure.	4924
	Climate risk management weighted average score	Weighted average of key issue management scores related to carbon emissions, carbon footprint, biodoversity and transition opportunities	3886
	Internal carbon price	The monetary value assigned to carbon emissions as reported and used by the company.	177
	Committed to SBTI target	Indicates that the company has copmmitted to develop and submit a target to SBTi	548 Yes *
	SBTI target approved	Indicates if company has one ore more active emission reduction target approved by SBTi	645 Yes *
	Has reduction plans	Indicates if the company has a carbon emissions reduction target	2496 Yes *
	Target progress	Describes the company's progress towards meeting its ongoing emissions reduction target(s) by comparing its reported progress toward achieving each target against a hypothetical linear path from the target's base year to the target year.	807 On track with all *
Green capex & patents	Green patents score	Score associated to granted low carbon patents that a company owns that are still valid.	950
	Issuance of green bonds	Indicates if company has an active green bond issuance or had issued a green bond that mature at most 5 years ago.	575 Yes
	Capex share on renewable power generation	Capital expenditure in renewable power generation assets (wind, solar, biomass, hydro and other renewables) as a proportion of total company capex	74
Green revenues	Green revenue share	Total of all revenues derived from any of the climate change environment impact themes including alternative energy, energy efficiency or green building	1644
	Green minus fossil fuel revenue share	Difference between green revenue share and fossil revenue share including gas, coal, liquid fuel and oil&gas extraction revenues	2043
Emission trend	3 year average target to realized emission ratio	Rolling average ratio of target emission divided by realized emission	705
	Alignment with PAII	Company's alignment category in the Paris Aligned Investment Initiative (PAII)'s Net Zero Investment Framework (NZIF),	371 Aligned*

*Data as of June 25, 2025. Only issuers with a history of consecutive reported emission data in 2023. * Backfilled from data in 2024 and 2025. Source: MSCI ESG Research*

Some of these indicators are correlated with one another, particularly when a metric's score is derived from component metrics also included in our analysis.[8] To illustrate these relationships, our next table presents a correlation table of indicator values from 2018 against emissions changes observed over the 2018–2023 period.

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[8] For example, climate risk management (CRM) weighted average score and environmental opportunities score is correlated because CRM has environmental opportunities as components.

Correlation between climate indicators in 2018 and the emission change over the next five years

	Governance and targets					Investment	Revenues		Trend	Other	
	Low Carbon Transition score	Environmental opportunities theme score	Greenhouse gas mitigation score	Climate risk management	log(internal carbon price)	log(green patents)	log(green revenues)	Green minus fossil revenue	Target-to-realized emission ratio	log(Scope 1+2 emissions)	last 3y revenue change
5y emission change (%)	-0.11	-0.11	-0.11	-0.10	-0.12	-0.13	-0.08	-0.06	-0.12	-0.01	0.15

Data as of June 25, 2025. Note: outlier filtering, as described in the Appendix, was applied to the emission change, low carbon transition (LCT) score and green minus fossil revenue datapoints to eliminate potential data issues (for emission change) or reduce fat tails (for LCT and green minus fossil revenue). The strong asymmetry of the green patent score and green revenue share variables was reduced by taking the log. Source: MSCI ESG Research

The most notable finding is that all indicators showed a negative correlation with emissions change, suggesting that higher scores for climate performance were generally associated with larger subsequent reductions in emissions. We also tested control variables not directly related to firms' climate performance. Initial emission levels showed only a negligible negative correlation with subsequent emissions change, while initial sales growth momentum displayed a small positive correlation. This indicates that companies with stronger sales growth tended to continue to increase emissions over the following years — likely as a byproduct of ongoing revenue expansion.

Definition of forecasting objectives

To carry out the empirical analysis, we first defined the emissions metric to be forecast. At a high level, there are two approaches:

1. The absolute or relative change in companies' emissions over time; absolute change is expressed in tons of CO2 and relative change is expressed as a percentage

2. The change in emissions intensity over time (again this can be absolute or relative)[9]

Our focus was primarily on forecasting relative emissions changes. Where data was available, we complemented our analysis with production-based intensity metrics, particularly for sectors such as utilities and energy due to their greater stability over time.[10] In contrast, emissions-intensity metrics based on financial variables tend to be more volatile and therefore less reliable for tracking decarbonization, unless supported by a robust attribution framework (Nagy et al., 2023).

Next, we defined the scope of emissions for analysis. In this case, we focused on reported Scope 1 and 2 emissions, which capture a company's direct and purchased energy-related emissions. We excluded

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[9] Emissions intensity normalizes emissions by company size or output. This can be based on financial metrics (revenues, market capitalization or enterprise value (cf. BIS, 2021)), production-based intensity metrics such as output (per megawatts generated, barrel of oil produced) or people (per employee or customer).

[10] Sector definitions are based on the Global Industry Classification Standard (GICS®). GICS is the industry-classification standard jointly developed by MSCI and S&P Dow Jones Indices.

model-estimated Scope 1 and 2 data and Scope 3 emissions. While such estimates may be appropriate for cross-sectional analysis, they lack the precision needed for reliable time-series forecasting.

To assess the feasibility of forecasting, we verified whether sufficient decarbonization had occurred in the dataset. Empirical analysis requires a meaningful share of companies to have reduced emissions over the observation period. See the Appendix for data that confirmed a wide dispersion of emissions outcomes across all sectors, with subsets of companies in each achieving significant reductions between 2018 and 2023; thus confirming the viability of our analysis.

Identifying the most predictive global and regional indicators

We tested for predictive power in historical data by comparing the average decarbonization rate of the best- versus worst-performing groups of companies for each indicator. Generally, an indicator demonstrates good predictive power when companies with stronger scores (according to the indicator variable itself) subsequently achieve faster average decarbonization than those with weaker scorers.

For categorical indicators (e.g., approved SBTi target), the categories themselves define the best and worst performers. For numerical indicators, companies within each sector are sorted by the indicator value, and the top and bottom tertiles are compared. We then calculate the mean realized emissions change in each tertile over the subsequent next three-, four- and five-year periods and test for significant differences between the top and bottom tertiles. Companies with no indicator data are grouped in a 'missing' category.

Finally, the analysis is repeated across regional subsets of the global universe, using the MSCI USA IMI, MSCI World ex USA IMI (i.e., developed markets excluding the U.S.) and MSCI Emerging Markets IMI indexes.

We found that in the MSCI ACWI IMI, a higher Climate Risk Management (CRM)[11] score in 2018 was associated with greater emissions reduction over the following five years through to 2023. There were clear regional differences: in emerging markets, where average emissions increased between 2018 and 2023, most companies in the top tertile of CRM scores (tertile 3) still managed to reduce their emissions, as shown below.

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[11] CRM score is the weighted average of the following key issue management scores: carbon emissions, product carbon footprint, climate change vulnerability, biodiversity and land use, opportunities in green building, renewable energy and clean technology. Weights are the corresponding key-issue weights.

Mean emissions changes between 2018 and 2023 by CRM-score tertiles and by region
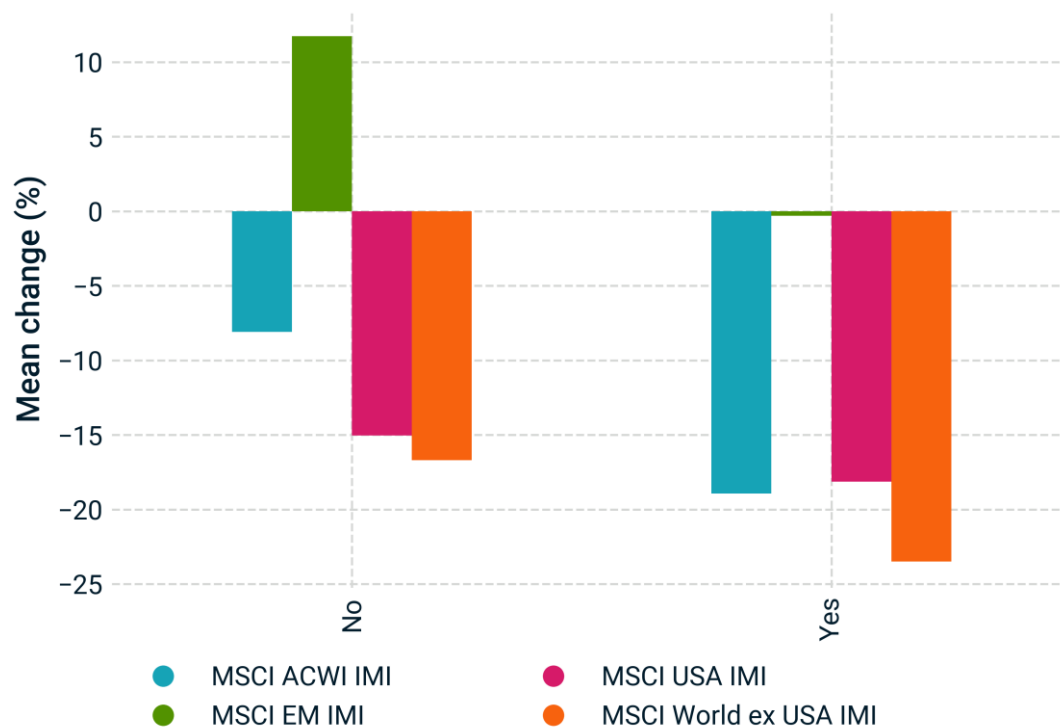

Data as of June 2025, sector adjusted. Source: MSCI ESG Research

The historical predictiveness of CRM was weakest for U.S.-listed companies, where higher scores were associated with slower emissions reduction. This reflects sector composition, with industrials, consumer discretionary and financials accounting for 42% of companies in the MSCI USA IMI between 2018 and 2023. Within each of these three sectors, companies in the top CRM tertile decarbonized more slowly, on average, than their sector peers in the bottom tertile. This is due to several factors, including a rebound in industrial activity (particularly in water equipment, aerospace and defense), the recovery in travel and leisure, return-to-office policies following the pandemic and acquisition activity.

By contrast, in other high-emission-intensive sectors — energy, utilities and materials — companies in the top tercile decarbonized faster on average than those in the bottom. For U.S.-listed companies overall, stronger predictive signals were observed for the presence of an internal carbon price and for SBTi-approved targets (see Appendix).

One challenge with testing indicators is the variation in historical data coverage. For example, very few companies had approved SBTi targets in 2018. Therefore, comparing companies with and without targets in 2018 is not meaningful. Instead, in the chart below we compare the mean emissions performance of companies that had targets validated by SBTi at any point between 2018 and 2023 with those that did not. In other words, the analysis is correlational rather than causal.

Mean emission changes between 2018 and 2023 for companies with and without SBTi targets, by region

Data as of June 2025, not sector adjusted, correlation only. Source: MSCI ESG Research

We observed that companies that had set SBTi targets during the five-year observation period decarbonized faster on average than companies without targets across all regions. These findings are in line with the aforementioned results found by Ioannou et al. (2016), as well as Dahlmann et al. (2019) and Freiberg et al. (2021).

We also caried out the analogous tertile analysis for all variables shown in the table on page 10 for the three-, four- and five-year periods ending in 2023. The results, presented in the table below, show the statistical confidence levels for differences in decarbonization rates between top- and bottom-tertile companies for each indicator.

Statistical relevance of indicators to predict Scope 1 and 2 emissions change from 2018 to 2023

Region	MSCI ACWI IMI			MSCI EM IMI			MSCI USA IMI			MSCI World ex USA IMI		
Analysis period (years)	3	4	5	3	4	5	3	4	5	3	4	5
Low carbon transition score	-3.06	-3.19	-2.70	0.01	-1.77	-0.30	0.73	-0.68	-1.91	-1.79	-0.94	-0.35
Low carbon transition management score	-6.25	-4.72		-2.84	-1.96		-0.39	0.19		-4.16	-1.61	
Environmental opportunities themes score	-2.80	-2.88	-2.62	0.39	-0.99	-0.32	0.23	-0.54	0.21	-1.99	-1.49	-1.97
Green house gas mitigation score	-0.80	-2.34	-2.64	0.01	-1.51	-1.47	-1.92	-1.85	-2.28	-0.89	-1.27	-0.39
Weighted average climate risk management score	-4.22	-4.22	-3.33	-1.81	-1.69	-1.45	0.32	0.01	1.12	-3.20	-3.19	-2.81
Log (internal carbon price)†	-0.96	-2.23	-0.92	0.30	-0.12	-0.46	1.36	0.54	0.80	0.47	-0.88	0.14
Has carbon price†	-2.38	-1.69	-2.34	-0.53	-1.19	-1.72	-2.23	-3.11	-2.10	-2.54	-1.79	-1.64
Committed to SBTi target†	-2.74	-3.68	-1.77	-1.33	-0.51	0.04	-0.81	0.57	0.48	-1.13	-2.16	-1.44
Has SBTi target†	-7.98	-7.52	-6.43	-3.08	-1.52	-2.15	-1.99	-1.23	-1.06	-3.31	-4.39	-3.26
Has reduction plans†	-9.64	-9.16	-7.43	-5.34	-4.65	-2.77	-1.71	-2.53	-0.97	-5.85	-4.42	-3.57
Target progress†	-6.62	-5.35	-3.56	-2.33	-2.78	-1.72	-1.55	-1.20	0.21	-4.75	-5.02	-3.29
Has issued green bonds	-4.21	-3.36	-2.21	-0.34	-0.17	0.53	1.81	1.28	0.82	-3.90	-3.42	-2.17
Log (green patents)	-1.05	-2.90	-3.64	1.52	-1.68	-0.29	-2.06	-2.54	-1.07	-1.27	-1.10	-0.54
Log (green revenues)	-1.72	-2.53	-1.67	0.59	1.07	0.03	0.10	-0.46	-1.68	-2.42	-2.91	-2.59
Green minus fossil revenues	-1.90	-3.16	-2.07	1.43	1.20	-0.16	0.06	-0.22	-0.12	-2.40	-3.46	-2.46
Target-to-realized emission ratio	-0.50	-0.74	-0.51	-1.06	-0.09	-1.38	0.99	-0.35		-0.23	-0.77	0.04
Is-Paris-aligned†	-7.63	-8.21	-7.91	-3.39	-2.86	-2.31	-2.81	-2.68	-2.68	-3.98	-4.81	-4.45

Data as of June 2025, for the period 2018 to 2023. A two-sided t-test with unequal variances was calculated to see if the mean of emission change in the top tertile is different from the mean in the bottom tertile. Negative values indicate faster reduction in the top tertile. Tertiles are constructed by sector, except for the greenhouse gas mitigation score where only global tertiles could be created due to the distribution of the score. For non-numerical variables like SBTi- and Paris-aligned indicators, the bottom bucket contains issuers with no target or that are not aligned; the top bucket contains issuers with an SBTi-approved target or are flagged as committed, aligned and aligning, respectively. Azure shading indicates results in the expected direction, raspberry shading indicates result in the unexpected direction. Dagger (†) indicates variables for which correlation and not forward-looking test was applied.
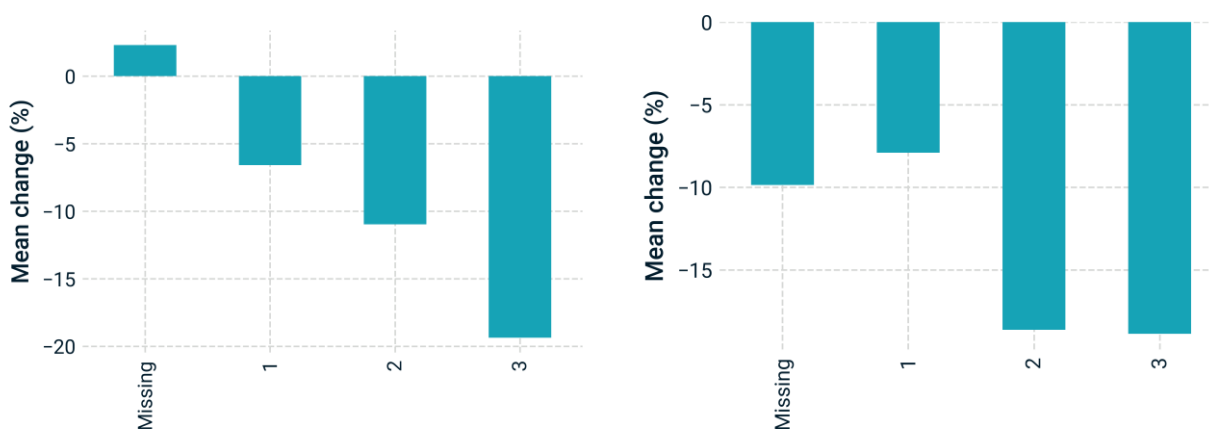
We observed clear regional differences in the results. Overall statistical significance was highest in the MSCI ACWI IMI, reflecting its broader coverage. Among sub-regions, statistical relevance was the lowest in the MSCI USA IMI universe, where some indicators, such as CRM score, internal carbon price or issuance of green bonds, showed the opposite sign, meaning companies with stronger climate indicators, on average, had lower emissions reductions. When the analysis was restricted to the most emissions-intensive sectors (energy, materials, industrials and utilities), results improved slightly for the U.S. and emerging markets but weakened slightly for the MSCI World ex USA IMI (see Appendix for the detailed table).

It is important to distinguish between indicators with sufficient history to allow forward-testing and those for which only correlation tests were possible (marked with a dagger in the previous table). The latter may contain some forward-looking bias, which could explain why they showed stronger results overall. For example, SBTi targets and the Net Zero Investment Framework Paris-aligned category showed statistically significant emissions reductions across all regions and time horizons. Among the indicators that could be forward-tested, the low carbon transition management score and the greenhouse gases mitigation score showed the strongest overall results.

Individual indicators testing in specific sectors

For the utilities and energy sectors, we tested production-based intensities, which offer a key advantage by controlling for changes in company output when measuring emissions. In addition, for utilities, we included the share of renewable capex as an indicator. The next chart shows the empirical results: Over the three-year study period, utilities companies with higher ratios of green versus fossil-fuel-based revenues, as well as those allocating a greater share of capex to renewables, achieved faster relative reduction in carbon emissions.

Mean change of emission intensities in the utilities sector for tertiles based on green revenues minus fossil-fuel revenues (left) and green capex share (right)

Data as of June 2025 for the period 2022 to 2023. Source: MSCI ESG Research

The results for the rest of the indicators in the utilities sector are shown in the next table. Most indicators that historically predicted decarbonization in a global setting were also statistically significant. One exception was the green-patent score, which displayed the opposite relationship with emissions reduction speed at the three-year horizon. The share of renewable capex pointed in the expected direction but, because of the small sample size, the difference between the top and bottom tertiles was not deemed significant.

Statistical relevance of indicators to predict Scope 1 and 2 emissions intensity (tCO2/MWh) change in the utilities industry excluding water utilities

Region	MSCI ACWI IMI	
Analysis period (years)	3	4
Low carbon transition score	-2.44	-2.43
Low carbon transition management score	-2.59	-1.48
Environmental opportunities themes score	-3.08	-2.53
Green house gas mitigation score	0.08	-3.16
Weighted average climate risk management score	-2.34	-2.35
Log (internal carbon price)†	0.48	-1.38
Has carbon price†	-0.14	-0.66
Committed to SBTi target†	-1.39	-1.46
Has SBTi target†	-1.26	-2.79
Has reduction plans†	0.18	0.71
Target progress†	-2.02	-2.58
Has issued green bonds	-1.25	-1.67
Log (green patents)	0.71	0.66
Renewable capex share	-1.60	-2.16
log(green revenues)	-3.33	-2.34
Green minus fossil rev	-3.07	-2.95
Target-to-realized emission ratio	-1.48	-1.54
Is-Paris-aligned†	-1.40	-1.20

Data as of June 2025 for the period 2022 to 2023. Azure shading indicates results in the expected direction, raspberry shading indicates result in the unexpected direction. Water utilities were excluded as energy is not their core business. Source: MSCI ESG Research

In the energy sector (as shown below), the statistical significance of predictive power was generally lower. Only the issuance of green bonds and the presence of emissions-reduction plans were associated with significantly faster reduction. The weaker significance levels are again not surprising and reflect both the small sample size and the sector's overall lower pace of decarbonization compared with utilities, as shown in the Appendix. It is also interesting to note that both the presence of an internal carbon price and, when used, a higher carbon price were indicators of a faster decarbonization.

Statistical relevance of indicators to predict Scope 1 and 2 emissions intensity (gCO2/MJ) change in the energy sector

Region	MSCI ACWI IMI	
Analysis period (years)	3	4
Low carbon transition score	-0.76	-0.51
Low carbon transition management score	-1.64	0.81
Environmental opportunities themes score	0.59	0.50
Green house gas mitigation score	-0.50	0.47
Weighted average climate risk management score	-1.15	0.90
Log (internal carbon price)†	-0.64	-0.40
Has carbon price†	-1.26	-0.36
Committed to SBTi target†	no data	no data
Has SBTi target†	no data	no data
Has reduction plans†	-3.08	-1.83
Target progress†	0.50	-0.52
Has issued green bonds	-6.82	no data
Log (green patents)	0.64	0.67
Renewable capex share	no data	no data
Log (green revenues)	1.52	-0.51
Green minus fossil rev	no data	0.38
Target-to-realized emission ratio	no data	no data
Is-Paris-aligned†	-0.48	0.76

Data as of June 2025 for the period 2022 to 2023. Azure shading indicates results in the expected direction, raspberry shading indicates result in the unexpected direction. Source: MSCI ESG Research

Multi-factor modeling

While analyzing transition indicators individually (as shown in the table on page 10) provides useful insights, a multi-variable framework can help unravel the complex influences shaping decarbonization trajectories. To this end, we turned to a multi-variable linear-regression model to provide a more comprehensive understanding and to generate more robust predictions.

Model design and data preparation

Our multi-variable analysis uses a linear-regression model with percentage change of Scope 1 and 2 emissions as the dependent variable. In shorthand notation, the model can be described as:

$$\Delta S12emission\%$$
$$= \alpha + \beta\ Transition\ indicators + \gamma\ 3year\ Revenue\ growth + \delta\ \log(Initial\ emissions)$$
$$+ Industry\ group\ dummies + Region\ dummies + Missingness\ dummies + \varepsilon$$

The explanatory variables are as follows:

- Transition indicators included the numerical and categorical variables listed in the previous section.

- Baseline controls. The initial log of emissions initial sales growth rate account for starting conditions. Higher initial emissions may imply different decarbonization potential, while baseline sales growth captures business growth dynamics that might affect emissions independently of decarbonization efforts.

- Industry and region effects: GICS industry group (second level in the GICS hierarchy) and regional indicators capture variations in decarbonization dynamics driven by technological, regulatory, market maturity or cultural factors.

- Missing values: The treatment of missing data is detailed in the Appendix.

Given the limited history available, the model was estimated in three variations only: three-, four- and five-year changes. We focus on the sign of the coefficients, which indicate whether a metric is associated with faster (negative sign) or slower (positive sign) reductions. We also analyzed the t-statistic to gauge statistical significance, helping distinguish meaningful predictors from noise.

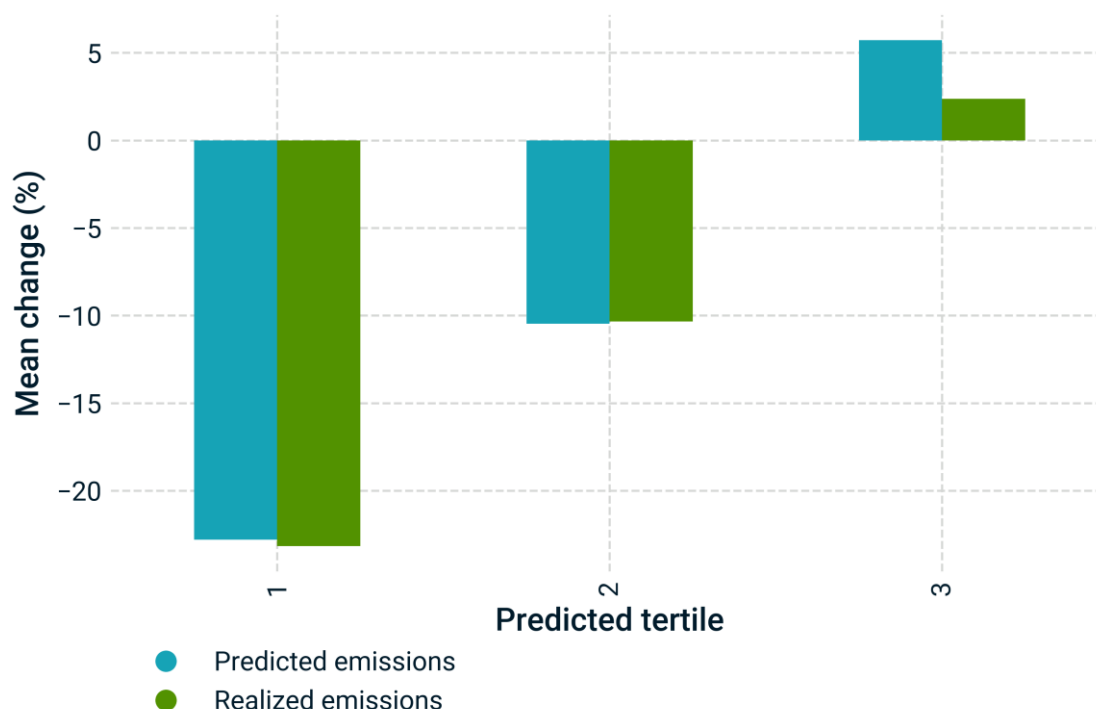**T statistics of regression coefficients**

Start year	2018	2019	2020
Intercept	2.60	2.05	2.81
Low carbon transition score	-0.69	-1.00	-0.65
Low carbon transition management score		0.92	-0.47
Environmental opportunities themes score	-0.70	-1.58	-0.99
Green house gas mitigation score	-1.19	0.60	-0.22
Weighted average climate risk management score	-0.84	-0.92	0.80
Log (internal carbon price)	0.82	-1.43	-1.73
Log (green patents)	-0.59	-0.03	-1.29
Log (green revenues)	-1.42	-0.82	0.56
Green minus fossil revenues	0.74	-0.29	0.34
Target-to-realized emission ratio	-1.21	-0.61	-0.02
Log (carbon emissions)	-3.34	-4.50	-3.73
3y revenue change	5.27	9.94	9.06

Data as of June 2025 for the period 2018 to 2023. Note: T-statistics of industry group, region and other indicator variables and missingness indicators are not shown. Azure shading indicates a coefficient with negative sign, and 95% confidence, whereas raspberry shading indicates a coefficient with positive sign. Adjusted R squared 14%, 14% and 12% respectively. Source: MSCI ESG Research

The results show that indicators that worked individually were not necessarily significant when used in a multi-factor model which also had to contend with uneven data coverage (e.g., LCT score and transition management score). The robustness of the approach is confirmed, however, by the observation that apart from the green minus fossil-fuel-revenue indicator, the direction of effects in the multi-factor setting was generally consistent with the individual analysis. As expected, t coefficient significance levels were lower when several variables were included in the model.

As an in-sample test, we created three tertiles for 2018 based on predicted emissions-change rates, just as we did in the section on our individual indicators. We then compared the average predicted and realized emissions change of the tertiles, as shown below. The accuracy was strong for the lowest and middle tertiles, whereas in the top quartile the predicted values were more conservative than the reductions ultimately realized.

Comparison of predicted and realized emission change between 2018-2023

Data as of June 2025. Source: MSCI ESG Research

Conclusion

Forecasting companies' emissions trajectories is essential for both assessing alignment with climate objectives and for building transition-aware investment portfolios. Despite the relatively short history of climate transition indicators (typically less than 10 years) we found statistically significant evidence that several of these indicators were predictive of companies' carbon-emissions declines over the study period.

Significant results emerged across four categories of transition indicators: governance and targets, green capex and patents, revenue data and emissions-trend data, with predictive horizons of three to five years within the MSCI ACWI IMI. Regional and sectoral differences were clear: results looked weakest in the MSCI USA IMI and strongest in the rest of global developed markets. Sectorally, utilities, where decarbonization has been more pronounced, showed stronger predictiveness than energy, where overall decarbonization has been slower.

We also found value in combining indicators. Conceptually, this allows for capturing different stages of a company's transition. Empirically, our regression analysis showed that multi-indicator models improved predictive power.

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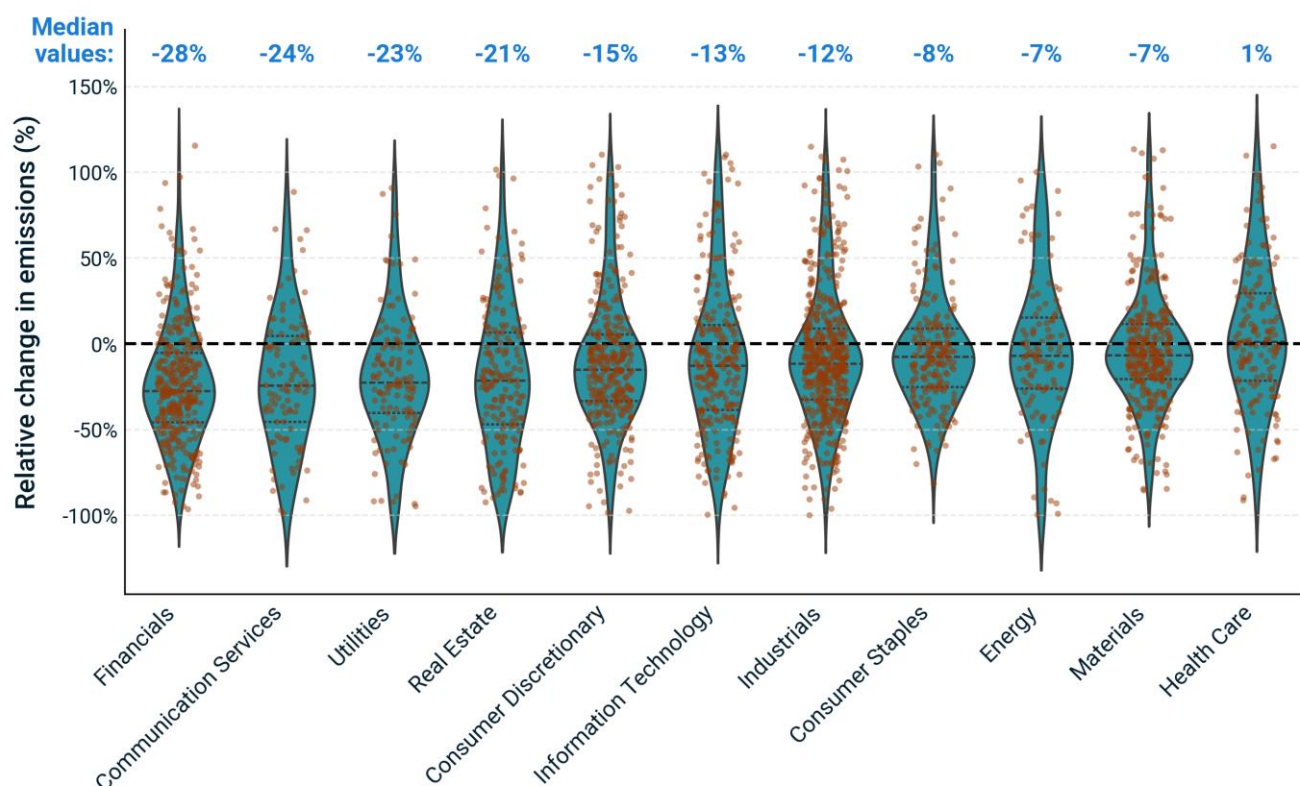
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Appendix

Distribution of emission changes

The chart below shows a wide dispersion of emissions outcomes across all sectors, with a subset of companies in each achieving significant reductions between 2018 and 2023.
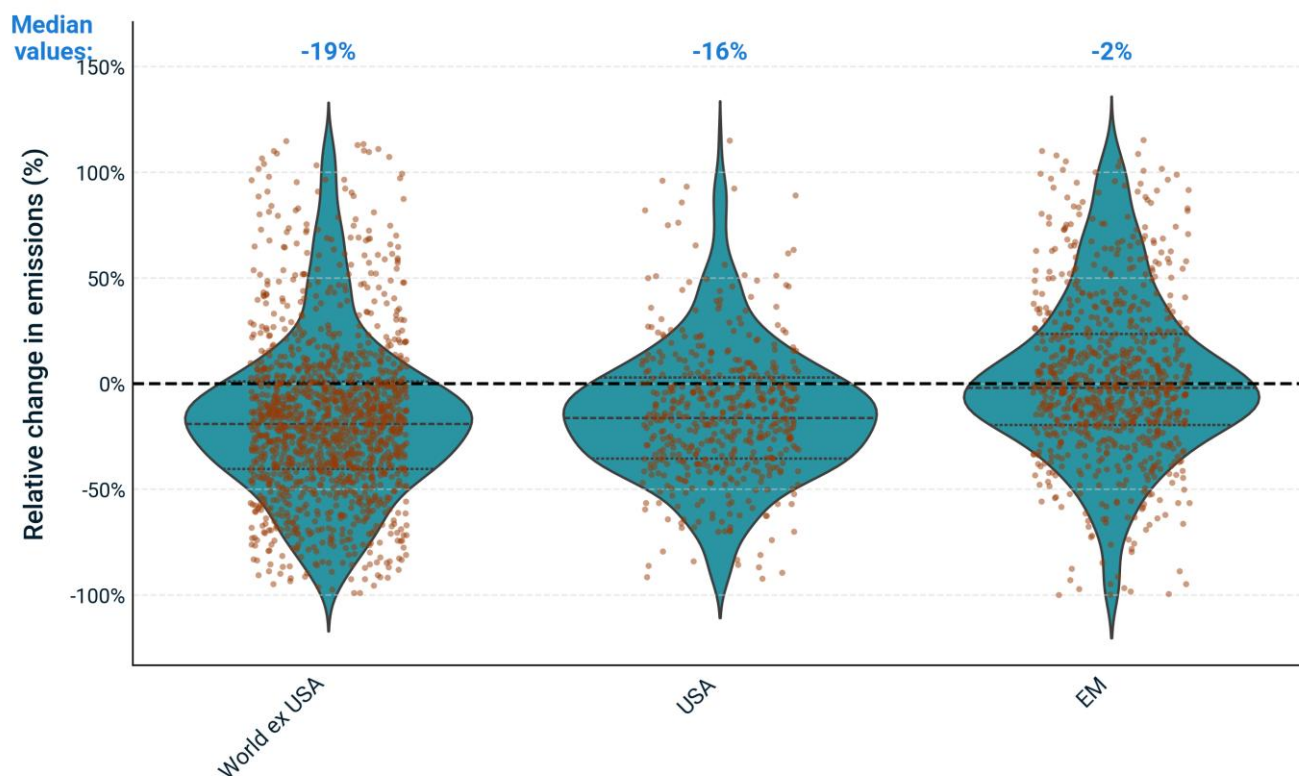
Distribution changes in companies' absolute Scope 1 and 2 emissions between 2018 and 2023, by sector

Data as of June 2025. Includes only issuers with consecutive reported emissions data through 2023. Distribution excludes 235 outliers beyond 3 standard deviations of the mean. Sectors are ordered by median relative change. Scope 1 and 2 emissions only. Source: MSCI ESG Research

We also observe regional variation. As shown below, emerging-market companies have, on average, decarbonized more slowly than those in developed markets.
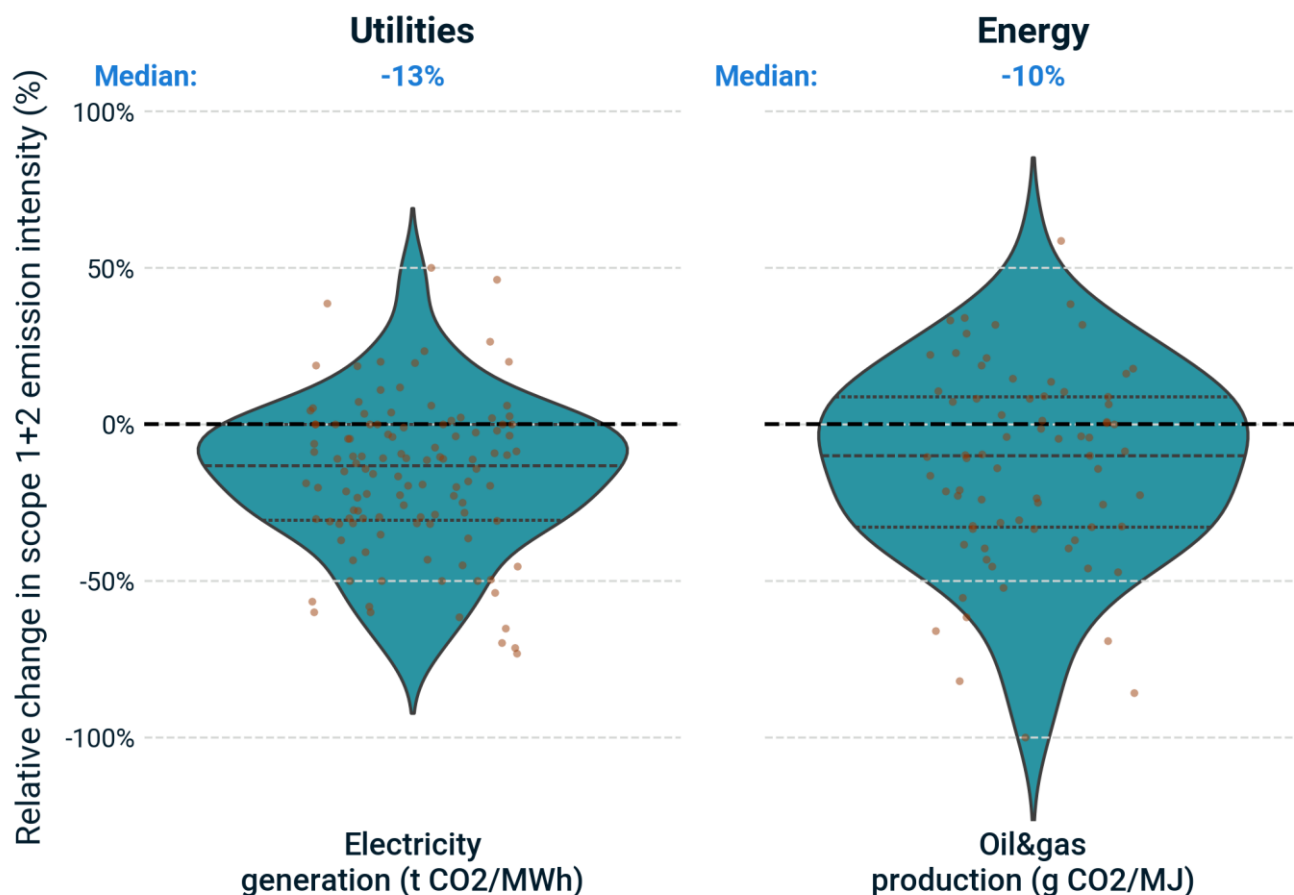
Distribution changes in companies' absolute Scope 1 and 2 emissions between 2018 and 2023, by region

Data as of June 2025. Includes only issuers with consecutive reported emissions data through 2023. Distribution excludes 235 outliers beyond 3 standard deviations of the mean. Sectors are ordered by median relative change. Scope 1 and 2 emissions only. Source: MSCI ESG Research

In addition to absolute emissions, we tested predictiveness using production-based intensity metrics where available. The next chart presents changes in emissions intensity for power generators (tons of CO_2 per MWh) and oil and gas producers (grams of CO_2 per MJ).

Distribution of changes in companies' production-based emissions intensities between 2019 and 2023

Data as of June 2025. Distribution excludes 10 outliers beyond 3 standard deviations of the mean. Source: MSCI ESG Research

Results for the most intensive sectors

The analysis in the table on page 15 was repeated for the four most emissions-intensive sectors: energy, materials, industrials and utilities. While the smaller sample size makes achieving statistical significance more difficult, the average significance did not decline markedly. In fact, results in the U.S. and EM subregions were slightly stronger on average, while results in the World ex USA subregion were slightly weaker.

Summary table of testing statistical relevance of indicators to predict 3-, 4- or 5-year Scope 1 and 2 emissions change between 2018 and 2023 in the energy, materials, industrials and utilities sectors

Region	MSCI ACWI IMI			MSCI EM IMI			MSCI USA IMI			MSCI World ex USA IMI		
analysis period (years)	3	4	5	3	4	5	3	4	5	3	4	5
Low carbon transition score	-3.06	-3.19	-2.70	0.01	-1.77	-0.30	0.73	-0.68	-1.91	-1.79	-0.94	-0.35
Low carbon transition management score	-6.25	-4.72		-2.84	-1.96		-0.39	0.19		-4.16	-1.61	
Environmental opportunities themes score	-2.80	-2.88	-2.62	0.39	-0.99	-0.32	0.23	-0.54	0.21	-1.99	-1.49	-1.97
Green house gas mitigation score	-0.80	-2.34	-2.64	0.01	-1.51	-1.47	-1.92	-1.85	-2.28	-0.89	-1.27	-0.39
Weighted average climate risk management score	-4.22	-4.22	-3.33	-1.81	-1.69	-1.45	0.32	0.01	1.12	-3.20	-3.19	-2.81
log(internal carbon price)†	-0.96	-2.23	-0.92	0.30	-0.12	-0.46	1.36	0.54	0.80	0.47	-0.88	0.14
Has carbon price†	-2.38	-1.69	-2.34	-0.53	-1.19	-1.72	-2.23	-3.11	-2.10	-2.54	-1.79	-1.64
Committed to SBTi target†	-2.74	-3.68	-1.77	-1.33	-0.51	0.04	-0.81	0.57	0.48	-1.13	-2.16	-1.44
Has SBTi target†	-7.98	-7.52	-6.43	-3.08	-1.52	-2.15	-1.99	-1.23	-1.06	-3.31	-4.39	-3.26
Has reduction plans†	-9.64	-9.16	-7.43	-5.34	-4.65	-2.77	-1.71	-2.53	-0.97	-5.85	-4.42	-3.57
Target progress†	-6.62	-5.35	-3.56	-2.33	-2.78	-1.72	-1.55	-1.20	0.21	-4.75	-5.02	-3.29
Has issued green bonds	-4.21	-3.36	-2.21	-0.34	-0.17	0.53	1.81	1.28	0.82	-3.90	-3.42	-2.17
log(green patents)	-1.05	-2.90	-3.64	1.52	-1.68	-0.29	-2.06	-2.54	-1.07	-1.27	-1.10	-0.54
log(green revenues)	-1.72	-2.53	-1.67	0.59	1.07	0.03	0.10	-0.46	-1.68	-2.42	-2.91	-2.59
Green minus fossil revenues	-1.90	-3.16	-2.07	1.43	1.20	-0.16	0.06	-0.22	-0.12	-2.40	-3.46	-2.46
Target-to-realized emission ratio	-0.50	-0.74	-0.51	-1.06	-0.09	-1.38	0.99	-0.35		-0.23	-0.77	0.04
Is-Paris-aligned†	-7.63	-8.21	-7.91	-3.39	-2.86	-2.31	-2.81	-2.68	-2.68	-3.98	-4.81	-4.45

Data as of June 2025 for the period 2018 to 2023. A two-sided t-test with unequal variances was calculated to see if the mean of emission change in the top tertile is different from the mean in the bottom tertile. Negative values indicate faster reduction in the top tertile. Tertiles are constructed by sector, except for the greenhouse gas mitigation score where only global tertiles could be created due to the distribution of the score. For non-numerical variables like SBTi- and Paris-aligned indicators, the bottom bucket contains issuers with no target or that are not aligned; the top bucket contains issuers with an SBTi approved target or are flagged as committed, aligned and aligning. Azure shading indicates results in the expected direction, raspberry shading indicates result in the unexpected direction. Dagger (†) indicates variables for which correlation and not forward-looking test was applied. Source: MSCI ESG Research

Data treatment and methodology

The dataset used in this study combines a wide range of datapoints with different histories, frequencies and coverage. In this Appendix, we describe the main assumptions and preprocessing steps applied to transform this heterogeneous dataset into a usable form.

Our global stock universe consists of the 8,183 issuers included in the MSCI ACWI IMI as of June 25, 2025. Scope 1 and 2 emissions data was collected from 2013 through 2024. Because 2024 coverage remains partial (411 issuers), this year was excluded from the analysis. Similarly, production-based emissions-intensity data was available from 2018 through 2023.

For Scope 1 and 2 analysis, we further filtered the dataset by removing estimated emissions values. Where issuers had both reported and estimated emissions data, we retained only the longest string of consecutive reported emissions.

Indicators related to GICS categories were also downloaded on June 25, 2025, and backfilled across the historical dataset. Similarly, region indicators are based on the three regional MSCI indexes as of June 25, 2025: MSCI Emerging Markets IMI, MSCI USA IMI, MSCI World ex USA IMI (i.e. developed markets excluding the U.S.) indexes and were backpropagated through the full history.

Preprocessing, outlier control

In cases where renewable capex share data was not timestamped by year but instead reported with a start and end year, we assumed a constant share between those two years.

Target-to-realized emission ratio: We constructed this ratio using company-declared absolute company-wide Scope 1 and 2 emissions-reduction targets that specified a base year, target year and reduction percentage. From this data, we calculated a hypothetical linear-reduction path, assuming equal annual reductions in CO_2 from the base-year level. The hypothetical emissions path was then divided by the company's realized Scope 1 and 2 emissions to calculate this ratio.

Where multiple targets or sources were available, we calculated all feasible hypothetical pathways and used the average ratio (other aggregation methods were also tested). Finally, a rolling three-year average of the ratio was calculated for each issuer.

Year-end data was used for most variables. Green or fossil-revenue-share data, which are based on reported past revenues and activities, were applied to the previous calendar year. Datapoints from the MSCI ESG Ratings model (key issue scores, key issue management scores and key issue weights) are also derived from past data but are intended to capture risks that may materialize in the future. Thus, they were considered forward looking and applied to the following calendar year.

Patent scores were log-transformed to correct for skewness, while zero values for revenue share, renewable-capex share and patent scores, were redefined as missing.

Our approach to outlier control consisted of two steps. First, we calculated the trimmed mean of the data after removing the lowest and highest 2.5% of datapoints, then a robust standard deviation was calculated by dividing the interquartile range by 1.349. Datapoints lying outside a +/-3 standard deviation

range from the trimmed mean were discarded. This process was especially important for the emissions-change calculations as it helped reduce the impact of data errors and distortions from major corporate events, such as mergers, acquisitions or divestments.

Target indicator data starts in 2022, while data on Paris Agreement alignment is only available from 2025. For the purposes of our analysis, these datapoints were backfilled for five and seven years respectively.

In the multivariable regression, uneven data coverage made the treatment of missing data both a highly technical and interpretational issue. To address this, we applied the following steps:

- Each original transition-indicator variable with missing entries was accompanied by an indicator variable set to 1 if the value was missing and imputed, and 0 otherwise. This inclusion allows the model to adjust for any systematic effects or biases associated with missingness itself.

- We chose a simple approach to missing data imputation. For most variables, missing values were replaced with the average value observed within the company's sector and geographic region. For green-revenue share and green-patent score, we assumed that missing data was more likely to reflect negligible or zero green activity. Consequently, missing values for these variables were filled in with very low numbers close to zero.

Data sources in ESG Manager

The table below lists the underlying datapoints from ESG Manager used in our study.

Factor names in ESG Manager for the indicator variables

Category	Data	ESG Manager datapoints used
Targets & governance	Low Carbon Transition score	CBN_LCT_SCORE
	Low Carbon Transition mgmt score	CBN_LCT_MGMT_SCORE
	Environmental opportunities theme score	ENVIRONMENTAL_OPPS_THEME_SCORE
	Greenhouse gas mitigation score	CARBON_EMISSIONS_GHG_MITIGATION_SCORE
	Climate risk management weighted average score	Use MGMT_SCORE and WEIGHT of these key issues: CARBON_EMISSIONS, PROD_CARB_FTPRNT, INS_CLIMATE_CHG_RISK,BIODIV_LAND_USE,OPPS:GREEN_BUILDING, OPPS_RENEW_ENERGY, OPSS_CLN_TECH
	Internal carbon price	Use INT_CBN_PRC_AMT_TS,INT_CBN_PRC_AMT_TYPE_TS,INT_CBN_PRC_AMT_CUR_TS
	Committed to SBTI target	HAS_COMMITTED_TO_SBTI_TARGET
	SBTI target approved	HAS_SBTI_APPROVED_TARGET
	Has reduction plans	CARBON_EMISSIONS_REDUCT_INITIATIVES
	Target progress	TARGET_SUMMARY_CURRENT_PROGRESS
Green capex & patents	Green patents score	GREEN_PAT_VAL_HISTORIC_TS
	Issuance of green bonds	Not in ESGM
	Capex share on renewable power generation	RENEW_ENERGY_CAPEX_VS_TOTAL_CAPEX_PCT_TS
Green revenues	Green revenue share	CT_CC_TOTAL_MAX_REV
	Green minus fossil fuel revenue share	Subtract from ct_cc_total_max_rev the sum of: GENERAT_MAX_REV_THERMAL_COAL, GENERAT_MAX_REV_LIQUID_FUEL, GENERAT_MAX_REV_NATURAL_GAS, THERMAL_COAL_MAX_REV_PCT, OG_REV_REFINING, OG_REV_EXTRACTION_PROD
Emission trend	3 year average target to realized emission ratio	Based on CBN_TARGET_BASE_YEAR, CBN_TARGET_YEAR, TARGET_CARBON_COVERAGE_PCT, TARGET_CARBON_CHANGE_PCT, TARGET_CARBON_TYPE, TARGET_CARBON_SCOPE_123_CATEGORY
	Alignment with PAII	PAII_NZIF_ALIGNMENT

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