Back to the Future: The Role of Forward-looking Climate Metrics in Decarbonization Portfolios[1]

Jieyan Fang-Klingler[2]

Maximilian Stroh[3]

Frederik Wisser[4]

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Abstract

We find that forward-looking climate metrics, such as a firm's carbon emission target, contain information about future carbon emission growth rates. Better forward-looking metrics are associated with lower future carbon emission growth rates relative to otherwise similar firms. This relation is stronger in the period after the Paris Agreement. However, firms with better forward-looking metrics are associated with inferior backward-looking metrics such as higher current carbon emissions. Thus, there is a tradeoff between forward- and backward-looking metrics when constructing decarbonization portfolios. Finally, we find evidence that mutual funds are more focused on backward-looking metrics even though this could hinder them from investing in many companies that contribute to decarbonizing the global economy.

JEL classification: G11, G18, Q54

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[2] Quoniam Asset Management GmbH, D-60327 Frankfurt, jieyan.fang-klinger@quoniam.com.

[3] Quoniam Asset Management GmbH, D-60327 Frankfurt, maximilian.stroh@quoniam.com.

[4] Quoniam Asset Management GmbH, D-60327 Frankfurt, frederik.wisser@quoniam.com

1. Introduction

Climate change and its negative consequences on the ecosystem as well as companies, governments, and households has become a major concern in the last decade. To tackle the problem of climate change collectively, several international initiatives have been launched. One of the most prominent initiatives is the Paris Agreement, adopted in 2015, which has about 190 members of the United Nations Framework Convention on Climate Changes. The goal of the Paris Agreement is to limit the temperature rise to well below 2°C above pre-industrial levels, preferably 1.5°C. This is an ambitious goal since it requires net-zero carbon emissions by the middle of the 21st century and a reduction of greenhouse gas emissions by 50% until 2030. According to the Paris Agreement, countries must set ambitious emission reduction goals and re-evaluate these goals regularly. An abundance of policies and regulations have been defined to reduce greenhouse gas emissions, with the introduction of carbon prices or taxes being very prominent examples.

Climate conscious investors who want to steer their portfolios towards reaching a climate goal must keep up with the ever-changing regulations and trends when identifying climate-friendly companies. While climate conscious investors surely keep a close eye on these developments, climate indifferent investors are also not completely sheltered from these effects—they need to be aware of the adverse side effects of future climate regulation on their (potentially brown) investment portfolio and avoid companies prone to financial risks induced by future climate regulation. Both investor types require a set of metrics to identify climate-friendly, or unfriendly companies. In the absence of a unified framework for judging climate friendliness investors enjoy freedom in choosing their own metrics. Through the lens of such an investor, we investigate the following questions: on which metric should "climate-friendly" firms be identified?

In this study, we shed light on, and discuss the consequences of, two different kinds of information to assess a company's climate friendliness: forward- and backward-looking information. Backward-looking (or ex-post) measures are based on past or current activities; for example, past/current carbon emissions. Forward-looking (or ex-ante) measures provide more information about the potential future development of a firm's carbon emissions trajectory; for example, if a firm sets a carbon reduction target. Should investors reward companies that currently have low emissions (or operate within low emission sectors), companies that may achieve the greatest reduction in the future, or a combination of the two?

This is an important question, since, in our study, firms with high current carbon emissions (poor backward-looking measures) score well on forward-looking measures, thus, raising the same question as the research by Cohen, Gurun, and Nguyen (2021): are exclusions of firms with high current carbon emission an optimal strategy? Based on our findings, climate investors may consider including forward-looking measures in their climate investing strategies because they can help investors identify firms with strong future carbon reduction. Our result is consistent with Carrion-Flores and Innes (2010) and Gao and Li (2021), who find that forward-looking measures in innovation help to reduce toxic emissions.

In summary, we provide two contributions to the existing literature. First, we investigate the relation between forward-looking measures and future carbon emission changes. We use the environment-related patents/total assets, the existence of climate targets, and carbon emission risk management scores as forward-looking measures. We find that firms with better forward-looking measures, ceteris paribus, tend to achieve lower carbon emission increases or a stronger reduction in carbon emissions than their peers. This difference is statistically and economically significant. For example, in the period between 2007 to2021, a firm with active carbon reduction targets compared to a median firm without active targets, is associated with -0.86%/-1.61%/-0.92%/-1.65% lower future growth rate in carbon intensity scope 1, carbon intensity scope 2, absolute carbon emission scope 1 and absolute carbon emission scope 2, respectively. Furthermore, we find evidence that the negative relation between forward-looking measures and the future growth rate in carbon emissions is stronger after the Paris Agreement than before. From 2019 to 2021, a firm with active carbon reduction targets compared to a median firm without targets, is associated with -1.96%/-2.55%/-1.56%/-2.25% lower future growth rate in carbon intensity scope1/scop2/absolute carbon emission scope 1/scope 2. In the analysis with different markets, we find that the association between forward-looking measures and future emission growth rate is stronger in developed markets than in emerging markets.

Second, we investigate whether mutual funds already consider forward- and backward-looking climate measures. We show that, in the past, investors relied more on backward-looking measures when forming portfolios: investing in firms with low current carbon emissions and excluding firms with high current carbon emissions. Firms with better backward-looking measures (low current emissions) exhibit higher mutual fund ownership than comparable firms with inferior backward-looking measures (high emissions). These results are statistically and economically significant; for example, a firm with one-standard deviation higher carbon

emission of scope 1 compared to an average firm in the sample, is associated with -1.49% lower mutual fund ownership. However, we do not find any significant positive impact of forward-looking climate measures on mutual fund ownership. It thus appears that mutual fund managers are currently focused on past and current carbon emission measures. This result is consistent with the previous ESG or climate literature, which tends to focus on decarbonization by using backward-looking measures like current carbon emission and carbon intensity (Andersson, Bolton, and Samama 2016; Cheema-Fox et al. 2021a).

Our paper contributes to the existing literature in the following ways: Firstly, our study investigates the relationship between forward-looking climate metrics and future emission changes in different periods and different markets, since the climate concern and regulations vary in different periods and markets. This analysis provides more insight into companies' behaviors. Secondly, we do not only examine green patents like the existing literature. We focus on three different forward-looking climate metrics, especially, climate targets of companies, which gain more attention from investors over time. Furthermore, we document for the first time the relationship between forward-looking climate metrics and mutual fund ownerships.

The paper is organized as follows. Section 2 provides a literature review. Section 3 describes the data we use to run our analyses. In Section 4, we examine the relation between forward-looking climate measures and future carbon emission changes. Our goal is to investigate the relation rather than to establish causality. Section 5 reports the determinants of mutual fund ownership in forward- and backward-looking climate measures. Section 6 concludes. Robustness checks are reported in the Appendix.

2. Related literature

Our study relates to the literature on forward-looking ESG measures. Most of these studies focus on patents. A recent study by Cohen et al. (2021) raises the question whether ESG strategies focusing on excluding firms with low ESG ratings are optimal. Cohen et al. (2021) analyze U.S. firms and their patents from 2008 through 2017. They find that a large percentage of the recent green patents is produced by firms with low ESG scores, especially by firms from the energy sector. Furthermore, the quality of patents from energy firms is higher than that of other firms. However, energy firms with many green patents do not exhibit an adequate improvement in their ESG rating in exchange for the green patents they produce. Cohen et al. (2021) use the number of green patents as a quantity measure and the number of citations per green patent as a quality measure.

Andriosopoulos, Czarnowski and Marshall (2021) also investigate green innovation. They find that investors seem to be indifferent with respect to green innovation, despite the general opinion that green innovation is the key factor for climate change mitigation. Carrion-Flores and Innes (2010) focus on the impact of innovation on toxic emission reduction. They investigate 127 manufacturing industries from 1989 to 2004. They find that environmental innovation is an important driver of reductions in U.S. toxic emission. Gao and Li (2021) find that green innovations can reduce a firm's toxic release in a nine-year window after patent filing dates.

Lee and Min (2015) investigate Japanese manufacturing firms and find that research and development (R&D) expenditures on green technologies lead to lower carbon emissions. Kalesnik, Wilkens, and Zink (2020) investigate the impact of forward-looking carbon scores from 2010 to 2016. They do not find a relationship between these scores and future changes in emissions. Sautner et al. (2022) use a natural language processing (NLP) method on earnings conference calls to measure a firm's individual exposures to climate related opportunities and physical and regulatory shocks. They find a positive relationship between climate regulatory exposure and opportunity exposure. Furthermore, firms with high regulatory exposure tend to hire more green tech workers over the next year. These findings are consistent with Cohen et al. (2021).

Another strand of the literature examines climate or ESG investment strategies. Most of the literature focuses on backward-looking measures (e.g., (current) carbon intensity or carbon emission and aggregate ESG ratings). Forward-looking measures are seldom considered. Cheema-Fox et al. (2021a, 2021b) investigate different rule-based strategies that buy low carbon intensity sectors, industries, or firms and short high carbon intensity firms. Their strategies are based on (current) carbon intensity and overall ESG ratings. They find that by using these climate metrics, investors can manage climate risk and simultaneously achieve superior returns.

Andersson, Bolton, and Samama (2016) present a passive optimized strategy based on carbon intensity as a hedge against climate risk. This strategy sacrifices no financial performance. Alessandrini and Jondeau (2020, 2021) examine different strategies based on aggregate ESG scores; for example, negative exclusion, best-in-class, and optimized approaches. These strategies can improve the ESG scores of investment portfolios and without deterioration of the risk-adjusted performance. Bender et al. (2018) provides an overview of the ESG data landscape and several popular methods for integrating ESG based on aggregate ESG scores and

carbon emission scores. They find that a positive performance impact from integrating carbon data and a slightly negative performance impact from integrating Sustainalytics ESG. Andersson et al. (2016) analyze the performance of different pure-play indices focusing on renewable energy, clean technology, and/or environmental services. These climate strategies do not concentrate on removing or underweighting firms with high carbon emissions. They find underperformance of pure-play indices compared with market indices. The reason of the underperformance could be the expectation changes due to financial crisis which scaled back the climate mitigation policies in different countries.

3. Data

We use companies within the Morgan Stanley Capital International (MSCI) worldwide universe. The data covers the time period from January 2007 to December 2021. We obtain stock prices and firm fundamentals for this universe such as stock return, debt/asset ratio, return on asset, and market capitalization from DataStream, Thomsen Reuters Worldscope, and the Thomsen Reuters MarketQA database. Mutual fund holdings are downloaded from Morningstar. The climate related ESG data comes from Trucost, MSCI, and Intellectual Property Rights (IPR) Strategies.

Trucost provides backward-looking scope 1, scope 2, and scope 3 greenhouse gas emissions in tons as well as their intensities (emission in tons/sales in million USD). Scope 1 emissions are generated directly by a company's operations. Scope 2 emissions are emissions related to a company's consumption of purchased electricity, steam, or heat. Scope 3 emissions contain other upstream and downstream emissions associated with a company's operations that are not directly owned by the company. While scope 1 and scope 2 emissions are usually reported by companies, scope 3 emissions are estimated by data vendors. Aswani, Raghunandan, and Rajgopal (2022) show that some results in the prior climate research are driven by vendor-estimated emissions, since estimated emissions are strongly correlated with firm size, sales growth, industry membership and time. This concern is especially relevant for scope 3 emissions. Therefore, we focus on emission scope 1 and scope 2 in the following analyses. Due to the nature of emissions data these are backward-looking and measure past and current emission of a company.

We use three forward-looking measures. MSCI ESG Rating assesses 35 ESG Key Issues connected to the main business of a company. We use the Management Score of the Key Issue "Carbon Emission" as our first forward-looking measure. This metric provides an assessment of a company's efforts to reduce their carbon exposure and the mechanism of implementation

of such efforts. Carbon emission management scores vary between 0 and 10. The higher the carbon emission management score, the better the assessment of the firm's management of its carbon risk. Carbon Emission Management Scores start in January 2013. There are some concerns regarding the aggregate assessment or ratings provided by data vendors (Delmas and Blass 2010; Semenova and Hassel 2015; Dorfleitner, Halbritter, and Nguyen 2015; Chatterji et al. 2016; Berg, Kölbel, and Rigobon 2022; Berg, Fabisik and Sautner 2021). These authors discuss the divergence of aggregate ratings based on different data vendors, stemming from differences in scope, weighting, measurement, opaqueness of methodologies, problems with backfilling of data. Therefore, we also analyze two forward-looking measures that are not aggregate assessments from rating agencies.

The second forward-looking measure is based on climate targets. Carbon reduction targets data are provided by MSCI. Using this data set (MSCI Climate Change Targets and Commitments), we construct a dummy variable *Climate target* that takes the value of 1 when a firm has at least one carbon reduction target, and 0 otherwise. An example of a carbon reduction target is "…commits to reduce absolute scope 1 and 2 GHG emission by 50% by 2025 from base year 2018.". Climate target data starts in 2007.

The third forward-looking measure is based on environment-related patents and provided by IPR Strategies. IPR Strategies analyzes the patent portfolio of a company and estimates the market value of environment-related patents. We use the market value of environment-related patents/total assets to measure the strength of a firm's environment-related patents. Our patent measure is different from the patent measures used in previous studies (Cohen et al. 2021; Carrion-Flores and Innes 2010; Gao and Li 2021) as it contains estimates of the market value of patents instead of number and citation of patents. Patent data starts in 2010.

The exact definitions of backward- and forward-looking climate measures and control variables used in our analyses can be found in Appendix A. Our dataset contains 8745 companies worldwide.

Insert Table 1 here

Table 1 reports descriptive statistics of variables used in the regression analyses. To eliminate the impact of outliers, all variables (except for climate target and carbon emission management score) are winsorized at the 1% and 99% tails. The average growth rate of carbon intensity scope 1/2 and carbon emission scope 1/2 equals 7.6%/68.4%/27.2%/154.0% respectively. The means are much larger than the median. Therefore, in our subsequent analyses we use the

natural logarithm to normalize these measures. We also normalize carbon intensity, carbon emission measures, which are strongly positively skewed. The carbon emission management score has an average of 3.7 and median of 3.3; although, the range of the score is from 0 to 10. The climate target is a dummy variable; therefore, the mean indicates the average percentage of the observations with carbon reduction targets. In our sample, about 14% of the observations set carbon reduction targets. The number of firms which have active climate targets is equal to 1057. They make up around 12% of the companies in our universe. The environment-related patents/total assets exhibits an average of 4.9% and median of 1.05%.

Table 2 reports time-averages of cross-sectional spearman correlations among different backward- and forward-looking climate measures. To simplify the interpretation, we multiply all backward-looking measures (carbon emission and carbon intensity) by -1 in this correlation analysis. By doing this, we get the same interpretation of the backward- and forward-looking measures. The higher the value, the greener the firms.

Insert Table 2 here

Backward-looking climate measures are generally negatively correlated with forward-looking measures. The magnitude is larger for absolute carbon emissions than carbon intensity measures. Specifically, the carbon emission management score is significantly negatively correlated with all backward-looking measures. The negative correlation between carbon intensity measures and carbon emission management scores varies between -0.0385 and -0.0945. The negative correlation between carbon emission measures and carbon emission management scores varies between -0.3673 and -0.445. The climate target dummy is significantly negatively correlated with carbon emission measures. The correlation varies between -0.2743 and -0.3542. A similar pattern can be observed for environment-related patents. The negative correlation means firms with worse backward-looking measures (higher carbon emission) tend to have better forward-looking exposure (higher environment-related patents/total assets, better management of their carbon risk, and firms with climate targets). The negative relation between backward- and forward-looking measures is especially strong and consistent for absolute carbon emission measures. The reason could be that firms that have very large absolute emissions are the ones that are under lots of pressure to innovate or to manage the corresponding risks better. This finding is consistent with evidence shown in the literature. Cohen et al. (2021) find that oil, gas, and energy firms produce more and significantly higher quality, green innovation than other firms. Sautner et al. (2022) find that utility firms with high regulatory risks also show high opportunity measures based on earnings conference calls.

Furthermore, different backward-looking measures based on carbon intensity and carbon emissions are significantly positively correlated. The correlation ranges between 0.3097 and 0.7758. The correlation among three forward-looking measures (environment-related patent, carbon emission management and climate target) is also positive and ranges between 0.0980 and 0.5116.

Table 3 provides statistics at the sector level.

Insert Table 3 here

The brownest sectors, as determined by backward-looking measures, are energy firms, industrials, materials, consumer staples, and utilities. Concurrently, these sectors also show favorable forward-looking measures; for example, information technology, materials, industrials, health care and energy exhibit the highest scores of environment-related patents/total assets. Utilities, consumer staples, materials, and industrials are the top 4 sectors when judged by the average carbon emission management score. The top 4 sectors with the highest percentage of firms with carbon reduction targets are utilities, consumer staples, real estate, and materials. This finding is consistent with the results reported in Table 2—that backward- and forward-looking climate measures are in most cases negatively correlated.

4. Relationship between forward-looking measures and future carbon emission changes

Cohen et al. (2021) find that energy firms, which are often excluded by ESG funds or other institutional investors, are the main climate innovators in the U.S. They produce a higher quantity and quality of green patents while also being responsible for most greenhouse gas emissions. These findings raise an important question—whether the exclusions of low ESG firms or firms with high carbon emission is the optimal strategy. To answer this question, we need to know, whether forward-looking measures, such as green patents, are associated with future carbon emissions. If more green patents, better carbon emission management, and climate targets of a firm are related to lower future carbon emission growth rates, forward-looking measures would be informative to an investor aiming at decarbonization.

Our empirical model for the analysis is as follows:

$$LnCarbonGrowthRate_{it} = \alpha + \beta_1 * Forward\text{-}looking\ measure_{it-1} + \gamma * X_{it-1} + \delta_c + \delta_j + \delta_t + \varepsilon_{it} \quad (1)$$

The dependent variables are different specifications of future carbon growth rates. We use the natural logarithm of 1 + growth rate of carbon intensity of scope 1/2 of firm i in year t compared

to t-1 and the natural logarithm of 1+ growth rate of absolute carbon emission of scope 1/2 of the firm i in year t compared to t-1.

We include forward-looking measures of firm i in year t-1 as independent variables to analyze the relationship between the forward-looking measures and the future emission growth rate in the next year. $CarbonEmissionManagement_{it-1}$, $Environment\text{-}related\ Patents/Total\ Assets_{it-1}$, and $Climate\ Target_{it-1}$ are the forward-looking measures that we include individually in the regressions. If good carbon emission risk management, high environment-related patents, and carbon reduction targets are associated with lower future carbon growth rates, we expect negative coefficients for $CarbonEmissionManagement_{it-1}$, $Environment\text{-}related\ Patents/Total\ Assets_{it-1}$, and $Climate\ Target_{it-1}$. X_{it-1} consists of a set of firm-level control variables which are lagged by one year. They are the one-year sales growth rate, the sales, the R&D expenses to total assets, the return on assets, the debt to assets ratio, the volatility of the corresponding stock return, the stock return, the stock's beta, the book-to-price ratio, and mutual fund ownership. Definitions of variables used in our analyses can be found in Appendix A. Similar as Sautner et al. (2022) and Cohen et al. (2021), we are interested in the cross-sectional within-industry variation between firms, therefore, we include country (δ_c), industry (δ_j), and year (δ_t) fixed effects. We use 6-digit GICS codes for industry classification. Standard errors are clustered by companies and years. Table 4 presents the results of the regression analysis.

Insert Table 4 here

In the first step, we explore the relationship for the whole research period. Panel A of Table 4 reports the results of the relation between climate target and future growth rate of absolute carbon emission and carbon intensity. In Panel B/Panel C, we explore the relation between environment-related patents/carbon emission management score and future growth rate of carbon emission, respectively

First, we find a negative relationship between the existence of climate targets and future growth rates in carbon intensity scope 1/scope 2, and absolute carbon emission scope 1/scope2 (Panel A of Table 4). This relationship is statistically and economically significant. A firm with active carbon reduction targets compared to a median firm without active targets, is associated with a -0.86%/-1.61%/-0.92%/-1.65% lower future growth rate in carbon intensity scope 1, carbon intensity scope 2, absolute carbon emission scope 1 and absolute carbon emission scope 2, respectively.

The second forward-looking measure, environment-related patents/total assets, exhibits negative coefficients in regressions with carbon intensity scope 1 and carbon emission scope 1 for the whole research period (Panel B of Table 4). However, none of the coefficients are statistically significant.

In Panel C, we find a significant negative relationship between carbon emission management score and future growth rate of carbon intensity scope 1. A firm with a one-standard-deviation higher carbon emission management score than a median firm, ceteris paribus, is associated with -0.64% lower future growth rate in carbon intensity scope 1.

Overall, for the whole research period, climate targets tend to exhibit a statistically and economically significant relation with future emission growth rate, but it depends on the variable how strong the effects are. The association between future emission growth rate and environment-related patents or the carbon emission management score is, in most cases, not statistically significant.

Relationship between forward-looking measures and future carbon emission changes in different time periods

Since climate change has become a recent focus of interest, especially due to the Paris Agreement in 2015, we expect that after the adoption of the Paris Agreement firms are under higher pressure to reduce their carbon emissions. Therefore, we may observe a stronger impact of forward-looking measures on future carbon emission changes.

We test this hypothesis in the next step, where we explore the relationship between forward-looking measures and future carbon emission growth rates for different time periods. We consider the period before and after the Paris Agreement separately. We also split the period after the Paris Agreement into two equal sub-periods of equal length to investigate the relationship in different regimes. More specially, we consider three time periods: 2007-2015 (before the Paris Agreement), 2016-2018 (three years after the Paris Agreement), 2019-2021 (fourth to sixth year after the Paris Agreement).

We run the Equation (1) with data from different periods. Table 5 presents the estimates.

Insert Table 5 here

Panel A of Table 5 reports the relation between climate targets and future emission growth rates in different time periods. The relation between climate targets and future growth rates in carbon intensity scope 1 depends on the time period. Before the Paris Agreement, the coefficient of the

climate target dummy is positive and not significant (coef = 0.0008). In the first three years after the Paris Agreement (2016-2018) the coefficient becomes negative while the t-statistics becomes stronger but is still not significant (coef = -0.0116, t-stat = -1.3946). In the next three years (2019-2021), we observe a significantly negative relation between climate targets and future growth rates in carbon intensity scope 1 (coef = -0.0197, t-stat = -2.9617). In the period 2019 to 2021, a firm with an active carbon reduction target compared to a median firm, is associated with a -1.93% lower future growth rate in carbon intensity scope 1. The same pattern can be observed in regressions with future growth rate in absolute carbon emission scope 1 and scope 2. The relation between climate targets and future growth rates becomes more negative and significant over time. From 2019 to 2021, a firm with an active carbon reduction target compared to a median firm without a target, is associated with -1.56%/-2.25% lower future growth rate in absolute carbon emission scope 1/scope 2.

Panel B of Table 5 presents the association between environment-related patents and future emission growth rates in different time periods. In the analysis of the whole research period, we do not find a significant relation. This result is driven by the period before the Paris Agreement. The coefficients of regressions with growth rate of carbon intensity scope 1 and absolute carbon emission scope 1 are significantly negative for the period 2019-2021. The impact is also economically significant. A firm with a one-standard-deviation higher environment-related patents than a median benchmark firm, shows -0.30%/-0.44% lower future growth rate in the carbon intensity scope 1/absolute carbon emission scope 1, respectively. We do not find a significant relation between environment-related patents and the growth rate of emissions of scope 2.

In Panel C of Table 5 we examine the third forward-looking measure, carbon emission management scores, in different periods. We find that the relation between carbon emission management scores and future growth rates in carbon intensity scope 1 and absolute carbon emission scope 1 becomes more negative and economically significant over time, especially for the period after the Paris Agreement. From 2016 to 2018, a firm with a one-standard-deviation higher carbon emission management score than a median benchmark firm, shows -0.51%/-0.30% lower future growth rate in the carbon intensity scope 1/absolute carbon emission scope 1, respectively. In the period from 2019 to 2021, the effect doubles. One-standard-deviation increase in carbon emission management score is associated with a -0.93%/-0.70% lower value for future changes in carbon intensity scope 1/absolute carbon emission scope 1, respectively. However, the coefficients are not statistically significant.

Overall, in the sub-period before the Paris Agreement, we do not find evidence that forward-looking measures are associated with future emission growth, which is consistent with Kalesnik et al. (2020). They examine forward-looking carbon scores provided by several ESG data vendors between 2010 and 2016. They do not find a significant relationship between these forward-looking carbon scores and future changes in emissions. In the sub-period after the Paris Agreement, especially between 2019 and 2021, we find that climate targets and environment-related patents/total assets are negatively associated with future changes in emissions.

Relationship between forward-looking measures and future carbon emission changes in different markets

We next examine the relation between forward-looking measures and future emission changes in different markets. We split firms into emerging markets and developed markets and run Equation (1). Since we found a significant relation for the period from 2019 and 2021 in the previous analyses, in this section we focus on this period. Table 6 presents the results.

Insert Table 6 here

Panel A of Table 6 reports the relation between climate targets and future emission changes in developed markets and emerging markets separately. Both in emerging markets and developed markets, the climate targets are negatively associated with future emission changes of all carbon metrics. In developed markets, firms' climate targets show a significantly negative relation with future emission changes in carbon intensity scope 2 and absolute carbon emission scope 2, while in emerging markets, climate targets are significantly negatively related with future emission changes in carbon intensity scope 1 and absolute carbon emission scope 1.

Turning to the environment-related patents (Panel B of Table 6), we find evidence that in developed markets environment-related patents are negatively associated with future emission changes in carbon intensity scope 1 and absolute carbon emission scope 1. We do not find the same evidence for emerging markets.

The analysis of carbon emission management scores (Panel C of Table 6) reveals an interesting insight. In the previous analysis of carbon emission management scores, we did not find a significant relation between carbon emission management scores and future emission changes in the period from 2019 and 2021. After we split the data into emerging and developed markets, we do find a significantly negative relation between carbon emission management score and future emission changes in carbon intensity scope 1 and scope 2 for developed markets.

Overall, we find evidence that firms with stronger forward-looking measures (such as having a climate target or a higher environment-related patent/total assets) tend to have lower future carbon emission growth rates. The relation is stronger in the sub-period after the Paris Agreement than before. Consequently, certain forward-looking measures might help investors identify firms that can achieve higher carbon emission reductions in the future in a cross-sectional context. As a robustness check, we also include the lagged growth rate of the corresponding dependent variable. The results are reported in Appendix B. The economic and statistical significance of forward-looking metrics on future growth rates of carbon emissions does not change after the inclusion of the lagged growth rate.

In the previous analyses we include year, country, and industry fixed effects. This conforms to the goal of an asset manager who is interested in picking firms with lower future carbon emission changes than otherwise similar firms within certain industry. However, there could exist unobserved time-invariant firm specific variables, which are related to carbon emission changes. Therefore, in another robustness analysis we include firm fixed effects. If we focus on within-firm variation instead of cross-sectional within-industry variation by including firm fixed effects the relationship becomes weaker but is still significant for climate target dummy. Again, we observe an increase over time in the strength of the relation between climate targets and future growth rates of carbon intensity scope 1 and absolute carbon emission scope 1. Note that a potential problem with the firm fixed effects analysis is that the forward-looking metrics we use are relatively persistent. The observed within-firm variation could be noisy. Therefore, we do not over-interpret the results based on firm fixed effects. The results are reported in Appendix C.

5. Determinants of mutual fund ownership

Based on the Global Sustainable Investing Review 2020 by The Forum for Sustainable and Responsible Investment (U.S. SIF Foundation) USD 35.3 trillion are invested in sustainable strategies, which make up of 35.9% of total assets under management globally. Due to the rising relevance of sustainable investment strategies, we expect environmental measures to be increasingly incorporated into portfolio strategies. We are interested in the following question: do investors load their portfolios on backward- and/or forward-looking emission measures? If forward- and/or backward-looking environmental metrics are considered during the stock selection process, we should observe a relationship between firms' climate measures and the proportion of shares held by mutual funds.

Previous literature regarding ESG investing focuses on aggregate ESG scores or backward-looking measures like carbon intensity. They investigate ESG/decarbonization investing by using exclusion lists, best-in-class, or optimized strategies based on backward-looking measures (Cheema-Fox et al. 2021a, 2021b; Andersson et al. 2016; Alessandrini and Jondeau 2020a, 2020b). Therefore, we expect that firms with relatively high carbon emissions tend to have low mutual fund ownership.

To analyze the determinants of mutual fund ownership, we perform the following panel regression analysis:

$$\begin{aligned} Mutual\ Fund\ Ownership_{it} = \alpha + \beta_1 * LnCarbonMetric_{it} + \\ \beta_2 * \frac{Environment\text{-}relatedPatents}{Total\ Assets}_{it} + \\ \beta_3 * Carbon\ Emission\ Management_{it} + \\ \beta_4 * Climate\ Target_{it} + \\ \gamma * X_{it} + \delta_c + \delta_j + \delta_t + \varepsilon_{it} \end{aligned} \quad (2)$$

The dependent variable is the number of shares owned by equity mutual funds of firm i in year t expressed as a percentage of the total number of free-floating shares of firm i in year t. The primary interest lies in the independent variables which are backward-looking measures $LogCarbonIntensityScope_{it}$ and $LogCarbonScope_{it}$ and forward-looking measures $CarbonEmissionManagement_{it}$, $Environment\text{-}related\ Patents/Total\ Assets_{it}$, and $Climate\ Target_{it}$. As control variables, we use the one-year sales growth rate, total assets in USD, R&D expenses to total assets, return on assets, the debt to assets ratio, the volatility of the corresponding stock returns, stock returns, the stock's beta, the book-to-price ratio, inverse stock price, trading volume, and a dummy variable indicating whether the stock is a member of the MSCI World Index. Control variables used here are closely related to those used by Bolton and Kacperczyk (2021). Similar as Bolton and Kacperczyk (2021), we are interested in the cross-sectional variation between firms, Therefore, we include country (δ_c), industry (δ_j), and year (δ_t) fixed effects. Standard errors are clustered at the company and year level. Table 7 presents the results of the regression analysis for different carbon intensities (scope 1 and scope 2) and absolute carbon emissions (scope 1 and scope 2).

Insert Table 7 here

First, we look at backward-looking measures in Table 7. Overall, we observe a negative relationship between carbon intensity/carbon emission and mutual fund ownership. Firms with higher carbon intensities/carbon emissions can generally expect a lower fraction of mutual fund

ownership. Coefficients of all carbon intensity metrics and absolute carbon emissions metrics are significantly negative. This finding suggests that mutual funds prefer firms with lower carbon emissions. The results are also economically significant. A firm with a one-standard deviation higher carbon intensity scope 1/carbon intensity scope 2/carbon emission of scope 1/carbon emission of scope 2 compared to average firm in the sample, is associated with -0.82%/-0.63%/-1.49%/-1.49% lower mutual fund ownership, respectively. Overall, we find strong evidence for the negative impact of backward-looking measures on mutual fund ownership. This result is not consistent with the findings of Bolton and Kacperczyk (2021), who only find a significantly negative relation between carbon intensity scope 1 and mutual fund ownership. However, Bolton and Kacperczyk's sample period and universe are very different from ours. They investigate U.S. firms in the period 2005–2017. We analyze companies worldwide and a large percentage of our sample period is after the Paris Agreement, in which decarbonization gains more and more attention and mutual funds are under high pressure to integrate environmental aspects in their investment strategies.

Next, we turn to the impact of forward-looking measures. In Table 7, forward-looking climate measures—the dummy variable of having a climate target, the carbon emission management score, and environment-related patents/total assets do not show a significantly positive impact on mutual fund ownership. This result means that firms with superior forward-looking metrics do not exhibit significantly higher mutual fund ownership than firms with inferior forward-looking metrics. The coefficients of climate targets and carbon emission management scores are not significant, while the coefficients of environment-related patents are significantly negative. There is even a negative relation between mutual fund ownership and environment-related patents. A possible explanation is that mutual funds are not investors with long-time investment horizon like pension funds. Therefore, they may not prefer firms with high environment-related patents which need a long-time horizon to bear fruits (Andriosopoulos et al. 2021; von Schickfus 2021; Bansal, Kiku, and Ochoa 2016). A similar pattern (significantly negative coefficients) can be observed for R&D/total assets. However, to better understand this observation a more detailed analysis would be warranted.

Overall, we conclude that mutual funds prefer firms with better backward-looking measures (low carbon emissions) and do not give the same attention to forward looking measures when making investment decision.

6. Conclusion

As the effects of global warming are increasingly showing up in peoples' daily lives, the call for investors to act has become stronger. One of the most critical challenges is to massively reduce carbon emissions. Many investors want to act accordingly by investing in climate-friendly firms. Based on their findings for U.S. firms, Cohen et al. (2021) question whether excluding firms with high carbon emissions from portfolios is sensible since these firm tend to produce more and higher quality green patents. Our main findings show that forward-looking measures, e.g., climate targets and environment-related patents, are negatively associated with future carbon emission changes. Firms with active climate targets compared to a median firm without targets, are associated with lower future emission growth rates. However, firms with favorable forward-looking measures often exhibit inferior backward-looking measures (high carbon emissions). There is a tradeoff between forward- and backward-looking metrics. Investors who aim for global decarbonization may want to use forward-looking measures to complement backward-looking measures when making investment decisions. Currently, it appears that mutual funds invest by looking at backward-looking measures only; for example, current carbon emissions. Mutual fund ownership is significantly higher for firms with lower current carbon emissions.

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Table 1: Descriptive statistics of variables

This table reports descriptive statistics for variables that are used for different regression analyses. The sample period is from January 2007 to December 2021. Definitions of variables can be found in Appendix A. Except carbon emission management score, climate target and MSCIWORLD, all variables are winsorized at the 1% and 99% tails.

	Average	Standard deviation	Median
Growth rate in carbon intensity scope1	7.627%	432.383%	-1.063%
Growth rate in carbon intensity scope2	68.388%	8352.432%	-1.385%
Growth rate in carbon emission scope1	27.227%	928.103%	1.868%
Growth rate in carbon emission scope2	154.029%	22668.917%	2.977%
LnCarbonGrowthRate (intensity scope 1)	-0.0208	0.2765	-0.0107
LnCarbonGrowthRate (intensity scope 2)	0.0110	0.2706	-0.0139
LnCarbonGrowthRate (emission scope 1)	0.0327	0.3513	0.0185
LnCarbonGrowthRate (emission scope 2)	0.0643	0.3477	0.0293
LnCarbonIntensityScope1	3.4927	1.6549	3.1256
LnCarbonIntensityScope2	3.2912	1.0325	3.2067
LnCarbonScope1	10.4463	2.6983	10.3011
LnCarbonScope2	10.2675	2.2067	10.2982
Carbon emission management score	3.7045	1.9588	3.3000
Environment-related patent/total assets	0.0491	0.0988	0.0105
Climate target	0.1416	0.3486	0.0000
R&D/TotalAsset	0.0311	0.0548	0.0118
Return on asset	0.0392	0.0719	0.0410
Debt/asset	0.0881	0.2376	0.0997
Beta	0.9817	0.3795	0.9688
Stock return volatility	0.3540	0.1175	0.3358
B/P	0.6647	0.5404	0.5165
stock return	0.0105	0.0363	0.0092
sales growth rate	0.0565	0.1696	0.0497
LnSales	20.7877	1.6639	20.9308
LnAssets	21.2113	1.5539	21.2415
Mutual fund ownership	19.9609	20.7275	12.8660
LnStockPriceInv	-2.5582	1.4411	-2.5879
Volume	1295062	6444999	106513
MSCIWORLD	0.2256	0.4180	0.0000

Table 2: Correlation of variables

This table reports the time-average of cross-sectional Spearman correlations among all backward- and forward-looking climate variables.

	LnCarbonIntensityScope1*(-1)	LnCarbonIntensityScope2*(-1)	LnCarbonScope1*(-1)	LnCarbonScope2*(-1)	Carbon emission management score	Climate target	Environment-related patent/total assets
LnCarbonIntensityScope1*(-1)	1.0000						
LnCarbonIntensityScope2*(-1)	0.5482***	1.0000					
LnCarbonScope1*(-1)	0.6936***	0.3934***	1.0000				
LnCarbonScope2*(-1)	0.3097***	0.5681***	0.7758***	1.0000			
Carbon emission management score	-0.0385***	-0.0945***	-0.3673***	-0.4609***	1.0000		
Climate target	0.0263***	-0.0113**	-0.2743***	-0.3542***	0.5116***	1.0000	
Environment-related patent/total assets	0.0174	-0.1186***	-0.0045	-0.0853***	0.1834***	0.0980***	1.0000

*p < .1, **p < .05, ***p < .01.

Table 3: Statistics of backward- and forward-looking variables by sector

This table reports the mean of backward- and forward-looking variables by sector.

	Consumer discretionary	Consumer staples	Energy	Financials	Healthcare	Industrials	Materials	Real estate	Information technology	Communication services	Utilities
LnCarbonIntensityScope1	2.9616	3.7251	5.4133	2.2311	2.9500	3.3918	5.4941	3.2200	2.6616	1.6350	6.2725
LnCarbonIntensityScope2	3.2527	3.4591	3.4764	2.8292	2.8620	3.1022	4.5571	3.6621	3.0100	2.7414	2.2075
LnCarbonScope1	10.5398	11.5661	13.3629	8.6705	9.3866	10.9554	13.0328	10.0719	9.4438	9.1499	14.4118
LnCarbonScope2	10.8653	11.3067	11.3724	9.6631	9.3049	10.6652	12.0880	10.5496	9.8829	10.4781	9.9725
Carbon emission management score	3.7084	4.3882	3.7706	2.5540	3.3701	4.0053	4.3374	3.4036	3.4657	3.3461	4.6878
Percentage of companies with climate targets	0.1322	0.2439	0.1263	0.0983	0.1296	0.1432	0.1490	0.1491	0.1302	0.1420	0.2693
Environment-related patent/total assets	4.8318	1.0405	2.4246	0.9350	2.4969	6.0985	6.1403	0.9458	5.6006	0.6989	1.6075

Table 4: Relation between forward-looking measures and future carbon growth rate

We present the results of regression (Equation (1)) of future carbon emission changes on forward-looking emission measures and control variables. The dependent variable is the future carbon intensity changes and carbon emission changes of firm i in year t for different scopes. Independent variables are forward-looking measures, climate target (Panel A), environment-related patents/total assets (Panel B) and carbon emission management score (Panel C). Control variables are the one-year sales growth rate, the sales in USD, the R&D expenses to total assets, the return on assets, the debt to assets ratio, the volatility of the corresponding stock return, the stock return, the stock's beta, the book to price ratio, and mutual fund ownership of firm i in t-1. Definitions of variables used in our analyses can be found in Appendix A. Variables are winsorized at the 1% and 99% tails. All regressions include year, industry, and country fixed effects. Standard errors are clustered at firm and year level. T-statistics are reported in parentheses.

Panel A: Climate targets 2007–2021

Dependent variable	Ln of (1 + Growth rate in total emission intensity and total emission)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Climate target t-1	-0.0087*	-0.0165*	-0.0091**	-0.0162**
	(-1.7445)	(-1.9159)	(-2.5504)	(-2.3999)
Beta t-1	0.0152**	0.0081	0.0316***	0.0232***
	(2.4612)	(1.2410)	(4.3426)	(3.3441)
Debt/asset t-1	0.0101	0.0123	0.0026	0.0036
	(1.5245)	(1.1737)	(0.4427)	(0.3259)
R&D/TotalAsset t-1	-0.0425*	-0.0085	0.0304	0.0486
	(-1.7216)	(-0.4747)	(0.7796)	(1.2461)
Return on asset t-1	-0.0762***	-0.0131	-0.1595***	-0.0945**
	(-3.4435)	(-0.5556)	(-4.2660)	(-2.3176)
Stock return volatility t-1	-0.0397***	-0.0031	-0.1191***	-0.0770***
	(-2.5890)	(-0.1271)	(-6.2347)	(-3.2611)
B/P t-1	0.0023	0.0049**	-0.0066	-0.0053
	(1.4969)	(2.2143)	(-1.1771)	(-0.9678)
Sales Growth t-1	-0.0757***	-0.0652***	0.6940***	0.6921***
	(-6.1834)	(-7.2316)	(14.4680)	(14.7890)
LnSales t-1	-0.0053***	0.0011	-0.0111***	-0.0047*
	(-2.6158)	(0.5464)	(-5.0090)	(-1.7076)
Mutual fund ownership t-1	-0.0001	0.0000	0.0002	0.0004**
	(-0.7163)	(0.2732)	(1.5586)	(2.4128)
Stock return t-1	0.0192	-0.0367	0.1249	0.0812
	(0.5868)	(-1.4519)	(1.2765)	(0.8467)
Intercept	0.1560***	-0.0409	0.2844***	0.0913
	(3.0866)	(-0.8398)	(4.7432)	(1.4507)
No. observations	46091	46091	46091	46091
R^2	0.96%	1.46%	12.51%	12.77%
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

*p < .1, **p < .05, ***p < .01.

Panel B: Environment-related patents/total assets 2010–2021

Dependent variable	Ln of (1 + Growth rate in total emission intensity and total emission)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Environment-related patents/total assets t-1	-0.0115	0.0238	-0.0204	0.0122
	(-0.4364)	(1.0299)	(-0.6878)	(0.4854)
Beta t-1	0.0018	0.0047	0.0171**	0.0188**
	(0.2358)	(0.4935)	(2.1434)	(2.2875)
Debt/asset t-1	0.0026	0.0014	0.0042	0.0033
	(0.2040)	(0.1324)	(0.4544)	(0.2896)
R&D/TotalAsset t-1	-0.0054	-0.0667**	0.0969*	0.0386
	(-0.1202)	(-2.0911)	(1.7645)	(0.6251)
Return on asset t-1	-0.0878***	-0.0314	-0.1236***	-0.0508
	(-2.7528)	(-0.8942)	(-3.0278)	(-1.2465)
Stock return volatility t-1	-0.0092	0.0391	-0.0915***	-0.0321
	(-0.4017)	(1.1187)	(-3.4595)	(-1.0538)
B/P t-1	0.0050	0.0050	0.0024	0.0012
	(1.4394)	(1.4208)	(0.3920)	(0.2312)
Sales Growth t-1	-0.0974***	-0.0847***	0.6302***	0.6274***
	(-4.6738)	(-4.7659)	(15.4150)	(17.1690)
LnSales t-1	-0.0054**	-0.0002	-0.0102***	-0.0045
	(-2.1297)	(-0.0547)	(-3.2913)	(-1.2735)
Mutual fund ownership t-1	-0.0002*	0.0001	0.0000	0.0004***
	(-1.7429)	(0.7727)	(-0.0015)	(2.6236)
Stock return t-1	-0.0077	-0.1725**	0.2113*	0.0409
	(-0.1527)	(-2.4494)	(1.9372)	(0.2887)
Intercept	0.1534**	-0.0142	0.2681***	0.0802
	(2.2100)	(-0.1931)	(3.4715)	(1.0430)
No. Observations	21409	21409	21409	21409
R^2	1.38%	1.91%	9.37%	10.93%
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

*p < .1, **p < .05, ***p < .01.

Panel C: Carbon emission management score 2013–2021

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Carbon emission management score t-1	-0.0033*	-0.0008	-0.0024	0.0009
	(-1.7408)	(-0.3413)	(-1.6112)	-0.3975
Beta t-1	0.0121	0.0175*	0.0345***	0.0402***
	(1.5487)	(1.9174)	(3.1875)	(4.2344)
Debt/asset t-1	0.0036	0.0038	-0.0174***	-0.0158
	(0.3446)	(0.3018)	(-2.6015)	(-1.0661)
R&D/TotalAsset t-1	-0.0305	-0.0360	0.0309	0.0026
	(-0.8116)	(-0.9244)	(0.8223)	(0.0587)
Return on asset t-1	-0.1046***	-0.0303	-0.1950***	-0.1171**
	(-3.6887)	(-1.0690)	(-4.3442)	(-2.3663)
Stock return volatility t-1	-0.0316	0.0191	-0.1444***	-0.0815*
	(-1.1882)	(0.4653)	(-4.6138)	(-1.8058)
B/P t-1	0.0084**	0.0098**	0.0100**	0.0067
	(1.9998)	(2.1829)	(2.4092)	(1.0242)
Sales Growth t-1	-0.1046***	-0.0765***	0.7284***	0.7403***
	(-4.3507)	(-5.6870)	(14.2720)	(13.0400)
LnSales t-1	-0.0042***	-0.0041	-0.0115***	-0.0125***
	(-2.9187)	(-1.4637)	(-6.6169)	(-3.8799)
Mutual fund ownership t-1	-0.0001	0.0002**	0.0001	0.0003**
	(-0.5324)	(2.2940)	(0.4019)	(2.5871)
Stock return t-1	0.0491	-0.0724	0.0419	-0.0682
	(1.5310)	(-1.4886)	(0.3766)	(-0.5252)
Intercept	0.1120***	0.0455	0.2449***	0.1984**
	(3.2604)	(0.6305)	(6.4749)	(2.5289)
No. observations	20404	20404	20404	20404
R^2	1.58%	1.74%	12.81%	13.94%
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

*p < .1, **p < .05, ***p < .01.

Table 5: Relation between forward-looking measures and future carbon growth rate in different periods

We present the results of regression (Equation (1)) of future carbon emission changes on forward-looking emission measures and control variables for different periods. The dependent variable is the future carbon intensity changes and carbon emission changes of firm i in year t for different scopes. Independent variables are forward-looking measures, climate target (Panel A), environment-related patents/total assets (Panel B), and carbon emission management score (Panel C). Control variables are the one-year sales growth rate, the sales in USD, the R&D expenses to total assets, the return on assets, the debt to assets ratio, the volatility of the corresponding stock return, the stock return, the stock's beta, the book to price ratio, and mutual fund ownership of firm i in t-1. Definitions of variables used in our analyses can be found in Appendix A. Variables are winsorized at the 1% and 99% tails. All regressions include year, industry, and country fixed effects. Standard errors are clustered at firm and year level. T-statistics are reported in parentheses.

Panel A: Climate targets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2007-2015				
Climate target t-1	0.0008	-0.0143	0.0039	-0.0095
	(0.1499)	(-1.4671)	(0.7073)	(-0.9703)
No. observations	16054	16054	16054	16054
R^2	1.19%	2.47%	11.31%	10.43%
After Paris Agreement: 2016-2018				
Climate target t-1	-0.0116	-0.0086	-0.0145***	-0.0115
	(-1.3946)	(-0.4759)	(-5.2050)	(-1.0773)
No. observations	11780	11780	11780	11780
R^2	2.07%	1.77%	9.45%	9.40%
After Paris Agreement : 2019-2021				
Climate target t-1	-0.0197***	-0.0267	-0.0154***	-0.0226*
	(-2.9617)	(-1.6148)	(-4.2239)	(-1.6949)
No. observations	18257	18257	18257	18257
R^2	1.91%	1.23%	17.00%	19.64%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

Panel B: Environment-related patents/total assets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2010-2015				
Environment-related patent/total assets t-1	0.0102	0.0567	0.0448	0.0869*
	(0.1452)	(1.2641)	(0.5977)	(1.8600)
No. observations	6022	6022	6022	6022
R^2	1.78%	3.31%	8.56%	10.76%
After Paris Agreement: 2016-2018				
Environment-related patent/total assets t-1	0.0079	0.0055	-0.0217	-0.0295
	(0.1460)	(0.7943)	(-0.3326)	(-1.2350)
No. observations	5960	5960	5960	5960
R^2	3.78%	2.80%	9.52%	9.98%
After Paris Agreement : 2019-2021				
Environment-related patent/total assets t-1	-0.0312**	0.0236	-0.0437**	0.0106
	(-2.2895)	(0.7266)	(-2.2187)	(0.3088)
No. observations	9427	9427	9427	9427
R^2	2.23%	2.36%	12.31%	14.28%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

Panel C: Carbon emission management score

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2013-2015				
Carbon emission management score t-1	0.0002	0.0005	0.0011	0.0018
	(0.1258)	(0.0775)	(0.8733)	(0.2576)
No. observations	2782	2782	2782	2782
R^2	4.69%	4.51%	9.53%	11.22%
After Paris Agreement: 2016-2018				
Carbon emission management score t-1	-0.0026	-0.0023	-0.0015	-0.0006
	(-1.0878)	(-0.8222)	(-1.1099)	(-0.2481)
No. observations	5692	5692	5692	5692
R^2	3.71%	3.28%	11.32%	12.32%
After Paris Agreement : 2019-2021				
Carbon emission management score t-1	-0.0048	-0.0014	-0.0035	0.0011
	(-1.5509)	(-0.3688)	(-1.3154)	-0.3474
No. observations	11930	11930	11930	11930
R^2	1.69%	1.69%	15.63%	16.74%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

Table 6: Relation between forward-looking measures and future carbon growth rate in different markets in period 2019-2021

We present the results of regression (Equation (1)) of future carbon emission changes on forward-looking emission measures and control variables. The dependent variable is the future carbon intensity change and carbon emission change of firm i in year t for different scopes. Independent variables are the forward-looking measures, climate target (Panel A), environment-related patents/total assets (Panel B), and carbon emission management score (Panel C). Control variables are the one-year sales growth rate, the sales in USD, the R&D expenses to total assets, the return on assets, the debt to assets ratio, the volatility of the corresponding stock return, the stock return, the stock's beta, the book to price ratio, and mutual fund ownership of firm i in t-1. Definitions of variables used in our analyses can be found in Appendix A. Variables are winsorized at the 1% and 99% tails. All regressions include year, industry, and country fixed effects. Standard errors are clustered at firm and year level. T-statistics are reported in parentheses.

Panel A: Climate targets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Developed markets				
Climate target t-1	-0.0119	-0.0340**	-0.0013	-0.0228*
	(-1.2662)	(-2.1265)	(-0.2159)	(-1.6983)
No. observations	10638	10638	10638	10638
R^2	3.13%	2.73%	19.28%	20.88%
Emerging markets				
Climate target t-1	-0.0343***	-0.0249	-0.0384***	-0.0317
	(-5.3083)	(-1.1996)	(-6.1380)	(-1.6261)
No. observations	7604	7604	7604	7604
R^2	2.25%	2.18%	15.80%	19.78%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

Panel B: Environment-related patents/total assets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Developed markets				
Environment-related patents/total assets t-1	-0.0574***	0.0286	-0.0714***	0.0159
	(-4.3251)	(0.6666)	(-3.2432)	(0.4186)
No. observations	6191	6191	6191	6191
R^2	3.16%	4.43%	12.64%	15.96%
Emerging markets				
Environment-related patents/total assets t-1	0.0417	-0.0070	0.0253	-0.0277
	(1.1602)	(-0.1942)	(1.0245)	(-0.5971)
No. observations	3233	3233	3233	3233
R^2	4.69%	4.52%	15.61%	16.67%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

Panel C: Carbon emission management score

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Developed markets				
Carbon emission management score t-1	-0.0059**	-0.0074**	-0.0020	-0.0023
	(-2.4875)	(-2.3770)	(-0.9647)	(-0.8426)
No. observations	7655	7655	7655	7655
R^2	2.82%	3.42%	18.17%	19.52%
Emerging markets				
Carbon emission management score t-1	-0.0021	0.0086	-0.0059	0.0068
	(-0.3760)	(1.5884)	(-1.1659)	(1.3508)
No. observations	4275	4275	4275	4275
R^2	2.64%	3.35%	14.05%	14.86%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

Table 7: Determinants of Mutual Fund Ownership

We present the results of regression analysis in Equation (3) for determinants of mutual fund ownership for the period 2013–2021. The dependent variable is the mutual fund ownership of firm i in year t. Independent variables are backward-looking measures, the natural logarithm of carbon intensity, and carbon emission of different scopes; and forward-looking measures, carbon emission management score, environment-related patents/total assets, and the climate target dummy. Control variables are the one-year sales growth rate, total assets in USD, R&D expenses to total assets, return on assets, the debt to assets ratio, the volatility of the corresponding stock return, stock return, the stock's beta, the book to price ratio, inverse stock price, trading volume, and an MSCI World inclusion dummy of firms. Definitions of variables used in our analyses can be found in Appendix A. Variables are winsorized at the 1% and 99% tails. All regressions include year, industry, and country fixed effects. Standard errors are clustered at firm and year level. T-stats reported in parentheses.

Dep. Variable	Mutual fund ownership (in percent)			
	IntensityScope1	IntensityScope1	IntensityScope1	IntensityScope1
LnCarbonIntensityScope1	-0.4955**			
	(-2.3155)			
LnCarbonIntensityScope2		-0.6143***		
		(-2.6459)		
LnCarbonScope1			-0.553***	
			(-3.2336)	
LnCarbonScope2				-0.6749***
				(-3.3931)
Carbon emission management score	0.0178	0.0750	0.0257	0.1018
	(0.1543)	(0.6421)	(0.2225)	(0.8722)
Environment-related patents/total assets	-0.0603**	-0.0584**	-0.0596**	-0.0576**
	(-2.1743)	(-2.1053)	(-2.1572)	(-2.0735)
Climate target	-0.3623	-0.3408	-0.3107	-0.2572
	(-0.7222)	(-0.6782)	(-0.6232)	(-0.5153)
Beta	2.0791**	2.0856**	2.1390**	2.1523**
	(2.2021)	(2.2169)	(2.2759)	(2.2887)
Debt/asset	-1.8187	-1.9486	-1.6624	-1.8045
	(-1.2532)	(-1.3489)	(-1.1359)	(-1.2422)
R&D/TotalAsset	-14.2400*	-14.4670*	-13.9420*	-13.9340*
	(-1.7830)	(-1.8016)	(-1.7391)	(-1.7308)
Return on asset	17.4540***	17.6050***	18.5440***	19.0700***
	(4.5043)	(4.5493)	(4.7237)	(4.9520)
Stock return volatility	6.2485	6.2842	6.0938	6.1327
	(1.4464)	(1.4721)	(1.4070)	(1.4412)
LnB/P	-1.1506**	-1.1467**	-1.1757**	-1.1859**
	(-2.2955)	(-2.3016)	(-2.3637)	(-2.3808)
Sales Growth	2.3430	2.2863	1.9523	1.8095
	(1.4306)	(1.3980)	(1.1509)	(1.1054)
LnAssets	0.6834**	0.6715**	1.2336***	1.3396***
	(2.4317)	(2.3850)	(4.1321)	(4.1026)
LnStockPriceInv	-1.7702***	-1.7518***	-1.7656***	-1.7406***
	(-5.6965)	(-5.6539)	(-5.6962)	(-5.6310)
MSCIWORLD	-1.3746	-1.3681	-1.4364	-1.4454
	(-1.5653)	(-1.5422)	(-1.6421)	(-1.6298)
Stock return	-14.6360**	-14.4630**	-14.8250**	-14.6840**
	(-1.9912)	(-2.0109)	(-2.0058)	(-2.0352)
Volume	-0.8850***	-0.8858***	-0.8739***	-0.8689***
	(-8.4318)	(-8.5346)	(-8.2541)	(-8.4182)
Intercept	7.4702	7.2154	-0.1470	-2.2640
	(1.1674)	(1.1181)	(-0.0220)	(-0.3421)
No. Observations	14698	14698	14698	14698
R-squared	12.27%	12.26%	12.37%	12.35%

Year Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Company and Year	Company and Year	Company and Year	Company and Year

*p < .1, **p < .05, ***p < .01.

Appendix A: Definitions of variables

This table reports the definitions of different backward-looking climate measures, forward-looking climate measures, and other firm characteristics.

Variable	Definition
LnCarbonGrowthRate (Intensity Scope 1)	Natural logarithm of (1 + growth rate of carbon intensity scope 1 (carbon emission scope 1/sales))
LnCarbonGrowthRate (Intensity Scope 2)	Natural logarithm of (1 + growth rate of carbon intensity scope 2 (carbon emission scope 2/sales))
LnCarbonGrowthRate (Intensity Scope 3)	Natural logarithm of (1 + growth rate of carbon intensity scope 3 (carbon emission scope 3/sales))
LnCarbonGrowthRate (Emission Scope 1)	Natural logarithm of (1 + growth rate of carbon emission scope 1)
LnCarbonGrowthRate (Emission Scope 2)	Natural logarithm of (1 + growth rate of carbon emission scope 2)
LnCarbonGrowthRate (Emission Scope 3)	Natural logarithm of (1 + growth rate of carbon emission scope 3)
Backward-looking measures	
LnCarbonIntensityScope1	Natural logarithm of (1 +carbon intensity of scope 1 (carbon emission scope 1/sales))
LnCarbonIntensityScope2	Natural logarithm of (1 +carbon intensity of scope 2 (carbon emission scope 1/sales))
LnCarbonIntensityScope3	Natural logarithm of (1 +carbon intensity of scope 3 (carbon emission scope 1/sales))
LnCarbonScope1	Natural logarithm of (1 +absolute carbon emission of scope 1)
LnCarbonScope2	Natural logarithm of (1 +absolute carbon emission of scope 2)
LnCarbonScope3	Natural logarithm of (1 +absolute carbon emission of scope 3)
Forward-looking measures	
Environment-related patents/total assets	Environment-related patents/total assets
Carbon emission management score	MSCI carbon emission management score between 0 and 10
Climate target	Dummy variable takes the value one when firm has at least one carbon reduction target, 0 otherwise
Other firm characteristics	
Mutual fund ownership	Number of shares owned by mutual fund/number of free-floating shares in year t
R&D/TotalAsset	Research and development to total assets in year t
Return on asset	Net income before extraordinary items and after preferred dividends to total assets in year t
Debt/asset	Debt to assets ratio in year t
Stock return volatility	Annualized stock return volatility based on 250 daily stock return in year t
Stock return	Average monthly stock return in year t
Beta	Beta based on time-series-regression analysis of stock return on market return by using 60 months data
B/P	Average book to price ratio in year t
LnStockPriceInv	Inverse natural logarithm of average stock price in USD in year t
Volume	Average daily stock trading volume in USD in year t
MSCIWORLD	Dummy variable takes the value one when firm is a member of the MSCI World index, 0 otherwise
LnAssets	Natural logarithm of (1 + total assets in USD in year t)
Sales Growth	One-year sales growth rate
LnSales	Natural logarithm of (1 + sales in USD in year t)

Appendix B: Relation between forward-looking measures and future carbon growth rate with the lagged growth rate as independent variable

We present the results of regression (Equation (1)) of future carbon emission changes on forward-looking emission measures and control variables. The dependent variable is the future carbon intensity changes and carbon emission changes of firm i in year t for different scopes. Independent variables are forward-looking measures, climate target (Panel A), environment-related patents/total assets (Panel B) and carbon emission management score (Panel C). Control variables are the lagged growth rate, the one-year sales growth rate, the sales in USD, the R&D expenses to total assets, the return on assets, the debt to assets ratio, the volatility of the corresponding stock return, the stock return, the stock's beta, the book to price ratio, and mutual fund ownership of firm i in t-1. Definitions of variables used in our analyses can be found in Appendix A. Variables are winsorized at the 1% and 99% tails. All regressions include year, industry, and country fixed effects. Standard errors are clustered at firm and year level or firm level. T-statistics are reported in parentheses.

Panel A: Climate targets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2007-2015				
Climate target t-1	0.0019	-0.0108	0.0015	-0.0094
	(0.3376)	(-1.0682)	(0.2908)	(-0.8722)
No. observations	16054	16054	16054	16054
R^2	0.59%	0.36%	8.02%	6.50%
After Paris Agreement: 2016-2018				
Climate target t-1	-0.0066	-0.0117	-0.0132	-0.0199
	(-1.3459)	(-0.5635)	(-1.5270)	(-1.3716)
No. observations	11780	11780	11780	11780
R^2	0.76%	0.82%	4.37%	3.40%
After Paris Agreement : 2019-2021				
Climate target t-1	-0.0173**	-0.0186	-0.0069***	-0.0104
	(-2.1622)	(-1.2245)	(-4.4322)	(-0.9410)
No. observations	17669	17669	17669	17669
R^2	7.08%	6.92%	21.23%	24.17%
After Paris Agreement : 2019-2021 developed markets				
Climate target t-1	-0.0127	-0.0281**	0.0040	-0.0121
	(-1.0934)	(-2.1649)	(0.7157)	(-1.1912)
No. observations	10249	10249	10249	10249
R^2	7.96%	5.35%	23.27%	24.10%
After Paris Agreement : 2019-2021 emerging markets				
Climate target t-1	-0.0284**	-0.0140	-0.0268*	-0.0159
	(-1.9738)	(-1.1424)	(-1.7465)	(-1.2043)
No. observations	7405	7405	7405	7405
R^2	7.30%	10.85%	19.92%	26.20%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Firm and Year	Firm and Year	Firm and Year	Firm and Year

Panel B: Environment-related patents/total assets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2010-2015				
Environment-related patent/total assets t-1	0.0118	0.0414	0.0405	0.0654*
	(0.1378)	(1.0291)	(0.4632)	(1.6520)
No. observations	5825	5825	5825	5825
R^2	5.62%	7.37%	11.31%	14.36%
After Paris Agreement: 2016-2018				
Environment-related patent/total assets t-1	0.0124	-0.0061	-0.0068	-0.0281
	(0.1635)	(0.3214)	(-0.0853)	(-0.8019)
No. observations	4813	4813	4813	4813
R^2	8.46%	6.95%	13.58%	14.02%
After Paris Agreement : 2019-2021				
Environment-related patent/total assets t-1	-0.0375***	0.0154	-0.0478***	0.0055
	(-2.8950)	(0.5010)	(-2.7984)	(0.1826)
No. observations	9281	9281	9281	9281
R^2	6.55%	7.39%	16.44%	18.62%
After Paris Agreement : 2019-2021 developed markets				
Environment-related patent/total assets t-1	-0.0577**	0.0289	-0.0695***	0.0194
	(-5.4445)	(0.6852)	(-3.0580)	(0.6431)
No. observations	6111	6111	6111	6111
R^2	6.55%	7.02%	16.26%	18.55%
After Paris Agreement : 2019-2021 emerging markets				
Environment-related patent/total assets t-1	0.0087	-0.0314*	0.0010	-0.0489
	(0.2729)	(-1.7914)	(0.0154)	(-1.2328)
No. observations	3167	3167	3167	3167
R^2	9.41%	11.57%	19.43%	22.55%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Firm and Year	Firm and Year	Firm and Year	Firm and Year

Panel C: Carbon emission management score

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2013-2015				
Carbon emission management score t-1	0.0007	0.0007	0.0017*	0.0021
	(0.9040)	(0.1075)	(1.7013)	(0.2569)
No. observations	2703	2703	2703	2703
R^2	8.25%	6.90%	12.93%	12.77%
After Paris Agreement: 2016-2018				
Carbon emission management score t-1	-0.0009	-0.0017	-0.0023	-0.0028
	(-0.3814)	(-0.5931)	(-1.3192)	(-0.9398)
No. observations	4984	4984	4984	4984
R^2	9.88%	6.95%	17.23%	16.10%
After Paris Agreement : 2019-2021				
Carbon emission management score t-1	-0.0032	0.0000	-0.0009	0.0033
	(-1.5568)	(0.0069)	(-0.4220)	(1.3135)
No. observations	11786	11786	11786	11786
R^2	6.43%	6.18%	19.85%	20.76%
After Paris Agreement : 2019-2021 developed markets				
Carbon emission management score t-1	-0.0043***	-0.0058***	0.0004	0.0003
	(-4.2952)	(-2.6027)	(0.3854)	(0.1174)
No. observations	7558	7558	7558	7558
R^2	6.76%	5.03%	21.35%	21.56%
After Paris Agreement : 2019-2021 emerging markets				
Carbon emission management score t-1	-0.0010	0.0085**	-0.0037	0.0080*
	(-0.1604)	(1.9677)	(-0.6660)	(1.8350)
No. observations	4228	4228	4228	4228
R^2	7.30%	10.85%	19.92%	26.20%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Country Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Firm and Year	Firm and Year	Firm and Year	Firm and Year

Appendix C: Relation between forward-looking measures and future carbon growth rate with firm fixed effects

We present the results of regression (Equation (1)) of future carbon emission changes on forward-looking emission measures and control variables in different periods and in different markets. The dependent variable is the future carbon intensity changes and carbon emission changes of firm i in year t for different scopes. Independent variables are forward-looking measures, climate target (Panel A), environment-related patents/total assets (Panel B) and carbon emission management score (Panel C). Control variables are the one-year sales growth rate, the sales in USD, the R&D expenses to total assets, the return on assets, the debt to assets ratio, the volatility of the corresponding stock return, the stock return, the stock's beta, the book to price ratio, and mutual fund ownership of firm i in t-1. Definitions of variables used in our analyses can be found in Appendix A. Variables are winsorized at the 1% and 99% tails. All regressions include year and firm fixed effects. Standard errors are clustered at industry and year level or firm level. T-statistics are reported in parentheses.

Panel A: Climate targets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2007-2015				
Climate target t-1	0.0149	-0.0381*	0.0090	-0.0422**
	(1.1572)	(-1.7500)	(0.5959)	(-2.1002)
No. observations	16054	16054	16054	16054
R^2	0.59%	0.36%	8.02%	6.50%
After Paris Agreement: 2016-2018				
Climate target t-1	-0.0276	0.0143	-0.0500	-0.0074
	(-1.0743)	(0.2625)	(-1.0673)	(-0.1318)
No. observations	11780	11780	11780	11780
R^2	0.76%	0.82%	4.37%	3.40%
After Paris Agreement : 2019-2021				
Climate target t-1	-0.0774**	-0.0487	-0.0759***	-0.0430
	(-2.5806)	(-1.0728)	(-2.8843)	(-0.8747)
No. observations	18257	18257	18257	18257
R^2	0.76%	0.27%	9.17%	11.74%
After Paris Agreement : 2019-2021 developed markets				
Climate target t-1	-0.0892**	-0.0393	-0.0941***	-0.0375
	(-2.3286)	(-0.5367)	(-3.0487)	(-0.4726)
No. observations	10638	10638	10638	10638
R^2	1.09%	0.51%	9.50%	11.65%
After Paris Agreement : 2019-2021 emerging markets				
Climate target t-1	-0.0539	-0.0658	-0.0303	-0.0448
	(-0.9450)	(-1.3719)	(-0.4525)	(-0.7689)
No. observations	7604	7604	7604	7604
R^2	0.64%	0.30%	9.46%	13.86%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Industry and Year	Industry and Year	Industry and Year	Industry and Year

Panel C: Environment-related patents/total assets

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2010-2015				
Environment-related patent/total assets t-1	-0.1641	-0.4072***	-0.1508	-0.4713***
	(-0.6997)	(-3.0210)	(-0.6355)	(-3.5416)
No. observations	6022	6022	6022	6022
R^2	0.64%	1.28%	5.98%	7.24%
After Paris Agreement: 2016-2018				
Environment-related patent/total assets t-1	-0.2837	-0.3347***	0.0347	-0.1394
	(-0.9248)	(-3.8489)	(0.1334)	(-0.3437)
No. observations	5960	5960	5960	5960
R^2	0.73%	1.49%	3.22%	2.46%
After Paris Agreement : 2019-2021				
Environment-related patent/total assets t-1	-0.0172	-0.0086	0.0172	-0.0157
	(-0.1509)	(-0.0783)	(0.1308)	(-0.1161)
No. observations	9427	9427	9427	9427
R^2	0.91%	0.42%	6.65%	9.22%
After Paris Agreement : 2019-2021 developed markets				
Environment-related patent/total assets t-1	-0.0168	0.0386	0.0568	-0.0110
	(-0.1164)	(0.2882)	(0.3038)	(-0.0570)
No. observations	6191	6191	6191	6191
R^2	1.16%	0.58%	6.44%	9.66%
After Paris Agreement : 2019-2021 emerging markets				
Environment-related patent/total assets t-1	-0.0267	0.1035	-0.0286	0.1934
	(-0.1386)	(0.9010)	(-0.1403)	(0.8710)
No. observations	3233	3233	3233	3233
R^2	0.78%	0.56%	7.10%	9.19%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Industry and Year	Industry and Year	Industry and Year	Industry and Year

Panel B: Carbon emission management score

Dep. Variable	Ln of (1 + Growth rate in emission metrics)			
	IntensityScope1	IntensityScope2	CarbonScope1	CarbonScope2
Before Paris Agreement: 2013-2015				
Carbon emission management score t-1	0.0047	0.0060	0.0047	0.0037
	(0.5119)	(0.6902)	(0.4752)	(0.4148)
No. observations	2782	2782	2782	2782
R^2	2.08%	1.38%	1.94%	4.26%
After Paris Agreement: 2016-2018				
Carbon emission management score t-1	-0.0046	0.0129	-0.0032	0.0135
	(-0.4171)	(1.0012)	(-0.3209)	(1.2623)
No. observations	5692	5692	5692	5692
R^2	1.08%	1.17%	5.10%	4.26%
After Paris Agreement : 2019-2021				
Carbon emission management score t-1	0.0133**	-0.0005	0.0133**	-0.0022
	(2.1903)	(-0.0895)	(1.9961)	(-0.3629)
No. observations	11930	11930	11930	11930
R^2	0.95%	0.34%	7.10%	8.24%
After Paris Agreement : 2019-2021 developed markets				
Carbon emission management score t-1	0.0047	-0.0049	0.0089	-0.0033
	(0.6936)	(-1.0264)	(1.3240)	(-0.7507)
No. observations	7655	7655	7655	7655
R^2	1.23%	0.66%	7.07%	8.40%
After Paris Agreement : 2019-2021 emerging markets				
Carbon emission management score t-1	0.0280****	0.0032	0.0222*	-0.0030
	(2.6908)	(0.2028)	(1.9289)	(-0.1862)
No. observations	4275	4275	4275	4275
R^2	0.85%	0.68%	7.59%	10.08%
Control variables	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Firm Fixed Effect	Yes	Yes	Yes	Yes
Standard error clustered by	Industry and Year	Industry and Year	Industry and Year	Industry and Year