Does the Carbon Premium Reflect Risk or Mispricing?*

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Abstract

Prior research has documented a carbon premium in realized returns, which have been assumed to proxy for expected returns and thus the cost of capital. We find that the carbon premium partially represents unexpected returns and thus mispricing. Companies with higher scope 1, scope 2, or scope 3 emissions enjoy superior earnings surprises and earnings announcement returns; quarterly earnings announcements account for 30-50% of the premium. We find similar results for changes in emissions but not scaled emissions, consistent with earlier findings on realized returns. Our results suggest that the carbon premium, where it exists, partially results from an unpriced externality, highlighting the need for government action.

JEL classifications: G12, G23, G38, J53, J81, J83, J88, K31

Keywords: Carbon Premium, Climate Finance, Socially Responsible Investing, Corporate Social Responsibility, ESG Investing

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* We thank Tom Gosling, Daniel Kim, Lubos Pastor, Ken Pucker, Zach Sautner, and Luke Taylor for helpful comments.
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Whether carbon transition risk is priced in financial markets has first-order implications for the likelihood and speed of a shift to a low-carbon economy. If stocks exposed to transition risk (as proxied by high carbon emissions) are heavily discounted, then companies have strong incentives to cut their emissions, investors will engage with companies to lower their emissions, and emitters will have difficulty raising capital. In contrast, if markets insufficiently price in transition risk, then companies may not reduce their emissions nor investors decarbonize their portfolios.

An influential paper by Bolton and Kacperczyk (2021a, "BK") finds that U.S. companies with high levels of and changes in carbon emissions have high realized stock returns. These results are consistent with such firms facing a high cost of equity and thus markets pricing in transition risk. Aswani, Raghunandan, and Rajgopal (2023a) show that this carbon premium becomes insignificant when either studying carbon intensities (emissions scaled by sales), or focusing on disclosed rather than estimated emissions. Bolton and Kacperczyk (2023a) respond that absolute emissions are the relevant measure of transition risk; Aswani, Raghunandan, and Rajgopal (2023b) disagree. Separately, Bolton and Kacperczyk (2023b) show that a carbon premium exists in many other countries around the world.

Regardless of whether levels, changes, or intensities are the appropriate measure, and whether estimated emissions are reliable, these results assume that realized returns are a good proxy for expected returns and thus the cost of capital. In addition to the authors themselves, 18 papers published in the *Journal of Finance*, *Journal of Financial Economics*, *Review of Financial Studies*, *Review of Finance*, *Journal of Financial and Quantitative Analysis*, *Management Science*, and *Annual Review of Financial Economics* since 2020 refer to the BK results as documenting higher "expected returns", a "risk premium", "carbon risk[s]", "climate risk[s]", or that "risk is priced".

However, a large literature on environmental, social, and governance ("ESG") investing uses realized abnormal returns as a measure of *un*expected returns and thus mispricing rather than risk. For example, Gompers, Ishii, and Metrick (2003) document high returns to well-governed companies, Fornell et al. (2006) and Fornell, Morgeson, and Hult (2016) to firms with high customer satisfaction, Edmans (2011, 2012) and Boustanifar and Kang (2022) to stocks with high employee satisfaction, and Lins, Servaes and Tamayo (2017) to high-trust businesses in the financial crisis. Similarly, practitioners interpret the high alpha to certain ESG strategies as evidence that ESG is good for firm value and underpriced by the market, rather than bad for firm value and exposing companies to excessive risk. ESG skeptics argue against ESG by pointing out how some strategies are associated with negative alpha, rather than claiming that the positive alpha to other strategies is evidence that ESG is risky.

A standard way to disentangle mispricing from risk is to study future earnings surprises. La Porta et al. (1997) find that value companies systematically beat analyst expectations. In an ESG context, Core, Guay, and Rusticus (2006) show that well-governed firms do not deliver positive earnings surprises; Giroud and Mueller (2006) find that they do in non-competitive industries. Edmans (2011) documents positive earnings surprises for companies with high employee satisfaction, Edmans et al. (2023) find similar results in non-U.S. countries with flexible labor markets, and Fornell et al. (2016) uncover analogous findings for stocks with high customer satisfaction.

This paper studies the relationship between carbon emissions and earnings surprises to help understand the source of the carbon premium. We find that carbon emissions have a remarkably similar association with earnings surprises as they do with stock returns. Both the level of and change in emissions are positively related to earnings surprises, just as BK find with realized returns. A one standard deviation increase in the level of scope 1, scope 2, or scope 3 emissions is associated with an increase in the one-year earnings surprise that is approximately twice its sample median and significant at the 1% level. In contrast, carbon intensities are unrelated to earnings surprises, as are emissions levels and changes when focusing on disclosed emissions only, consistent with Aswani, Raghunandan, and Rajgopal (2023a). These results suggest that the carbon premium, where it exists, at least partly results from mispricing.

We find similar results when relating carbon emissions to three-day earnings announcement returns. A one standard deviation increase in scope 1 emissions levels (changes) is associated with a 0.12% (0.19%) higher announcement return, controlling for size and book-to-market effects. Analogous figures are 0.20% (0.23%) for scope 2 emission levels (changes) and 0.45% (0.43%) for scope 3 emission levels (changes). The four quarterly earnings announcements per year account for 30-50% of the carbon premium based on both levels and changes.

Taken together, our results suggest that the market is not fully pricing in carbon transition risk, casting doubt on whether market forces alone can bring about the shift to a low-carbon economy. This may be because companies and investors view carbon emissions as an externality that harms society but not the polluting firms, even in the long term. Thus, some firms choose not to invest in lowering their emissions, and enjoy higher earnings and stock returns as a result. While it is frequently claimed that "climate risk is investment risk", the risk to society may not be fully borne by investors. These findings highlight the criticality of government intervention to achieve the carbon transition, and the trade-off that investors face between fiduciary duty and net-zero alignment in the absence of such action (see also Gosling and MacNeil, 2023).

Our results are related to three strands of existing literature. One is the robustness of the association between carbon emissions and realized returns. In addition to the papers already cited, Zhang (2023) finds that no carbon premium exists when studying lagged measures of emissions available to investors rather than contemporaneous returns. In contrast, Lioui and Misra (2023) use Fama and MacBeth (1973) cross-sectional regressions to estimate carbon factors, and find that these factors command a significant premium. Our paper takes no position on the correct measure of carbon emissions, nor does it contradict prior research. Instead, our contribution is to study earnings surprises given that realized returns may stem from either mispricing or risk. Due to the difficulty of interpreting realized stock returns, Halling, Yu, and Zechner (2021) and Kim and Pouget (2023) study the link between environmental performance and bond yields, which are a good proxy for expected bond returns.

A second is on the theoretical link between carbon emissions and expected returns. Edmans (2023) points out that textbook corporate finance recommends modelling any risk as principally affecting expected cash flows. The discount rate does not change if the risk is idiosyncratic, for example if government action is unrelated to economic conditions and instead driven by factors such as successful global coordination. Moreover, the carbon premium could be negative (i.e. emitting companies bear lower systematic risk) if government action is more likely in an economic upswing where production and thus pollution is higher (Giglio, Kelly, and Stroebel, 2021), or if government inaction leads to a climate disaster which causes the market to collapse but brown stocks to outperform (Baker, Hollifield, and Osambela, 2022). In contrast, Pastor, Stambaugh, and Taylor (2021) show that the carbon premium is positive if government action is prompted by a welfare-reducing climate disaster, or if investors dislike holding brown stocks and demand a higher expected return to own them. The theoretical ambiguity on the link between emissions and systematic risk is consistent with our finding that the carbon premium may result at least in part from mispricing rather than risk.

A third is on the distinction between expected and realized returns in an ESG context. Pastor, Stambaugh, and Taylor (2022) find high realized returns to *green* stocks, as defined by MSCI's environmental scores. Carbon emissions are one of 13 characteristics that enter these scores; others include raw material sourcing, toxic waste, and opportunities in clean tech, green building, and renewable energy. These dimensions are more likely to be internalized by the company, potentially explaining the opposite sign to the carbon premium. The authors decompose the source of the "greenium", guided by the model of Pastor, Stambaugh, and Taylor (2021). They find that it arises from unexpected increases in environmental concerns, rather than high expected returns. Green stocks also enjoyed positive earnings surprises, although these surprises only explain a small proportion of the high realized returns.

1. Data and Methodology

We obtain data on carbon emissions between 2002 and 2021 from Trucost. Trucost adheres to the Greenhouse Gas Protocol and thus classifies emissions into three categories. Scope 1 emissions arise directly from operations owned or controlled by a company, such as a factory or vehicle. Scope 2 emissions come from the production of purchased heat, electricity and steam consumed by a company. Scope 3 emissions stem from operations not directly owned or controlled by the company. They can occur upstream from purchased goods or services, or downstream as customers use a company's products. Following BK, we focus on upstream scope 3 emissions since the available time-series for downstream scope 3 emissions is much shorter.

Trucost obtains data from a variety of public sources such as company annual reports, company websites and environmental data providers such as the Carbon Disclosure Project. If a company does not voluntarily disclose its emissions, then Trucost estimates them based on a proprietary model. BK run their results separately for disclosed and estimated emissions, but do not state how they conduct their classification. Trucost's "data source" variable does not neatly flag data as either "disclosed" or "estimated" but takes 29 different values, which can be grouped into: (i) estimated emissions for firms that do not disclose, (ii) directly disclosed total emissions, and (iii) total emissions figures derived through other firm-level emissions disclosures. Following Aswani, Raghunandan and Rajgopal (2023a), we classify (ii) and (iii) as disclosed, and (i) as estimated if it contains the keyword "estimate".[1]

[1] Aswani, Raghunandan, and Rajgopal (2023a) use this classification because Trucost also provides another variable, the weighted average disclosure score. Observations in category (i) have a mean score of less than 1 out of 100 while observations in categories (ii) and (iii) have mean scores close to 95.

Following prior literature, we calculate level, growth and intensity measures for carbon emissions under all three scopes. The level of emissions is the natural logarithm of carbon dioxide equivalent (CO_2e) emissions in tons. The change in emissions is the annual percentage growth in CO_2e emissions. Emissions intensity is the level of emissions scaled by the company's revenues (in million US dollars), divided by 100. Following BK, the last two measures are winsorized at the 2.5% level.

We obtain stock returns and market equity from CRSP, book equity from COMPUSTAT, and analyst forecasts from I/B/E/S. We calculate three measures of earnings surprises. *SUE1* is the one-year earnings surprise and calculated as the actual earnings per share (EPS) for the fiscal year ending in year *t* minus the median analyst forecast, scaled by the year-end stock price. The analyst consensus forecast is taken eight months prior to the end of the forecast period, i.e. four months after the prior fiscal year-end, to ensure that analysts observe prior earnings when making their forecasts. *SUE2* is the two-year earnings surprise and calculated in an analogous manner, with the consensus forecast taken 20 months prior to the end of the forecast period. As in Easterwood and Nutt (1999), Giroud and Mueller (2011), and Edmans (2011), we remove observations where the forecast error is larger than 10% of the stock price. *LTG* is the long-term growth surprise and equal to the actual five-year EPS growth taken from I/B/E/S minus the median growth forecast from 56 months earlier.

To measure earnings announcement returns, we calculate *CAR*, the three-day (-1,+1) cumulative abnormal returns in excess of a market model estimated over (-300, -46). Table 1 presents summary statistics for our carbon emissions, earnings surprises, and earnings announcement return metrics.

2. Results

We study the relationship between emissions and earnings surprises by estimating the following cross-sectional regression model using pooled ordinary least squares ("OLS"):

$$Surprise_{it} = b_0 + b_1 Emissions_{it} + b_2 X_{it-j} + \gamma_{year} + \delta_{ind} + \varepsilon_{it} \qquad (1)$$

The dependent variable, $Surprise_{it}$, is one of the three measures of earnings surprises described earlier for firm *i* and quarter *t*. The independent variable of interest, $Emissions_{it}$, is the level of, change in, or intensity of one of the three scopes. X_{it-j} is a vector of controls: firm size (log market equity) and the book-to-market ratio, measured either one, two or five years prior to the end of the forecast period depending on the surprise metric used. We include year (γ_{year}) and Fama-French 48 industry (δ_{ind}) fixed effects and cluster standard errors by firm and year. The intercept and coefficients for the control variables are not reported for brevity.

Table 2 presents the results for the full sample, which contains both disclosed and estimated emissions. Panel A considers the level of emissions. In univariate regressions, all three measures of carbon emissions are positively and significantly associated with all three measures of earnings surprises (*SUE1*, *SUE2*, and *LTG*). Eight of the nine coefficients are significant at the 1% level, with the ninth significant at 5%. A one standard deviation increase in the level of scope 1 emissions increases *SUE1* by 0.0021 which is twice the median value of this variable; these numbers are 0.0020 and 0.0019 for scopes 2 and 3. When we control for firm size and the book-to-market ratio, the point estimates increase in all nine specifications. Six coefficients are significant at the 1% level and the remaining three at the 5% level.

Panel B shows similar results for changes in emissions. Out of the 18 regressions (three measures of emissions, three measures of earnings surprises, and with and without controls), 16 coefficients are significant at the 1% level and one at the 5% level. In contrast, Panel C finds no positive relationship between scaled emissions and earnings surprises in any specification, and a significantly negative relationship in three. These results are consistent with BK and Aswani, Raghunandan, and Rajgopal (2023) who document a carbon premium for emission levels and changes, but not intensities.

Table 2 also demonstrates similar results when the dependent variable is the two-year earnings surprise (*SUE2*) or long-term growth surprise (*LTG*). All twelve coefficient estimates for *SUE2* are significant at the 1% level; eleven coefficients for *LTG* are significant at the 5% level or better. In terms of economic significance, in univariate regressions, a one-standard deviation increase in emission levels (changes) is associated with a 0.0021-0.0023 (0.0024-0.0060) increase in *SUE2* depending on the scope used; these figures are 1.92%-3.61% and 0.76%-3.73% for *LTG*, and all ranges are even higher under multivariate specifications. We again find no relation between emission intensities and earnings surprises.

We next estimate model (1) for estimated and disclosed emissions separately. Table 3 presents the results for estimated emissions. Panel A demonstrates that all three measures of emission levels are significantly associated with all three measures of earnings surprises in both univariate and multivariate regressions, with 17 coefficients significant at the 1% level and one at the 5% level. Compared to the full sample results of Table 2, coefficient estimates are generally higher. Panel B finds similar results for emission changes, with 17 coefficients again significant at the 1% level; Panel C reports only one significant coefficient for emission intensities.

Table 4 illustrates the results for disclosed emissions. Out of the 36 regressions using both the level and change in emissions, we only find 5 positive coefficients that are significant at the 5% level or better. There are no significantly positive coefficients when studying emissions intensities. These results are consistent with Aswani, Raghunandan, and Rajgopal (2023a), who show that the carbon premium is driven by estimated rather than disclosed emissions. Taken together, the results in Tables 2, 3 and 4 suggest that, where the carbon premium exists (i.e. for estimated levels and changes in emissions), it is at least partially the result of mispricing that manifests itself in earnings announcements.

We study the stock price consequences of these earnings surprises by estimating the following cross-sectional regression model using pooled OLS:

$$CAR_{it} = b_0 + b_1 Emissions_{it} + b_2 X_{it-j} + \gamma_{year} + \delta_{ind} + \varepsilon_{it} \quad (2)$$

The dependent variable, CAR_{it}, is the three-day abnormal announcement return over the market model of firm *i* during quarter *t*. We regress *CAR* on level, change and intensity metrics associated with the three scopes, controlling for firm size and book-to-market ratios. We continue to include year and industry fixed-effects and to cluster standard errors by firm and year.

Table 5 presents the results. The full-sample results in column (1) show that *CAR* is positively associated with both the level of and change in all three emissions measures, with five out of the six coefficients being significant, and no positive relationship with emissions intensities. A one standard deviation increase in the level of scope 1 emissions is associated with a higher *CAR* of 12, 20, and 45 basis points for scopes 1, 2, and 3, respectively. With four quarterly earnings announcements per year, earnings surprises account for 0.5%-1.8% of the annual carbon premium. BK report that a one standard deviation increase in the level of scope 1, scope 2 and scope 3 emissions leads to an annualized increase in stock returns of 1.5%, 2.8% and 3.6%, respectively. Thus, earnings announcements account for about 30-50% of the carbon premium. Moving to the change in emissions, a one standard deviation increase in the change in scope 1, 2, and 3 emissions is respectively associated with a 19, 23, and 43 basis point increase in *CAR*, i.e. 0.8-1.7% per year, compared to an annual carbon premium of 2.7%, 1.9% and 3.4% in BK. Thus, similar to our results for levels, we find that earnings surprises account for 30-50% of the carbon premium based on changes.

BK also consider the possibility that emitting firms have received positive shocks. For robustness, they omit the 1-day return to earnings announcements and find that the carbon premium remains. However, they only consider a 1-day return, in contrast to the common (-1, +1) window for event studies; they also do not investigate the relationship between emissions and earnings surprises. Note that we study a short announcement window to ensure that the realized returns are attributable to earnings announcements rather than other news. It is, therefore, possible that earnings surprises account for even more than 30-50% of the carbon premium given the existence of post-earnings announcement drift (Bernard and Thomas, 1989).

Columns (2) and (3) repeat the results for estimated and disclosed emissions only. They demonstrate that the significantly positive relation between emission levels/changes and announcement returns is confined to estimated emissions, and the coefficients tend to be higher than in the full sample.[2] These results are again consistent with earlier work which attributes the carbon premium to estimated emissions. Taken together, these findings suggest that a significant portion of the carbon premium is driven by mispricing that is revealed during earnings announcements and imputed into stock prices.[3]

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[2] Table A.11 of BK finds that that the level of disclosed Scope 1 emissions is positively related to stock returns and significant at the 10% level, but changes and intensities are unrelated. However, Table OA.3 of Aswani, Raghunandan, and Rajgopal (2023) finds that this result only exists when using Trucost industry definitions (not GICS, SIC, or Fama-French 48 industries) and counting only category (ii) of Trucost's "data source variable" (emissions directly disclosed to the CDP or in environmental/CSR reports) as "disclosed" emissions, omitting category (iii) (total emissions figures derived through other firm-level emissions disclosures). In unreported results, we find that Scope 1 levels (but not changes or intensities) are positively related to earnings announcement returns and significant at the 10% level when using Trucost industry definitions and under the more conservative definition of disclosure. Thus, even in the specification in which BK obtain a carbon premium for disclosed emissions, the premium is at least partly driven by mispricing.

[3] Table A.11 of Bolton and Kacperczyk (2021) finds that that the level of disclosed Scope 1 emissions is positively related to stock returns and significant at the 10% level, but the change in emissions and emissions intensities is unrelated. However, Table OA.3 of Aswani, Raghunandan, and Rajgopal (2023) finds that this result only exists when using Trucost industry definitions (not GICS, SIC, or Fama-French 48 industries) and counting only category (ii) of Trucost's "data source variable" (emissions directly disclosed to the CDP or in environmental/CSR reports) as "disclosed" emissions, omitting category (iii) (total emissions figures derived through other firm-level emissions disclosures). In unreported results, we find that the level of Scope 1 emissions is positively related to earnings announcement returns and significant at the 10% level when using Trucost industry definitions and under the more conservative definition of disclosure, but the change in emissions and emissions intensities is unrelated. Thus, even in

3. Discussion

Our results have shown that companies with higher levels of and changes in estimated emissions enjoy positive earnings surprises and earnings announcement returns. There are two potential reasons for this association. First, some companies may focus entirely on shareholder value and view carbon emissions as an externality that they can "get away with" due to doubts about government action. Such firms do not spend money on reducing their emissions, thus delivering higher earnings than the market anticipated. Investors rationally respond positively to these higher earnings because they also view government action as unlikely. This is consistent with the infamous claim by HSBC's Stuart Kirk that, while climate change is a serious risk to society, it is not yet a serious risk to investors.

Under the same interpretation, low-emission companies are sacrificing shareholder value to curb their carbon emissions. They announce earnings that are lower than expected and investors respond negatively to these lower earnings, perhaps because they signal that these companies are not maximizing shareholder value. Such a sacrifice may either be due to an agency problem (executives pursuing social goals without shareholder approval) or shareholders' objective function containing both shareholder value and carbon emissions.

Second, our results may be driven by an omitted variable. It may be that high carbon emissions do not "cause" higher earnings surprises, but that some companies receive a positive shock to demand, which causes them to produce more. This increases emissions levels and changes but not intensities since revenues also rise. These demand shocks generate favorable earnings surprises that investors welcome because they do not believe that the accompanying high emissions will lead to future costs. Under this interpretation, it remains the case that investors are not fully pricing in transition risk and government intervention remains necessary.

That our results only arise for estimated and not disclosed emissions may be due to the endogeneity of the disclosure decision, which Bolton and Kacperczyk (2021b) offer as an explanation for why they find a lower carbon premium for disclosed emissions. Assume firm A has received a positive shock to demand, which increases both revenues and emissions, and leads to positive earnings surprises. Since reported emissions would be high, the firm chooses not to

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the specification in which BK obtain a carbon premium for disclosed emissions, the premium is at least partly driven by mispricing.

disclose its emissions. While Trucost's estimation model is proprietary, Aswani et al. (2023a) find that estimated emissions are strongly correlated with revenues[4]. Thus, estimated emissions will be high[5], leading to a positive link between estimated emissions and earnings surprises. Now consider firm B, which also enjoys a positive demand shock, but this increased output does not lead to higher emissions, either because it is in a sector (e.g. services) where revenues can increase without emissions doing so, because it invests in reducing its emissions, or because it enjoys a negative shock to emissions. Since its emissions do not rise, it is willing to disclose them. Because positive demand shocks do not lead to high disclosed emissions, there is no link between disclosed emissions and earnings surprises.

Similar logic applies if disclosure is an irreversible decision, i.e. once a firm has decided to disclose, it cannot stop doing so. A company whose output is largely decoupled from emissions is more likely to disclose since it can grow its business without having to disclose ever-increasing emissions. Demand shocks will be uncorrelated with disclosed emissions for such firms, also explaining the absence of a link.

Regardless of the reason for the association between emissions and earnings surprises, the implications for investors are similar. By buying firms with high levels of or changes in total or estimated emissions, they earn higher returns that are at least partially due to mispricing. Indeed, buying emitting companies just before earnings announcements and selling just after would lead to abnormal returns with negligible exposure to transition risk (due to a three-day window). Conversely, responsible investing strategies that screen out high emitting companies sacrifice returns, in contrast to common claims that investors can "do well by doing good."[6] The survey of Krueger, Sautner, and Starks (2020) finds that improving investor returns is a major motivation for why investors incorporate climate risks into the investment process. Our evidence suggests that avoiding firms exposed to transition risk can actually decrease investment returns.

4. Conclusion

[4] Aswani et al. (2023a) document a 0.699 correlation between log scope 1 emissions and log sales, compared to a 0.525 correlation with log market cap and a 0.463 correlation with log assets.

[5] Even though estimated emissions are also high, the company may still choose not to disclose emissions due to the cost of doing so (Bolton and Kacperczyk, 2021b).

[6] See Cornell and Damodaran (2020) for theoretical arguments and empirical findings suggesting that investors cannot always do well by doing good.

Prior literature uncovered that the level of and change in carbon emissions is associated with significantly higher realized returns, but carbon intensities are not. While it interpreted realized returns as expected returns, they instead may be at least partially unexpected. We study the relationship between carbon emissions and earnings surprises to shed light on whether the carbon premium results from mispricing and risk. We find remarkably similar results to the prior literature – the level of and change in all three scopes of carbon emissions is significantly associated with both higher earnings surprises and higher earnings announcement returns, but carbon intensities are not. The four earnings announcements each year account for 30-50% of the carbon premium in both levels and changes.

Our results imply a more skeptical view of financial markets' ability to accelerate the carbon transition than suggested by prior literature. Financial markets may not be fully pricing in carbon transition risk, potentially because of doubts about the likelihood of government action. As a result, emissions may be an unpriced externality that harms wider society but not the emitting company; emitting firms are able to enjoy superior earnings surprises, earnings announcement returns, and realized returns because they do not fully bear the consequences of their polluting activity. These findings highlight the pressing need for government action to address climate change.

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Table 1: Summary Statistics

This table presents summary statistics for the emission measures, earnings surprises and earnings announcement returns. Level of emissions is calculated as the natural logarithm of carbon dioxide equivalent (CO_2e) emissions measured in tons. Change in emissions is calculated as the annual percentage growth in CO_2e emissions winsorized at the 2.5% level. Intensity of emissions is expressed as the ratio of tons of CO_2e emissions to the company's revenues (in million US dollars) divided by 100, also winsorized at the 2.5% level. *SUE1* (*SUE2*) is the one-year (two-year) earnings surprise measured as the actual EPS minus the I/B/E/S median analyst forecast 8 (20) months prior to the end of the forecast period, scaled by the stock price. *LTG* is the long-term growth surprise measured as the actual five-year annualized EPS growth rate minus the I/B/E/S median analyst long-term growth forecast from 56 months earlier. *CAR* is the three-day (-1,+1) cumulative abnormal return to quarterly announcements relative to a market model in which the coefficients are estimated over (-300, -46). The sample period is from 2002 to 2021.

	Mean	Median	StDev	Min	P25	P75	Max
Scope 1 Level	9.968	9.961	3.165	2.907	7.939	11.905	19.506
Scope 2 Level	10.103	10.373	2.584	3.593	8.663	11.807	17.165
Scope 3 Level	11.863	12.074	2.533	5.005	10.210	13.642	19.251
Scope 1 Change	0.098	0.033	0.402	-0.652	-0.066	0.164	1.749
Scope 2 Change	0.125	0.037	0.435	-0.568	-0.066	0.190	1.990
Scope 3 Change	0.095	0.046	0.284	-0.439	-0.045	0.170	1.151
Scope 1 Intensity	1.364	0.139	4.144	0.004	0.040	0.325	22.664
Scope 2 Intensity	0.309	0.179	0.365	0.010	0.079	0.416	1.754
Scope 3 Intensity	1.466	0.887	1.467	0.226	0.367	2.057	6.166
SUE1	0.000	0.001	0.022	-0.081	-0.005	0.006	0.100
SUE2	-0.003	0.000	0.027	-0.087	-0.012	0.007	0.100
LTG	-0.041	-0.025	0.253	-0.685	-0.126	0.048	5.941
CAR	0.332	0.193	8.410	-22.412	-3.404	3.911	270.822

Table 2: Earnings Surprises (Full Sample)

This table presents results from regressions of earnings surprises on emissions. *SUE1* (*SUE2*) is the one-year (two-year) earnings surprise measured as the actual EPS minus the I/B/E/S median analyst forecast 8 (20) months prior to the end of the forecast period, scaled by the stock price. *LTG* is the long-term growth surprise measured as the actual five-year annualized EPS growth rate minus the I/B/E/S median analyst long-term growth forecast from 56 months earlier. The multivariate specification controls for the log market value of equity and the book-to-market ratio. All regressions include industry and year fixed-effects. The intercept terms and coefficients of the control variables are not reported for brevity. All coefficients are multiplied by 1,000. *t*-statistics with standard errors clustered at the firm and year level are in parentheses, and the number of observations is below the *t*-statistic. ***,**, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

	SUE1		*SUE2*		*LTG*	
	Univariate	Multivariate	Univariate	Multivariate	Univariate	Multivariate
Panel A: Level of Emissions						
Scope 1	0.673***	0.710**	0.724***	1.147***	10.182***	16.597***
	(3.73)	(2.28)	(4.16)	(5.50)	(3.64)	(4.29)
	19,208	15,470	17,838	14,268	3,815	3,123
Scope 2	0.769***	1.163**	0.832***	2.045***	7.447**	14.334***
	(3.84)	(2.51)	(4.36)	(6.53)	(2.46)	(3.32)
	19,208	15,470	17,838	14,268	3,815	3,123
Scope 3	0.760***	1.192**	0.891***	2.486***	14.232***	39.615***
	(4.07)	(2.22)	(3.66)	(4.60)	(4.12)	(4.75)
	19,221	15,483	17,850	14,280	3,820	3,128
Panel B: Changes in Emissions						
Scope 1	3.528***	3.667***	6.045***	6.001***	18.886	24.597**
	(3.81)	(3.93)	(5.61)	(5.84)	(1.62)	(1.99)
	17,463	14,114	16,354	13,132	3,747	3,063
Scope 2	3.491***	3.945***	5.604***	5.988***	20.858***	29.873***
	(4.92)	(5.06)	(6.17)	(6.80)	(2.66)	(3.63)
	17,463	14,114	16,354	13,132	3,747	3,063
Scope 3	11.662***	12.509***	21.240***	22.814***	131.386***	141.308***
	(4.94)	(5.12)	(6.70)	(8.27)	(5.80)	(5.53)
	17,474	14,125	16,365	13,143	3,752	3,068
Panel C: Emissions Intensity						
Scope 1	-0.077	-0.103**	-0.044	-0.041	-0.362	-0.519
	(-1.51)	(-2.32)	(-0.57)	(-0.49)	(-0.30)	(-0.46)
	19,221	15,483	17,850	14,280	3,820	3,128
Scope 2	0.520	0.072	0.487	0.247	-34.963***	-35.476***
	(0.52)	(0.08)	(0.54)	(0.28)	(-2.92)	(-3.10)
	19,221	15,483	17,850	14,280	3,820	3,128
Scope 3	-0.211	-0.265	-0.055	-0.011	-5.819	-5.495
	(-0.91)	(-1.03)	(-0.16)	(-0.03)	(-0.90)	(-0.71)
	19,221	15,483	17,850	14,280	3,820	3,128
Controls	None	Size, B/M	None	Size, B/M	None	Size, B/M
Fixed effects	Industry, year	Industry, year	Industry, year	Industry, year	Industry, year	Industry, year

Table 3: Earnings Surprises (Estimated Emissions)

This table presents results from regressions of earnings surprises on estimated emissions. *SUE1* (*SUE2*) is the one-year (two-year) earnings surprise measured as the actual EPS minus the I/B/E/S median analyst forecast 8 (20) months prior to the end of the forecast period, scaled by the stock price. *LTG* is the long-term growth surprise measured as the actual five-year annualized EPS growth rate minus the I/B/E/S median analyst long-term growth forecast from 56 months earlier. The multivariate specification controls for the log market value of equity and the book-to-market ratio. All regressions include industry and year fixed-effects. The intercept terms and coefficients of the control variables are not reported for brevity. All coefficients are multiplied by 1,000. *t*-statistics with standard errors clustered at the firm and year level are in parentheses, and the number of observations is below the *t*-statistic. ***,**, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

	SUE1		*SUE2*		*LTG*	
	Univariate	Multivariate	Univariate	Multivariate	Univariate	Multivariate
Panel A: Level of Emissions						
Scope 1	0.990***	1.234***	1.095***	1.852***	27.142***	49.675***
	(4.05)	(3.04)	(4.72)	(5.48)	(3.94)	(4.62)
	13,036	10,210	11,980	9,274	1,556	1,211
Scope 2	1.203***	1.828***	1.261***	2.845***	20.203***	46.514***
	(4.39)	(3.24)	(5.25)	(6.07)	(3.45)	(3.99)
	13,556	10,706	12,458	9,735	1,661	1,316
Scope 3	0.787***	1.207**	0.891***	2.437***	15.459***	41.539***
	(4.07)	(2.21)	(3.68)	(4.58)	(4.32)	(4.83)
	17,812	14,272	16,531	13,145	3,396	2,775
Panel B: Changes in Emissions						
Scope 1	6.600***	6.704***	11.694***	12.044***	69.498***	58.941***
	(3.53)	(3.35)	(5.32)	(6.70)	(3.40)	(2.88)
	11,368	8,923	10,562	8,197	1,496	1,159
Scope 2	6.553***	7.430***	11.478***	12.939***	74.307**	95.313***
	(4.51)	(4.53)	(5.28)	(6.62)	(2.57)	(3.47)
	11,848	9,378	11,003	8,622	1,598	1,260
Scope 3	11.642***	12.536***	21.090***	22.623***	122.411***	126.657***
	(4.86)	(5.08)	(6.21)	(7.78)	(4.83)	(3.88)
	16,149	12,991	15,122	12,074	3,333	2,718
Panel C: Emissions Intensity						
Scope 1	0.103	0.082	-0.049	-0.045	9.142*	9.991**
	(0.82)	(0.74)	(-0.24)	(-0.20)	(1.74)	(1.98)
	13,036	10,210	11,980	9,274	1,556	1,211
Scope 2	1.719	1.300	1.020	0.957	47.162	69.880
	(1.01)	(0.86)	(0.65)	(0.59)	(1.01)	(1.50)
	13,556	10,706	12,458	9,735	1,661	1,316
Scope 3	-0.250	-0.329	-0.088	-0.071	-3.654	-2.545
	(-1.03)	(-1.19)	(-0.24)	(-0.20)	(-0.55)	(-0.34)
	17,812	14,272	16,531	13,145	3,396	2,775
Controls	None	Size, B/M	None	Size, B/M	None	Size, B/M
Fixed effects	Industry, year	Industry, year	Industry, year	Industry, year	Industry, year	Industry, year

Table 4: Earnings Surprises (Disclosed Emissions)

This table presents results from regressions of earnings surprises on disclosed emissions. *SUE1* (*SUE2*) is the one-year (two-year) earnings surprise measured as the actual EPS minus the I/B/E/S median analyst forecast 8 (20) months prior to the end of the forecast period, scaled by the stock price. *LTG* is the long-term growth surprise measured as the actual five-year annualized EPS growth rate minus the I/B/E/S median analyst long-term growth forecast from 56 months earlier. The multivariate specification controls for the log market value of equity and the book-to-market ratio. All regressions include industry and year fixed-effects. The intercept terms and coefficients of the control variables are not reported for brevity. All coefficients are multiplied by 1,000. *t*-statistics with standard errors clustered at the firm and year level are in parentheses, and the number of observations is below the *t*-statistic. ***,**, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

	SUE1		*SUE2*		*LTG*	
	Univariate	Multivariate	Univariate	Multivariate	Univariate	Multivariate
Panel A: Level of Emissions						
Scope 1	0.236	0.049	0.325*	0.505**	4.680	11.768***
	(1.54)	(0.18)	(1.70)	(2.21)	(1.64)	(2.78)
	6,172	5,260	5,858	4,994	2,259	1,912
Scope 2	0.363	0.243	0.338	0.914***	-1.901	2.137
	(1.53)	(0.53)	(1.46)	(3.17)	(-0.62)	(0.57)
	5,652	4,764	5,380	4,533	2,154	1,807
Scope 3	-2.094	2.969	1.505	13.756*	-46.896*	36.227
	(-0.77)	(0.86)	(0.68)	(1.78)	(-1.83)	(0.34)
	1,409	1,211	1,319	1,135	424	353
Panel B: Changes in Emissions						
Scope 1	0.635	0.698	1.205	0.982	-2.850	6.075
	(0.88)	(1.02)	(1.45)	(1.00)	(-0.21)	(0.45)
	6,095	5,191	5,792	4,935	2,251	1,904
Scope 2	0.803	1.112*	0.653	0.735	2.742	3.749
	(1.37)	(1.71)	(0.79)	(0.82)	(0.33)	(0.37)
	5,615	4,736	5,351	4,510	2,149	1,803
Scope 3	-0.559	1.325	14.868***	15.420***	-227.871***	-229.188
	(-0.10)	(0.22)	(5.76)	(3.53)	(-3.47)	(-0.75)
	1,325	1,134	1,243	1,069	419	350
Panel C: Emissions Intensity						
Scope 1	-0.227***	-0.253***	-0.110	-0.107	-0.890	-1.107
	(-3.94)	(-4.29)	(-1.30)	(-1.17)	(-0.59)	(-0.73)
	6,185	5,273	5,870	5,006	2,264	1,917
Scope 2	-1.038	-1.139	-0.851	-1.085	-50.231***	-53.112***
	(-1.28)	(-1.48)	(-1.01)	(-1.07)	(-5.01)	(-4.90)
	5,665	4,777	5,392	4,545	2,159	1,812
Scope 3	0.599	-4.849	-2.809	-3.010	10.727	-60.583
	(0.20)	(-1.20)	(-1.15)	(-0.81)	(0.35)	(-1.05)
	1,409	1,211	1,319	1,135	424	353
Controls	None	Size, B/M	None	Size, B/M	None	Size, B/M
Fixed effects	Industry, year	Industry, year	Industry, year	Industry, year	Industry, year	Industry, year

Table 5: Earnings Announcement Returns

This table presents results from regressions of earnings announcement returns on emissions. We present results for the full sample, estimated emissions only, and disclosed emissions only. All regressions control for the log market value of equity and the book-to-market ratio, and include industry and year fixed-effects. The intercept terms and coefficients of the control variables are not reported for brevity. *t*-statistics with standard errors clustered at the firm and year level are in parentheses, and the number of observations is below the *t*-statistic. ***,**, and * represent statistical significance at the 1%, 5% and 10% levels, respectively.

	Full Sample	Estimated	Disclosed
Panel A: Level of Emissions			
Scope 1	0.038	0.066*	-0.018
	(1.49)	(1.80)	(-0.60)
	65,319	43,684	21,635
Scope 2	0.077**	0.145***	-0.060
	(2.26)	(2.88)	(-1.56)
	65,319	45,710	19,609
Scope 3	0.179***	0.175***	-0.622
	(4.29)	(4.13)	(-0.61)
	65,363	60,307	5,056
Panel B: Changes in Emissions			
Scope 1	0.466***	1.106***	-0.197*
	(3.72)	(5.33)	(-1.95)
	59,649	38,292	21,357
Scope 2	0.515***	1.110***	0.020
	(4.26)	(5.24)	(0.20)
	59,649	40,156	19,493
Scope 3	1.526***	1.535***	-1.019
	(5.83)	(5.70)	(-1.09)
	59,693	54,978	4,715
Panel C: Emissions Intensity			
Scope 1	0.001	-0.032	0.004
	(0.11)	(-1.30)	(0.44)
	65,363	43,684	21,679
Scope 2	-0.268***	-0.335*	-0.327***
	(-2.69)	(-1.69)	(-2.60)
	65,363	45,710	19,653
Scope 3	-0.035	-0.051	1.178
	(-1.02)	(-1.37)	(1.00)
	65,363	60,307	5,056
Controls	Size, B/M	Size, B/M	Size, B/M
Fixed effects	Industry, year	Industry, year	Industry, year