Review of Economics and Statistics Fellowship for NBER Summer Institute

Personal Details:

Jitendra Aswani
Ph.D. (Finance) (Expected completion date : May, 2022)
Gabelli School of Business, Fordham University
Email: jaswani@fordham.edu
Website: http://www.jitendraaswani.com

Summary of Research Activity:

My areas of interest are corporate governance, empirical corporate finance, Environment, Social & Governance (ESG), Corporate Social Responsibility (CSR), debt markets, and behavioral economics. Also, due to my chemical engineering background and work experience in Oil & Gas sector, I also have industry specific knowledge about energy and environmental related areas. Brief about the projects I am working on in these areas are provided below.

Are Carbon Emissions Associated with Stock Returns?

(*with Shivaram Rajgopal (Columbia University) and Aneesh Raghunandan (London School of Economics*)

The paper explores an association between stock returns and carbon emissions conditioned on firm size, industry, and business expansion. We find no evidence that there is any association between stock returns and emissions conditioned on these factors. This is because emissions is a by-product of the amount of raw material (non-renewables or electricity or both) used, which is directly proportional to plant capacity and, hence, to size. Also, high emissions can be due to business expansion or due to industry-specific factors. Thus, the amount of emissions is just a proxy of these factors and not a new risk factor for which investors should pay a premium. We also check this relation for disclosed values versus vendor estimated values. I presented this paper at MIT Asia Accounting Conference, FMA 2021, Ph.D. symposium 2021 at UT Austin, and scheduled to be presented at SFS Cavalcade North America 2022, Western Finance Association (WFA) 2022, and China International Conference in Finance (CICF) 2022 . After gathering feedback and suggestions from top finance scholars, we submitted the paper to the top journal.

Three Aspects of Green Bonds

(Solo Paper)

This paper investigates basic questions about this asset class: (1) *How shareholders react to green bonds issuance in different countries?* (2) *What type of firms issue these bonds?*, and (3) *Who supports their issuance?* The stylized facts

suggest that green bonds issuance is highly concentrated among a few firms (and their subsidiaries) in the U.S. and Europe but diversified in the Asian region. On analyzing stockholder reaction to green bonds issuance in 19 countries, I find a difference in market reaction (in magnitude and direction) to the issuance of green bonds in all these countries. I also find that firms with a low environment score, low ESG score, high unscaled carbon emissions, and with no target emissions issue more green bonds compared to others. The latter result supports a signaling hypothesis. Also, only domestic (and not foreign) institutional investors support the issuance of green bonds, implying a home-bias effect. Similar to market reaction, the latter result also varies across countries. In sum, this paper suggests that it is crucial to understand the intricacies of corporate green bond issuance to correctly emulate stockholder reaction, highlight the identity of green bond issuers, and know what kind of institutional investors support green bonds issuance. This paper is presented at FMA 2021, AEA 2022, AFA 2022 (Doctoral Session), and The Econometric Society Meetings (Winter School 2021 as well as at CUHK (Shenzhen) 2022).

Further details on other projects are provided in CV as well as on the website.

NBER Summer Institute (Interested)

Environmental & Energy Economics / Development Economics / Corporate Finance

Jitendra Aswani
Gabelli School of Business
Fordham University
Email: jaswani@fordham.edu
Website: www.jitendraaswani.com

EDUCATION

Doctor of Philosophy (Ph.D.), Business (Major: Finance) 2016-2022 (Expected)
Gabelli School of Business, Fordham University, US

Master of Philosophy (M.Phil), Finance 2018-2019
Gabelli School of Business, Fordham University, US

Master of Science (M.S.), Global Finance 2016-2018
Gabelli School of Business, Fordham University, US

Doctor of Philosophy (Ph.D.), Economics 2015-2016 (ABD)
IGIDR, Advanced Research Institute of Reserve Bank of India (RBI), India

Master of Philosophy (M.Phil), Economics
IGIDR, Advanced Research Institute of Reserve Bank of India (RBI), India 2013-2015

Bachelor of Technology (B.Tech), Chemical Engineering
National Institute of Technology (NIT), Jaipur, India 2005-2009

Ph.D. courses at New York University (NYU) and Columbia University
Advanced Corporate Finance (Kose John), Banking and Institutions (Anthony Saunders, Kose John, and Iftekhar Hasan), Macro-Finance (Thomas Philippon), Accounting Seminar (Mary Billings), Accounting Seminar (Baruch Lev), Research on Regulation and Accounting (Shivaram Rajgopal).

IGIDR - CAFRAL Winter School 2015
Wharton Summer School (Finance Theory Group) 2019

RESEARCH

Interests: Corporate Governance, Empirical Corporate Finance, ESG & CSR, Behavioral Finance, and Debt Markets.

Main Articles

Group Identity and Agency Frictions : Evidence using Big Data

- Seminars: Stevens Institute of Technology; University of North Texas.
- Conferences: American Finance Association (AFA) 2021 (Doctoral Session); Financial Management Association (FMA) PhD Consortium, 2020; Australasian Finance and Banking Conference (AFBC), 2020; Royal Economic Society (RES) Annual Meeting 2021; The Econometric Society Meeting 2021 (Asia); The Econometric Society Meeting 2021 (North America); NEUDC 2021.
- Media Coverage : Oxford Law School's Blog, BeingBrief.in, World Bank Blog.

Are Carbon Emissions Associated With Returns ? (with Shivaram Rajgopal and Aneesh Raghunandan) [under review]

- Seminars: Ohio State University *, University of Sydney * , Monash University *.

- Conference: MIT Asia Accounting Conference 2021; Financial Management Association (FMA) 2021 (Schedule); Ph.D. Symposium 2021 (UT Austin); SFS Cavalcade North America 2022 (Scheduled).
- Media Coverage : Forbes ("An Inconvenient Truth", 15th July 2021)

Three Aspects of Green Bonds
- Conference: Financial Management Association (FMA) 2021 , American Economic Association 2022; American Finance Association 2022 (Doctoral Session); CMI Field Workshop 2021, The Econometric Society Meeting 2021 (Winter School) .

How do Debt Markets React to CSR?: Evidence from Indian Companies Act 2013 (with Iftekhar Hasan and N.K. Chidambaran)
- Conferences: New York University (NYU) - National Stock Exchange (NSE) Conference, 2018 * ; Global PhD Colloquium, 2019 ; Financial Management Association (FMA), 2020.
- Media Coverage: NSE White Paper

The Cost (and Unbenefit) of Conscious Capitalism (with Alokha Bilokha, Mingying Cheng, Benjamin Cole)
- Conferences: Financial Management Association (FMA), 2019; American Finance Association (AFA) 2021 (Doctoral Session)*; Midwest Finance Association, 2021.
- Media Coverage : Columbia Law School's Blog, Calcorporatelaw.com, The Active Investor

Impact of JOBS Act on M&As (with Sudip Gupta, Iftekhar Hasan and Anthony Saunders)
- Conferences: Mid-West Finance (MFA), 2018; Financial Management Association (FMA), 2018 ; 31st Australasian Finance and Banking Conference (UNSW, Sydney), 2018 *.
- Media Coverage: Columbia Law School's Blog

Tournament Culture and Corporate Misconduct(with Franco Fiordelisi).
- Conferences: Financial Management Association (FMA), 2020; FRG Field Workshop, 2020.
- Media Coverage : Oxford Law School's Blog

*Presentation by co-author

TEACHING INSTRUCTOR

- **Financial Management** (with James McCann) Rating: 4/5
  Undergraduate class of 100+ students. (Spring Semester, 2021)
- **Applied Finance** (with Robert George)
  Graduate class of 35+ students. (Spring Semester, 2020)
- **International Corporate Finance** (with Gautam Goswami) Rating: 4/5
  Undergraduate class of 60+ students. (Spring Semester, 2019)

ADHOC REFEREE

Journal of Financial Markets, Institutions and Instruments ; Emerging Markets Review; Journal of Futures Markets.

NON-ACADEMIC WORK EXPERIENCE

Intern, Research and Development, Indian Oil Corp. Limited May, 2008 - June, 2008
Senior Executive, Indian Oil Corp. Limited 2009-2013

MEMBERSHIP

American Finance Association (AFA); The Econometric Society; American Economic Association (AEA); Financial Management Association (FMA); Beta Gamma Sigma Society.

RELEVANT SKILLS

Computing: R, STATA, Python, Gephi, Big Data Analyitcs, ARCGIS, Dynare

OTHERS

- Selected for Harvard Asia Conference, 2015. (Panel: Finance and World Economy)
- Selected for Harvard Asia Conference, 2016. (Panel : Business and World Economy)
- Selected for Asia Economic Community Forum, 2015 (Similar to World Economic Forum, Davos)
- Q&A meeting with Harvey Schwartz (President and Co-COO of Goldman Sachs)

REFERENCES

Sris Chatterjee
Professor
Gabelli Chair in Global Security Analysis
Gabelli School of Business
Fordham University
New York, United States
Email: chatterjee@fordham.edu

Sanjai Bhagat
Professor
Provost Professor of Finance
Leeds School of Business
University of Colarado, Boulder
Colarado, United States
Email: sanjay.bhagat@colorado.edu

N.K. Chidambaran
Associate Professor
Gabelli School of Business
Fordham University
New York, United States
Email: chidambaran@fordham.edu

Gayane Hovakimian
Associate Professor
Gabelli School of Business
Fordham University
New York, United States
Email: hovakimian@fordham.edu

Shivaram Rajgopal
Professor
Roy Bernard Kester and T.W. Byrnes Chair
Columbia Business School
Columbia University
New York, United States
Email: sr3269@gsb.columbia.edu

Are carbon emissions associated with stock returns?

Jitendra Aswani
Fordham University

Aneesh Raghunandan
London School of Economics

Shiva Rajgopal
Columbia Business School

January 20, 2022

Abstract:

An influential emerging literature documents strong correlations between emissions and both stock returns and operating performance. We re-examine that data, using a sample of 2,729 U.S. firms from 2005-2019, and conclude that these associations are driven by three factors. First, unscaled raw emissions (in metric tons of CO_2), the variable typically used in academic literature, is correlated with stock returns but emissions intensity (emissions scaled by firm size), a more commonly used measure in practice, is not. Second, stock returns are correlated only with unscaled emissions *estimated* by the vendor compiling emissions data, but not with unscaled emissions *actually disclosed* by individual firms. The fact that vendor-estimated emissions exhibit systematic differences from firm-disclosed emissions, and are highly correlated with fundamental performance measures such as sales and assets, suggests that prior inferences merely capture the well-known association between stock returns and operating performance. Consistent with this assertion, the associations between emissions and stock return and operating performance disappear once we account for firm size, industry clustering of standard errors, and estimated versus disclosed emissions. Investors might want to be cautious about assuming that carbon emissions are priced by equity markets.

Keywords: Carbon Emissions, Stock Returns, Operating Performance, Trucost, Estimated Emissions

JEL classification: M14, G23, G34

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Are carbon emissions associated with stock returns?

1. Introduction

In this paper we evaluate whether carbon emissions are associated with stock returns, operating performance and Tobin's Q for a sample of 2,729 U.S. firms from 2005-2019. There is considerable interest in the disclosure and eventual reduction of carbon emissions generated by U.S. firms among the Biden administration,[1] the SEC,[2] large index providers such as BlackRock,[3] socially conscious investors,[4] proxy advisors,[5] and the media.[6] Investors are also interested in understanding whether reduction of emissions by firms in their portfolio can contribute to greater expected stock returns and better operating performance. In response to such demand among policymakers and practitioners, an emerging set of influential papers (Bolton and Kacperczyk 2021a and b; Matsumura, Prakash, and Vera-Munoz 2014; Garvey, Iyer, and Nash 2018; In, Park, and Monk 2019) find strong associations between carbon emissions and fundamental measures of firms' financial performance such as stock returns, operating profitability, and Tobin's Q. However, these papers rely on (i) specific research design choices such as relying on unscaled emissions or absence of clustering standard errors by industry or time, as well as (ii) the assumption that vendor-estimated carbon emissions are not systematically different from firm-disclosed carbon emissions. Our goal in this paper is to examine (i) and (ii) in detail and, in turn, to revisit the findings from the papers cited above.

The carbon emissions literature cumulatively proposes two economic arguments that would link carbon emissions to stock returns. The first argument is risk-driven. Specifically, in light of increasing pressure to "go green" by stakeholders such as those noted above, there is

[1] https://joebiden.com/climate-plan/
[2] https://www.sec.gov/news/speech/lee-playing-long-game-110520
[3] https://www.nytimes.com/2020/01/14/business/dealbook/larry-fink-blackrock-climate-change.html
[4] https://documents.nuveen.com/Documents/Nuveen/Default.aspx?uniqueId=CB6DF5E9-6268-4389-8317-E2B1C569398E
[5] https://www.issgovernance.com/esg/climate-solutions/carbon-risk-rating/
[6] https://www.ft.com/content/7ab0bfb0-b37c-463d-b132-0944b6fe8e8b

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greater risk of a reduction in the future cash flows of high-emissions firms. This risk captures factors such as the potential introduction of large carbon taxes by governments; changing tastes by consumers for greener products such as electric cars; or remedial costs to clean up carbon pollution imposed by regulators, society or courts. In turn, investors should seek a risk premium for holding high-emissions stocks. This argument, which underlies the findings in several recent studies (e.g., Bolton and Kacpercyzk 2021a, Pedersen, Fitzgibbons, and Pomorski 2021) suggests a positive association between emissions and stock returns.

Other studies (Cheng, Hong, and Shue 2020; Krueger 2015) suggest an alternative argument: that corporate actions undertaken for social responsibility purposes, including carbon emissions reduction efforts, reflect agency problems. More specifically, a firm that reduces its emissions may do so out of a desire by top executives to boost their public image rather than for bona fide economic reasons. In turn, the firm should then exhibit operational underperformance and, as a result, stock market underperformance. This argument suggests a negative relation between carbon emissions and stock returns.

Recent academic work emphasizes the correlation between unscaled carbon emissions (i.e., total metric tons of CO_2 emitted) and stock market performance. However, because of the economic nature of emissions with respect to a firm's production and output, it is not clear whether such correlations can be used to draw conclusions about the relation between a firm's stock market performance and its carbon performance.

Emissions arise from a firm's core operations and, absent significant short-term innovations in a firm's production process, unscaled emissions are largely a deterministic function of the quantity of goods produced and sold. To this end, within-firm variation in unscaled carbon emissions is almost entirely driven by variation in units of goods produced. Hence, we argue that on a standalone basis, a relation between unscaled emissions and stock returns – the focus of most prior academic work – can only be interpreted as evidence of a

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relation between a firm's productivity and its stock market performance, or a relation between firm's revenue, a proxy for quantity of units produced, and stock returns or performance. Conversely, studying emissions *intensity* – a metric favored by industry, reflecting the ratio of emissions to net sales – better reflects a firm's emissions performance by avoiding mechanical correlations with measures of firm size. As an analogy, using unscaled emissions rather than emissions intensity to measure carbon risk is analogous to using net income rather than ratio-based measures such as return on assets (ROA) to measure a firm's financial performance.

We take a closer look at this collective evidence on emissions and valuation in the current paper. We document several stylized facts related to emissions and stock returns. First, the literature cited above primarily uses unscaled emissions or changes in unscaled emissions as the key independent variable in testing the link between emissions and returns. We show that unscaled emissions are strongly correlated with firm size, industry composition and time. However, emissions intensity does not correlate with stock returns.

The finding above is especially important in light of our second stylized fact: the correlation between stock returns and emissions documented in prior research (e.g., Bolton and Kacperczyk 2021a, 2021b) is driven *entirely* by vendor-estimated emissions, as opposed to firm-disclosed actual emissions figures. That is, while we observe a relation between vendor-estimated emissions and stock returns, we find no relation between emissions and stock returns for firms that disclose actual CO_2 emissions values. This finding is particularly salient because roughly 80% of emissions figures in standard emissions databases are estimated by the data vendor as opposed to voluntarily disclosed by firms. We provide empirical evidence of systematic differences between vendor-disclosed and firm-estimated emissions figures.

Moreover, estimated emissions appear to be a nearly deterministic function of size, sales growth rates, industry membership (i.e., an "industry fixed effect") and time, rather than capturing *within-industry* differences in carbon efficiency that reflect within-industry

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heterogeneity in business models. For example, the univariate correlation between estimated scope 1 emissions and sales is 0.74, while the correlation between disclosed scope 1 emissions and sales is only 0.29. Similarly, the correlation between estimated (disclosed) scope 1 emissions growth rate and sales growth rate is 0.73 (0.24). Our results thus collectively suggest that prior findings documenting a link between stock returns and emissions are in fact merely replicating the well-known association between stock returns and operating performance.

We view this as the most plausible explanation for a statistical relation between emissions and stock returns: if firms' production processes are assumed by the vendor to remain relatively similar, then higher emissions, or emissions growth, primarily indicates firm growth (which investors have traditionally rewarded). This is a particularly important point for researchers and practitioners to appreciate because data coverage has significantly expanded in recent years (e.g., since 2016 in the Trucost database that we study). However, nearly all of this coverage expansion reflects an increase in vendor-estimated, rather than firm-disclosed, emissions. As a result, studies that focus on recent years – when discussion of carbon risk has become more politically relevant – will be particularly susceptible to this issue.

Third, because stock returns are also correlated with firm size, industry composition and time, correcting for these confounds eliminates the correlation documented before between stock returns and emissions. For robustness, we also explore three alternative measures of emissions (growth in emissions, carbon intensity measured as the ratio of unscaled emissions to revenues and change in carbon intensity) with similar non-results.

We find similar outcomes when we consider the relation between various measures of operating profitability (return on assets (ROA), EBITDA, return on sales (ROS)) and emissions. That is, correcting for confounds introduced by firm size, industry composition and time weakens or eliminates associations between operating profitability and the four versions of emissions discussed here. Moreover, the correlation documented by prior work between

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Tobin's Q and emissions is not robust to the issues highlighted here (confounds associated with size, industry composition, autocorrelation in emissions, and results stemming from estimated emissions as opposed to disclosed emissions).

For external validity, in additional analyses we consider European firms. Emissions disclosure is much more commonplace in Europe and, arguably, investors in European firms have traditionally placed greater weight on companies' nonfinancial performance (Gibson, Glossner, Krueger, Matos, and Steffen 2021). Despite these factors, our main results in the European setting are consistent with our U.S. results: we continue to observe no relation between carbon emissions and stock returns or fundamental measures of performance after accounting for potential clustering and systematic differences by size and industry.

Our findings suggest that socially conscious investors, policymakers and academics may want to be cautious in interpreting correlations between carbon emissions and either valuation constructs (Tobin's Q and stock returns) or fundamental accounting data (operating profitability). To be clear, we take no position on whether disclosing and/or cutting emissions is desirable or not. Rather, our paper is a comment on the methodological architecture and data underlying associations documented by prior research between emissions and firm valuation. In this regard, our paper is perhaps most similar to Larcker and Watts (2020), who establish a similar result in the context of green bonds.

The remainder of the paper is laid out as follows. Section 2 reviews why emissions may be priced and the related literature. Section 3 describes the data. Section 4 highlights issues that arise when using vendor-estimated rather than firm-disclosed emissions figures. Sections 5 and 6 report analyses related to whether emissions are associated with stock returns, fundamental measures of firm performance (operating profitability) or firm value (Tobin's *Q*). Section 7 extends some of our main analyses to the European setting. Section 8 concludes.

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2. Why should emissions be associated with stock returns or firm fundamentals?

2.1 Prior literature

A large emerging literature investigates whether climate risk is reflected in operating performance, valuation, stock returns and cost of capital (e.g., Andersson, Bolton, and Samama 2016, Baldauf, Garlappi, and Yannelis 2020, Bakkensen and Barrage 2021, Bernstein, Gustafson, and Lewis 2019, Chava 2014, Giglio, Maggiori, Rao, Stroebel, and Weber 2021, Hong, Li, and Xu 2019, Krueger, Sautner, and Starks 2020). As with most of these studies, our focus in this paper is specifically on carbon risk measured using CO_2 emissions. We view this measure as of first-order importance given its prevalence in academic literature, the media, and amongst ESG rating agencies.[7]

Prior literature linking emissions to financial performance primarily views carbon emissions as a source of firm risk, for which investors seek compensation for holding stocks of high carbon emitters. Such compensation would manifest as a risk premium, observable as a positive relation between carbon risk and stock returns. Carbon-related risk potentially arises from heightened firm exposure to future cash flow shocks resulting from both direct actions (e.g., governmental carbon taxes or remedial environmental costs that the emitter might be forced to incur on behalf of the taxpayer) as well as indirect actions (e.g., consumer taste functions increasingly incorporating 'greenness'). In line with this argument, Khan, Serafeim and Yoon (2016) claim that firms that have disproportionately reduced their emissions can generate higher than expected earnings. Similarly, Matsumura et al. (2014) find a relation between higher emissions and lower firm values. Other studies more directly tie emissions performance to stock market performance: for example, In et al. (2019) find a stock returns alpha by buying (shorting) low (high) emission stocks. Finally, in a notable recent paper,

[7] For instance, Sustainalytics provides as a supplementary product to its main ESG ratings a "Carbon Solutions Suite" and frequently references decarbonization commitments in its blog posts (e.g., https://www.sustainalytics.com/esg-blog/the-race-to-net-zero-decarbonization-commitments-in-the-oil-gas-industry/). Several other ratings providers offer similar products.

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Bolton and Kacperczyk (2021a) document a positive association between unscaled emissions and both stock returns and operating profitability, arguing that this supports the risk premium argument. Notably, in their primary tests, these studies all measure carbon performance differently; our goal in this paper is to highlight the effect of such measurement choices.

2.2 Does a relation between emissions and returns actually reflect a carbon risk premium?

As discussed above, several studies in accounting and finance document evidence of a relation between a firm's total emissions (in metric tons of CO_2) and both lower firm values and higher stock returns, interpreted as evidence of a risk premium. It is useful to consider alternative reasons that a firm's total emissions may relate to its stock market performance, in terms of a firm's underlying economics. Specifically, carbon emissions arise as a byproduct of a firm's production process and, in the absence of sudden technical change, are likely to be highly correlated with the quantity of firms' output over time. In other words, emissions are a variable rather than fixed quantity for a firm, and not subject to the economies of scale that may arise in other parts of a firm's production process (e.g., overhead). To that end, if firms' production processes do not substantially change within a given time period then it is difficult for a firm to substantially reduce its emissions per unit of goods produced.

In turn, emissions are highly correlated with sales. To that end, year-over-year increases in emissions primarily indicate firm growth. This may explain Garvey et al.'s (2018) finding of a negative relation between the *change* in unscaled emissions and firms' operating profitability, as growth firms can exhibit lower short-term profits while they incur up-front investment costs. It is difficult to argue that this result is primarily driven by emissions per se; rather, it reflects the correlation between a primary determinant of emissions (the firm's level of output) and capital market performance.

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2.3 Emissions, operating performance, and stock market performance

The issues described above do not imply that emissions *cannot* directly affect a firm's financial performance. For example, high emissions can directly lead to subsequent clean up-costs, carbon taxes, or inefficient use of productive resources (Garvey et al. 2018). In turn, this gives rise to an alternative hypothesis, relative to the risk premium hypothesis outlined in Section 2.1, on the relation between emissions and stock market performance. Specifically, the costs associated with high emissions should be reflected in future cash outflows of high-emissions firms, because higher cost of equity and debt capital would potentially lead to under-investment in capital projects. Underinvestment may result in lower operating performance, which in turn should result in lower stock returns.

2.4 Measurement issues

To test the competing theories laid out in Sections 2.1 and 2.3, it is necessary to distinguish emissions from other measures of size. As we highlight in Section 2.2, however, it is very difficult to use a firm's *total* emissions output to do this, because of the mechanistic way in which emissions relate to production in the short term within industries. To that end, a relation between emissions and operating or stock market performance may simply reflect the relation between size or growth and performance. As a result, we argue – following common industry practice – that emissions intensity (the ratio of emissions to measures of size, e.g., sales) represents the appropriate way to measure a firm's carbon footprint and risk. One goal in this paper is, therefore, to highlight the different conclusions that a researcher can draw when using total emissions as opposed to emissions intensity as a measure of carbon footprint.

Even a model that controls for size, but that does not appropriately account for systematic differences across industries, suffers from the possibility that a correlation between returns and emissions simply reflects industry trends. In this case, the onus is then on the

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researcher to show that the under- or over-performance of an industry reflects emissions concerns rather than other issues (e.g., political instability in major oil-producing countries). To this end, we argue that to accurately document a relation between emissions and financial performance, *within*-industry comparisons will typically be more appropriate. Many of the studies noted above do not account for fixed effects or clustering at the industry (or more granular) level; as we will show, doing so materially affects inferences.

3. Data and descriptive properties of carbon emissions

3.1 Financial data

Our primary carbon emissions database is Trucost, which provides carbon emissions data for both U.S. and global firms from 2005-2019. We merge Trucost data with stock returns data from CRSP and fundamental financial data from COMPUSTAT by matching on CUSIP number. The intersection of CRSP, COMPUSTAT and Trucost provides us with a sample of 2,729 unique firms corresponding to 214,229 firm-month observations.[8] We outline our process for arriving at the set of 2,729 distinct firms in Table 1.

3.2 Emissions data

We obtain emissions data from Trucost. Trucost uses various publicly disclosed sources, such as company financial reports (annual reports, financial statements, 10-K/20-F reports, regulatory filings), environmental data sources (corporate social responsibility [CSR], sustainability, or environmental reports, the Carbon Disclosure Project, Environmental Protection Agency filings), and data published on company websites or other public sources.[9] If a firm does not disclose emissions data voluntarily, Trucost uses an environmentally

[8] Out of 4,023 firms covered by Trucost's US database, we retain firms that meet the following criteria: (i) ISIN and CUSIP identifiers are not missing; (ii) the firm is US incorporated; (iii) the firm's status is not "out of business"; and (iv) emissions and returns data is not missing.

[9] https://www.spglobal.com/spdji/en/documents/additional-material/faq-trucost.pdf

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extended input-output (EEIO) model to estimate environmental impacts for a company's own operations and across its global supply chain. The EEIO model combines industry-specific environmental impact data with quantitative macroeconomic data on the flow of goods and services between different sectors in the economy. Most data provided by Trucost reflects estimated rather than firm-disclosed figures; we document later on systematic biases in these figures and the effects of such bias on the link between carbon emissions and stock returns.

Emissions data are usually reported under the Greenhouse Gas (GHG) protocol and are measured in tons of CO_2 (carbon dioxide) per year. The GHG protocol specifies three scopes of emissions. Scope 1 reflects direct emissions sources that are owned or controlled by a company. For example, scope 1 includes the emissions produced by the internal combustion engines of a trucking company's trucking fleet. Scope 2 emissions are from the consumption of purchased electricity, steam, or other sources of energy generated upstream from a company's direct operations. Scope 3 encompasses all other emissions associated with a company's operations that are not directly owned or controlled by the company.[10]

Scope 3 emissions include several sources of indirect emissions in both the company's supply chain and from use by customers of the company's products. For example, if a shipping company purchases a truck from a truck manufacturer, the emissions caused by the shipping company's usage of the truck contributes toward the shipping company's scope 1 emissions and the manufacturer's scope 3 emissions. Given the expansive definition of scope 3 emissions, scope 3 represents the majority of a company's emissions footprint in most industries.[11] We

[10] Scope 3 emissions arise from two sources: upstream or downstream. Upstream sources reflect purchased goods and services, purchased capital goods, fuel and energy related activities, transportation and distribution of raw materials, waste generated in operations in the upstream input suppliers, business travel, employee commuting, leased assets. Downstream sources include transportation and distribution of products sold, processing, use and end-of-life treatment of sold products, investments in other businesses that generate emissions and leasing out assets to businesses that generate emissions.

[11] For more details on scope 3 emissions, please refer to https://www.epa.gov/climateleadership/scope-3-inventory-guidance

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provide descriptive statistics for all variables in Table 2. In the Online Appendix in Table OA1, we additionally provide mean values of carbon emissions as well as emissions intensity by year and industry for each of scope 1, 2, and 3 emissions.

3.3 Trucost expanded coverage in 2016

Table 3, Panel A depicts the yearly distribution of observations found in the Trucost database. As can be seen from Columns (1) and (2), coverage in Trucost ranges from 690 to 859 distinct firms for years between 2005 and 2015. Beginning in 2016, Trucost substantially expanded its coverage, nearly tripling from 2015 to 2016. However, most of this expanded coverage is a result of Trucost estimating emissions figures for these firms, an issue we discuss in greater detail in Section 4. The number of firms covered between 2016 and 2019 ranges from 1992 to 2645 distinct firms. Because we conduct returns tests at the firm-month level following Bolton and Kacperczyk (2021a), the number of observations corresponds to approximately 12 times the number of firms per year.[12]

Panel B of Table 3 details coverage of firms sorted by industry based on 6-digit GICS industry classification. For brevity, in this panel we only provide the ten most and least common industries; a full list can be found in Online Appendix Table OA2. The five most represented industries in terms of number of distinct firms are (i) banks (230 firms); (ii) biotechnology (179 firms); and (iii) REITs (168 firms); (iv) software (118 firms); and (v) oil, gas and consumable fuels (98 firms). Apart from oil and gas, these industries are those that one would not expect to be large emitters of greenhouse gases. Moreover, as we show later, the proportion of estimated emissions in these industries is substantially higher than the sample average (e.g., nearly *all* financial institutions' emissions figures are estimated by the vendor rather than actual firm-provided figures).

[12] Certain firm-years may have returns data missing for some months. When a company has dual-class shares we also include return observations for both share classes, which is why the number of observations is sometimes greater than 12 times the number of distinct firms. In un-tabulated analyses, we verify that the deletion of dual-class shares does not alter any reported inferences.

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3.4 Firm size is highly correlated with unscaled emissions and returns

In Table 4, Panel A we present data on correlations between the three types of carbon emissions (scope 1, 2, and 3) in terms of both raw emissions and emissions intensity. We observe that the three types of emissions are highly correlated with one another in Panel A; the Pearson correlation between the natural logarithm of scope 1 emissions and the natural logarithm of scope 2(3) emissions is 0.988 (0.999).

In Panel B we observe a strong correlation between raw emissions and three measures of firm size (the natural logarithms of market capitalization, the number of employees, and net sales). For instance, the correlation between log scope 1 emissions and log sales is 0.719, with log market cap is 0.523 and with log employees is 0.611. The log of scope 3 emissions exhibits an even higher correlation with all three measures of firm size. This likely reflects measurement limitations; because scope 3 emissions are harder for the firm to directly measure, they are more likely to be estimated by the data vendor. The correlations reported in Table 4, Panel B suggest that a key component of the models used to estimate scope 3 emissions is firm size.

As can be seen from Table 4, Panel B, the correlation between carbon intensity and firm size is much lower. For instance, the correlations between scope 1 emissions intensity and log market cap, log employees, and log sales are 0.082, 0.045, and 0.125, respectively. We observe similarly low figures for the correlations between scope 2 and 3 emissions intensity and firm size. Hence, measuring carbon emissions in terms of intensity, rather than its raw value, effectively neutralizes any mechanical correlation with firm size.

4. Disclosed vs. vendor-estimated emissions

Trucost data contains a mix of emissions data directly disclosed by firms as well as Trucost-estimated emissions figures for non-disclosing firms. This practice is standard among emissions data vendors. Busch, Johnson, and Pioch (2020) study the emissions figures provided

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by various emissions data vendors and document a high correlation (around 0.97) among the disclosed values of emissions reported by various commercial data providers such as CDP (Carbon Disclosure Project), Trucost, MSCI, Sustainalytics, and Thomson Reuters, suggesting that when actual (firm-disclosed) emissions data exists it is captured accurately by data providers. However, the correlation among estimated values reported by these vendors is only 0.66. This pattern raises concerns about the validity of proprietary estimation methods used by data providers. If proprietary estimation methods rely heavily on firm fundamentals and industry-level factors (e.g., assuming that all firms in a given industry use similar transportation or waste disposal practices, and accordingly estimating emissions generated through such activities), then two potential problems arise.

First, it would not be possible to use vendor-estimated emissions figures to assess *within-industry* relative differences in carbon performance because within-industry differences reflected in estimated emissions figures would *only* reflect within-industry differences in financial fundamentals such as operating costs or sales. Second, and relatedly, a correlation between vendor-estimated emissions and stock market performance would *only* reflect the well-known correlations between various firm fundamentals and stock prices. By way of an example, prior literature documents a positive correlation between stock returns and sales growth rates. If estimated emissions are a mechanical function of sales growth rates, then a researcher who documents a positive correlation between estimated emissions and stock returns may improperly interpret this as evidence of a carbon risk premium when the result simply reflects the well-known correlation between sales growth and stock returns.

To underscore the importance of understanding whether systematic differences in firm-disclosed and vendor-estimated emissions figures affect prior inferences, Table 5 highlights the pervasive nature of vendor-estimated values of emissions in the data. As can be seen in the rightmost column of Panel A, the proportion of estimated values is as high as 86% in 2005, the

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first year for which Trucost is available. Voluntary disclosure of emissions steadily increases such that estimated values fall to a sample low of 54% in 2015. However, the large increase in Trucost's coverage universe starting in 2015 is driven almost entirely by estimated values, which causes the proportion of estimated figures to once again jumps significantly. The number of firms voluntarily disclosing emissions during this time period increased relatively slowly from 396 in 2015 to 540 in 2018. Eighty percent of observations reported by Trucost in 2018 are estimated. Data for 2019 appears to be incomplete, as of when we obtained the data (in October 2020), in that only 1992 firms are covered.

Panel B of Table 5 lists the proportion of observations that are estimated versus disclosed in the top ten and bottom ten industries, by proportion of observations estimated, for industries with at least 10 distinct firms. The industries reporting the lowest proportion of estimated emissions are (i) airlines (7%); (ii) multi-utilities (7%); (iii) technology, hardware, storage and peripherals (40%); (iv) containers and packaging (44%); and (v) food products (44%). The industries reporting the highest proportion of estimated emissions are (i) diversified consumer services (100%); (ii) health care technology (100%); (iii) thrifts and mortgage finance (100%); (iv) REITs (100%); and (v) biotechnology (93%). Perhaps more worrisome, several industries populated by large numbers of firms such as banks (230 firms), REITs (168 firms), software (118 firms), biotechnology (193 firms) and specialty retail (84 firms) are dominated by estimated emissions (in excess of 80% of observations).[13]

To test for systematic differences in Trucost-estimated versus firm-disclosed emissions, we exploit the fact that firms gradually began disclosing emissions figures more frequently over the sample period (see Table 5 Panel A). We observe 431 firms which have Trucost-estimated emissions figures during parts of the sample period before subsequently disclosing

[13] We provide a full list of industries and the proportion of observations that are estimated versus disclosed for each of those industries in the Online Appendix, Table OA2.

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emissions figures. If Trucost's estimates are a fully accurate reflection of the idiosyncratic components of firms' business models beyond industry and size, we should not observe any statistically significant within-firm difference between estimated and disclosed figures. We test this assertion using the following set of regression models:

$$Emissions_{it} = \alpha_0 + \alpha_1 Estimated_{it} + \alpha_2\, Controls_{it} + \theta_i + \gamma_t + \varepsilon_{it} \qquad (1)$$

In Equation (1), $Emissions_{it}$ reflects the natural logarithm of either scope 1, 2, or 3 emissions while $Estimated_{it}$ is an indicator variable that equals 1 if the corresponding emissions figure was estimated. For example, if $Emissions_{it}$ reflects scope 3 emissions, then $Estimated_{it}$ equals one if firm *i*'s scope 3 emissions figure corresponding to month-year *t* is vendor-estimated and zero if firm *i*'s scope 3 emissions figure corresponding to month-year *t* is firm-disclosed. The quantities θ_i and γ_t denote firm and time fixed effects, respectively.

The presence of the firm fixed effect θ_i means that the coefficient α_1 on $Estimated_{it}$ is driven by *within-firm* changes over time in emissions disclosure status (and, as such, identified by the 431 distinct firms that have both estimated and disclosed emissions at some point during the sample period. If Trucost estimates are accurate, then disclosure should not reveal new information about the firm's levels of emissions and, in turn, we would expect α_1 to be statistically insignificant (because within-firm changes over time should be similar irrespective of disclosure status). Conversely, if Trucost estimates are systematically biased upward (downward), we would expect α_1 to be positive (negative).

Results from estimating Equation (1) are presented in Table 6. In Columns (1) – (3) we begin by estimating the most basic form of Equation (1), including only firm and time fixed effects and the indicator $Estimated_{it}$ on the right-hand side. We see that Trucost's scope 1 emissions appear to be systematically biased upward, while Trucost-provided scope 2 and 3 emissions appear to be systematically biased downward. In Columns (4) – (6) we introduce several control variables, based on those in Bolton and Kacperczyk (2021a). Our results

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continue to hold. In addition, we observe a strong correlation between emissions (all of scope 1, 2, and 3) and log sales, sales growth, and PP&E, suggesting that firm size and sales growth are the primary drivers of emissions estimation models.

The results above highlight the importance of understanding whether the relation documented in prior papers, such as Bolton and Kacperczyk (2021a), between emissions and stock returns holds for both estimated and actual emissions. If the relation between stock returns and Trucost emissions figures is driven entirely by *estimated* emissions, that would suggest that such a relation is merely picking up a correlation between firm fundamentals and stock returns rather than a carbon risk premium or carbon penalty. We provide empirical tests pertaining to this issue in Sections 5 and 6.

5. Do carbon emissions explain stock returns?

Several studies, most notably Bolton and Kacperczyk (2021a, 2021b), document a strong correlation between emissions and contemporaneous stock returns. In this section, we first replicate their findings and then extend them to argue that the association they document is attributable to a combination of three factors. First, unscaled emissions is largely a proxy for firm size and emissions scaled by size loses its predictive power for returns. Second, the link between unscaled emissions and returns is clustered in industries that have significantly under- or over-performed during the sample period and, hence clustering standard errors by industry removes evidence of the correlation between emissions and returns. Third, the association between emissions and returns is entirely attributable to vendor-estimated emissions numbers, which are a mechanistic function of financial fundamentals (see Section 4), rather than firm-disclosed emission numbers.

5.1 Regression of returns on emissions

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To formally document the association between returns and emissions, and to highlight the importance of research design choices in the process, we first replicate the cross-sectional specification used in Bolton and Kacperczyk (2021a). We then extend this formulation by (i) introducing industry fixed effects and (ii) by clustering standard errors at the industry and month-year level. We introduce (i) and (ii) because both stock price performance and emissions are correlated with industry membership and time. For all three categories of emissions, the independent variable, "Emissions," can take one of four forms: (i) companies' unscaled emissions; (ii) year-over-year growth in unscaled emissions; (iii) carbon intensity; and (iv) change in carbon intensity. These four independent variables are meant to cover the most-commonly used carbon variables in prior academic work and in practice. We estimate the following cross-sectional regression model:

$$RET_{it} = \alpha_0 + \alpha_1 \, Emissions_{it} + \alpha_2 \, Controls_{it} + \gamma_t + \delta_{industry} + \varepsilon_{it} \qquad (2)$$

The dependent variable (RET) in Equation (2) is monthly stock returns for firm *i* in month-year *t.* As mentioned above, the main independent variable *Emissions* takes the form of log unscaled emissions, growth in unscaled emissions, and carbon intensity for scope 1, scope 2, and scope 3 emissions.[14] For robustness, following Garvey et al. (2018), we also study the year-over-year change in carbon intensity. The vector of controls includes a host of firm-specific variables known to be associated with stock returns, following Bolton and Kacperczyk (2021a). These variables are the natural logarithm of sales (LOGSALES), return on equity (ROE), leverage (LEVERAGE), the ratio of capital expenditures to assets (INVEST/A), industry Herfindahl concentration index (HHI), the natural logarithm of property, plant, and equipment (LOGPPE), sales growth (SALESGR), and growth in earnings per share (EPSGR).

[14] Trucost provides emissions data according to calendar year. However, to remain consistent with prior literature (e.g., Bolton and Kacperczyk 2021a), we match returns with emissions in the same calendar year and estimate our regressions at the firm-month-year level rather than the firm-year level. In untabulated work, we find that our results are robust to substituting lagged values of control variables for contemporaneous values.

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The coefficients γ_t and $\delta_{industry}$ represent month-year and GICS industry fixed effects. Standard errors are two-way clustered at the 6-digit GICS industry and month-year level.

Table 7 presents results from estimating Equation (1). Panel A shows results for the baseline scenario and for a reduced set of controls. Columns (1)-(3) show the negative association between returns and emissions documented earlier. However, controlling for firm size in columns (4)-(6) renders the coefficient on emissions insignificant.[15]

Contrary to what we find in Panel A, Bolton and Kacperczyk (2021a) hypothesize and find that carbon risk is reflected in the data as a positive association between emissions and monthly stock returns.[16] One possibility for this disparity is that the positive association they document is an artefact of control variable selection choices. We provide support for this assertion in Panel B of Table 7 by introducing a battery of control variables as used in Bolton and Kacperczyk (2021a) and demonstrating how the coefficient on the carbon emissions variables change. For brevity, we tabulate results only using Scope 1 emissions. We see from Table 7 Panel B that including just $LOGSALE_{it}$ (the natural logarithm of firm *i*'s total sales in year *t*) renders the coefficient on emissions insignificant in predicting stock returns. When we then add further control variables (PP&E or the ratio of investment to total assets), the coefficient on emissions flips to positive. In essence, the risk-based explanation for emissions is sensitive to the introduction of specific control variables to the regression specification.[17]

We next turn to our main specifications, in Table 7 Panel C. Columns 1-3 report the complete specifications estimated by Bolton and Kacperczyk (2021a). Consistent with their

[15] Following Bolton and Kacperczyk (2021a), in a sensitivity test we drop 106 firm-month observations where returns are greater than 100%. We also check outliers of stock returns; the 1st and 99th percentile of stock returns are -29% and 34%, respectively. Our results are not driven by outliers beyond these two cutoff points; when we re-run our specifications using winsorized returns (at the 1% level), our results continue to hold.

[16] We work with contemporaneous monthly returns to be consistent with the design choice adopted by Bolton and Kacperczyk (2021a). Our inferences are robust to re-estimating Equation (2) using one month ahead returns.

[17] Following Bolton and Kacperczyk (2021a), we winsorize LEVERAGE and INVEST/A at the 2.5% level, and SALESGR and EPSGR at the 0.5% level. Our inferences are robust to winsorizing at the 1% level instead.

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reported specifications, the coefficients on log scope 1, 2 and 3 emissions are positive and statistically significant. Note that columns (1)-(3) do not (i) incorporate industry fixed effects or (ii) adjust standard errors by clustering along either industry or time dimensions. Instead, standard errors are not clustered on any dimension.

Columns (4)-(6) relax one of these constraints in that industry fixed effects are introduced. Consistent with the industry patterns associated with stock returns mentioned earlier in section 3, the coefficient on emissions loses statistical significance. Columns (7)-(9) represent an even more rigorous econometric regimen in that standard errors are now clustered at both the industry level and month-year level. This is necessary because errors in returns (and emissions) are correlated within industry and over time, especially within months. The coefficients on emissions continue to remain insignificant. It is useful to note that, regardless of the specification used, the following variables retain statistical significance: (i) positive coefficients on ROE and on sales growth; and (ii) negative coefficients on leverage and investments. These results are consistent with prior literature in asset pricing linking stock returns to firm fundamentals, suggesting that returns are higher for growing and profitable firms and lower for firms with greater leverage and investments. In additional analyses (see Online Appendix Table OA3), we confirm that these results are robust to using future stock returns in lieu of concurrent returns as our dependent variable.

Panels D, E and F of Table 7 report the results of similar regressions with one change: carbon intensity, change in unscaled emissions and change in carbon intensity replaces log of unscaled emissions as the primary independent variable of interest. As can be seen, apart from the change in unscaled emissions, there is no significant association between any of these three variants of emissions and stock returns.

5.2 Vendor-estimated vs. firm-disclosed emissions

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In Table 8, we turn to potential differences in vendor-estimated and firm-provided carbon emissions disclosures. We partition the sample according to whether the emissions figure for a given firm-year corresponds to disclosed or estimated figures. To ensure that our results are driven by the estimated vs. disclosed distinction, rather than the other design choices highlighted in Section 5.1 above, we mimic the main specification from Bolton and Kacperczyk (2021a) as closely as possible: the same control variables as theirs, month-year but not industry fixed effects, and no clustering of standard errors.

Using this specification, in columns (1) – (3) of Panel A, we estimate Equation (1) for firm-disclosed emissions observations only and show that the coefficient on disclosed values of unscaled emissions is statistically insignificant. In contrast, in Columns (4) – (6), we re-estimate Equation (1) only for vendor-estimated emissions observations and find that the coefficient on estimated values of unscaled emissions is positive and significant at the 1% level (shown in columns (4) – (6)). This suggests that the positive relation between returns and emissions found in prior work stems *entirely* from estimated emission values generated by Trucost using proprietary models. This result is surprising, as one would expect firms' voluntary disclosures to be more reliable than emissions estimated by a vendor. Moreover, estimated emissions are largely a mechanistic function of financial fundamentals, as we illustrate in Table 6. Collectively, these results suggest that prior empirical evidence of a relation between emissions and stock returns merely reflects the well-known correlation between firm fundamentals and stock returns.

In Panels B, C, and D of Table 8, we re-run the estimation in Panel A but using as our emissions variable emissions intensity (in Panel B), year-over-year growth in carbon emissions (in Panel C), and the year-over-year absolute change in carbon emissions intensity (in Panel D). We find mixed evidence of a positive relation between estimated emissions intensity and stock returns. However, we find no relation between firm-disclosed emissions intensity and

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returns. Similarly, in Panel C, we find robust evidence that estimated emissions growth is associated with *higher* stock returns but again little evidence of a relation between firm-disclosed emissions growth and returns. This result may be driven by the importance of net sales and/or sales growth in Trucost's emissions estimation procedure: the univariate correlation between sales growth and *disclosed* emissions growth is 0.249, while the correlation between sales growth and *estimated* emissions growth is nearly three times at high at 0.726. Finally, in Panel D, we observe limited evidence of a correlation between the year-over-year change in scope 3 emissions and stock returns – but no results for scope 1 or scope 2. Given that scope 3 emissions are often not disclosed even when scope 1 emissions are disclosed, we interpret Panel D as consistent with there being no relation between the change in actual (rather than estimated) emissions intensity and stock returns.

In sum, the association between returns and emissions documented by prior work is attributable to (i) unscaled emissions being correlated with firm size; (ii) industry clustering in returns and emissions; and (iii) estimated emissions numbers generated by Trucost, which are heavily reliant on firm fundamentals such as sales, as opposed to self-disclosed emissions variables by firms.

6. Do carbon emissions explain operating performance?

A possible explanation for our results thus far is that, as discussed in Section 2.3, carbon emissions may have an *indirect* effect on firm performance through a relation with firm fundamentals. To assess this possibility, we directly test the relation between emissions and five popular measures of profitability or operating performance defined as follows: (i) EBIT Margin_{it}, which is the ratio of earnings before interest and taxes by sales for firm *i* in year *t*; (ii) EBITDA Margin_{it} ,which is the ratio of earnings before interest, taxes, depreciation, and amortization by sales for firm *i* in year *t*; (iii) ROA_{it}, which is return on assets, and is measured

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as the ratio of operating income after depreciation to total assets for firm *i* in year *t*; (iv) ROS_{it}, which is return on sales, measured as the ratio of operating income after depreciation to sales for firm *i* in year *t*; and (v) Tobin's Q, which is measured as the ratio of (market value of equity plus book value of assets minus book value of equity) to total assets.

To examine the association between operating performance and emissions, we estimate the following regression:

$$Performance_{it} = \alpha_0 + \alpha_1 Emissions_{it} + \alpha_2 Controls_{it} + \gamma_t + \delta_{industry} + \varepsilon_{it} \quad (3)$$

The dependent variable, $Performance_{it}$, is one of the five measures described above for firm *i* and month-year t.[18] The main independent variable *Emissions* takes the form of log of unscaled emissions, growth in unscaled emissions, carbon intensity and the change in carbon intensity. We use the same controls as in the return specification. To address the time invariant and industry invariant un-observables, month-year fixed effects (γ_t) and industry fixed effects ($\delta_{industry}$) are introduced. Standard errors are clustered by industry and month-year to address the concern that profitability and emissions are correlated for the same industry and over time.

Table 9 reports regression results corresponding to this specification. For brevity, we tabulate results using only scope 1 emissions. In addition, in Table 9 we tabulate only results using log emissions and emissions intensity; additional results using our other two measures of carbon emissions (growth in emissions as well as change in emissions intensity) are available in Online Appendix Table OA4. Panel A shows that EBIT margin, EBITDA margin and ROS are positively associated with unscaled scope 1 emissions. However, Panel B suggests that carbon intensity is not associated with any of these profitability measures.[19] Moreover, the

[18] Although all variables in Equation (2) are measured at the firm-month year level, we also estimate the model at the firm-year level. Our findings (un-tabulated) are unchanged if we instead estimate Equation (2) at the firm-year level.

[19] Garvey et al. (2018) show that the change in carbon intensity is negatively associated with future ROA. We confirm their results (see Internet Appendix Table IA2) using the same specification. However, this result is sensitive to model specification: when we instead use the control variables from Bolton and Kacperczyk (2021), we no longer find a significant relation between the change in carbon intensity and future ROA.

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correlations documented in Panel A between emissions and EBIT margin, EBITDA margin, and ROS disappear when we consider only firm-disclosed emissions figures in Panel C. In contrast, we do observe a negative correlation between Tobin's Q, a proxy for firm value, and emissions. That is, consistent with Matsumura et al. (2014), the natural logarithm of unscaled scope 1 emissions is negatively correlated with Tobin's Q in column (5) of each of Panels A and C of Table 9. However, this may simply reflect a correlation between Tobin's Q and firm size; the association between Tobin's Q and other transformations of carbon emissions is mixed or statistically insignificant (see Online Appendix Table OA5). For instance, in column (5) of Panel B of Table 9, carbon intensity is uncorrelated with Tobin's Q. In un-tabulated results, we also document a positive association between Tobin's Q and the growth in unscaled scope 1 emissions (but this result disappears on the subsample of observations with firm-disclosed emissions) and no relation between Tobin's Q and the change in emissions intensity. In sum, we do not find compelling evidence that emissions indirectly affect stock returns through an effect on firm performance.

7. Europe

Our results thus far focus on US firms, in line with much of the prior literature we cite. However, one limitation of a US focus is that the financial and regulatory environment in the US may significantly differ from those of other countries, which in turn may lead to a relation between carbon emissions and financial or stock market performance in those settings. Should such a relation exist, it is likely to be in areas of the world with the strongest pressures to 'go green', because these are the areas in which investors are likely to be most conscious of carbon risk. We therefore directly test for a potential relation between stock market performance and carbon emissions in one such setting: European firms. Existing literature (e.g., Gibson et al. 2021) argues that European investors appear more credible in their commitments to responsible

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investing than American investors, which in turn may lead to a genuine relation between carbon emissions and stock returns in Europe even if no such relation exists in the US. In doing so, our tests in this section serve as a validation exercise of a concurrent working paper, Bolton and Kacperczyk (2021b), who extend the approach in their published paper (Bolton and Kacperczyk 2021a) and find evidence of a carbon premium in both cases.

7.1 European data

As with our US data, we obtain carbon emissions data from the European setting from Trucost. In the Online Appendix, we provide a detailed breakdown (analogous to Tables 1-3) of our European sample by year, industry, and country, as well as according to the proportion of observations that are estimated versus disclosed. Of note is the fact that emissions are much more commonly disclosed in Europe vis-à-vis the US: 46% of firm-years disclose emissions figures in Europe relative to the 25% figure in our sample. We observe significant heterogeneity across countries; for instance, 62% of UK firm-years disclose emissions figures while only 43% of Swiss firm-years make such disclosures. As with the US, the proportion of firms that disclose emissions steadily rises over time until 2016, when Trucost's data expansion injects a number of firms with estimated figures into the sample.

To construct tests in the European setting, we obtain financial fundamental data as well as stock returns data from Datastream. After imposing similar screens to the US setting, we obtain 254,717 firm-month observations spanning 36 countries between 2005 and 2019. Of these observations, countries most commonly occurring in our sample are the United Kingdom (30.4% of observations), France (10.5%), Germany (9.0%), and Switzerland (7.9%).[20]

7.2 Results

[20] We provide complete descriptive information on properties of emissions in Europe in Tables OA6 – OA11 (which mimic Tables 1-6 in the main body of the draft, for the US setting).

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We present results pertaining to European firms in Table 10. For brevity we do not tabulate the complete set of results presented thus far in the body of the text. We instead focus, in this section, on (i) the importance of properly accounting for clustering within industries and time periods and (ii) the distinction between unscaled carbon emissions and emissions intensity.

In Panel A of Table 10, we re-estimate Equation (2), with one minor modification: because we are now using a cross-country sample, we incorporate country fixed effects. We begin in columns (1)-(3) by following Bolton and Kacperczyk's (2021b) specification, using time and country fixed effects but neither industry fixed effects nor clustered standard errors. Consistent with Bolton and Kacperczyk's (2021b) results for non-US firms, we document a positive and significant correlation between carbon emissions and stock returns in columns (1)-(3) of Panel A, providing what appears to be evidence consistent with a carbon risk premium. However, accounting for clusters in industry and time as well as industry membership, in columns (4)-(6), removes this effect. We observe similar non-results in Panel B, where we instead consider carbon emissions intensity rather than unscaled emissions; in fact, in column (4), we even observe a weakly negative coefficient on scope 1 emissions intensity after accounting for industry membership. We provide additional analyses in support of this conclusion in the Online Appendix, table OA12, where we construct a table analogous to Table 9 for the European setting. As before, our results suggest that properly accounting for size and industry clustering in returns removes evidence of a carbon premium. Collectively, our results in this section provide external validity for the findings in Section 5.

8. Conclusion

Research on climate finance has exploded in recent years driven by demand for such work by both policy and practice. Researchers have documented mixed results with respect to

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the value relevance of CO_2 emissions. For instance, Bolton and Kacperczyk (2021a) and Garvey et al. (2018) document a positive relation between unscaled carbon emissions and stock returns and operating profitability while Matsumura et al. (2014) find a negative relation between Tobin's Q and emissions.

Consistent with Bolton and Kacperczyk (2021a), we find a positive relation between the natural logarithm unscaled emissions (or growth in unscaled emissions) and stock returns. However, these results weaken or disappear once we (i) scale emissions by firm size (revenue); (ii) add industry fixed effects to account for industry clustering in emissions and returns; and (iii) cluster standard errors of a regression of returns on emissions at industry and time. To probe the nature of the emission data further, we partition the emissions data into observations where the firm voluntarily discloses CO_2 data versus those estimated by the vendor of such data. We find that, even in the absence of steps (i)-(iii) above, the association between stock returns and unscaled emissions in Bolton and Kacperczyk (2021a) comes entirely from estimated rather than firm-disclosed emissions. Estimated emissions are far more strongly correlated with firm size, industry composition and time than firm-disclosed emissions, suggesting that a statistical relation between "carbon emissions" and stock returns in prior work merely reflects well-known correlations between firm fundamentals and stock returns.

Consistent with Garvey et al (2018), we confirm a negative association between profitability (measured as return on assets) and change in carbon intensity using the same specification as given in their paper. However, these results are not robust to controls for size, industry fixed effects and standard errors clustered at the industry and month level. Moreover, as with stock returns, the association between emissions and profitability is found only for estimated values and not for disclosed ones. This again suggests that prior results merely capture associations between various measures of firms' financial fundamentals. Similar mixed

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or statistically insignificant inferences are also obtained when we consider the earlier correlations documented between Tobin's Q and unscaled emissions.

In sum, this paper shows that the positive or negative relation between carbon emissions and stock returns, profitability and firm value documented in past papers is driven by two main factors: (i) omitted variable bias (size, industry and time) and (ii) carbon emissions data vendors' estimation procedures that place a high weight on financial fundamentals when estimating carbon emissions. Researchers, practitioners and policy makers might want to be careful about interpreting statistical associations between carbon emissions and valuation and fundamental firm characteristics such as operating profitability. To be clear, we say nothing about the desirability or otherwise of disclosing or cutting carbon emissions. Instead, the paper is intended to explore research design choices that underlie documented correlations between emissions and valuation and profitability outcomes.

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APPENDIX
Appendix A: Variable Definitions

Variable	Definition	Data Source
Returns	Monthly stock return (expressed in percentage).	CRSP
ROS	Return on sales, measured as the ratio of operating income after depreciation to total year-end sales.	COMPUSTAT
ROA	Return on assets, measured as the ratio of operating income after depreciation to year-end total assets.	COMPUSTAT
Tobin's Q	(Market value of equity plus total assets minus book value of equity) divided by year total assets.	COMPUSTAT
EBIT Margin	Ratio of earnings before interest and taxes to total sales at year end.	COMPUSTAT
EBITDA Margin	Ratio of earnings before interest, taxes, depreciation, and amortization to total sales at year end.	COMPUSTAT
HHI	Herfindahl concentration index of firm sales with respect to the industry.	COMPUSTAT
ROE	Return on equity, measured as the ratio of net income divided by the value of its equity.	COMPUSTAT
Invest / A	Ratio of capital expenditures divided by year-end total assets.	COMPUSTAT
Log PPE	Natural logarithm of property, plant, and equipment.	COMPUSTAT
Leverage	Ratio of long-term debt to assets.	COMPUSTAT
SalesGR	Change in annual firm revenues normalized by prior-year revenue.	COMPUSTAT
EPSGR	Change in annual earnings per share normalized by prior-year earnings per share.	I/B/E/S
Log Market Cap	Natural logarithm of total market capitalization of a firm in a given year.	Compustat
Number of Employees	Number of employees working for a firm in a given year.	Compustat
Log Sale	Logarithm of total sales of a firm in a given year.	Compustat
Log Scope 1	Natural logarithm of scope 1 emissions (measured in tons of CO_2). Scope 1 emissions cover direct emissions from establishments that are owned or controlled by the company and include all emissions from fossil fuels used in production.	Trucost
Log Scope 2	Natural logarithm of scope 2 emissions (measured in tons of CO_2). Scope 2 emissions come from the generation of purchased heat, steam, and electricity consumed by the company.	Trucost
Log Scope 3	Natural logarithm of scope 3 emissions (measured in tons of CO_2). Scope 3 emissions are caused by the operations and products of the company but occur from sources not owned or controlled by the company.	Trucost
Scope 1 Growth	Change in scope 1 emissions divided by prior-year scope 1 emissions.	Trucost
Scope 2 Growth	Change in scope 2 emissions divided by prior-year scope 3 emissions.	Trucost
Scope 3 Growth	Change in scope 3 emissions divided by prior-year scope 3 emissions.	Trucost
Carbon Intensity Scope 1	Ratio of scope 1 emissions (tons CO_2) to revenues (millions of dollars).	Trucost
Carbon Intensity Scope 2	Ratio of scope 2 emissions (tons CO_2) to revenues (millions of dollars).	Trucost
Carbon Intensity Scope 3	Ratio of scope 3 emissions (tons CO_2) to revenues (millions of dollars).	Trucost
Change in Carbon Intensity Scope 1	Year-over-year change in scope 1 emissions intensity.	Trucost
Change in Carbon Intensity Scope 2	Year-over-year change in scope 2 emissions intensity.	Trucost
Change in Carbon Intensity Scope 3	Year-over-year change in scope 3 emissions intensity.	Trucost
Disclosed Values	Indicator variable for whether emissions values are disclosed. We label an observation as containing disclosed values if it obtained its scope 1 emissions figure from any of the following sources: exact value from CDP disclosure, value derived from CDP disclosure, value split from data provided in CDP disclosure, value from fuel gas disclosure provided to CDP, and stack gas data disclosure.	Trucost
Estimated Values	Indicator variable for whether emissions values are estimated by Trucost. Estimated values reflect observations for which scope 1 emissions are estimated by Trucost using proprietary models.	Trucost

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Table 1: Sample Selection

This table outlines the process we use to select the firms underlying our sample from Trucost's North America carbon emissions database.

Filters		Number of Distinct Firms
Start: Firms in Trucost North America database		4,028
Less: Firms labeled by Trucost as being based outside the continental US	(552)	3,476
Less: Non-US incorporated firms (S&P US firms)	(600)	2,876
Less: Firms missing ISIN/CUSIP	(79)	2,797
Less: Firms not matched with COMPUSTAT and CRSP	(41)	2,756
Less: Firms missing stock returns or emissions data	(27)	2,729

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Table 2: Summary Statistics

This table provides summary statistics for variables used in our main regressions (i.e., Table 9). Following Bolton and Kacperczyk (2021), we winsorize different variables at different values; where we do so, we provide the winsorization cutoff based on the percentage of observations in each tail of the distribution. Please refer to Appendix A for variable definitions.

Variable	Mean	Median	Standard Deviation	Winsorization cutoff (%)
Dependent Variables				
Monthly Returns (%)	1.097	1.002	11.688	-
ROS	-0.107	0.13	1.718	1
ROA	0.057	0.06	0.139	1
Tobin's Q	2.039	1.53	1.438	1
EBIT Margin	-0.107	0.06	1.718	1
EBITDA Margin	-0.083	0.09	1.892	1
Emissions Variables				
Log Scope 1 Emissions	10.088	10.049	3.035	-
Log Scope 2 Emissions	10.228	10.438	2.473	-
Log Scope 3 Emissions	11.947	12.128	2.41	-
Scope 1 Intensity	1.316	0.141	4.072	2.5
Scope 2 Intensity	0.307	0.18	0.351	2.5
Scope 3 Intensity	1.430	1.403	0.879	2.5
Scope 1 Growth	0.076	0.033	0.300	2.5
Scope 2 Growth	0.103	0.040	0.337	2.5
Scope 3 Growth	0.073	0.042	0.215	2.5
Change in Scope 1 Intensity	-0.047	-0.001	0.630	1
Change in Scope 2 Intensity	-0.001	-0.003	0.101	1
Change in Scope 3 Intensity	0.000	0.000	0.002	1
Controls				
Log Market Cap	8.067	8.09	1.69	-
Log Sales	7.483	7.581	1.817	-
Log PPE	5.981	6.073	2.225	2.5
ROE (in %)	6.901	10.234	31.855	2.5
Invest/A	0.036	0.023	0.04	2.5
Book to Market	0.482	0.407	0.359	2.5
SaleGR	0.125	0.067	0.394	0.5
EPSGR	-0.029	0.026	3.421	0.5
HHI	0.157	0.111	0.13	-
Leverage	0.233	0.207	0.195	2.5

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Table 3: Yearly and Industry Distribution of Number of Firms and Observations

This table shows the distribution of the number of firms and firm-month observations for the full estimation sample (representing firms in the intersection of Trucost, CRSP, and Compustat coverage). Panel A provides data on observations by year, while Panel B provides data on observations by industry.

Panel A: Yearly Distribution

This table shows the yearly distribution of the number of firms and firm-month observations for the full estimation sample (representing firms in the intersection of Trucost, CRSP, and Compustat coverage).

Year	Distinct Firms	Firm-Month Observations
2005	700	8,549
2006	706	8,600
2007	693	8,453
2008	690	8,515
2009	709	8,708
2010	704	8,669
2011	715	8,799
2012	727	8,913
2013	800	9,738
2014	829	10,082
2015	859	10,532
2016	2,369	28,465
2017	2,509	30,164
2018	2,645	31,881
2019	1,992	24,161
Full Sample	2,729	214,229

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Panel B: Top 10 and Bottom 10 Industries in Sample by Number of Observations

GICS	Industry	Distinct Firms	Firm-Month Observations	
401010	Banks	230	14,427	
601010	Equity Real Estate Investment Trusts	168	13,429	
201060	Machinery	93	8,395	
101020	Oil, Gas & Consumable Fuels	98	8,355	
352010	Biotechnology	179	8,087	Top 10
403010	Insurance	70	7,621	
255040	Specialty Retail	84	7,492	
451030	Software	118	6,880	
351010	Health Care Equipment & Supplies	92	6,277	
402030	Capital Markets	65	6,199	
201050	Industrial Conglomerates	6	793	
501020	Wireless Telecommunication Services	7	691	
151020	Construction Materials	7	689	
255010	Distributors	6	541	
302030	Tobacco	6	477	
551050	Independent Power and Renewable Electricity Producers	5	469	Bottom 10
151050	Paper & Forest Products	7	435	
402010	Diversified Financial Services	5	349	
203030	Marine	3	276	
203050	Transportation Infrastructure	1	60	
	Full Sample	2,729	214,229	

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Table 4: Correlations

This table shows univariate correlations corresponding to our main emissions and financial performance variables. Panel A provides correlations between our main emissions measures; Panel B provides correlations between our main emissions measures and three measures of firm size; and Panel C provides correlations between our measures of firm performance and profitability. Please refer to Appendix A for variable definitions

.

Panel A: Correlation between Emissions Variables

This panel shows univariate correlations between log emissions and emissions intensity for scope 1, 2, and 3 emissions.

Correlation Table						
	Log Scope 1	Log Scope 2	Log Scope 3	Carbon Intensity Scope1	Carbon Intensity Scope2	Carbon Intensity Scope3
Log Scope 1	1					
Log Scope 2	0.988	1				
Log Scope 3	0.999	0.993	1			
Carbon Intensity Scope 1	0.960	0.919	0.954	1		
Carbon Intensity Scope 2	0.910	0.926	0.919	0.889	1	
Carbon Intensity Scope 3	0.749	0.651	0.731	0.878	0.673	1

Panel B: Correlation between Emissions and Firm Size

This panel shows univariate correlations between carbon emissions and firm size.

	Log Market Cap	Log Employees	Log Sales	Log Scope 1	Log Scope 2	Log Scope 3	Carbon Intensity Scope 1	Carbon Intensity Scope 2	Carbon Intensity Scope 3
Log Market Cap	1								
Log Employees	0.658	1							
Log Sales	0.800	0.874	1						
Log Scope 1	0.523	0.611	0.719	1					
Log Scope 2	0.650	0.735	0.840	0.804	1				
Log Scope 3	0.667	0.806	0.901	0.852	0.880	1			
Carbon Intensity Scope 1	0.082	0.045	0.125	0.542	0.130	0.235	1		
Carbon Intensity Scope 2	0.062	0.058	0.104	0.399	0.506	0.232	0.237	1	
Carbon Intensity Scope 3	0.047	0.181	0.198	0.517	0.351	0.541	0.344	0.338	1

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Panel C: Correlation in Financial Performance Measures

This panel shows univariate correlations between measures of firm correlation between measures of firms' financial performance.

	ROS	ROA	Tobin's Q	EBIT Margin	EBITDA Margin
ROS	1.000				
ROA	0.624	1.000			
Tobin's Q	-0.155	0.064	1.000		
EBIT Margin	1.000	0.624	-0.155	1.000	
EBITDA Margin	0.998	0.606	-0.158	0.998	1.000

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Table 5: Disclosed vs. Estimated Values

This table provides a breakdown of the number of firms and firm-month observations with disclosed vs. vendor-estimated figures. We define a firm to have estimated emissions if its scope 1 emissions are estimated by the vendor. In Panel A we provide the distribution of disclosed vs. estimated observations by year; in Panel B we provide the distribution of disclosed vs. estimated observations by industry. For brevity, in Panel B we show only the top 10 and bottom 10 industries, for industries with at least 10 distinct firms, according to the percentage of observations with estimated values.

Panel A: Estimated Values by Year

	Full Sample		Disclosed Values		Estimated Values		% Observations with Estimated Values
Year	Firms	Observations	Firms	Observations	Firms	Observations	
2005	700	8,549	99	1,199	601	7,350	86
2006	706	8,600	124	1,515	582	7,085	82
2007	693	8,453	165	2,009	528	6,444	76
2008	690	8,515	190	2,317	500	6,198	72
2009	709	8,708	235	2,875	474	5,833	67
2010	704	8,669	280	3,434	424	5,235	60
2011	715	8,799	314	3,840	401	4,959	56
2012	727	8,913	337	4,113	390	4,800	54
2013	800	9,738	354	4,308	446	5,430	56
2014	829	10,082	374	4,568	455	5,514	55
2015	859	10,532	396	4,844	463	5,688	54
2016	2369	28,465	446	5,447	1923	23,018	81
2017	2509	30,164	491	6,004	2018	24,160	80
2018	2645	31,881	540	6,627	2105	25,254	80
2019	1992	24,161	101	1,207	1891	22,954	95
		214,229		54,307		159,922	75

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Panel B: Top Ten and Bottom Ten Industries by Highest Percent of Estimated Values

This panel presents the top ten and bottom ten industries in our sample according to the percentage of emissions observations that are estimated rather than disclosed, for industries with at least ten distinct firms. We define a firm to have estimated emissions if its scope 1 emissions are estimated by Trucost.

GICS	Industry	Distinct Firms	Firm-Month Observations	% Obs. with Estimated Emissions	
253020	Diversified Consumer Services	23	1,998	100	
351030	Health Care Technology	19	1,023	100	
401020	Thrifts & Mortgage Finance	42	2,414	100	
402040	Mortgage Real Estate Investment Trusts	34	1,674	100	
551020	Gas Utilities	11	937	99	Top 10
352010	Biotechnology	179	8,087	93	
201030	Construction & Engineering	27	2,059	91	
502010	Media	47	4,787	91	
201070	Trading Companies & Distributors	33	2,400	90	
401010	Banks	230	14,427	90	
203010	Air Freight & Logistics	11	1,008	61	
301010	Food & Staples Retailing	20	1,885	59	
302020	Food Products	38	3,761	49	
151010	Chemicals	59	4,967	47	
151030	Containers & Packaging	16	2,376	44	Bottom
452020	Technology Hardware, Storage & Peripherals	19	1,871	40	10
302010	Beverages	11	1,860	39	
203020	Airlines	11	872	7	
551030	Multi-Utilities	15	2,114	7	
551010	Electric Utilities	27	3,568	5	
	Full Sample	2,729	214,229	75	

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Table 6: Do Estimated Emissions Systematically Differ from Disclosed Emissions?

This table estimates an emissions prediction model for each of scope 1, 2, and 3 emissions. In Columns (1), (2), and (3) the dependent variable is the natural logarithm of scope 1, 2, and 3 emissions, respectively. In Column (1) the independent variable of interest is Scope 1 Estimated, an indicator for whether the firm's scope 1 emissions corresponding to month-year *t* are vendor-estimated; in Column (2), the independent variable of interest is Scope 2 Estimated, an indicator for whether the firm's scope 2 emissions corresponding to month-year *t* are vendor-estimated; and in Column (3) the independent variable of interest is Scope 3 Estimated, an indicator for whether the firm's scope 3 emissions corresponding to month-year *t* are vendor-estimated. Columns (1) – (3) include firm and month-year fixed effects but no other control variables. Columns (4) – (6) replicate the specifications in Columns (1) – (3) but with the inclusion of control variables. Standard errors are two-way clustered by firm and month-year. Please refer to Appendix A for variable definitions. We report standard errors in parentheses beneath coefficient estimates. In all panels, *, **, and *** indicate statistical significance at 10% ,5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Log Scope 1	Log Scope 2	Log Scope 3	Log Scope 1	Log Scope 2	Log Scope 3
Scope 1 Estimated Indicator	0.379***			0.485***		
	(0.069)			(0.068)		
Scope 2 Estimated Indicator		-0.242***			-0.141**	
		(0.064)			(0.061)	
Scope 3 Estimated Indicator			-0.141***			-0.040***
			(0.031)			(0.013)
Log Sales				0.877***	0.876***	1.011***
				(0.044)	(0.045)	(0.032)
HHI				-0.008	0.092	-0.102
				(0.209)	(0.168)	(0.116)
Book to Market				0.017	0.048	0.002
				(0.032)	(0.035)	(0.020)
SaleGR				0.139***	0.119***	0.113***
				(0.027)	(0.025)	(0.024)
EPSGR				-0.000	-0.003***	0.000
				(0.001)	(0.001)	(0.001)
Leverage				0.020	-0.056	-0.021
				(0.096)	(0.094)	(0.058)
Log PPE				0.057**	0.106***	0.039**
				(0.027)	(0.028)	(0.019)
ROE				0.000	-0.000	0.000
				(0.000)	(0.000)	(0.000)
Invest/A				-0.353	0.284	-0.473***
				(0.325)	(0.378)	(0.170)
Constant				3.381***	2.939***	4.255***
				(0.280)	(0.275)	(0.193)
Observations	214,227	214,227	214,227	197,186	197,186	197,186
R-squared	0.970	0.950	0.073	0.981	0.967	0.992
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes	Yes

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Table 7: Stock Returns and Carbon Emissions

This table provides results from estimating regressions of stock returns on four measures of carbon emissions. In Panels A, B, and C we estimate the relation between monthly stock returns and the natural logarithm of raw scope 1, 2, and 3 carbon emissions. The dependent variable in all panels is monthly stock returns, expressed as a percentage. In Panels D, E, and F we replace the emissions variables with carbon emissions intensity, the year-over-year growth in carbon emissions, and the year-over-year change in carbon emissions intensity, respectively. Please refer to Appendix A for variable definitions. We report standard errors in parentheses. In all panels, *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Panel A: Log Emissions

This panel provides results from regressions of monthly returns on log emissions. In Columns (1), (2), and (3) we report results from regressions of returns on scope 1, 2, and 3 emissions, respectively, as well as month-year fixed effects (but no other control variables). Columns (4) – (6) replicate Columns (1) – (3) but with the addition of firm sales as a control.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret
Log Scope1	-0.027***			-0.008		
	(0.008)			(0.011)		
Log Scope2		-0.035***			-0.001	
		(0.010)			(0.017)	
Log Scope3			-0.035***			0.018
			(0.010)			(0.022)
Log Sale				-0.052***	-0.060**	-0.083***
				(0.019)	(0.024)	(0.030)
Constant	1.372***	1.453***	1.515***	1.566***	1.556***	1.498***
	(0.085)	(0.105)	(0.126)	(0.108)	(0.111)	(0.127)
Observations	214,229	214,229	214,229	214,132	214,132	214,132
R-squared	0.181	0.181	0.181	0.181	0.181	0.181
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Impact of Controls and Fixed Effects

This panel provides results from regressions of monthly returns on log scope 1 emissions, illustrating the impact of adding various control variables one at a time on the conclusions that can be drawn about this relation.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret
Log Scope 1	-0.038***	-0.027***	-0.008	0.006	0.030**	0.024*
	(0.008)	(0.008)	(0.011)	(0.011)	(0.013)	(0.012)
Log Sale			-0.052***	-0.057***	0.024	-0.081***
			(0.019)	(0.019)	(0.024)	(0.020)
Leverage				-0.681***		
				(0.122)		
Log PPE					-0.127***	
					(0.021)	
Invest / A						-3.641***
						(0.643)
Constant	1.484***	1.372***	1.566***	1.625***	1.384***	1.595***
	(0.088)	(0.085)	(0.108)	(0.109)	(0.120)	(0.108)
Observations	214,229	214,229	214,132	213,439	199,931	213,403
R-squared	0.000	0.181	0.181	0.182	0.179	0.181
Month-Year	No	Yes	Yes	Yes	Yes	Yes

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Panel C: Stock Returns and Log Total Emissions

This panel provides results from regressions of monthly stock returns on the natural logarithm of scope 1, 2, and 3 emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret	Ret	Ret	Ret
Log Scope 1	0.052***			-0.015			-0.015		
	(0.014)			(0.023)			(0.026)		
Log Scope 2		0.066***			-0.014			-0.014	
		(0.020)			(0.029)			(0.039)	
Log Scope 3			0.056**			-0.025			-0.025
			(0.025)			(0.043)			(0.064)
Log Sales	-0.081***	-0.124***	-0.108***	-0.086**	-0.083*	-0.072	-0.086	-0.083	-0.072
	(0.028)	(0.034)	(0.037)	(0.037)	(0.043)	(0.054)	(0.068)	(0.081)	(0.088)
HHI	-0.309*	-0.339*	-0.327*	-1.472***	-1.471***	-1.474***	-1.472**	-1.471**	-1.474**
	(0.185)	(0.185)	(0.185)	(0.446)	(0.446)	(0.446)	(0.587)	(0.587)	(0.586)
SaleGR	0.946***	0.943***	0.947***	0.943***	0.943***	0.944***	0.943***	0.943***	0.944***
	(0.063)	(0.063)	(0.063)	(0.065)	(0.065)	(0.065)	(0.223)	(0.224)	(0.224)
EPSGR	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.010
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.011)	(0.011)	(0.011)
Leverage	-0.450***	-0.463***	-0.410***	-0.646***	-0.646***	-0.649***	-0.646*	-0.646*	-0.649*
	(0.134)	(0.135)	(0.134)	(0.149)	(0.149)	(0.150)	(0.340)	(0.340)	(0.338)
Log PPE	-0.045*	-0.017	-0.024	0.021	0.019	0.019	0.021	0.019	0.019
	(0.024)	(0.023)	(0.023)	(0.029)	(0.029)	(0.029)	(0.045)	(0.044)	(0.045)
ROE	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Invest/A	-3.817***	-3.755***	-3.364***	-5.017***	-4.991***	-5.022***	-5.017***	-4.991***	-5.022***
	(0.749)	(0.750)	(0.734)	(0.877)	(0.878)	(0.877)	(1.577)	(1.595)	(1.582)
Constant	1.565***	1.580***	1.471***	2.169***	2.155***	2.225***	2.169***	2.155***	2.225***
	(0.130)	(0.130)	(0.152)	(0.184)	(0.181)	(0.243)	(0.374)	(0.389)	(0.457)
Observations	197,348	197,348	197,348	197,348	197,348	197,348	197,348	197,348	197,348
R-squared	0.183	0.183	0.183	0.184	0.184	0.184	0.184	0.184	0.184
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	No	No	No	No	Yes	Yes	Yes

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Panel D: Stock Returns and Carbon Intensity

This panel provides results from regressions of monthly stock returns on scope 1, 2, and 3 carbon emissions intensity and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Ret	Ret		Ret	Ret		Ret	Ret	
Carbon Intensity Scope 1	0.012*			0.007			0.007		
	(0.006)			(0.009)			(0.010)		
Carbon Intensity Scope 2		0.142*			-0.023			-0.023	
		(0.073)			(0.095)			(0.140)	
Carbon Intensity Scope 3			0.012			-0.027			-0.027
			(0.017)			(0.031)			(0.030)
Log Sales	-0.037	-0.045*	-0.049*	-0.094***	-0.098***	-0.098***	-0.094	-0.098*	-0.098
	(0.027)	(0.026)	(0.026)	(0.033)	(0.033)	(0.033)	(0.057)	(0.057)	(0.059)
HHI	-0.304	-0.300	-0.324*	-1.476***	-1.475***	-1.481***	-1.476**	-1.475**	-1.481**
	(0.186)	(0.186)	(0.186)	(0.446)	(0.446)	(0.446)	(0.588)	(0.589)	(0.587)
SaleGR	0.946***	0.946***	0.946***	0.943***	0.942***	0.941***	0.943***	0.942***	0.941***
	(0.063)	(0.063)	(0.063)	(0.065)	(0.065)	(0.065)	(0.224)	(0.224)	(0.223)
EPSGR	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.010	0.010
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.011)	(0.011)	(0.011)
Leverage	-0.386***	-0.405***	-0.385***	-0.648***	-0.648***	-0.651***	-0.648*	-0.648*	-0.651*
	(0.133)	(0.134)	(0.133)	(0.149)	(0.150)	(0.150)	(0.340)	(0.340)	(0.339)
Log PPE	-0.033	-0.025	-0.020	0.015	0.019	0.019	0.015	0.019	0.019
	(0.025)	(0.023)	(0.023)	(0.029)	(0.029)	(0.029)	(0.043)	(0.043)	(0.045)
ROE	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Invest/A	-3.120***	-3.288***	-3.140***	-4.965***	-5.005***	-5.059***	-4.965***	-5.005***	-5.059***
	(0.727)	(0.731)	(0.727)	(0.879)	(0.877)	(0.879)	(1.560)	(1.593)	(1.580)
Constant	1.637***	1.632***	1.648***	2.107***	2.130***	2.163***	2.107***	2.130***	2.163***
	(0.129)	(0.129)	(0.129)	(0.171)	(0.172)	(0.176)	(0.404)	(0.399)	(0.403)
Observations	197,348	197,348	197,348	197,348	197,348	197,348	197,348	197,348	197,348
R-squared	0.183	0.183	0.183	0.184	0.184	0.184	0.184	0.184	0.184
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	No	No	No	No	Yes	Yes	Yes

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Panel E: Growth in Carbon Emissions

This panel provides results from regressions of monthly stock returns on the year-over-year growth in scope 1, 2, and 3 carbon emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret	Ret	Ret	Ret
Scope 1 Growth	0.579***			0.524***			0.524***		
	(0.107)			(0.108)			(0.170)		
Scope 2 Growth		0.216**			0.180*			0.180	
		(0.096)			(0.097)			(0.135)	
Scope 3 Growth			0.955***			0.870***			0.870*
			(0.174)			(0.176)			(0.473)
Log Sales	-0.007	-0.004	-0.009	-0.054	-0.057	-0.060*	-0.054	-0.057	-0.060
	(0.028)	(0.028)	(0.028)	(0.035)	(0.035)	(0.035)	(0.054)	(0.053)	(0.053)
HHI	-0.271	-0.235	-0.259	-1.533***	-1.541***	-1.516***	-1.533**	-1.541***	-1.516**
	(0.194)	(0.194)	(0.194)	(0.468)	(0.468)	(0.468)	(0.585)	(0.580)	(0.574)
SaleGR	0.672***	0.836***	0.570***	0.636***	0.795***	0.544***	0.636**	0.795***	0.544**
	(0.087)	(0.087)	(0.099)	(0.089)	(0.089)	(0.101)	(0.254)	(0.278)	(0.256)
EPSGR	0.017**	0.017**	0.016**	0.014*	0.014*	0.014*	0.014	0.014	0.014
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.012)	(0.012)	(0.013)
Leverage	-0.182	-0.161	-0.162	-0.550***	-0.536***	-0.547***	-0.550	-0.536	-0.547
	(0.142)	(0.142)	(0.142)	(0.160)	(0.160)	(0.160)	(0.334)	(0.333)	(0.334)
Log PPE	-0.021	-0.025	-0.018	0.028	0.029	0.033	0.028	0.029	0.033
	(0.025)	(0.025)	(0.025)	(0.031)	(0.031)	(0.031)	(0.046)	(0.046)	(0.046)
ROE	0.011***	0.011***	0.011***	0.012***	0.012***	0.011***	0.012***	0.012***	0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Invest/A	-4.077***	-3.911***	-4.069***	-5.309***	-5.233***	-5.427***	-5.309***	-5.233***	-5.427***
	(0.784)	(0.784)	(0.784)	(0.948)	(0.948)	(0.949)	(1.664)	(1.660)	(1.609)
Constant	1.192***	1.180***	1.176***	1.602***	1.610***	1.604***	1.602***	1.610***	1.604***
	(0.141)	(0.141)	(0.141)	(0.184)	(0.184)	(0.184)	(0.461)	(0.458)	(0.460)
Observations	167,964	167,964	167,964	167,964	167,964	167,964	167,964	167,964	167,964
R-squared	0.193	0.193	0.193	0.194	0.194	0.194	0.194	0.194	0.194
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	No	No	No	No	Yes	Yes	Yes

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Panel F: Change in Carbon Intensity

This panel provides results from regressions of monthly stock returns on the year-over-year change in scope 1, 2, and 3 carbon emissions intensity and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret	Ret	Ret	Ret
Change in Scope 1 Intensity	0.032			0.045			0.045		
	(0.039)			(0.040)			(0.056)		
Change in Scope 2 Intensity		0.183			0.173			0.173	
		(0.251)			(0.252)			(0.288)	
Change in Scope 3 Intensity			-0.315***			-0.332***			-0.332
			(0.106)			(0.107)			(0.210)
Log Sales	-0.007	-0.005	-0.007	-0.058	-0.058	-0.061*	-0.058	-0.058	-0.061
	(0.028)	(0.028)	(0.028)	(0.035)	(0.035)	(0.035)	(0.053)	(0.053)	(0.053)
HHI	-0.239	-0.233	-0.219	-1.552***	-1.549***	-1.539***	-1.552***	-1.549***	-1.539***
	(0.194)	(0.194)	(0.194)	(0.468)	(0.468)	(0.468)	(0.580)	(0.580)	(0.578)
SaleGR	0.957***	0.956***	0.943***	0.896***	0.895***	0.879***	0.896***	0.895***	0.879***
	(0.069)	(0.069)	(0.069)	(0.072)	(0.072)	(0.072)	(0.258)	(0.259)	(0.254)
EPSGR	0.017**	0.017**	0.017**	0.014*	0.014*	0.014*	0.014	0.014	0.014
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.012)	(0.012)	(0.012)
Leverage	-0.162	-0.162	-0.163	-0.536***	-0.536***	-0.531***	-0.536	-0.536	-0.531
	(0.142)	(0.142)	(0.142)	(0.160)	(0.160)	(0.160)	(0.334)	(0.334)	(0.335)
Log PPE	-0.022	-0.024	-0.025	0.030	0.030	0.031	0.030	0.030	0.031
	(0.025)	(0.025)	(0.025)	(0.031)	(0.031)	(0.031)	(0.046)	(0.046)	(0.046)
ROE	0.011***	0.011***	0.011***	0.012***	0.012***	0.012***	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Invest/A	-3.886***	-3.883***	-3.922***	-5.191***	-5.194***	-5.207***	-5.191***	-5.194***	-5.207***
	(0.783)	(0.783)	(0.784)	(0.948)	(0.948)	(0.948)	(1.666)	(1.668)	(1.665)
Constant	1.196***	1.193***	1.200***	1.622***	1.620***	1.625***	1.622***	1.620***	1.625***
	(0.141)	(0.141)	(0.141)	(0.184)	(0.184)	(0.184)	(0.460)	(0.459)	(0.460)
Observations	167,964	167,964	167,964	167,964	167,964	167,964	167,964	167,964	167,964
R-squared	0.193	0.193	0.193	0.194	0.194	0.194	0.194	0.194	0.194
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	No	No	No	No	No	No	Yes	Yes	Yes

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Table 8: Returns and Disclosed vs. Vendor-Estimated Emissions

This table replicates the specifications provided in Panels C – F of Table 9, regressing monthly stock returns on four different measures of carbon emissions (for each of scope 1, 2, and 3 emissions). In each panel, we partition the sample according to whether an observation has estimated scope 1 emissions or firm-disclosed emissions; we then run analyses separately for these two subsamples. Please refer to Appendix A for variable definitions. We report standard errors in parentheses beneath coefficient estimates. In all panels, *, **, and *** indicate statistical significance at 10% ,5%, and 1% levels, respectively.

Panel A: Log Carbon Emissions

This panel provides results from regressions of monthly stock returns on the natural logarithm of scope 1, 2, and 3 emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate this relation on the set of observations with firm-disclosed emissions values; in Columns (4), (5), and (6) we estimate this relation on the set of observations with vendor-estimated emissions values. All specifications include month-year fixed effects.

	Disclosed			Estimated		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret
Log Scope 1	0.034			0.069***		
	(0.021)			(0.019)		
Log Scope 2		-0.026			0.118***	
		(0.024)			(0.027)	
Log Scope 3			0.002			0.068**
			(0.040)			(0.030)
Log Sales	-0.094**	-0.087*	-0.111*	-0.106***	-0.179***	-0.117**
	(0.048)	(0.051)	(0.058)	(0.037)	(0.044)	(0.046)
HHI	-0.101	-0.153	-0.156	-0.407*	-0.387	-0.374
	(0.257)	(0.254)	(0.254)	(0.238)	(0.238)	(0.238)
SaleGR	1.176***	1.142***	1.151***	0.937***	0.934***	0.940***
	(0.185)	(0.184)	(0.185)	(0.070)	(0.070)	(0.070)
EPSGR	0.020*	0.019	0.019*	0.010	0.011	0.010
	(0.012)	(0.012)	(0.012)	(0.008)	(0.008)	(0.008)
Leverage	-0.406	-0.322	-0.342	-0.470***	-0.549***	-0.416***
	(0.262)	(0.259)	(0.262)	(0.159)	(0.161)	(0.158)
Log PPE	-0.013	0.042	0.038	-0.049*	-0.029	-0.039
	(0.050)	(0.039)	(0.039)	(0.029)	(0.029)	(0.029)
ROE	0.007***	0.007***	0.007***	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Invest/A	-5.800***	-5.471***	-5.587***	-3.537***	-3.806***	-2.872***
	(1.193)	(1.190)	(1.186)	(0.930)	(0.934)	(0.901)
Constant	1.692***	1.912***	1.841***	1.626***	1.571***	1.478***
	(0.325)	(0.316)	(0.361)	(0.161)	(0.162)	(0.188)
Observations	51,915	51,915	51,915	145,433	145,433	145,433
R-squared	0.252	0.252	0.252	0.174	0.174	0.174
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes

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Panel B: Carbon Intensity

This panel provides results from regressions of monthly stock returns on the scope 1, 2, and 3 emissions intensity and including the full set of control variables. In Columns (1), (2), and (3) we estimate this relation on the set of observations with firm-disclosed emissions values; in Columns (4), (5), and (6) we estimate this relation on the set of observations with vendor-estimated emissions values. All specifications include month-year fixed effects.

	Disclosed			Estimated		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret
Carbon Intensity Scope 1	0.011			0.019		
	(0.007)			(0.014)		
Carbon Intensity Scope 2		-0.039			0.335***	
		(0.077)			(0.117)	
Carbon Intensity Scope 3			-0.005			0.019
			(0.024)			(0.023)
Log Sales	-0.069	-0.115**	-0.112**	-0.036	-0.037	-0.043
	(0.053)	(0.047)	(0.047)	(0.033)	(0.032)	(0.032)
HHI	-0.090	-0.170	-0.164	-0.379	-0.321	-0.368
	(0.258)	(0.256)	(0.257)	(0.238)	(0.239)	(0.239)
SaleGR	1.163***	1.149***	1.147***	0.940***	0.944***	0.942***
	(0.184)	(0.184)	(0.185)	(0.070)	(0.070)	(0.070)
EPSGR	0.019*	0.019*	0.019*	0.010	0.010	0.010
	(0.012)	(0.012)	(0.012)	(0.008)	(0.008)	(0.008)
Leverage	-0.360	-0.330	-0.331	-0.393**	-0.446***	-0.394**
	(0.259)	(0.259)	(0.262)	(0.157)	(0.159)	(0.157)
Log PPE	0.000	0.042	0.039	-0.043	-0.043	-0.037
	(0.045)	(0.039)	(0.039)	(0.030)	(0.029)	(0.029)
ROE	0.007***	0.007***	0.007***	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Invest/A	-5.445***	-5.556***	-5.597***	-2.573***	-2.965***	-2.556***
	(1.189)	(1.187)	(1.187)	(0.887)	(0.900)	(0.888)
Constant	1.723***	1.874***	1.860***	1.686***	1.637***	1.686***
	(0.320)	(0.314)	(0.315)	(0.160)	(0.161)	(0.161)
Observations	51,915	51,915	51,915	145,433	145,433	145,433
R-squared	0.252	0.252	0.252	0.174	0.174	0.174
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes

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Panel C: Growth in Carbon Emissions

This panel provides results from regressions of monthly stock returns on the year-over-year growth in scope 1, 2, and 3 emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate this relation on the set of observations with firm-disclosed emissions values; in Columns (4), (5), and (6) we estimate this relation on the set of observations with vendor-estimated emissions values. All specifications include month-year fixed effects.

	Disclosed			Estimated		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret
Scope 1 Growth	-0.008			1.247***		
	(0.114)			(0.169)		
Scope 2 Growth		-0.099			0.891***	
		(0.094)			(0.177)	
Scope 3 Growth			-1.076***			1.573***
			(0.283)			(0.216)
Log Sales	-0.095**	-0.099**	-0.096**	-0.001	0.008	0.003
	(0.048)	(0.048)	(0.048)	(0.036)	(0.036)	(0.036)
HHI	-0.172	-0.172	-0.150	-0.339	-0.219	-0.254
	(0.258)	(0.258)	(0.258)	(0.259)	(0.258)	(0.259)
SaleGR	1.142***	1.188***	1.741***	0.336***	0.456***	0.342***
	(0.193)	(0.193)	(0.245)	(0.115)	(0.126)	(0.115)
EPSGR	0.020*	0.020*	0.021*	0.017*	0.017*	0.016*
	(0.012)	(0.012)	(0.012)	(0.009)	(0.009)	(0.009)
Leverage	-0.336	-0.342	-0.380	-0.171	-0.131	-0.137
	(0.264)	(0.264)	(0.264)	(0.172)	(0.172)	(0.172)
Log PPE	0.049	0.051	0.045	-0.041	-0.049	-0.043
	(0.039)	(0.039)	(0.039)	(0.032)	(0.032)	(0.032)
ROE	0.006***	0.006***	0.007***	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Invest/A	-6.301***	-6.293***	-6.294***	-3.629***	-3.359***	-3.579***
	(1.221)	(1.221)	(1.221)	(0.984)	(0.983)	(0.984)
Constant	1.646***	1.676***	1.699***	1.216***	1.169***	1.172***
	(0.319)	(0.320)	(0.319)	(0.180)	(0.179)	(0.179)
Observations	50,014	50,014	50,014	117,950	117,950	117,950
R-squared	0.255	0.255	0.255	0.182	0.182	0.182
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes

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Panel D: Change in Carbon Intensity

This panel provides results from regressions of monthly stock returns on the year-over-year change in scope 1, 2, and 3 emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate this relation on the set of observations with firm-disclosed emissions values; in Columns (4), (5), and (6) we estimate this relation on the set of observations with vendor-estimated emissions values. All specifications include month-year fixed effects.

	Disclosed			Estimated		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Ret	Ret	Ret	Ret	Ret	Ret
Change in Scope 1 Intensity	0.026			0.097		
	(0.034)			(0.095)		
Change in Scope 2 Intensity		0.200			0.419	
		(0.213)			(0.716)	
Change in Scope 3 Intensity			-0.352***			-0.272*
			(0.124)			(0.155)
Log Sales	-0.099**	-0.094**	-0.095**	0.009	0.010	0.008
	(0.048)	(0.048)	(0.048)	(0.036)	(0.036)	(0.036)
HHI	-0.181	-0.166	-0.153	-0.210	-0.209	-0.195
	(0.258)	(0.258)	(0.258)	(0.258)	(0.258)	(0.259)
SaleGR	1.152***	1.151***	1.090***	0.955***	0.954***	0.946***
	(0.188)	(0.188)	(0.188)	(0.078)	(0.078)	(0.079)
EPSGR	0.020*	0.020*	0.020*	0.017*	0.017*	0.017*
	(0.012)	(0.012)	(0.012)	(0.009)	(0.009)	(0.009)
Leverage	-0.334	-0.340	-0.347	-0.133	-0.130	-0.131
	(0.264)	(0.264)	(0.264)	(0.172)	(0.172)	(0.172)
Log PPE	0.053	0.049	0.046	-0.049	-0.050	-0.050
	(0.040)	(0.039)	(0.039)	(0.032)	(0.032)	(0.032)
ROE	0.006***	0.006***	0.006***	0.013***	0.013***	0.013***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Invest/A	-6.352***	-6.348***	-6.357***	-3.197***	-3.214***	-3.266***
	(1.222)	(1.222)	(1.221)	(0.983)	(0.983)	(0.983)
Constant	1.655***	1.636***	1.661***	1.179***	1.179***	1.179***
	(0.319)	(0.319)	(0.319)	(0.179)	(0.179)	(0.179)
Observations	50,014	50,014	50,014	117,950	117,950	117,950
R-squared	0.255	0.255	0.255	0.182	0.182	0.182
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes

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Table 9: Operating Performance and Carbon Emissions

This table provides results from regressions of five measures of operating performance and profitability – EBIT margin (the ratio of EBIT to assets), EBITDA margin (the ratio of EBITDA to assets), ROA (return on assets), ROS (return on sales), and Tobin's *q* – on the four measures of carbon emissions that we use throughout the paper. For brevity we only tabulate results using scope 1 emissions. Panel A considers the relation between operating performance and the natural logarithm of total carbon emissions; Panel B instead considers carbon intensity. Finally, in Panel C, we replicate Panel A but only for the subsample of observations with disclosed (rather than vendor-estimated figures). Please refer to Appendix A for variable definitions. We report standard errors in parentheses beneath coefficient estimates. In all panels, *, **, and *** indicate statistical significance at 10% ,5%, and 1% levels, respectively.

Panel A: Log Scope 1 Emissions

This panel provides results from regressions of operating performance on the natural logarithm of scope 1 emissions. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's *q*
Log Scope 1	0.368*	0.405*	0.008	0.368*	-0.055**
	(0.194)	(0.218)	(0.005)	(0.194)	(0.025)
Log Sales	0.034	0.002	0.031***	0.034	0.136**
	(0.040)	(0.044)	(0.006)	(0.040)	(0.064)
HHI	0.798	0.843	0.032	0.798	-0.413
	(0.534)	(0.572)	(0.040)	(0.534)	(0.286)
SaleGR	0.144	0.169	-0.001	0.144	0.309***
	(0.128)	(0.133)	(0.007)	(0.128)	(0.107)
EPSGR	-0.006**	-0.006**	-0.000	-0.006**	0.013***
	(0.003)	(0.003)	(0.000)	(0.003)	(0.003)
Leverage	0.247	0.308	-0.009	0.247	-0.295
	(0.238)	(0.263)	(0.026)	(0.238)	(0.245)
Log PPE	-0.189*	-0.187	-0.020***	-0.189*	-0.201***
	(0.111)	(0.128)	(0.005)	(0.111)	(0.058)
ROE	0.008***	0.008***	0.001***	0.008***	0.004***
	(0.002)	(0.003)	(0.000)	(0.002)	(0.001)
Invest/A	2.478*	2.751*	0.432***	2.478*	7.729***
	(1.391)	(1.481)	(0.113)	(1.391)	(1.622)
Constant	-3.345**	-3.494**	-0.167**	-3.345**	2.583***
	(1.523)	(1.659)	(0.063)	(1.523)	(0.239)
Observations	197,348	195,865	197,348	197,348	197,187
R-squared	0.427	0.412	0.495	0.427	0.327
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Panel B: Scope 1 Carbon Intensity

This panel provides results from regressions of operating performance on scope 1 emissions intensity. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Scope 1 Intensity	0.009	0.009	-0.000	0.009	-0.004
	(0.006)	(0.006)	(0.000)	(0.006)	(0.005)
Log Sales	0.313*	0.301*	0.037***	0.313*	0.093
	(0.157)	(0.170)	(0.008)	(0.157)	(0.059)
HHI	0.900	0.949	0.034	0.900	-0.428
	(0.624)	(0.668)	(0.041)	(0.624)	(0.281)
SaleGR	0.161	0.189	-0.001	0.161	0.306***
	(0.161)	(0.172)	(0.008)	(0.161)	(0.110)
EPSGR	-0.007**	-0.008**	-0.000	-0.007**	0.013***
	(0.004)	(0.004)	(0.000)	(0.004)	(0.003)
Leverage	0.264	0.322	-0.009	0.264	-0.297
	(0.260)	(0.284)	(0.025)	(0.260)	(0.246)
Log PPE	-0.107	-0.087	-0.018***	-0.107	-0.212***
	(0.072)	(0.081)	(0.005)	(0.072)	(0.059)
ROE	0.008***	0.009***	0.001***	0.008***	0.004***
	(0.003)	(0.003)	(0.000)	(0.003)	(0.001)
Invest/A	2.354*	2.556*	0.428***	2.354*	7.732***
	(1.388)	(1.448)	(0.115)	(1.388)	(1.612)
Constant	-2.219**	-2.238**	-0.143***	-2.219**	2.423***
	(1.003)	(1.069)	(0.052)	(1.003)	(0.230)
Observations	197,348	195,865	197,348	197,348	197,187
R-squared	0.374	0.356	0.492	0.374	0.325
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Panel C: Log Scope 1 Emissions, Firm-Disclosed Emissions Only

This panel provides results from regressions of operating performance on the natural logarithm of scope 1 emissions, only for the subsample of observations with disclosed (rather than vendor-estimated) scope 1 emissions figures. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Log Scope 1	-0.001	-0.004	-0.004	-0.001	-0.089***
	(0.008)	(0.008)	(0.003)	(0.008)	(0.033)
Log Sales	0.033	-0.010	0.027***	0.033	0.197*
	(0.027)	(0.029)	(0.006)	(0.027)	(0.099)
HHI	-0.050	-0.089	-0.000	-0.050	-0.578
	(0.089)	(0.089)	(0.024)	(0.089)	(0.390)
SaleGR	0.173***	0.149***	0.048***	0.173***	0.314*
	(0.051)	(0.042)	(0.013)	(0.051)	(0.182)
EPSGR	0.006	0.006	0.001*	0.006	0.009*
	(0.004)	(0.004)	(0.001)	(0.004)	(0.005)
Leverage	-0.022	-0.000	-0.025	-0.022	0.115
	(0.053)	(0.058)	(0.031)	(0.053)	(0.361)
Log PPE	-0.009	0.031	-0.018***	-0.009	-0.182**
	(0.029)	(0.032)	(0.005)	(0.029)	(0.077)
ROE	0.001***	0.001***	0.001***	0.001***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Invest/A	-0.047	0.166	0.359**	-0.047	5.774***
	(0.313)	(0.284)	(0.144)	(0.313)	(2.078)
Constant	-0.082	0.088	0.023	-0.082	2.372***
	(0.147)	(0.149)	(0.034)	(0.147)	(0.372)
Observations	51,915	51,867	51,915	51,915	51,914
R-squared	0.219	0.236	0.373	0.219	0.426
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Table 10: Are Emissions Priced in Europe?

This table provides results on the relation between carbon emissions and stock returns for European firms. In Panel A we test for a relation between stock returns and unscaled carbon emissions; in Panel B, we test for a relation between stock returns and carbon emissions intensity.

Panel A: Stock Returns and Carbon Emissions

This panel provides results from regressions of monthly stock returns on the natural logarithm of unscaled scope 1, 2, and 3 emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using country and month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Return	Return	Return	Return	Return	Return
Log Scope1	0.042***			-0.006		
	(0.013)			(0.014)		
Log Scope2		0.041**			0.017	
		(0.017)			(0.023)	
Log Scope3			0.104***			0.063
			(0.024)			(0.043)
Log Sales	-0.103***	-0.107***	-0.176***	-0.035	-0.052	-0.103
	(0.023)	(0.025)	(0.031)	(0.044)	(0.040)	(0.064)
Leverage	-0.061***	-0.064***	-0.062***	-0.046*	-0.047*	-0.047*
	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)	(0.027)
Invest/A	0.277***	0.282***	0.282***	0.246**	0.244**	0.248**
	(0.099)	(0.099)	(0.099)	(0.101)	(0.103)	(0.102)
ROE	0.015***	0.015***	0.015***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Log PPE	-0.056***	-0.046***	-0.048***	-0.063**	-0.069**	-0.067***
	(0.018)	(0.017)	(0.017)	(0.025)	(0.027)	(0.024)
HHI	2.909	3.212	3.189	7.564	7.481	7.549
	(2.081)	(2.082)	(2.080)	(8.536)	(8.566)	(8.607)
Sales Growth	0.021***	0.021***	0.021***	0.020***	0.020***	0.020***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
EPSG	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.642***	2.689***	3.298***	1.689**	1.839**	2.307**
	(0.406)	(0.413)	(0.446)	(0.837)	(0.797)	(0.951)
Observations	150,377	150,208	150,377	150,377	150,208	150,377
R-squared	0.203	0.203	0.203	0.203	0.203	0.203
Country	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	No	Yes	Yes	Yes

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Panel B: Stock Returns and Carbon Intensity

This panel provides results from regressions of monthly stock returns on scope 1, 2, and 3 carbon emissions intensity and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using country and month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Return	Return	Return	Return	Return	Return
Carbon Intensity Scope1	0.004			-0.019*		
	(0.008)			(0.010)		
Carbon Intensity Scope2		0.123***			0.026	
		(0.044)			(0.064)	
Carbon Intensity Scope3			0.045***			0.029
			(0.012)			(0.028)
Log Sales	-0.078***	-0.065***	-0.074***	-0.041	-0.038	-0.042
	(0.022)	(0.023)	(0.022)	(0.040)	(0.042)	(0.040)
Leverage	-0.063***	-0.063***	-0.063***	-0.046*	-0.046*	-0.047*
	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)	(0.027)
Invest/A	0.281***	0.283***	0.283***	0.243**	0.248**	0.249**
	(0.099)	(0.099)	(0.099)	(0.102)	(0.102)	(0.101)
ROE	0.015***	0.015***	0.015***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Log PPE	-0.035**	-0.048***	-0.043***	-0.061**	-0.067**	-0.064**
	(0.017)	(0.017)	(0.016)	(0.024)	(0.026)	(0.024)
HHI	3.021	3.512*	3.185	7.553	7.525	7.554
	(2.081)	(2.087)	(2.081)	(8.544)	(8.547)	(8.589)
Sales Growth	0.021***	0.021***	0.021***	0.020***	0.020***	0.020***
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
EPSG	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.438***	2.186***	2.308***	1.764**	1.687**	1.709**
	(0.405)	(0.414)	(0.404)	(0.799)	(0.835)	(0.801)
Observations	150,377	150,377	150,377	150,377	150,377	150,377
R-squared	0.203	0.203	0.203	0.203	0.203	0.203
Country	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	No	Yes	Yes	Yes

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ONLINE APPENDIX

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Table OA1: Yearly and Industry Distribution of Carbon Emissions

Panel A: Yearly Distribution of Carbon Emissions

This panel shows the yearly distribution of total carbon emissions and carbon intensity per firm. Columns (2)-(4) show the yearly distribution of total carbon emissions for scope 1, scope 2 and scope 3. Column (5)-(7) provide the yearly distribution of carbon emissions intensity (defined as the ratio of carbon emissions to revenues) for scope 1, scope 2, and scope 3. All variables are defined in Appendix A.

	Carbon Emissions			Carbon Intensity		
Year	Scope 1	Scope 2	Scope 3	Scope 1	Scope 2	Scope 3
2005	2,668,653	334,616	2,690,746	387.37	35.82	226.17
2006	2,479,067	388,577	2,471,110	315.28	38.52	200.42
2007	2,879,432	431,273	2,583,982	295.90	37.67	189.04
2008	2,826,499	487,236	2,319,337	267.71	39.84	162.64
2009	2,546,851	426,567	2,209,255	280.18	41.56	181.80
2010	2,712,481	458,462	2,364,297	276.39	40.91	171.06
2011	2,796,321	472,956	2,564,335	262.92	39.03	168.51
2012	2,583,049	463,398	2,573,500	268.25	38.18	162.30
2013	2,332,113	429,522	2,334,366	260.33	38.46	160.25
2014	2,318,945	453,798	2,188,704	241.11	55.50	149.02
2015	2,240,545	441,955	1,922,495	242.35	56.70	151.28
2016	838,532	186,068	882,716	131.17	33.50	139.20
2017	834,325	179,222	949,472	132.58	34.83	142.81
2018	819,281	170,940	934,741	121.45	32.56	132.33
2019	240,998	54,832	294,582	72.49	24.57	110.84

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Panel B: Scope 1 Emissions by Industry

This panel shows average raw scope 1 emissions as well as average scope 1 emissions intensity for firm-years in each of the 69 distinct six-digit GICS industries. All variables are defined in Appendix A.

GICS	Industry	Raw Scope 1 Emissions	Scope 1 Emissions Intensity
101010	Energy Equipment & Services	464,497	188.42
101020	Oil, Gas & Consumable Fuels	7,837,752	573.70
151010	Chemicals	3,245,775	440.38
151020	Construction Materials	1,163,078	942.80
151030	Containers & Packaging	1,865,806	241.65
151040	Metals & Mining	3,590,588	557.49
151050	Paper & Forest Products	1,187,580	394.13
201010	Aerospace & Defense	229,165	19.20
201020	Building Products	313,106	91.31
201030	Construction & Engineering	248,237	100.93
201040	Electrical Equipment	49,171	25.42
201050	Industrial Conglomerates	1,668,187	73.38
201060	Machinery	157,150	43.34
201070	Trading Companies & Distributors	83,295	34.99
202010	Commercial Services & Supplies	1,009,012	248.36
202020	Professional Services	18,020	6.78
203010	Air Freight & Logistics	4,381,417	164.15
203020	Airlines	17,028,837	1,074.43
203030	Marine	1,047,149	777.95
203040	Road & Rail	1,935,181	243.35
203050	Transportation Infrastructure	427,222	253.72
251010	Auto Components	190,375	20.35
251020	Automobiles	944,273	13.03
252010	Household Durables	171,809	36.36
252020	Leisure Products	40,164	17.89
252030	Textiles, Apparel & Luxury Goods	92,201	31.56
253010	Hotels, Restaurants & Leisure	609,078	76.55
253020	Diversified Consumer Services	32,226	20.60
255010	Distributors	173,083	23.59
255020	Internet & Direct Marketing Retail	181,206	7.71
255030	Multiline Retail	193,759	12.62
255040	Specialty Retail	128,699	16.68
301010	Food & Staples Retailing	1,001,097	22.05
302010	Beverages	700,197	43.36
302020	Food Products	1,147,700	114.05
302030	Tobacco	330,145	13.55
303010	Household Products	957,789	60.63
303020	Personal Products	70,985	26.01
351010	Health Care Equipment & Supplies	50,597	17.35
351020	Health Care Providers & Services	205,274	15.94
351030	Health Care Technology	5,466	7.44
352010	Biotechnology	13,385	17.57
352020	Pharmaceuticals	202,122	17.33
352030	Life Sciences Tools & Services	31,050	13.89
401010	Banks	6,029	1.16
401020	Thrifts & Mortgage Finance	395	0.97
402010	Diversified Financial Services	70,743	18.32
402020	Consumer Finance	7,041	1.20
402030	Capital Markets	3,767	1.36
402040	Mortgage Real Estate Investment Trusts	4,971	4.27
403010	Insurance	22,833	1.72
451020	IT Services	29,590	4.93
451030	Software	7,674	4.63
452010	Communications Equipment	21,742	15.48

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452020	Technology Hardware, Storage & Peripherals	142,800	30.26
452030	Electronic Equipment, Instruments & Components	67,056	21.22
453010	Semiconductors & Semiconductor Equipment	147,027	38.30
501010	Diversified Telecommunication Services	201,175	6.11
501020	Wireless Telecommunication Services	25,159	5.11
502010	Media	20,969	3.50
502020	Entertainment	90,600	5.88
502030	Interactive Media & Services	16,354	3.95
551010	Electric Utilities	33,611,613	4,392.65
551020	Gas Utilities	852,319	263.73
551030	Multi-Utilities	18,513,566	2,468.00
551040	Water Utilities	56,520	99.62
551050	Independent Power and Renewable Electricity Producers	34,166,773	3,483.46
601010	Equity Real Estate Investment Trusts	53,693	20.36
601020	Real Estate Management & Development	20,480	14.69

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Panel C: Scope 2 Emissions by Industry

This panel shows average raw scope 2 emissions as well as average scope 3 emissions intensity for firm-years in each of the 69 distinct six-digit GICS industries. All variables are defined in Appendix A.

GICS	Industry	Raw Scope 2 Emissions	Scope 2 Emissions Intensity
101010	Energy Equipment & Services	86,845	26.95
101020	Oil, Gas & Consumable Fuels	1,048,688	72.49
151010	Chemicals	1,137,617	140.32
151020	Construction Materials	232,031	121.14
151030	Containers & Packaging	885,013	106.91
151040	Metals & Mining	1,076,416	181.87
151050	Paper & Forest Products	457,469	116.12
201010	Aerospace & Defense	337,958	25.39
201020	Building Products	215,980	56.34
201030	Construction & Engineering	61,514	17.48
201040	Electrical Equipment	70,397	26.18
201050	Industrial Conglomerates	764,044	36.01
201060	Machinery	147,033	28.31
201070	Trading Companies & Distributors	46,332	14.42
202010	Commercial Services & Supplies	62,584	23.06
202020	Professional Services	37,165	10.11
203010	Air Freight & Logistics	353,653	14.86
203020	Airlines	117,653	4.83
203030	Marine	34,530	21.00
203040	Road & Rail	88,513	12.27
203050	Transportation Infrastructure	54,477	32.82
251010	Auto Components	281,374	36.17
251020	Automobiles	2,005,152	20.71
252010	Household Durables	143,173	26.52
252020	Leisure Products	54,698	19.81
252030	Textiles, Apparel & Luxury Goods	96,629	27.04
253010	Hotels, Restaurants & Leisure	380,397	71.32
253020	Diversified Consumer Services	94,194	69.01
255010	Distributors	122,237	16.68
255020	Internet & Direct Marketing Retail	339,311	24.01
255030	Multiline Retail	863,768	46.30
255040	Specialty Retail	354,416	39.25
301010	Food & Staples Retailing	2,260,035	33.29
302010	Beverages	472,054	30.48
302020	Food Products	617,388	48.70
302030	Tobacco	345,663	13.21
303010	Household Products	1,066,230	57.14
303020	Personal Products	42,939	16.69
351010	Health Care Equipment & Supplies	67,400	18.97
351020	Health Care Providers & Services	289,814	19.28
351030	Health Care Technology	6,484	7.42
352010	Biotechnology	15,123	22.78
352020	Pharmaceuticals	215,003	21.73
352030	Life Sciences Tools & Services	47,059	17.77
401010	Banks	58,441	3.33
401020	Thrifts & Mortgage Finance	1,193	2.42
402010	Diversified Financial Services	87,981	21.70
402020	Consumer Finance	54,663	7.87
402030	Capital Markets	38,043	8.32
402040	Mortgage Real Estate Investment Trusts	21,083	19.86
403010	Insurance	37,805	3.30
451020	IT Services	105,059	11.20
451030	Software	51,995	8.22
452010	Communications Equipment	75,331	16.57

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452020	Technology Hardware, Storage & Peripherals	293,315	22.59
452030	Electronic Equipment, Instruments & Components	128,689	29.97
453010	Semiconductors & Semiconductor Equipment	204,697	42.44
501010	Diversified Telecommunication Services	1,555,041	29.14
501020	Wireless Telecommunication Services	109,883	14.26
502010	Media	66,355	10.98
502020	Entertainment	135,006	13.94
502030	Interactive Media & Services	312,589	16.38
551010	Electric Utilities	798,976	149.03
551020	Gas Utilities	22,702	11.26
551030	Multi-Utilities	550,873	64.86
551040	Water Utilities	92,008	46.36
551050	Independent Power and Renewable Electricity Producers	69,672	7.91
601010	Equity Real Estate Investment Trusts	91,639	64.49
601020	Real Estate Management & Development	63,857	42.64

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Panel D: Scope 3 Emissions by Industry

This panel shows average raw scope 3 emissions as well as average scope 3 emissions intensity for firm-years in each of the 69 distinct six-digit GICS industries. All variables are defined in Appendix A.

GICS	Industry	Raw Scope 3 Emissions	Scope 3 Emissions Intensity
101010	Energy Equipment & Services	1,102,553	258.64
101020	Oil, Gas & Consumable Fuels	8,168,938	201.39
151010	Chemicals	2,621,048	363.81
151020	Construction Materials	878,822	472.42
151030	Containers & Packaging	2,692,098	391.67
151040	Metals & Mining	3,326,545	534.87
151050	Paper & Forest Products	808,877	272.03
201010	Aerospace & Defense	2,923,396	174.45
201020	Building Products	848,761	317.98
201030	Construction & Engineering	562,266	202.89
201040	Electrical Equipment	789,617	266.20
201050	Industrial Conglomerates	4,636,339	225.70
201060	Machinery	1,682,392	324.82
201070	Trading Companies & Distributors	197,988	63.86
202010	Commercial Services & Supplies	440,719	173.13
202020	Professional Services	113,540	34.24
203010	Air Freight & Logistics	2,046,971	94.81
203020	Airlines	2,375,303	135.42
203030	Marine	179,764	116.41
203040	Road & Rail	636,082	107.18
203050	Transportation Infrastructure	193,482	116.98
251010	Auto Components	2,141,244	365.12
251020	Automobiles	18,299,331	324.09
252010	Household Durables	1,304,561	238.47
252020	Leisure Products	728,168	262.62
252030	Textiles, Apparel & Luxury Goods	1,152,166	190.84
253010	Hotels, Restaurants & Leisure	600,922	122.61
253020	Diversified Consumer Services	155,344	99.26
255010	Distributors	378,625	53.61
255020	Internet & Direct Marketing Retail	873,148	60.29
255030	Multiline Retail	1,449,293	70.10
255040	Specialty Retail	676,600	72.94
301010	Food & Staples Retailing	6,038,132	105.38
302010	Beverages	6,273,917	399.37
302020	Food Products	13,045,781	818.23
302030	Tobacco	8,146,452	353.33
303010	Household Products	4,651,963	271.71
303020	Personal Products	546,560	130.26
351010	Health Care Equipment & Supplies	573,920	139.70
351020	Health Care Providers & Services	1,739,824	69.12
351030	Health Care Technology	39,341	46.17
352010	Biotechnology	106,609	80.65
352020	Pharmaceuticals	1,317,103	106.32
352030	Life Sciences Tools & Services	313,823	116.42
401010	Banks	140,356	21.37
401020	Thrifts & Mortgage Finance	10,974	20.31
402010	Diversified Financial Services	3,024,457	342.36
402020	Consumer Finance	233,553	26.79
402030	Capital Markets	153,211	36.15
402040	Mortgage Real Estate Investment Trusts (REITs)	19,272	32.40
403010	Insurance	334,401	30.50
451020	IT Services	275,046	42.14
451030	Software	186,587	39.07
452010	Communications Equipment	614,347	114.66

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452020	Technology Hardware, Storage & Peripherals	3,146,521	149.64
452030	Electronic Equipment, Instruments & Components	465,454	149.72
453010	Semiconductors & Semiconductor Equipment	663,989	152.58
501010	Diversified Telecommunication Services	1,693,760	53.87
501020	Wireless Telecommunication Services	336,343	53.90
502010	Media	410,518	65.51
502020	Entertainment	477,441	54.36
502030	Interactive Media & Services	562,012	47.39
551010	Electric Utilities	2,787,080	334.82
551020	Gas Utilities	776,014	260.48
551030	Multi-Utilities	2,244,533	301.97
551040	Water Utilities	42,336	73.42
551050	Independent Power and Renewable Electricity Producers	1,455,942	188.81
601010	Equity Real Estate Investment Trusts (REITs)	85,323	43.92
601020	Real Estate Management & Development	88,984	65.66

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Table OA2: Industries by Percentage of Vendor-Estimated Emissions Figures

This table presents the full list of industries in our sample, along with the percentage of observations that are Trucost-estimated (rather than firm-disclosed). The table is sorted from highest to lowest according to the percentage of emissions observations that are estimated rather than disclosed. We define a firm to have estimated emissions if its scope 1 emissions are estimated by Trucost.

GICS	Industry	Distinct Firms	Firm-Month Observations	% Obs. with Estimated Emissions
401020	Thrifts & Mortgage Finance	42	2,414	100
253020	Diversified Consumer Services	23	1,998	100
402040	Mortgage Real Estate Investment Trusts	34	1,674	100
351030	Health Care Technology	19	1,023	100
255010	Distributors	6	541	100
203050	Transportation Infrastructure	1	60	100
551020	Gas Utilities	11	937	99
501020	Wireless Telecommunication Services	7	691	97
352010	Biotechnology	179	8,087	93
151020	Construction Materials	7	689	93
402010	Diversified Financial Services	5	349	93
502010	Media	47	4,787	91
201030	Construction & Engineering	27	2,059	91
401010	Banks	230	14,427	90
201070	Trading Companies & Distributors	33	2,400	90
502020	Entertainment	20	1,579	90
255020	Internet & Direct Marketing Retail	25	1,864	89
202020	Professional Services	35	2,520	88
303020	Personal Products	12	874	86
601010	Equity Real Estate Investment Trusts	168	13,429	85
255040	Specialty Retail	84	7,492	85
252010	Household Durables	43	3,686	85
101010	Energy Equipment & Services	52	4,028	84
402020	Consumer Finance	25	1,641	83
451030	Software	118	6,880	82
452030	Electronic Equipment, Instruments & Components	53	4,294	82
201040	Electrical Equipment	29	2,532	82
601020	Real Estate Management & Development	18	1,151	81
551040	Water Utilities	9	836	80
351010	Health Care Equipment & Supplies	92	6,277	79
403010	Insurance	70	7,621	78
402030	Capital Markets	65	6,199	78
351020	Health Care Providers & Services	60	5,053	78
502030	Interactive Media & Services	17	1,173	78
252020	Leisure Products	17	1,214	77
451020	IT Services	71	5,419	76
202010	Commercial Services & Supplies	51	4,455	76
252030	Textiles, Apparel & Luxury Goods	26	2,136	76
251010	Auto Components	24	1,737	73
201060	Machinery	93	8,395	72
253010	Hotels, Restaurants & Leisure	72	6,012	72
151040	Metals & Mining	33	3,242	71
352020	Pharmaceuticals	59	2,920	71
501010	Diversified Telecommunication Services	18	1,364	71
201020	Building Products	25	1,858	70
201010	Aerospace & Defense	33	2,818	68
452010	Communications Equipment	34	2,419	68
453010	Semiconductors & Semiconductor Equipment	64	5,739	66
352030	Life Sciences Tools & Services	24	2,159	65
203040	Road & Rail	28	2,346	64
255030	Multiline Retail	12	1,785	64

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201050	Industrial Conglomerates	6	793	64
101020	Oil, Gas & Consumable Fuels	98	8,355	61
203010	Air Freight & Logistics	11	1,008	61
301010	Food & Staples Retailing	20	1,885	59
151050	Paper & Forest Products	7	435	54
302020	Food Products	38	3,761	49
151010	Chemicals	59	4,967	47
302030	Tobacco	6	477	47
151030	Containers & Packaging	16	2,376	44
251020	Automobiles	6	810	44
203030	Marine	3	276	43
452020	Technology Hardware, Storage & Peripherals	19	1,871	40
302010	Beverages	11	1,860	39
303010	Household Products	9	1,049	28
551050	Independent Power and Renewable Electricity Producers	5	469	19
551030	Multi-Utilities	15	2,114	7
203020	Airlines	11	872	7
551010	Electric Utilities	27	3,568	5

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Table OA3: Are Future Returns Associated with Emissions?

This table provides results from estimating regressions of future stock returns on the natural logarithm of scope 1, 2, and 3 emissions and including the full set of control variables, analogous to columns (7)-(9) of Table 7 Panel C. The dependent variable in all columns is monthly stock returns for month *t*+1, expressed as a percentage. Please refer to Appendix A for variable definitions. All specifications include industry and month-year fixed effects, and standard errors are clustered by industry and month-year. We report standard errors in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	Ret(t+1)	Ret(t+1)	Ret(t+1)
Log Scope 1	-0.022		
	(0.035)		
Log Scope 2		-0.029	
		(0.049)	
Log Scope 3			0.032
			(0.095)
Log Sales	0.019	0.030	-0.030
	(0.077)	(0.087)	(0.107)
HHI	-0.512	-0.501	-0.522
	(1.109)	(1.114)	(1.114)
SaleGR	-0.251*	-0.251*	-0.252*
	(0.129)	(0.130)	(0.129)
EPSGR	-0.002	-0.002	-0.002
	(0.012)	(0.012)	(0.012)
Leverage	0.278	0.279	0.281
	(0.352)	(0.351)	(0.351)
Log PPE	-0.046	-0.049	-0.054
	(0.055)	(0.053)	(0.055)
ROE	0.000	0.000	0.000
	(0.002)	(0.002)	(0.002)
Invest/A	1.173	1.229	1.208
	(1.619)	(1.600)	(1.615)
Constant	1.345***	1.335***	1.141*
	(0.474)	(0.503)	(0.645)
Observations	166,923	166,923	166,923
R-squared	0.193	0.193	0.193
Industry	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes
Clustering	Yes	Yes	Yes

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Table OA4: Are Future Returns Associated with Emissions?

This table provides results from regressions of five measures of operating performance and profitability – EBIT margin (the ratio of EBIT to assets), EBITDA margin (the ratio of EBITDA to assets), ROA (return on assets), ROS (return on sales), and Tobin's *q* – on two alternative measures of emissions (growth in emissions and change in emissions intensity). For brevity we only tabulate results using scope 1 emissions. Panel A considers the relation between operating performance and the the year-over-year emissions growth rate, while Panel B instead considers the year-over-year change in emissions intensity. Please refer to Appendix A for variable definitions. We report standard errors in parentheses beneath coefficient estimates. In all panels, *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Panel A: Growth in Scope 1 Emissions

This panel provides results from regressions of operating performance on the year-over-year growth in scope 1 emissions. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Scope 1 Growth	0.185	0.205	0.001	0.185	0.251***
	(0.147)	(0.161)	(0.006)	(0.147)	(0.083)
Log Sales	0.283*	0.267*	0.037***	0.283*	0.094
	(0.144)	(0.155)	(0.008)	(0.144)	(0.060)
HHI	0.888	0.921	0.036	0.888	-0.412
	(0.616)	(0.647)	(0.042)	(0.616)	(0.277)
SaleGR	0.089	0.111	-0.002	0.089	0.186
	(0.144)	(0.150)	(0.009)	(0.144)	(0.118)
EPSGR	-0.007*	-0.008**	-0.000	-0.007*	0.012***
	(0.004)	(0.004)	(0.000)	(0.004)	(0.004)
Leverage	0.297	0.351	-0.006	0.297	-0.287
	(0.265)	(0.282)	(0.023)	(0.265)	(0.232)
Log PPE	-0.088	-0.065	-0.018***	-0.088	-0.210***
	(0.062)	(0.070)	(0.005)	(0.062)	(0.060)
ROE	0.008***	0.008***	0.001***	0.008***	0.004***
	(0.003)	(0.003)	(0.000)	(0.003)	(0.001)
Invest/A	2.054*	2.243*	0.444***	2.054*	7.655***
	(1.170)	(1.194)	(0.131)	(1.170)	(1.671)
Constant	-2.077**	-2.073**	-0.143***	-2.077**	2.387***
	(0.967)	(1.023)	(0.053)	(0.967)	(0.234)
Observations	167,964	166,733	167,964	167,964	167,868
R-squared	0.354	0.337	0.477	0.354	0.325
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Panel B: Change in Scope 1 Intensity

This panel provides results from regressions of operating performance on the year-over-year change in carbon intensity. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Change in Scope 1 Intensity	0.004	0.010	-0.003	0.004	0.002
	(0.009)	(0.009)	(0.002)	(0.009)	(0.012)
Log Sales	0.282*	0.265*	0.037***	0.282*	0.092
	(0.143)	(0.154)	(0.008)	(0.143)	(0.060)
HHI	0.881	0.913	0.036	0.881	-0.422
	(0.612)	(0.643)	(0.042)	(0.612)	(0.277)
SaleGR	0.180	0.212	-0.002	0.180	0.310***
	(0.168)	(0.178)	(0.008)	(0.168)	(0.110)
EPSGR	-0.007*	-0.008**	-0.000	-0.007*	0.012***
	(0.004)	(0.004)	(0.000)	(0.004)	(0.004)
Leverage	0.302	0.357	-0.006	0.302	-0.280
	(0.269)	(0.287)	(0.023)	(0.269)	(0.231)
Log PPE	-0.087	-0.064	-0.018***	-0.087	-0.209***
	(0.062)	(0.069)	(0.005)	(0.062)	(0.060)
ROE	0.008***	0.008***	0.001***	0.008***	0.004***
	(0.003)	(0.003)	(0.000)	(0.003)	(0.001)
Invest/A	2.097*	2.291*	0.444***	2.097*	7.713***
	(1.207)	(1.235)	(0.131)	(1.207)	(1.682)
Constant	-2.070**	-2.065**	-0.143***	-2.070**	2.397***
	(0.962)	(1.017)	(0.053)	(0.962)	(0.236)
Observations	167,964	166,733	167,964	167,964	167,868
R-squared	0.353	0.336	0.477	0.353	0.323
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Table OA5: Are Future Returns Associated with Firm-Disclosed Emissions?

This table is analogous to Panel C of Table 9, but instead considers alternative measures of emissions to the natural logarithm of unscaled emissions. We provide results from regressions of five measures of operating performance and profitability – EBIT margin (the ratio of EBIT to assets), EBITDA margin (the ratio of EBITDA to assets), ROA (return on assets), ROS (return on sales), and Tobin's *q* – on three measures of carbon emissions: carbon emissions intensity, the year-over-year emissions growth rate, and the year-over-year change in emissions intensity. For brevity we only tabulate results using scope 1 emissions. Panel A considers the relation between operating performance and carbon intensity; Panel B considers the year-over-year emissions growth rate; and Panel C considers the year-over-year change in emissions intensity. Please refer to Appendix A for variable definitions. We report standard errors in parentheses beneath coefficient estimates. In all panels, *, **, and *** indicate statistical significance at 10% ,5%, and 1% levels, respectively.

Panel A: Scope 1 Emissions Intensity

This panel provides results from regressions of operating performance on scope 1 emissions intensity, only for the subsample of observations with disclosed (rather than vendor-estimated) scope 1 emissions figures. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Scope 1 Intensity	0.001	0.001	-0.001	0.001	-0.005
	(0.002)	(0.002)	(0.000)	(0.002)	(0.006)
Log Sales	0.034	-0.009	0.024***	0.034	0.159*
	(0.031)	(0.033)	(0.006)	(0.031)	(0.094)
HHI	-0.047	-0.084	0.002	-0.047	-0.518
	(0.092)	(0.091)	(0.023)	(0.092)	(0.372)
SaleGR	0.174***	0.151***	0.049***	0.174***	0.345*
	(0.051)	(0.042)	(0.012)	(0.051)	(0.187)
EPSGR	0.006	0.006	0.001*	0.006	0.010*
	(0.004)	(0.004)	(0.001)	(0.004)	(0.005)
Leverage	-0.024	-0.003	-0.025	-0.024	0.110
	(0.054)	(0.060)	(0.031)	(0.054)	(0.374)
Log PPE	-0.011	0.026	-0.020***	-0.011	-0.241***
	(0.027)	(0.030)	(0.005)	(0.027)	(0.085)
ROE	0.001***	0.001***	0.001***	0.001***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Invest/A	-0.035	0.185	0.357**	-0.035	5.818***
	(0.319)	(0.292)	(0.144)	(0.319)	(2.043)
Constant	-0.093	0.067	0.012	-0.093	2.083***
	(0.130)	(0.130)	(0.033)	(0.130)	(0.393)
Observations	51,915	51,867	51,915	51,915	51,914
R-squared	0.219	0.236	0.370	0.219	0.419
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Panel B: Growth in Scope 1 Emissions

This panel provides results from regressions of operating performance on the year-over-year growth in scope 1 emissions, only for the subsample of observations with disclosed (rather than vendor-estimated) scope 1 emissions figures. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Scope 1 Growth	-0.014	-0.009	-0.005	-0.014	-0.093*
	(0.014)	(0.014)	(0.003)	(0.014)	(0.050)
Log Sales	0.026	-0.017	0.024***	0.026	0.166*
	(0.029)	(0.032)	(0.006)	(0.029)	(0.095)
HHI	-0.034	-0.068	0.000	-0.034	-0.541
	(0.069)	(0.069)	(0.023)	(0.069)	(0.399)
SaleGR	0.188***	0.164***	0.053***	0.188***	0.391*
	(0.039)	(0.033)	(0.011)	(0.039)	(0.206)
EPSGR	0.006	0.006	0.001*	0.006	0.009*
	(0.004)	(0.004)	(0.001)	(0.004)	(0.005)
Leverage	-0.017	0.002	-0.021	-0.017	0.160
	(0.044)	(0.048)	(0.030)	(0.044)	(0.380)
Log PPE	-0.009	0.028	-0.020***	-0.009	-0.248***
	(0.027)	(0.030)	(0.005)	(0.027)	(0.086)
ROE	0.001***	0.001**	0.001***	0.001***	0.005***
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Invest/A	-0.123	0.096	0.346**	-0.123	5.821***
	(0.318)	(0.284)	(0.158)	(0.318)	(2.093)
Constant	-0.029	0.132	0.014	-0.029	2.051***
	(0.100)	(0.108)	(0.033)	(0.100)	(0.404)
Observations	50,014	49,966	50,014	50,014	50,014
R-squared	0.228	0.249	0.378	0.228	0.419
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Panel C: Change in Carbon Intensity

This panel provides results from regressions of operating performance on the year-over-year change in scope 1 emissions intensity, only for the subsample of observations with disclosed (rather than vendor-estimated) scope 1 emissions figures. In Column (1) the dependent variable is EBIT margin, in Column (2) the dependent variable is EBITDA margin; in Column (3) the dependent variable is ROA; in Column (4) the dependent variable is ROS; and in Column (5) the dependent variable is Tobin's *q*. All specifications include industry and month-year fixed effects. Standard errors are two-way clustered by industry and month-year.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EBIT Margin	EBITDA Margin	ROA	ROS	Tobin's Q
Change in Carbon Intensity	-0.006	-0.004	-0.001	-0.006	0.004
	(0.006)	(0.005)	(0.002)	(0.006)	(0.006)
Log Sales	0.026	-0.017	0.024***	0.026	0.168*
	(0.029)	(0.032)	(0.006)	(0.029)	(0.095)
HHI	-0.031	-0.066	0.001	-0.031	-0.531
	(0.068)	(0.067)	(0.023)	(0.068)	(0.399)
SaleGR	0.179***	0.158***	0.050***	0.179***	0.356*
	(0.039)	(0.035)	(0.011)	(0.039)	(0.192)
EPSGR	0.006	0.006	0.001*	0.006	0.009*
	(0.004)	(0.004)	(0.001)	(0.004)	(0.005)
Leverage	-0.018	0.002	-0.022	-0.018	0.156
	(0.044)	(0.047)	(0.030)	(0.044)	(0.382)
Log PPE	-0.009	0.028	-0.021***	-0.009	-0.250***
	(0.027)	(0.029)	(0.005)	(0.027)	(0.086)
ROE	0.001***	0.001***	0.001***	0.001***	0.005***
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Invest/A	-0.122	0.097	0.345**	-0.122	5.788***
	(0.318)	(0.285)	(0.157)	(0.318)	(2.081)
Constant	-0.029	0.132	0.014	-0.029	2.048***
	(0.101)	(0.108)	(0.033)	(0.101)	(0.405)
Observations	50,014	49,966	50,014	50,014	50,014
R-squared	0.228	0.249	0.378	0.228	0.418
Industry	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes
Clustering	Yes	Yes	Yes	Yes	Yes

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Table OA6: Sample Selection for European Firms

This table outlines the process we use to select the firms underlying our sample from Trucost's European carbon emissions database.

Filters		Number of Distinct Firms
Start: Firms in TRUCOST European database		2,914
Less: Firm identifier (ISIN) is missing	-15	2,899
Less: Firms not matched to Datastream or COMPUSTAT Global	-61	2,838
Less: Firms missing returns or emissions data	-41	2,797

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Table OA7: Summary Statistics for European firms

This table provides summary statistics for variables used in our main European returns regressions. Following Bolton and Kacperczyk (2021a, 2021b), we winsorize different variables at different values; where we do so, we provide the winsorization cutoff based on the percentage of observations in each tail of the distribution. Please refer to Appendix A for variable definitions.

Variable	Mean	Median	Standard Deviation	Winsorization cutoff (%)
Dependent Variables				
Monthly Return (in %)	0.970	0.700	11.030	-
ROA	5.330	5.220	9.180	
EBIT Margin	39.210	34.840	24.860	
Emission Variables				
Log Scope 1	9.920	9.700	3.070	-
Log Scope 2	9.920	9.930	2.400	-
Log Scope 3	11.850	11.900	2.400	-
Carbon Intensity Scope 1	1.170	0.140	3.000	2.5
Carbon Intensity Scope 2	0.340	0.160	0.500	2.5
Carbon Intensity Scope 3	1.620	0.940	1.740	2.5
Growth Scope 1	0.130	0.010	0.760	2.5
Growth Scope 2	0.150	0.010	0.840	2.5
Growth Scope 3	0.060	0.030	0.300	2.5
Change in Intensity Scope1	-2.300	-0.120	37.540	1
Change in Intensity Scope2	-0.260	-0.280	10.090	1
Change in Intensity Scope3	-3.050	-1.120	19.830	1
Control Variables				
Log Sales	21.080	21.050	1.950	-
ROE (in %)	11.660	11.970	24.380	2.5
Invest/A	0.140	0.030	0.510	2.5
Leverage	0.650	0.200	1.920	2.5
EPSG (in %)	39.770	9.030	157.430	0.5
Sales Growth (in %)	10.440	5.940	26.510	0.5
Log PPE	5.881	5.830	2.611	2.5
Book_Market	0.696	0.528	0.636	1
HHI	0.013	0.010	0.010	-

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Table OA8: Yearly, Country, and Industry Distribution of Firms and Observations

This table shows the distribution of the number of firms and firm-month observations for the full European estimation sample (representing firms in the intersection of Trucost, Datastream, and Compustat Global coverage). Panel A provides data on observations by year, Panel B provides data on observations by country, and Panel C provides data on observations by industry. For brevity, in Panel C we show only the top 10 and bottom 10 industries by frequency; a full list is available from the authors upon request.

Panel A: Yearly Distribution

This table shows the yearly distribution of the number of firms and firm-month observations for the full estimation sample (representing firms in the intersection of Trucost, Datastream, and Global Compustat coverage).

Year	Distinct Firms	Firm-Month Observations
2005	957	11,242
2006	1019	12,003
2007	1117	13,142
2008	1071	12,782
2009	1087	13,007
2010	1117	13,269
2011	1142	13,625
2012	1151	13,753
2013	1465	17,417
2014	1573	18,533
2015	1616	19,144
2016	2156	25,567
2017	2241	26,480
2018	2295	27,374
2019	1451	17,379

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Panel B: Country-Level Distribution

This Table reports the country level distribution of distinct firms, firm-month observations, and percentage of estimated observations. Please refer to Appendix A for variable definitions.

	Country	Distinct Firms	Firm-Month Observations	% of Estimated Observations
1	AUSTRIA	44	4,375	48
2	BELGIUM	73	6,128	54
3	BOSNIA AND HERZEGOVINA	1	12	100
4	BULGARIA	5	312	100
5	CYPRUS	9	202	76
6	CZECH REPUBLIC	8	714	61
7	DENMARK	61	5,598	45
8	ESTONIA	3	216	33
9	FINLAND	64	6,269	35
10	FRANCE	292	26,860	44
11	GERMANY	280	22,947	52
12	GREECE	43	3,473	65
13	HUNGARY	6	708	36
14	ICELAND	4	122	100
15	IRELAND	64	4,292	55
16	ISLE OF MAN	5	132	64
17	ITALY	165	13,326	47
18	JERSEY	14	303	72
19	LIECHTENSTEIN	2	144	17
20	LITHUANIA	2	156	100
21	LUXEMBOURG	44	2,089	65
22	MALTA	5	108	89
23	MONACO	6	131	100
24	NETHERLANDS	113	9,004	40
25	NORWAY	110	7,305	49
26	POLAND	72	6,803	71
27	PORTUGAL	23	2,040	25
28	ROMANIA	7	520	79
29	RUSSIAN FEDERATION	70	5,661	58
30	SERBIA	3	192	81
31	SLOVENIA	2	168	14
32	SPAIN	110	9,853	38
33	SWEDEN	220	16,484	48
34	SWITZERLAND	235	20,075	57
35	UKRAINE	6	396	55
36	UNITED KINGDOM	734	77,599	38
	Total	2,797	254,717	

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Panel C: Top 10 and Bottom 10 Industries in European Sample by Number of Observations

This table shows the industry distribution of the number of firms and firm-month observations for the full estimation sample (representing firms in the intersection of Trucost Datastream, and Global Compustat coverage).

GICS	Industry	Distinct Firms	Firm-Month Observations	
401010	Banks	144	13,419	
601020	Real Estate Management & Development	167	11,753	
201060	Machinery	151	11,229	
502010	Media (discont. 2018)	95	8,699	
101020	Oil, Gas & Consumable Fuels	106	8,639	Top 10
403010	Insurance	77	8,453	
402030	Capital Markets	114	7,953	
201030	Construction & Engineering	84	7,754	
253010	Hotels, Restaurants & Leisure	93	7,707	
151040	Metals & Mining	81	7,584	
303020	Personal Products	11	870	
303010	Household Products	10	857	
502020	Entertainment	27	787	
255010	Distributors	12	785	
302030	Tobacco	5	621	
551020	Gas Utilities	8	588	Bottom 10
401020	Thrifts & Mortgage Finance	9	540	
351030	Health Care Technology	10	528	
253020	Diversified Consumer Services	8	437	
502030	Interactive Media & Services	9	299	
	Full Sample	2,729	214,229	

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Table OA9: Correlations

This table shows univariate correlations corresponding to our main emissions and financial performance variables. Panel A provides correlations between our main emissions measures; Panel B provides correlations between our main emissions measures and three measures of firm size; and Panel C provides correlations between our measures of firm performance and profitability. Please refer to Appendix A for variable definitions
.

Panel A: Correlation between Emissions Variables

This panel shows univariate correlations between log emissions and emissions intensity for scope 1, 2, and 3 emissions.

	Log Scope 1	Log Scope 2	Log Scope 3	Carbon Intensity Scope 1	Carbon Intensity Scope 2	Carbon Intensity Scope 3
Log Scope 1	1					
Log Scope 2	0.787	1				
Log Scope 3	0.824	0.835	1			
Carbon Intensity Scope 1	0.594	0.231	0.259	1		
Carbon Intensity Scope 2	0.336	0.474	0.146	0.317	1	
Carbon Intensity Scope 3	0.460	0.378	0.521	0.311	0.340	1

Panel B: Correlation between Emissions Variables and Firm Size

This panel shows univariate correlations between carbon emissions and firm size.

	Log Market Cap.	Log Sales	Log Employees	Log Scope 1	Log Scope 2	Log Scope 3	Carbon Intensity Scope 1	Carbon Intensity Scope 2	Carbon Intensity Scope 3
Log Market Cap.	1								
Log Sales	0.788	1							
Log Employees	0.643	0.866	1						
Log Scope 1	0.486	0.681	0.635	1					
Log Scope 2	0.604	0.768	0.720	0.780	1				
Log Scope 3	0.664	0.889	0.817	0.817	0.830	1			
Carbon Intensity Scope 1	0.091	0.147	0.114	0.605	0.239	0.269	1		
Carbon Intensity Scope 2	0.017	0.011	0.044	0.346	0.485	0.157	0.324	1	
Carbon Intensity Scope 3	0.044	0.152	0.190	0.459	0.375	0.522	0.316	0.348	1

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Panel C: Correlation between Emissions Variables and Financial Performance Measures

This panel shows univariate correlations between firms' financial performance and Emission measures.

	ROA	EBIT Margin	Log Scope 1	Log Scope 2	Log Scope 3	Carbon Intensity Scope 1	Carbon Intensity Scope 2	Carbon Intensity Scope 3
ROA	1							
EBIT Margin	0.184	1						
Log Scope 1	0.066	-0.343	1					
Log Scope 2	0.130	-0.229	0.776	1				
Log Scope 3	0.152	-0.347	0.826	0.829	1			
Carbon Intensity Scope 1	-0.047	-0.160	0.602	0.224	0.260	1		
Carbon Intensity Scope 2	-0.021	-0.047	0.313	0.480	0.141	0.300	1	
Carbon Intensity Scope 3	0.037	-0.279	0.431	0.368	0.539	0.289	0.305	1

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TABLE OA10: Disclosed vs. Estimated Values

This table provides a breakdown of the number of firms and firm-month observations with disclosed vs. vendor-estimated figures. We define a firm to have estimated emissions if its scope 1 emissions are estimated by the vendor. In Panel A we provide the distribution of disclosed vs. estimated observations by year; in Panel B we provide the distribution of disclosed vs. estimated observations by industry. For brevity, in Panel B we show only the top 10 and bottom 10 industries, for industries with at least 10 distinct firms, according to the percentage of observations with estimated values.

Panel A: Estimated Values by Year

Panel A provides the distribution of full sample and disclosed vs. estimated observations by year

	Full Sample		Disclosed Values		Estimated Values		% of Estimated Observations
Year	Firms	Observations	Firms	Observations	Firms	Observations	
2005	957	11,242	299	3,575	658	7,667	68
2006	1019	12,003	380	4,490	639	7,513	63
2007	1117	13,142	446	5,300	671	7,842	60
2008	1071	12,782	501	5,997	570	6,785	53
2009	1087	13,007	555	6,654	532	6,353	49
2010	1117	13,269	637	7,602	480	5,667	43
2011	1142	13,625	671	8,031	471	5,594	41
2012	1151	13,753	705	8,436	446	5,317	39
2013	1465	17,417	845	10,068	620	7,349	42
2014	1573	18,533	956	11,385	617	7,148	39
2015	1616	19,144	1027	12,214	589	6,930	36
2016	2156	25,567	1169	13,926	987	11,641	46
2017	2241	26,480	1273	15,210	968	11,270	43
2018	2295	27,374	1341	16,056	954	11,318	41
2019	1451	17,379	716	8,572	735	8,807	51

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Panel B: Top Ten and Bottom Ten Industries by Highest Percent of Estimated Values

This panel presents the top ten and bottom ten industries in our sample according to the percentage of emissions observations that are estimated rather than disclosed, for industries with at least ten distinct firms. We define a firm to have estimated emissions if its scope 1 emissions are estimated by Trucost.

GICS Industry Name	Distinct Firms	Firm-Month Observations	% of Estimated Observations	
Diversified Financial Services	62	3955	84	
Biotechnology	74	3,563	82	
Entertainment	27	787	82	
Software	81	4,571	78	
Internet Software & Services	26	987	76	Top 10
Interactive Media & Services	9	299	68	
Technology Hardware, Storage & Periphery	84	1,520	66	
Real Estate Management & Development	167	11,753	65	
Health Care Technology	10	528	64	
Health Care Providers & Services	40	2,202	63	
Paper & Forest Products	23	2,062	23.9	
Water Utilities	10	888	21.6	
Tobacco	5	621	20.8	
Air Freight & Logistics	17	1,431	18.5	
Electric Utilities	52	4,460	15.7	Bottom 10
Household Products	10	857	14.6	
Construction Materials	27	1,971	14.5	
Multi-Utilities	22	1,973	11.6	
Automobiles	12	1,105	9.9	
Gas Utilities	8	588	6.1	
	2,797	254,717		

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Table OA11: Differences Between Estimated and Disclosed Emissions in Europe

This table estimates an emissions prediction model for each of scope 1, 2, and 3 emissions. In columns (1), (2), and (3) the dependent variable is the natural logarithm of scope 1, 2, and 3 emissions, respectively. In Column (1) – Column (3), the independent variable of interest is Estimated Indicator, a dummy for whether the firm's emissions corresponding to month-year *t* are vendor-estimated. All specifications include control variables, firm fixed effects, and month-year fixed effects. Standard errors are two-way clustered by firm and month-year. Please refer to Appendix A for variable definitions. We report standard errors in parentheses beneath coefficient estimates. In all panels, *, **, and *** indicate statistical significance at 10% ,5%, and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	Log Scope1	Log Scope2	Log Scope3
Estimated Indicator	0.608***	0.372***	-0.008
	(0.060)	(0.052)	(0.009)
Log Sales	0.801***	0.703***	0.942***
	(0.097)	(0.079)	(0.052)
Leverage	0.062***	0.038**	0.004
	(0.023)	(0.017)	(0.004)
Invest/A	-0.006	0.006	0.019
	(0.087)	(0.076)	(0.027)
ROE	-0.001	-0.000	-0.001
	(0.001)	(0.001)	(0.000)
Log PPE	0.057	0.123***	0.010
	(0.044)	(0.036)	(0.016)
HHI	-0.593	3.261**	-0.638
	(1.646)	(1.611)	(0.453)
Sales Growth	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.000)
EPSG	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)
Book to Market	0.104***	0.131***	0.016
	(0.035)	(0.038)	(0.014)
Constant	-7.085***	-5.644***	-7.665***
	(1.967)	(1.612)	(1.115)
Observations	150,089	149,920	150,089
R-squared	0.961	0.930	0.993
Firm FE	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes
Cluster	Yes	Yes	Yes

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Table OA12: Stock Returns and Carbon Emissions in Europe – All Specifications

This table provides results from estimating regressions of stock returns on four measures of carbon emissions. In Panels A, B, and C we estimate the relation between monthly stock returns and the natural logarithm of raw scope 1, 2, and 3 carbon emissions. The dependent variable in all panels is monthly stock returns, expressed as a percentage. In Panels D, E, and F we replace the emissions variables with carbon emissions intensity, the year-over-year growth in carbon emissions, and the year-over-year change in carbon emissions intensity, respectively. Please refer to Appendix A for variable definitions. We report standard errors in parentheses. In all panels, *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

Panel A: Log Emissions

This panel provides results from regressions of monthly returns on log emissions. In Columns (1), (2), and (3) we report results from regressions of returns on scope 1, 2, and 3 emissions, respectively, country fixed effects as well as month-year fixed effects (but no other control variables). Columns (4) – (6) replicate Columns (1) – (3) but with the addition of firm sales as a control.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Return	Return	Return	Return	Return	Return
Log Scope 1	-0.028***			-0.003		
	(0.007)			(0.009)		
Log Scope 2		-0.036***			0.004	
		(0.009)			(0.013)	
Log Scope 3			-0.028***			0.074***
			(0.009)			(0.019)
Log Sales				-0.063***	-0.070***	-0.147***
				(0.015)	(0.017)	(0.023)
Constant	1.239***	1.320***	1.292***	2.327***	2.400***	3.186***
	(0.072)	(0.090)	(0.107)	(0.258)	(0.265)	(0.311)
Observations	254,717	254,440	254,717	254,209	253,932	254,209
R-squared	0.159	0.159	0.159	0.160	0.160	0.160
Country	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: Impact of Controls and Fixed Effects

This panel provides results from regressions of monthly returns on log scope 1 emissions, illustrating the impact of adding various control variables one at a time on the conclusions that can be drawn about this relation.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Return	Return	Return	Return	Return	Return	Return
Log Scope1	-0.023***	-0.028***	-0.003	-0.001	0.001	-0.005	0.022**
	(0.007)	(0.007)	(0.009)	(0.009)	(0.013)	(0.009)	(0.009)
Log Sales			-0.063***	-0.064***	0.063***	-0.061***	-0.157***
			(0.015)	(0.015)	(0.023)	(0.015)	(0.015)
Leverage				-0.050***			
				(0.017)			
Log PPE					-0.111***		
					(0.018)		
Invest/A						0.115*	
						(0.065)	
ROE							0.029***
							(0.001)
Constant	1.191***	1.239***	2.327***	2.350***	0.326	2.295***	3.737***
	(0.077)	(0.072)	(0.258)	(0.258)	(0.397)	(0.261)	(0.258)
Observations	254,717	254,717	254,209	254,149	194,659	252,331	248,933
R-squared	0.001	0.159	0.160	0.160	0.153	0.160	0.169
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	No	Yes	Yes	Yes	Yes	Yes	Yes

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Panel C: Stock Returns and Log Total Emissions

This panel provides results from regressions of monthly stock returns on the natural logarithm of scope 1, 2, and 3 emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using country and month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Return	Return	Return	Return	Return	Return	Return	Return	Return
Log Scope1	0.042***			-0.006			-0.006		
	(0.013)			(0.017)			(0.014)		
Log Scope2		0.041**			0.017			0.017	
		(0.017)			(0.021)			(0.023)	
Log Scope3			0.104***			0.063			0.063
			(0.024)			(0.039)			(0.043)
Log Sales	-0.103***	-0.107***	-0.176***	-0.035	-0.052*	-0.103**	-0.035	-0.052	-0.103
	(0.023)	(0.025)	(0.031)	(0.028)	(0.029)	(0.047)	(0.044)	(0.040)	(0.064)
Leverage	-0.061***	-0.064***	-0.062***	-0.046**	-0.047**	-0.047**	-0.046*	-0.047*	-0.047*
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)	(0.027)
Invest/A	0.277***	0.282***	0.282***	0.246**	0.244**	0.248**	0.246**	0.244**	0.248**
	(0.099)	(0.099)	(0.099)	(0.100)	(0.100)	(0.100)	(0.101)	(0.103)	(0.102)
ROE	0.015***	0.015***	0.015***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Log PPE	-0.056***	-0.046***	-0.048***	-0.063***	-0.069***	-0.067***	-0.063**	-0.069**	-0.067***
	(0.018)	(0.017)	(0.017)	(0.021)	(0.021)	(0.020)	(0.025)	(0.027)	(0.024)
HHI	2.909	3.212	3.189	7.564*	7.481*	7.549*	7.564	7.481	7.549
	(2.081)	(2.082)	(2.080)	(4.213)	(4.210)	(4.211)	(8.536)	(8.566)	(8.607)
Sales Growth	0.021***	0.021***	0.021***	0.020***	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
EPSG	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.642***	2.689***	3.298***	1.689***	1.839***	2.307***	1.689**	1.839**	2.307**
	(0.406)	(0.413)	(0.446)	(0.462)	(0.466)	(0.574)	(0.837)	(0.797)	(0.951)
Observations	150,377	150,208	150,377	150,377	150,208	150,377	150,377	150,208	150,377
R-squared	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	No	No	No	No	Yes	Yes	Yes

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Panel D: Stock Returns and Carbon Intensity

This panel provides results from regressions of monthly stock returns on scope 1, 2, and 3 carbon emissions intensity and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using country and month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Return	Return	Return	Return	Return	Return	Return	Return	Return
Carbon Intensity Scope1	0.004			-0.019*			-0.019*		
	(0.008)			(0.010)			(0.010)		
Carbon Intensity Scope2		0.123***			0.026			0.026	
		(0.044)			(0.055)			(0.064)	
Carbon Intensity Scope3			0.045***			0.029			0.029
			(0.012)			(0.020)			(0.028)
Log Sales	-0.078***	-0.065***	-0.074***	-0.041*	-0.038	-0.042*	-0.041	-0.038	-0.042
	(0.022)	(0.023)	(0.022)	(0.025)	(0.025)	(0.025)	(0.040)	(0.042)	(0.040)
Leverage	-0.063***	-0.063***	-0.063***	-0.046**	-0.046**	-0.047**	-0.046*	-0.046*	-0.047*
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.027)	(0.027)	(0.027)
Invest/A	0.281***	0.283***	0.283***	0.243**	0.248**	0.249**	0.243**	0.248**	0.249**
	(0.099)	(0.099)	(0.099)	(0.100)	(0.100)	(0.100)	(0.102)	(0.102)	(0.101)
ROE	0.015***	0.015***	0.015***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Log PPE	-0.035**	-0.048***	-0.043***	-0.061***	-0.067***	-0.064***	-0.061**	-0.067**	-0.064**
	(0.017)	(0.017)	(0.016)	(0.020)	(0.021)	(0.020)	(0.024)	(0.026)	(0.024)
HHI	3.021	3.512*	3.185	7.553*	7.525*	7.554*	7.553	7.525	7.554
	(2.081)	(2.087)	(2.081)	(4.211)	(4.211)	(4.211)	(8.544)	(8.547)	(8.589)
Sales Growth	0.021***	0.021***	0.021***	0.020***	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
EPSG	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.438***	2.186***	2.308***	1.764***	1.687***	1.709***	1.764**	1.687**	1.709**
	(0.405)	(0.414)	(0.404)	(0.448)	(0.456)	(0.448)	(0.799)	(0.835)	(0.801)
Observations	150,377	150,377	150,377	150,377	150,377	150,377	150,377	150,377	150,377
R-squared	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203	0.203
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	No	No	No	No	Yes	Yes	Yes

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Panel E: Growth in Carbon Emissions

This panel provides results from regressions of monthly stock returns on the year-over-year growth in scope 1, 2, and 3 carbon emissions and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using country and month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Return	Return	Return	Return	Return	Return	Return	Return	Return
Scope 1 Growth	0.014			0.018			0.018		
	(0.034)			(0.034)			(0.044)		
Scope 2 Growth		0.009			0.004			0.004	
		(0.030)			(0.031)			(0.035)	
Scope 3 Growth			0.052			0.032			0.032
			(0.130)			(0.130)			(0.189)
Log Sales	-0.071***	-0.071***	-0.071***	-0.024	-0.025	-0.024	-0.024	-0.025	-0.024
	(0.023)	(0.023)	(0.023)	(0.027)	(0.027)	(0.027)	(0.041)	(0.041)	(0.041)
Leverage	-0.056***	-0.056***	-0.055**	-0.039*	-0.038*	-0.038*	-0.039	-0.038	-0.038
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.031)	(0.031)	(0.031)
Invest/A	0.294***	0.294***	0.294***	0.257**	0.255**	0.256**	0.257**	0.255**	0.256**
	(0.107)	(0.107)	(0.107)	(0.108)	(0.108)	(0.108)	(0.107)	(0.107)	(0.106)
ROE	0.014***	0.014***	0.014***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Log PPE	-0.029*	-0.029*	-0.029*	-0.067***	-0.066***	-0.066***	-0.067***	-0.066***	-0.066***
	(0.017)	(0.017)	(0.017)	(0.022)	(0.022)	(0.022)	(0.025)	(0.025)	(0.024)
HHI	3.042	3.055	3.043	4.478	4.448	4.449	4.478	4.448	4.449
	(2.234)	(2.233)	(2.234)	(4.568)	(4.565)	(4.567)	(7.410)	(7.411)	(7.412)
Sales Growth	0.019***	0.020***	0.019***	0.018***	0.019***	0.018***	0.018***	0.019***	0.018***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)
EPSG	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.166***	2.173***	2.175***	1.356***	1.377***	1.369***	1.356	1.377*	1.369
	(0.429)	(0.430)	(0.429)	(0.480)	(0.480)	(0.480)	(0.821)	(0.820)	(0.822)
Observations	133,212	133,056	133,212	133,212	133,056	133,212	133,212	133,056	133,212
R-squared	0.208	0.208	0.208	0.209	0.209	0.209	0.209	0.209	0.209
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	No	No	No	No	Yes	Yes	Yes

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Panel F: Change in Carbon Intensity

This panel provides results from regressions of monthly stock returns on the year-over-year change in scope 1, 2, and 3 carbon emissions intensity and including the full set of control variables. In Columns (1), (2), and (3) we estimate regressions using month-year fixed effects but neither industry fixed effects nor clustering of standard errors; in Columns (4), (5), and (6) we add industry fixed effects (but not clustering of standard errors); and in Columns (7)-(9) we include industry fixed effects, month-year fixed effects, as well as clustering of standard errors by both industry and month-year. Please refer to Appendix A for variable definitions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Return	Return	Return	Return	Return	Return	Return	Return	Return
Change in Scope 1 Intensity	-0.001			-0.001			-0.001		
	(0.001)			(0.001)			(0.001)		
Change in Scope 2 Intensity		-0.002			-0.002			-0.002	
		(0.002)			(0.002)			(0.002)	
Change in Scope 3 Intensity			-0.000			0.001			0.001
			(0.001)			(0.001)			(0.002)
Log Sales	-0.071***	-0.071***	-0.071***	-0.025	-0.024	-0.024	-0.025	-0.024	-0.024
	(0.023)	(0.023)	(0.023)	(0.027)	(0.027)	(0.027)	(0.041)	(0.041)	(0.041)
Leverage	-0.055**	-0.055**	-0.055***	-0.038*	-0.038*	-0.038*	-0.038	-0.038	-0.038
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.031)	(0.031)	(0.031)
Invest/A	0.297***	0.294***	0.294***	0.259**	0.256**	0.256**	0.259**	0.256**	0.256**
	(0.107)	(0.107)	(0.107)	(0.108)	(0.108)	(0.108)	(0.106)	(0.106)	(0.107)
ROE	0.014***	0.014***	0.014***	0.015***	0.015***	0.015***	0.015***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Log PPE	-0.030*	-0.029*	-0.029*	-0.066***	-0.066***	-0.067***	-0.066***	-0.066***	-0.067***
	(0.017)	(0.017)	(0.017)	(0.022)	(0.022)	(0.022)	(0.025)	(0.025)	(0.025)
HHI	3.083	3.058	3.059	4.482	4.415	4.453	4.482	4.415	4.453
	(2.234)	(2.233)	(2.234)	(4.567)	(4.567)	(4.567)	(7.409)	(7.409)	(7.409)
Sales Growth	0.019***	0.020***	0.020***	0.018***	0.019***	0.019***	0.018***	0.019***	0.019***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
EPSG	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.175***	2.177***	2.170***	1.377***	1.373***	1.361***	1.377*	1.373*	1.361
	(0.429)	(0.429)	(0.429)	(0.480)	(0.480)	(0.480)	(0.825)	(0.821)	(0.825)
Observations	133,212	133,212	133,212	133,212	133,212	133,212	133,212	133,212	133,212
R-squared	0.208	0.208	0.208	0.209	0.209	0.209	0.209	0.209	0.209
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	No	No	No	No	No	No	Yes	Yes	Yes

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