

**Simon Dietz, Charles Fruitiere, Carlota Garcia-Manas,
William Irwin, Bruno Rauis and Rory Sullivan**

An assessment of climate action by high-carbon global corporations

**Article (Accepted version)
(Refereed)**

Original citation:

Dietz, Simon and Fruitiere, Charles and Garcia-Manas, Carlotta and Irwin, William and Rauis, Bruno and Sullivan, Rory (2018) *An assessment of climate action by high-carbon global corporations*. [Nature Climate Change](#). ISSN 1758-678X

© 2018 [Springer Nature](#)

This version available at: <http://eprints.lse.ac.uk/90489/>

Available in LSE Research Online: October 2018

LSE has developed LSE Research Online so that users may access research output of the School. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LSE Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain. You may freely distribute the URL (<http://eprints.lse.ac.uk>) of the LSE Research Online website.

This document is the author's final accepted version of the journal article. There may be differences between this version and the published version. You are advised to consult the publisher's version if you wish to cite from it.

An assessment of climate action by high-carbon global corporations

Simon Dietz^{a,b*}, Charles Fruitiere^c, Carlota Garcia-Manas^d, William Irwin^a, Bruno Rausis^a and Rory Sullivan^{c,e}

^a ESRC Centre for Climate Change Economics and Policy, and Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science (LSE), London, UK

^b Department of Geography and Environment, LSE, London, UK

^c FTSE Russell, London, UK

^d Church Commissioners for England and Church of England Pensions Board, London, UK

^e ESRC Centre for Climate Change Economics and Policy, Sustainability Research Institute, and School of Earth and Environment, University of Leeds, UK

* Corresponding author: e-mail s.dietz@lse.ac.uk

11th October 2018

Corporations are a significant source of greenhouse gas emissions¹⁻³ and an important actor in mitigating climate change.⁴ This paper presents and analyses a database of corporate climate action, which provides an up-to-date assessment of companies' carbon management practices, as well as systematically benchmarking companies' emissions pathways against international targets. Our analysis covers 138 companies in 7 high-emitting sectors, accounting for 21% of emissions from all listed companies globally.⁵ While a majority of companies has implemented basic carbon management practices, we find that less than half of them have implemented more strategic practices. Further analysis indicates companies separate into a class that hardly undertakes any carbon management practices, and a class that undertakes most. Perhaps surprisingly, most corporate emissions targets in our sample are aligned with the Paris Agreement goals, although most companies are yet to set quantified targets. Companies that have implemented more carbon management practices today are more likely to have set 2°C-aligned targets. Carbon management and emissions performance are associated most strongly with where companies are headquartered and their size.

This paper introduces and analyses a new database of corporate climate action; the Transition Pathway Initiative or TPI (www.transitionpathwayinitiative.org). TPI is a consortium of investors, a commercial data provider and a university (see Methods). The database comprises the largest companies globally by market value in sectors with a high lifecycle carbon footprint. At the time of writing, the database includes the 19-20 largest publicly listed companies in each of the automotive, cement, coal mining, electricity, oil and gas, paper, and steel sectors. Each company is evaluated on its carbon management practices, as well as forward-looking emissions trajectories that test the ambition of companies' emissions targets. Company data originate from a content analysis of all relevant company disclosures, including annual reports, sustainability reports, responses to the CDP (formerly Carbon Disclosure Project) questionnaire, etc.

TPI assesses corporate management of carbon emissions in four thematic areas: (i) acknowledgement of climate change and the need to reduce carbon emissions; (ii) corporate disclosures on emissions and the business costs of climate change; (iii) company targets to reduce emissions; and (iv) the extent to which climate change is a boardroom or “c-suite” issue. The high-level results are presented in Figure 1 and all the raw company data can be found in the Supplementary Information (SI), while the online tool is regularly updated.

Panel (a) shows that 85% of the 138 companies assessed have a published policy or equivalent statement on climate change, which commits them to addressing the issue, e.g. by improving energy efficiency or reducing emissions. But only 67% explicitly recognise climate change is significant for, or material to, the business, and only 40% demonstrate support for public policy to mitigate climate change.

Panel (b) shows that 77% of the companies disclose their operational (i.e. so-called Scope 1 and 2) emissions, but only 47% have had these data independently verified by a third party, or have used an international assurance standard. Fifty six per cent of the companies disclose some wider (i.e. Scope 3) emissions data, although this is often narrowly defined (e.g. reporting on emissions from business travel only). Only 34% provide information on the business costs of climate change, for example capital investments or the costs of tradable emissions allowances.

Panel (c) shows that 54% of the 138 companies have set some kind of time-specific target to increase their energy efficiency, or reduce their emissions. These targets may be qualitative or quantitative, relative or absolute, and relate to processes or outcomes. Forty six per cent have set quantitative targets to reduce their operational emissions, but only 38% have set a long-term quantitative target, defined as at least five years from the point of announcement.

Lastly, panel (d) shows that 49% of the companies have assigned boardroom responsibility for climate change by explicitly nominating a board member or committee to oversee the company’s climate change policy. Similarly 47% have incorporated environmental, social and governance issues into executive remuneration.

{Figure 1 about here}

Looking across all 12 practices, it is clear that progress on corporate management of carbon emissions is incomplete. A majority of companies has taken initial steps, including publishing a policy to act and explicitly recognising climate change as significant/material (acknowledgement), disclosing operational and some value-chain emissions (disclosure), and setting some form of energy/emissions target. However, to date only a minority has taken the more advanced steps, such as setting long-term emissions targets, or assigning boardroom responsibility for climate change.

Figure 2 explores company-level variation by counting the number of practices each company has implemented. The distribution is multi-modal. Relatively many companies implement just a few practices, while the biggest peak comprises companies that implement almost all of them. This provides some evidence that companies separate into a class that hardly undertakes any carbon management, and a class that has reached an advanced stage. Stronger evidence for this comes from studying correlations between the practices, and from cluster and exploratory factor analysis (see SI). The correlations are almost all strongly positive (i.e. Yes to one practice is associated with Yes to another), indicating that, rather than there being different clusters of management practices commonly undertaken, companies either undertake most/all practices or few/none. This is further corroborated by the cluster analysis. According to the exploratory factor analysis, one common

factor explains most of the covariation between the practices and all the practices load positively on to this factor, which may be interpreted as overall carbon management competence/effort.

{Figure 2 about here}

The SI also looks at the association between the count of carbon management practices implemented and company sector, size and region of headquartering. There are significant differences with respect to all three. Automobile manufacturers and electricity utilities implement the most carbon management practices, while coal-mining companies and steel makers implement the fewest. Companies with a large market capitalisation implement more carbon management practices than medium and small companies. Companies headquartered in Western Europe and to a lesser extent the Industrialised Asia-Pacific region do more than companies headquartered in emerging markets and in North America. Sector, size and region are associated with each other. Controlling for the influence of each, the evidence suggests region and size matter more.

While management practices are an input to corporate climate action, emissions are the ultimate output. Therefore we also assess companies on their current and future carbon footprint, using the Sectoral Decarbonization Approach (SDA).⁶ We use the SDA to 'benchmark' companies' carbon footprints against international climate goals. We set two benchmarks corresponding with (i) limiting warming to no more than 2°C, and (ii) the Nationally Determined Contributions or NDCs to the Paris Agreement, which as they stand will not limit warming to 2°C.⁷

The SDA relies on integrated modelling to apportion a carbon budget consistent with these international climate goals to individual sectors. This budget is then combined with projections of sectoral activity/production from the same models to derive a benchmark pathway for companies' emissions intensity, with the scope of emissions being sector-specific. A company with lower (higher) emissions intensity than the benchmark pathway is said to be (not) aligned with that benchmark. Reductions in emissions intensity do not of course necessarily result in absolute emissions reductions,⁸ but the SDA method ensures the overall carbon budget is adhered to. Further details of how we apply the SDA can be found in the Methods.

Figure 3 reports the share of companies aligned with the benchmarks in the historical period (2013/14 to 2015/16, depending on the availability of company data), in 2020, 2025 and 2030 (see the SI for all the underlying data). Note that this part of our assessment excludes the two extractive industries (coal mining, and oil and gas production). The vast majority of lifecycle emissions in these two sectors comes from fossil-fuel burning downstream in the value chain, yet companies generally provide insufficient data on this, and hardly any companies have set targets covering these emissions. The total number of companies considered in the analysis of carbon performance is therefore 98.

{Figure 3 about here}

Two results stand out. First, there is limited availability of comparable emissions data and availability falls markedly as we look to the future. Twenty eight per cent of the 98 companies do not disclose their historical emissions and activity/production in a comparable form (panel a). This is a higher share of companies than do not make any emissions disclosures (cf. Figure 1), because the SDA requires a more exact form of disclosure to enable meaningful quantitative comparisons. Moreover the share of companies with no data rises steadily to 86% in 2030. This reflects a lack of long-term targets, which are the basis of future projections in the SDA.

Second, perhaps surprisingly, a large share of company targets would, if achieved (see Methods), see these companies aligned with the NDCs and 2°C. In 2020, 59% of the 41 companies with data/targets are aligned with the 2°C benchmark and a further 12% are aligned with the NDCs benchmark only (panel b). In 2030, the corresponding shares are 50% and 21% respectively of 14 companies (panel d). This comparatively good performance might have been because companies with 2020/30 targets start with an emissions intensity that is below average. In other words, the sample of companies with 2020/30 targets might have been biased towards those that perform well today, and do not have to try too hard to stay aligned. But the data do not support this explanation. The standardised historical emissions intensity of companies with 2020 targets is -0.03 standard deviations on average, implying their historical emissions intensity is close to the average of all companies. Similarly the standardised historical emissions intensity of companies with 2030 targets is -0.17 on average. The alternative explanation is that the majority of long-term emissions targets are ambitious enough to be consistent with international climate goals, even 2°C. The main problem is that not enough companies have set such targets.

The SI looks at the association between alignment with the Paris Agreement, as measured by alignment with the NDCs specifically, and company sector, size and region of headquartering. It finds that companies headquartered in Western Europe are significantly more likely to have adopted an emissions target aligned with the NDCs, particularly in 2020 (note this refers a global benchmark that is the sum of NDCs and does not necessarily mean that companies headquartered in Western Europe are aligned with the specific NDCs of the countries in which they are headquartered or operate). It is harder to ascertain significant size and sector effects on alignment with the NDCs, though the sample size is particularly small (98 observations). The SI also compares the characteristics of the subset of TPI companies that respond to the CDP questionnaire with the subset that don't. We find that CDP responders perform significantly better on carbon management and emissions, which indicates a risk of sample bias in relying on CDP data alone, versus compiling information from CDP together with other sources.

What is the relationship between companies' carbon management and their emissions intensity? The correlation coefficient between the count of management practices implemented by each company and companies' standardised historical emissions intensity is 0.09, so there is no relationship. What about *future* emissions intensity? For this we count only the 9 management practices that do not concern whether companies have set targets for future emissions. The average count of management practices implemented by companies aligned with 2°C in 2020 is 6.6 out of 9, compared with 4.7 for companies that are not aligned, or provide no data (difference is significant at 1% level). In 2030, the respective counts are 7 and 5 (difference significant at 10% level). Therefore companies aligned with 2°C in 2020 and 2030 are likely to have implemented more carbon management measures today. The existing literature on the relationship between carbon/environmental management, as evidenced by disclosures, and performance is rather inconclusive, both in terms of theoretical predictions and empirical results.⁹⁻¹³ However, the latest evidence suggests that, although current management, as evidenced by disclosures, may not be reliably related to current performance, better disclosure/management might be associated with better future performance.¹⁴ Assuming companies meet their future targets, this is also what we find.

There are several limitations to this study. Chief among them is our reliance on company disclosures to form an impression of corporate climate action. Critical perspectives highlight that companies may 'greenwash' their disclosures in order to legitimise their activities.¹⁵⁻¹⁷ Our approach does not allow us to compare what companies report with what they actually do, which is perhaps the best

empirical test of the greenwash hypothesis. For example, companies may be publicly supportive of climate policy, but lobby against it in private, or otherwise behave in contradictory ways towards the issue.¹⁸ Alternatively companies may be taking climate actions that they fail to disclose. Another limitation is that the sample of companies is not random. One can therefore think of the companies included at this stage as the *population* of large, publicly listed corporations in high-emitting sectors, but must avoid drawing inferences about other, smaller corporations in these sectors, about other sectors, or about unlisted or state-owned companies.

Despite these limitations, we can draw policy-relevant conclusions from the evidence provided. While a majority of companies has implemented basic carbon management practices like publishing a climate change policy and disclosing operational emissions, less than half of companies have implemented more strategic practices. Most large corporations in high-emitting sectors have a long way to go before they can be said to manage carbon strategically. The ability to assess the future emissions performance of large corporations is constrained by the lack of quantitative emissions targets, particularly those stretching beyond 2020. Nonetheless, perhaps surprisingly, most long-term quantitative corporate targets are aligned with the Paris Agreement goals. We also find that companies, which have implemented more carbon management practices today, are more likely to have set long-term emissions targets aligned with the 2°C goal. This implies that investors and other stakeholders should focus on getting companies to set long-term corporate targets, as part of a larger set of carbon management practices.

References

1. Covington, H., Thornton, J. & Hepburn, C. J. Shareholders must vote for climate-change mitigation. *Nature* 530, 156 (2016).
2. Heede, R. Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854-2010. *Clim. Change* 122, 229–241 (2014).
3. Moorhead, J. & Nixon, T. Global 500 Greenhouse Gases Performance 2010–2013: 2014 Report on Trends. (2014).
4. Persson, Å. & Rockström, J. Business leaders. *Nat. Clim. Chang.* 1, 426–427 (2011).
5. Trucost. Trucost EBoard Screening Tool. (2017). Available at: <https://www.trucost.com/capital-markets/eboard-data-analytics/> (Accessed: 15th November 2017)
6. Krabbe, O. et al. Aligning corporate greenhouse-gas emissions targets with climate goals. *Nat. Clim. Chang.* 5, 1057–1060 (2015).
7. Rogelj, J. et al. Paris Agreement climate proposals need a boost to keep warming well below 2°C. *Nature* 534, 631–639 (2016).
8. Cadez, S. & Guilding, C. Examining distinct carbon cost structures and climate change abatement strategies in CO₂ polluting firms. *Accounting, Audit. Account. J.* 30, 1041–1064 (2017).
9. Cho, C. H. & Patten, D. M. The role of environmental disclosures as tools of legitimacy: A research note. *Accounting, Organ. Soc.* 32, 639–647 (2007).
10. Freedman, M. & Jaggi, B. in *Sustainability, Environmental Performance and Disclosures (Advances in Environmental Accounting & Management, Volume 4)* (eds. Freedman, M. & Jaggi, B.) 129–160 (Emerald Group Publishing Limited, 2009).
11. Hughes, S. B., Anderson, A. & Golden, S. Corporate environmental disclosures: Are they useful in determining environmental performance? *J. Account. Public Policy* 20, 217–240 (2001).
12. Luo, L. & Tang, Q. Does voluntary carbon disclosure reflect underlying carbon performance? *J. Contemp. Account. Econ.* 10, 191–205 (2014).
13. Doda, B., Gennaioli, C., Gouldson, A., Grover, D. & Sullivan, R. Are Corporate Carbon Management Practices Reducing Corporate Carbon Emissions? *Corp. Soc. Responsib. Environ. Manag.* 23, 257–270 (2016).
14. Qian, W. & Schaltegger, S. Revisiting carbon disclosure and performance: Legitimacy and management views. *Br. Account. Rev.* 49, 365–379 (2017).
15. Beder, S. *Global Spin: the Corporate Assault on Environmentalism.* (Chelsea Green Publishing, 1997).
16. Laufer, W. S. Social accountability and corporate greenwashing. *Journal of Business Ethics* 43, 253–261 (2003).
17. Delmas, M. A. & Burbano, V. C. The drivers of greenwashing. *Calif. Manage. Rev.* 54, 64–87 (2011).

18. Nasiritousi, N. Fossil fuel emitters and climate change: unpacking the governance activities of large oil and gas companies. *Env. Polit.* 26, 621–647 (2017).

Methods

1. About the Transition Pathway Initiative

The Transition Pathway Initiative (TPI) is an initiative led by asset owners and supported by asset managers, who collectively account for over £7/\$9.3 trillion of assets under management (as of 5th June 2018). The purpose of the initiative is to assess companies' progress on the transition to a low-carbon economy, focusing on:

- The quality of companies' management of their greenhouse gas emissions and of risks and opportunities related to the low-carbon transition, and;
- Companies' carbon emissions performance and how it compares to the international targets and national pledges made as part of the 2015 UN Paris Agreement.

TPI publishes the results of this analysis through an open-access online tool that is hosted by the Grantham Research Institute on Climate Change and the Environment at the London School of Economics (LSE). The tool, as well as further information about TPI, can be accessed at <http://www.transitionpathwayinitiative.org>.

TPI was established as a joint initiative between the National Investing Bodies of the Church of England (the Church of England Pensions Board, Church Commissioners and CBF Church of England Funds) and the Environment Agency Pension Fund, two UK-based asset owners with a commitment to sustainable investing. Its initial development has been overseen by a Steering Group of asset owners from Europe and the US. Currently about 30 asset owners and managers officially support TPI and they have committed to use the data in a number of different ways, including informing their investment decision-making, shareholder engagement with companies, and dialogues with fund managers and with policy-makers. The UN-supported Principles of Responsible Investment is also a partner of the initiative.

Analysis for TPI is conducted by a team of academics at LSE, in partnership with FTSE Russell, a commercial provider of benchmarking, analytics and data solutions.

2. Company sampling procedure

The TPI database has been amassed by first selecting high-emitting sectors of the economy, and then in each sector sampling the largest 20 publicly listed companies by market capitalization, subject to companies within this list being part of FTSE Russell's research universe (which explains why, in the case of the cement and paper sectors, only 19 companies are eventually included). The selection of sectors has also been guided by the engagement and investment priorities of the asset owners supporting the initiative, and has been informed by the availability of data, particularly those data necessary to benchmark emissions (see below). As a result, the following sectors are currently included in the database:

- Automobile manufacturing;
- Cement;
- Coal mining (i.e. specialist coal-mining companies, but also diversified mining companies who mine coal);
- Electricity;
- Oil and gas;
- Paper;

- Steel.

This sampling procedure allows a relatively small number of companies in a relatively small number of sectors to account for a relatively large share of global emissions. We estimate that the 138 companies in the TPI database collectively account for about 21% of emissions from all listed companies globally. This is based on Scope 1, 2 and 3 emissions data for the year 2015, obtained using the Trucost EBoard “Screening Tool” on 15 November 2017, selecting all sectors, geographies and market capitalisations (6,152 individual companies in the 2015 dataset).⁵ 136 of our 138 companies contribute 22.59% of all emissions reported by Trucost. According to Trucost, their dataset comprises 93% of global markets by market capitalisation. Therefore $0.93 \times 22.59 = 21\%$. Two companies covered by TPI are not in the Trucost database.

Having a relatively small number of sectors makes the application of the Sectoral Decarbonization Approach feasible (see below). However, note that some large corporations in high-carbon sectors do not themselves have high emissions. The automobile manufacturer Tesla is a good example.

3. Corporate carbon management assessment methodology

This paper focuses on 12 corporate carbon management practices, including whether the company has in place a policy on climate change, the extent of its emissions disclosures and targets, and whether climate change is demonstrably a boardroom issue. Supplementary Table 1 provides detailed information on the criteria used to establish whether a company undertakes each practice.

The preliminary assessment of each company goes through a company review stage, in which the company is contacted with a draft of TPI’s assessment and invited to check the veracity of the disclosed data being used, as well as being requested to answer specific queries in some cases. Companies may propose corrections, but they must be evidenced by publicly available data and cannot be altered on the basis of data that are only communicated privately to TPI.

4. Applying the Sectoral Decarbonization Approach to assess emissions performance

TPI’s assessment of corporate emissions is based on the Sectoral Decarbonization Approach (SDA).⁶ The SDA translates emissions targets made at the international level (e.g. under the Paris Agreement to the UN Framework Convention on Climate Change) into appropriate benchmarks, against which the performance of individual companies can be compared.

The SDA is built on the principle of recognising that different sectors of the economy (e.g. oil and gas production, electricity generation and automobile manufacturing) face different challenges arising from the low-carbon transition, including where emissions are concentrated in the value chain, and how costly it is to reduce emissions. Therefore the SDA takes a sector-by-sector approach, comparing companies within each sector against each other and against sector-specific benchmarks, which establish the performance of an average company that is aligned with international emissions targets. In taking a sector-by-sector approach, the SDA differs from other approaches to translating international emissions targets into company benchmarks, which have applied the same decarbonisation pathway to all sectors, regardless of the differences between sectors.¹⁹

Applying the SDA can be broken down into the following steps:

1. A global carbon budget is established, which is consistent with international emissions targets, for example keeping global warming below 2°C. To do this rigorously, some input from a climate model is required.

2. The global carbon budget is allocated across time and to different regions and industrial sectors. This typically requires an energy systems model, and these models usually allocate emissions reductions by region and by sector according to where it is cheapest to reduce emissions and when (i.e. the allocation is cost-effective). Cost-effectiveness is, however, subject to some constraints, such as political and public preferences, and the availability of capital. This step is therefore driven primarily by economic and engineering considerations, but with some awareness of political and social factors.
3. In order to compare companies of different sizes, sectoral emissions are normalised by a relevant measure of sectoral activity (e.g. physical production, economic activity). This results in a benchmark path for emissions *intensity* in each sector:

$$\text{Emissions intensity} = \frac{\text{Emissions}}{\text{Activity}}$$

Assumptions about sectoral activity need to be consistent with the emissions modelled and are therefore taken from the same energy systems modelling.

4. Companies' recent and current emissions intensity is calculated and their future emissions intensity can be estimated based on emissions targets they have set (i.e. this assumes companies exactly meet their targets). Together these establish emissions intensity pathways for companies. For companies with absolute emissions targets, their activity is assumed to grow at the same rate as the sector according to the energy systems model used to create the benchmark paths (this amounts to assuming that the company's market share remains constant).
5. Companies' emissions intensity paths are compared with each other and with the relevant sectoral benchmark paths.

One can reasonably doubt whether companies' targets are indicative of their future emissions performance. Companies may under-deliver on their targets, or indeed over-deliver (the data in the SI show that some companies already have an emissions intensity that is below their future target, e.g. American Electric Power). There is a large and long-standing literature in management studies on the relationship between the act of setting targets and company performance, both in the private and public sectors. In terms of private companies, this debate played out mostly in the 1970s and 1980s under the auspices of Management By Objectives (MBO). Most studies found that target setting was positively associated with company performance on various metrics.^{20,21} Nowadays the notion that setting targets is constitutive of best management practice is mainstream. Subsequently various studies looked into the relationship between target-setting and performance in the public sector, in response to the public sector importing MBO from the private sector. Again the relationship appears to be positive.^{22,23} More recent and rigorous empirical studies have shown that companies who set targets that are, by various yardsticks, well-formulated are more productive, more profitable, etc.²⁴ In relation to corporate climate action, previous work has assessed the credibility of companies' voluntary greenhouse gas emissions targets in depth, taking the example of UK supermarkets, and found various indications that they are credible, in the sense of being likely to be achieved.²⁵

In each sector, TPI evaluates companies against two benchmark pathways:

- A 2 Degrees scenario.
- An NDCs (sometimes referred to as 'Paris Pledges') scenario. The Paris Agreement incorporates emissions reduction pledges by individual countries; Nationally Determined

Contributions (NDCs). There is variation in the ambition of countries' NDCs.²⁶ On aggregate, they are forecast to reduce global emissions well below business as usual (assuming they are fully implemented), but they are currently insufficient to put the world on a path to limit warming to 2°C.²⁷⁻²⁹

Supplementary Table 2 summarises the measure of emissions intensity used in each sector, as well as the source of the benchmark scenarios. The integrated modelling that underpins the benchmark scenarios provides all the data required to complete steps 1-3 above (i.e. the scenarios include emissions and activity data and are consistent with a given emissions budget). Note that the benchmarks do not always require companies to reduce their emissions intensity. As the SI shows, the benchmark emissions intensity of cement and steel is allowed to slightly rise in the near term under the less stringent NDC scenario. This reflects the greater economy-wide carbon budget in this scenario, as well as the higher costs of, and other barriers to, reducing emissions in the cement and steel sectors relative to other sectors.

Companies' emissions and activity data are derived from public disclosures as far as possible (including their annual and sustainability reports, and, for those that participate, their responses to the annual CDP questionnaire). With the exception of automobile manufacturing, only company disclosures are used to estimate recent and current emissions intensity, and company disclosures are also the source of information on targets for future emissions. In automobile manufacturing, data on fleet emissions performance are usually held by regulatory agencies in the main markets (i.e. China, the EU and US), and companies do not always disclose these data themselves. These regulatory data can be combined with companies' disclosures of their regional sales to estimate global fleet emissions performance. The TPI website contains a detailed report on the methodology for each sector.

The SDA is also the basis for the Science Based Targets Initiative, which engages companies seeking to set ambitious emissions targets. Broadly speaking, a target we judge to be aligned with 2°C can be described as 'science-based' in the sense of the Science Based Targets Initiative. There is one difference in the detail of how we apply the SDA compared with the Science Based Targets Initiative, however. Where we have to project future production in order to estimate future emissions intensity, we assume any such company maintains a constant market share, whereas the Science Based Targets Initiative invites the companies it engages to explicitly forecast how their market share changes. In theory this can drive a difference between the assessments. Our approach is born of the fact that we are making third-party assessments and must make consistent assumptions across companies. In that context it is difficult to make any other assumption than that market shares stay constant.

As with carbon management, the preliminary assessment of companies' emissions performance goes through a company review stage.

References

19. Randers, J. Greenhouse gas emissions per unit of value added ('GEVA'): a corporate guide to voluntary climate action. *Energy Policy* 48, 46–55 (2012).
20. Kondrasuk, J. N. Studies in MBO effectiveness. *Academy of management review. Academy of Management* 6, 419–430 (1981).
21. Rodgers, R. & Hunter, J. E. Impact of management by objectives on organizational productivity. *J. Appl. Psychol.* 76, 322–336 (1991).
22. Rodgers, Robert and Hunter, J. A foundation of good management practice in government: management by objectives. *Public Adm. Rev.* 52, 27–39 (1992).
23. Boyne, G. A. & Chen, A. A. Performance targets and public service improvement. *Journal of Public Administration Research and Theory* 17, 455–477 (2008).
24. Bloom, N. & Van Reenen, J. Measuring and explaining management practices across firms and countries. *Quarterly Journal of Economics* 122, 1351–1408 (2007).
25. Gouldson, A. & Sullivan, R. Long-term corporate climate change targets: what could they deliver? *Environ. Sci. Policy* 27, 1–10 (2013).
26. Aldy, J. et al. Economic tools to promote transparency and comparability in the Paris Agreement. *Nat. Clim. Chang.* 6, 1000–1004 (2016).
27. United Nations. Adoption of the Paris Agreement. (2015).
28. UNEP. The Emissions Gap Report 2015: A UNEP Synthesis Report. (2015).
29. Boyd, R., Cranston Turner, J. & Ward, B. Intended nationally determined contributions: what are the implications for greenhouse gas emissions in 2030? (2015).

Data availability

The authors declare that the data supporting the findings of this study are available within the paper and its supplementary information files.

Correspondence and requests for materials should be addressed to SD.

Author contributions

RS designed the methodology for assessing carbon management practices, with input from CGM and SD. SD designed the methodology for assessing emissions performance, with input from CGM, WI, BR and RS. SD, CF, WI, BR and RS analysed the data. SD and WI drafted the paper with input from CF, CGM, BR and RS.

Competing financial interests

No competing financial interests have affected the conduct or results of this research.

Acknowledgements

TPI is funded and supported by a group of asset owners and managers listed at www.transitionpathwayinitiative.org. SD would also like to acknowledge the support of the UK's Economic and Social Research Council (ESRC), and the Grantham Foundation for the Protection of the Environment. The input of the TPI Steering and Technical Advisory Groups has helped steer this research.

Figure Captions

Figure 1 Share of companies implementing each management practice. The share of companies that has implemented a management practice is shaded blue, the share that has not is shaded red and stippled. Management practices are classified into four thematic areas, (a) acknowledgement and support, (b) disclosure, (c) targets and (d) boardroom.

Figure 2 Distribution of the count of management practices implemented by companies.

Figure 3 Share of companies with an emissions intensity aligned with (i.e. below) international climate goals. The four panels correspond with (a) the historical period (2013/14 – 2015/16), (b) 2020, (c) 2025 and (d) 2030. Companies are distinguished in terms of alignment with the Paris Agreement NDCs, the Paris Agreement 2°C target, companies with targets that are not in alignment with either of the Paris goals, and companies for whom there are no data.